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[72]	Inventor	David E. Perlman Rochester, N. Y.
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[73]	Assignee	Detection Systems Inc. East Rochester, N. Y. a corporation of New York

[56]

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Primary Examiner—James W. Lawrence

Assistant Examiner—C. M. Leedom

Attorney—Warren W. Kurz

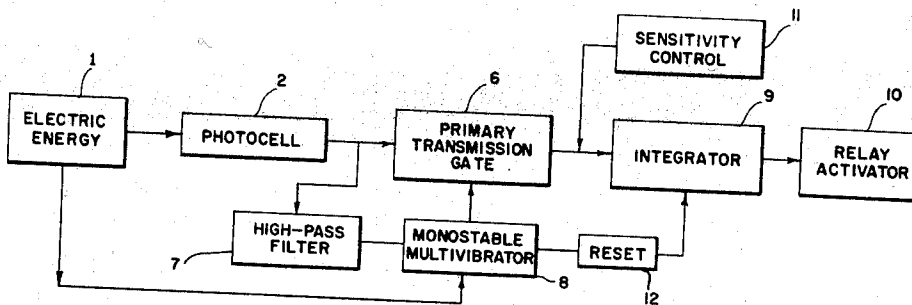
**[54] PHOTOELECTRIC CIRCUITRY FOR PASSIVE
DETECTION SYSTEMS**
4 Claims, 3 Drawing Figs.

[52] U.S. Cl..... 250/214,
250/221, 340/276

[51] Int. Cl. H01j 39/12

[50] **Field of Search**..... 250/222,
221, 214; 340/276

ABSTRACT: A photoelectric control circuit adapted for use in passive intruder detection systems. The circuit is provided with means for detecting only that type of change in lighting conditions which normally accompanies the presence of an unauthorized person in a darkened area protected by such system. The circuit includes means for discriminating against transient lighting conditions which occur faster or slower than certain predetermined rates.



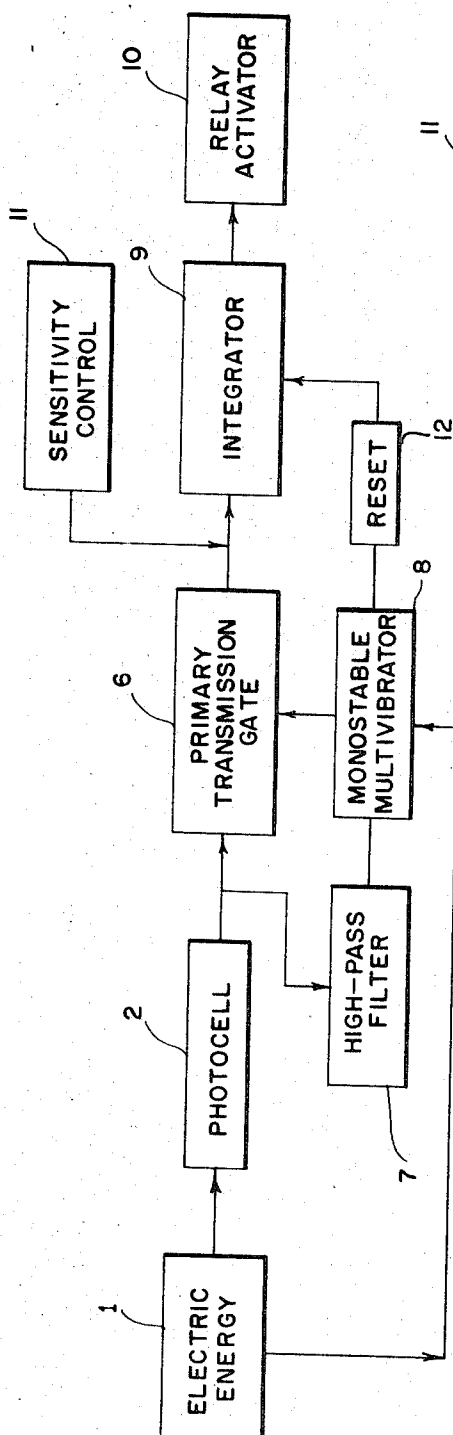


FIG. 1

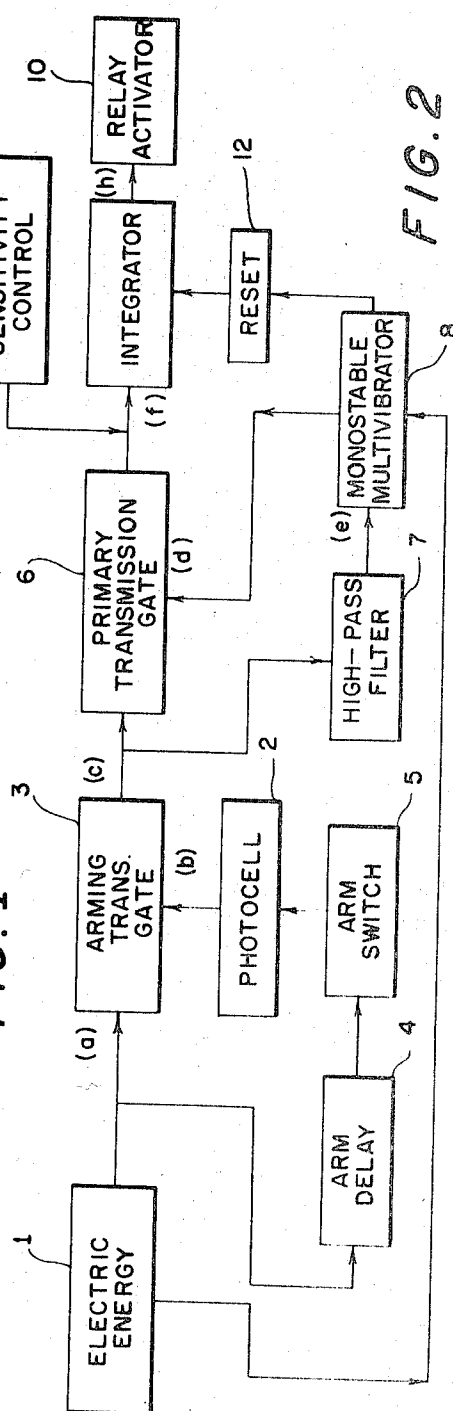
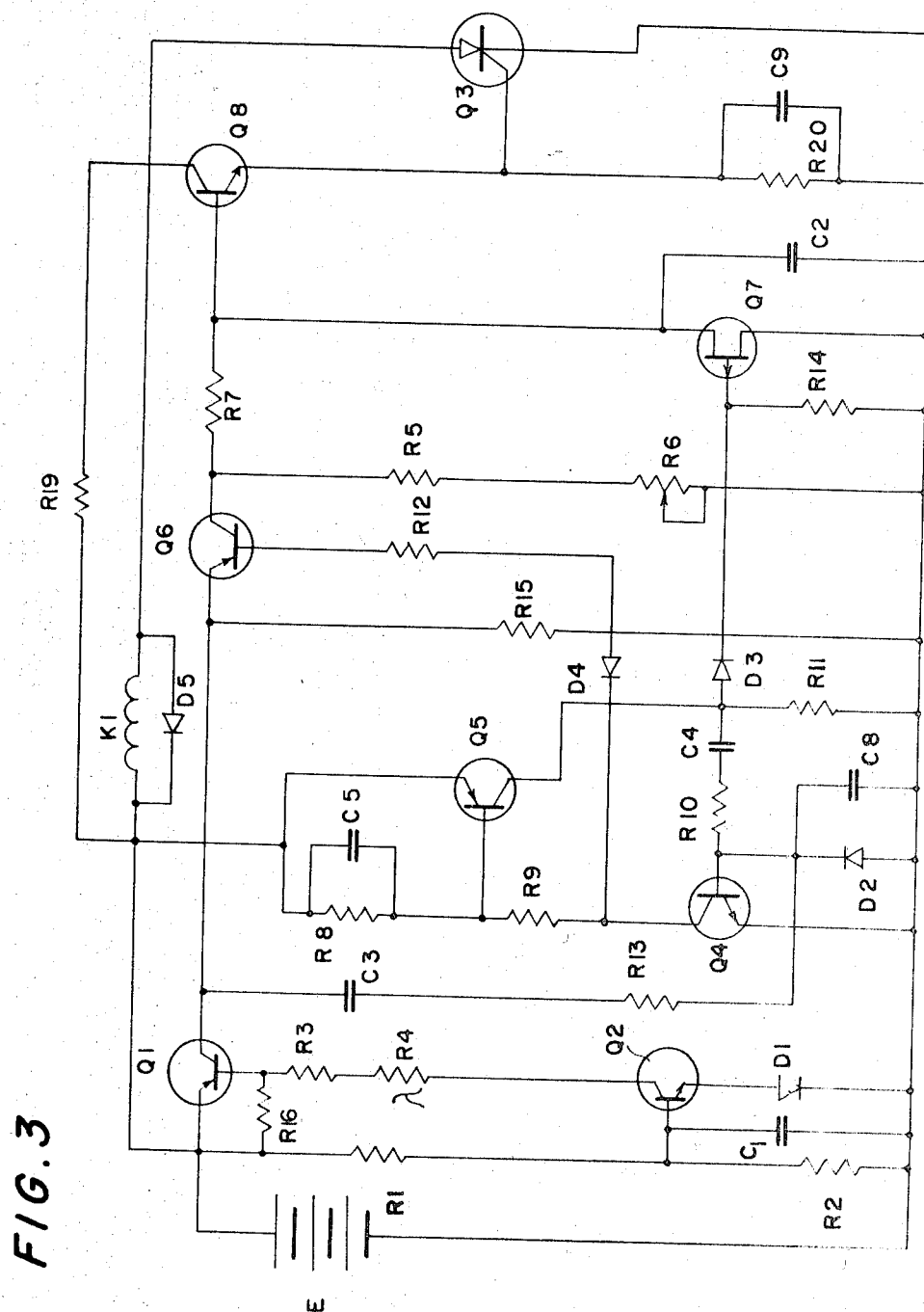


FIG. 2

INVENTOR
DAVID E. PERLMAN

BY

Warren W. Kury
AGENT



INVENTOR
DAVID E. PERLMAN

BY

Warren W. Kury
AGENT

PHOTOELECTRIC CIRCUITRY FOR PASSIVE DETECTION SYSTEMS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to passive photoelectric intruder detection devices and more particularly to improved photo-responsive electronic circuits for use in such devices.

2. Description of the Prior Art

Photoelectric alarm systems are generally either "active" or "passive" in nature. "Active" commonly denotes that type of system which employs its own light source as a means for detecting the presence of intruders or unauthorized personnel in an area protected by such a system. Usually means are provided (e.g. mirrors, prisms, lenses, etc.) for directing a pencil beam of light from the source, across the area to be protected, to a photosensitive element which is operatively connected to an alarm of some type. Activation of the alarms depends upon the breaking of the light beam by the intruder as he passes through the protected area. In view of the limited area of surveillance of such systems, this area being restricted to the rather minute region through which the beam passes, inadequate protection is often provided. Moreover, the inherent necessity of a light source which draws considerable power and is subject to burnout, and the necessity of accurately aligning the photosensitive element with the light beam, can result in relatively expensive operation and installation costs.

"Passive" systems, on the other hand, require no light source as a part of the detection system. The operation of such systems depends upon the intruder himself causing the ambient light level in the protected area to vary in such a manner as to be detected by the system's photosensitive element. A detectable variation in ambient light level might result from the intruder's use of a flashlight or lamp in a normally darkened area, or it might result simply from the intruder's presence in the protected area which presence might cause a shadow to be cast upon the photosensitive element or otherwise cause a change in the reflected light striking the element. Upon detecting such changes in ambient light level, the photosensitive element will cause activation of the alarm. Although passive systems are advantageous in that a large area may be maintained under surveillance by a single photosensitive circuit which draws relatively little current, such systems, heretofore, have been readily prone to generating false alarms. This deficiency stems from the fact that passive photoelectric alarms of the prior art have been generally incapable of distinguishing light level changes caused by spurious sources (e.g. by lightning, passing automobile headlights and the advent of daylight and nightfall) from the type of light level changes which generally accompany the presence of an intruder or other unauthorized person.

BRIEF SUMMARY OF THE INVENTION

The primary object of the invention is to provide an improved photoelectric intruder detection system.

Another object of this invention is to provide an improved photoelectric control circuit adapted for use in a passive intruder detection system of the type which is sensitive to an unnatural presence of light in a normally darkened area. Still another object of the invention is to provide a photoelectric detection circuit capable of battery operation for long periods of time.

In accordance with a preferred embodiment of the invention, a photoelectric control circuit is provided which is capable of distinguishing the transient illumination conditions which normally accompany the presence of an intruder or burglar from the transient conditions generated by spurious sources such as those mentioned hereinabove. Basically, the circuit includes the following elements: a high pass filter for discriminating against very slowly changing lighting conditions (e.g. the change resulting as the sun rises in the morning); means responsive to a sudden increase in light level for ac-

tivating an integrator for a predetermined period, the integrator serving as the trigger for an alarm when a predetermined increase in light level is sensed during the period of activation; and means responsive to a return of the light level to that which existed prior to activation of the integrator for deactivating the integrator prior to alarm activation, whereby a rapid transient in light level (e.g. that generated by a flash of lightning or the fleeting passage of automobile headlights through the protected area) may be discriminated against.

In accordance with another feature of the invention, means are provided for delaying the application of electric energy to the photoelectric circuit for a predetermined period subsequent to the activation of the energy source, whereby sufficient time is afforded an authorized person to extinguish the lights and leave the protected area without activating the alarm.

Other objects and advantages of this invention will become obvious upon an understanding of the illustrative embodiments to be described hereinafter. For a better understanding of the invention and of the circuits embodying the same, reference may be had to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram explanatory of the invention.

FIG. 2 is a block diagram of a circuit comprising the preferred embodiment of the invention; and

FIG. 3 is a schematic diagram of a circuit capable of implementing the preferred embodiment of this invention.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Referring now to FIG. 1, a photoelectric control circuit embodied by the present invention is illustrated in block form. The circuit is particularly adapted for use in a passive photoelectric intruder detection system of the type designed to protect a normally darkened area; i.e. the circuit is responsive to any increase in illumination of a predetermined character. The following basic elements, arranged as shown, comprise the circuit: (a) a source of electric energy 1, for example, a simple storage battery; (b) a radiation-sensitive element 2, such as, for instance, a photoconductive cadmium sulfide cell; (c) a transmission gate 6 which is designed to pass a signal for a predetermined period only when the voltage across element 2 varies in a predetermined manner; (d) an integrator 9 which is designed to accumulate the signal passed by gate 6 during the period the latter is in a transmitting state; and (e) an alarm actuating relay 10 which is actuable only if and when the signal accumulated by integrator 9 attains a predetermined value.

The opening of gate 6 is designed to be triggered by the output of a monostable multivibrator 8 which, in turn, is activated when the voltage across element 2 is caused to vary at a rate sufficiently rapid as to be passed by a high pass filtering network 7, in series with the trigger input terminal of multivibrator 8. If the voltage passed by gate 6 and accumulated by integrator 9 is insufficient to activate relay 10, reset 12 is provided for discharging the accumulated voltage.

Optionally, the circuit is provided with a sensitivity control means 11 for varying the output of gate 6 in accordance with the lighting conditions of the area protected by the system.

In addition to the basic elements set forth above, the control circuit preferably includes an additional transmission gate 3, shown in FIG. 2 and hereinafter referred to as the "arming gate," which may be automatically switched to a transmitting state after a predetermined delay has elapsed subsequent to the activation of source 1. The opening of arming gate 3 is controlled by an arming switch 5 which, in turn, is actuated by a simple RC network, referred to as the "arming delay" 4, when sufficient voltage has been accumulated by the capacitive element thereof.

Briefly, the circuit illustrated in FIG. 2 operates in the following manner: first, energy source 1 is applied to the circuit,

thereby causing current to flow directly to input *a* of arming gate 3, the latter being in its normally closed state. At the same time, the capacitive element of arming delay 4 commences to slowly build up a voltage sufficient to actuate arm switch 5 and thereby cause current to flow through the radiation-sensitive element 2 to input *b* of arming gate 3. The time required for delay 4 to build up a voltage sufficient to actuate switch 5 is designed so as to be sufficient to permit an authorized person to energize the alarm circuit in a brightly lighted area and then to lower the light level in that area to the surveillance level and leave the protected area. Arming gate 3 is designed such that a very small current at input *b* is sufficient for gate 3 to open and pass at least a portion of the current applied at input *a* to output *c* thereof. The current passed by gate 3 will increase in proportion to the amount of illumination incident upon element 2 until it reaches a maximum value whose magnitude is established by the design of gate 3. Further increase in illumination will not cause any further increase in the output of gate 3. Note, however, that even when gate 3 is in a transmitting state, the output thereof cannot be transmitted any further unless transmission gate 6 is activated, and the latter is normally inactive unless, as explained below, element 2 experiences a change in illumination at a rate in excess of a predetermined minimum. Thus, because only a small portion of the circuit is active when the illumination of element 2 is at a steady state, there is minimal power drain on source 1.

To activate gate 6, a current must flow into input *d* thereof and such current can only exist when the monostable multivibrator 8 is in its conducting state. In order for the latter to conduct, a current must appear at its input terminal *e*. In order for a current to appear at input *e*, the change in current at the output *c* of gate 3 must be such as to be passed by high pass filter 6, arranged in series with the input terminal of monostable multivibrator 8. Filter 6 is designed such that it will only transmit a current that changes faster than some minimum rate. By the proper selection of elements for filter 6, the circuit may be made insensitive to changes in illumination produced, for instance, by the advent of daylight.

Should the change in current at output *c* of gate 3 be such as to permit the passage by filter 6, then the monostable multivibrator 8 is activated. Only a small current at input *e* of multivibrator 8 causes the same to switch from zero conduction to full conduction. In its conducting state, multivibrator 8 applies a current to input terminal *d* of primary transmission gate 6 thereby causing this gate to open and create a low resistance conducting path between the output terminal *c* of gate 3 and the input terminal *f* of integrator 9. Once triggered, the monostable multivibrator 8 will remain in the full conducting state for a predetermined interval; i.e., the period during which it is in the timing state. The timing period may, of course, be varied in accordance with the conditions in which the circuit is operating. At the end of this period, multivibrator 8 returns to its normal nonconducting state, thereby closing gate 6. Means are provided (discussed below) for turning off multivibrator 8 prior to the termination of the timing period if the voltage at input *e* decreases rapidly. Thus, although the onset of a lightning flash, for example, will activate multivibrator 8, it will be immediately turned off again in response to the rapid extinction of the flash.

During the interval that gate 6 is in a transmitting state (i.e. during the timing period of the multivibrator 8) the current flowing from the output of gate 3 is transmitted to integrator 9 which accumulates a voltage that is proportional to the product of the current received and its duration. As indicated above, if the voltage accumulated by the integrator 9 attains a predetermined level within the transmission period of gate 6, then relay 10 is actuated. If the accumulated voltage fails to reach such a level in the allotted time, then the circuit is reset to a passive state, as described hereinafter. Since the magnitude of the current at integrator input *f* is limited to a maximum determined by gate 3, bright flashes (such as occurring from lightning) are of too short a duration to produce a voltage at the output *h* of integrator 9 sufficient to activate alarm relay 10.

The voltage at integrator output *h* would, ordinarily, decrease very slowly upon the removal of current into input *f*. If no provision were made to dispose of this voltage, the voltage at *h* could, conceivably, build up during several successive lightning flashes to a level sufficient to activate the alarm switch 10. To prevent such buildup, a means for resetting the circuit is provided. The resetting means is operated by the turning off of multivibrator 8 in response to a rapid extinction of the flash which caused gate 6 to transmit initially.

In view of the foregoing description, the control circuit embodied by the invention may be best described as one having two levels of awareness. The circuit is initially sensitive to any relatively sudden change in light level in the area under surveillance. After such change is detected, the circuit then operates in a second state of awareness in which it is sensitive to a longer lasting presence of illumination which would presumably be attributed to the presence of an unauthorized person. In short, only after two conditions are satisfied (i.e. the sudden onset and lingering presence of illumination) is the alarm relay actuated. If the voltage accumulated by integrator 9 is insufficient to actuate alarm relay 10, then gate 6 closes and the circuitry returns to a passive state. Moreover, a very slow onset of illumination, regardless of its final intensity, will not activate the alarm relay because high pass filter 7 prevents the opening of gate 6 by the monostable multivibrator 8.

A typical circuit for carrying out the aforescribed operation is depicted schematically in FIG. 3. As shown, the circuit is designed to be battery operated, for instance, by a simple storage battery E which provides direct current to the circuit. Radiation-sensitive element 2 is shown as a photoconductive cell, R4, preferably cadmium sulfide or cadmium selenide. However, since the function of element 2 is merely to control the amount of current flowing through the circuit, it is readily apparent that a photovoltaic cell has equal utility. Preferably, photocell R4 has a spectral response in the visible portion of the spectrum. Such a response would then be sensitive to the source of illumination usually employed by intruders. Arming transmission gate 3 is comprised of transistor Q1 and resistors R3 and R16. When photoresistive cell R4 is in a darkened environment, the combined resistance of R3 and R4 is too high to permit conduction of Q1. However, as the cell illumination gradually increases, thereby reducing the resistance of R4, Q1 will gradually begin to conduct. Resistor R3 serves to limit the maximum current passing through gate 3 when the system is subjected to a sudden intense flash of light (e.g. lightning). Moreover, resistor R3 determines the amount of standby current required when the system is operating in a passive state (i.e. not sensing an increase in illumination). By selecting a high resistance for R3 the standby current, during daylight conditions (such condition existing subsequent to the advent of daylight) may be limited to a few microamperes. Resistor R16 is preferably variable and serves to regulate the bias of the base of transistor Q1, thereby providing a means for adjusting the sensitivity or bias value at which gate 3 will open.

The arm delay 4 merely comprises resistors R1 and R2 and capacitor C1. The time constant of this RC network determines the delay between the activation of source 1 and the closure of arming switch 5. Resistors R1 and R2 are typically of the order of one megohm so as to limit the standby current drain.

Arm switch 5 is comprised of transistor Q2 and diode D1. Transistor Q2 acts purely as a normally closed switch and only conducts when the voltage across capacitor C1 builds up to a predetermined value. Normally, the base voltage of transistor Q2 is less than that required for conduction to occur. As capacitor C1 charges subsequent to the activation of source 1, the voltage at the base of transistor Q2 increases. When the voltage across capacitor C1 builds up to a level equal to the sum of the forward drops across diode D1 and the base-emitter diode of transistor Q2, then transistor Q2 begins to conduct. Typically, this level is of the order of 1.2 volts for silicon semiconductors. Thus, diode D1 raises the turn-on threshold of gate Q2.

Primary transmission gate 6 is comprised of transistor Q6, resistor R12 and diode D4. As in the case of gate 3, the base of Q6 is normally in series with a very high resistance, causing Q6 to be cut off. In order for Q6 to conduct, current must flow through R12 and D4. Such current flow is accomplished when the cathode end of D4 is grounded via the saturated conduction of transistor Q4 which, as hereinafter explained, is a part of the monostable multivibrator 8. Diode D4 functions to protect the emitter base junction of Q6 from excessive reverse voltage when multivibrator 8 is in a nonconducting state. Resistor R12 functions to regulate the base bias current for Q6.

Resistor R13 and capacitor C3 comprise high pass filter 7. The elements of such filter are arranged in series and the filter itself is arranged in series with the output of gate 3 and the trigger input to multivibrator 8. Filter 7 acts as a differentiator on any signal passed by gate 3. Thus, filter 7 will act upon a step function input (e.g. that produced by a sudden increase in photocell illumination) to produce a positive current spike which is used as a triggering pulse to turn on multivibrator 8. Similarly, if filter 7 is subjected to a sudden decrease in current (e.g. that resulting when the photocell illumination is rapidly extinguished), a negative current spike will be passed to multivibrator 8 and will cause the latter to turn off. Thus, although a sudden flash of light (e.g., a flash of lightning) will be passed by filter 7 and cause multivibrator 8 to activate, the rapid extinction of the flash will cause the multivibrator to turn off, even before its normal conducting period has expired. In regard to slow current transients, filter 7 will not pass a triggering pulse because the derivative of such a change is extremely small. In order to discharge C3 when illumination changes are insufficient to cause Q6 to conduct, a high resistance path through resistor R15 is provided.

Multivibrator 8 is comprised of transistors Q4 and Q5, resistors R8-R11, capacitors C4, C5 and C8, and diode D2. The circuitry is conventional. Its primary advantage is that it draws no standby power. Before triggering, both Q4 and Q5 are nonconducting. When a pulse of current from filter 7 is received by the base of Q4, both Q4 and Q5 switch regeneratively into the saturated state, thereby acting as closed switches connecting the collector of Q4 to ground and the collector of Q5 to source 1. Conduction continues until C4 is nearly charged to the supply voltage of source 1, at which point the base current into Q4 decreases below the critical value and Q4 becomes nonconductive again. The circuit is automatically reset as C4 discharges through D2, R10 and R11, thereby making the circuit sensitive to a rapid change in current again and capable of its full time duration of conduction. Small value capacitors C5 and C8, serve to guard against spurious triggering from electrical noise pulses generated by nearby machinery or fluorescent lamps.

Integrator 9 is comprised of resistor R7 and capacitor C2. During the period multivibrator 8 is in a conducting state, C2 accumulates charge via the collector current of Q6. If the voltage arising from accumulated charge on C2 is insufficient to activate relay activator 10, then means are provided to discharge C2 when multivibrator 8 shuts off. Such capacitor discharging means is comprised of a P-channel junction field effect transistor Q7, resistor R14, and diode D3. Transistor Q7 provides a very high impedance open circuit when the gate lead thereof is connected to source 1, as when Q5 is in a conducting state. However, when Q5 shuts off, Q7 becomes conductive, thereby providing a discharge path from C2 to ground. Thus, it is apparent that Q7 is normally conductive (i.e. it conducts when the circuit is not detecting a change in light level) and only becomes nonconductive when the circuit senses an increase in illumination, such increase having a characteristic as to be passed by filter 7. Diode D3 protects multivibrator 8 from such discharge by isolating Q7 therefrom.

The alarm activating network (i.e. relay activator 10) is comprised of transistor Q8, resistors R19 and R20, capacitor C9 and the silicon controlled rectifier Q3. These elements act, in cooperation with the other circuit elements, to activate the

alarm relay K1. Q8, functioning as an emitter follower, serves to prevent Q3 from loading the integrator capacitor C2. R20 is of low resistance to reduce the sensitivity of Q3 to thermal triggering. Similarly, C9 reduces the sensitivity of Q3 to electrical noise transients. R19 merely serves to limit the current passing through Q8. Once Q3 is triggered, it stays conducting continuously until reset by momentarily removing energy source 1 from the circuit. To protect Q8 from inductive transients arising from current changes in relay K1, diode D5 is provided in parallel with K1.

In order to vary the overall sensitivity of the circuit, means are provided for varying the input to integrator 9. Such means is the sensitivity control 11 which comprises resistors R5 and R6, the latter being of the variable type. By isolating the sensitivity control 11 from the input of gate 6, the circuit is most sensitive when in a passive state. Thus, very low transients can activate multivibrator 8 and, when activated, Q6 connects sensitivity control 11 into the circuit, thereby shunting current away from the integrator and reducing the sensitivity thereof. Note, if control 11 were connected at the input to gate 6, Q1 would conduct more current during daylight hours and drain source 1, needlessly.

The aforescribed circuit operates as follows: A small increase in illumination in the area surveyed by photocell 2 will transmit a voltage to integrator 9 for a period determined by the conducting period or timing period of multivibrator 8. If, during this period, the product of illumination intensity and duration is sufficient, relay K1 is activated by relay activator 10. If the product of illumination intensity and duration is insufficient to trigger activator 10 during the conducting period of multivibrator 8, gate 6 closes and any voltage accumulated by integrator 9 is discharged by the reset circuitry 12. A slow onset of photocell illumination will not activate alarm relay K1 because high pass filter 7 prevents the signal generated by such illumination from activating multivibrator 8, and hence gate 6 remains closed. Moreover, multivibrator 8 may be turned off before its normal deactivation time if the current at its input decreases rapidly.

From the foregoing it may be seen that a photoelectric control circuit has been provided which is capable of discriminating against sudden flashes of photocell illumination (e.g. those generated by lightning, automobile headlights, etc.) and very slow increases in photocell illumination (e.g. those produced by the advent of daylight). At the same time, the circuit is fully sensitive to illumination of the type which typically accompanies the presence of an intruder in a darkened environment. Moreover, because the primary transmission gate 6 is normally closed, the circuit draws minimal standby current, thereby permitting battery operation for extended periods of time. Also, because the circuit is adapted for battery operation, the entire intruder system is readily portable.

Although, the invention has been described in detail with particular reference to a preferred embodiment thereof, it will be understood that variations and modifications can be effected within the spirit and scope of the invention as described hereinabove and as defined in the appended claims.

I claim:

1. In circuit with a source of electric energy:

a radiation-sensitive element for producing an output having an amplitude proportional to the quantity of radiation incident upon said element;

integrating means, operably coupled with said radiation-sensitive element for accumulating the output produced by said radiation-sensitive element;

gate means, operably coupled with said radiation-sensitive element and said integrating means and having a normally non conducting state whereby transmission of the output of said radiation-sensitive element to said integrating means is prevented; and

switching means, operably coupled with the output of said radiation-sensitive element, for switching said gate means to a conductive state in response to a predetermined time rate of change in the output of said radiation-sensitive

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element whereby said radiation-sensitive element output may be transmitted to said integrating means.

2. The circuit according to claim 1 further comprising alarm means, coupled with said integrating means and actuatable only when said integrating means accumulates an output having an amplitude in excess of a predetermined threshold value. 5

3. The circuit according to claim 1 further comprising means for discharging said integrating means in the event said integrating means fails to accumulate an output having an amplitude exceeding a predetermined value within a predetermined time. 10

4. The circuit according to claim 1 wherein said switching means comprises:
a high pass filter operably coupled with the output of said 15

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radiation-sensitive element, said filter including means for differentiating said output, thereby suppressing relatively slow changes in said output; and

a monostable multivibrator operably coupled with said high pass filter for receiving the differentiated output of said radiation-sensitive element, said monostable multivibrator having a normally non conductive state and being capable of producing an output to said gate means for a predetermined time interval in response to the receipt of an output of from said high pass filter having an amplitude in excess of the predetermined threshold value, whereby said gate means may be switched to said conductive state.

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