OPTICAL SPACE ALARM

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FIG. 1

FIG. 3

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This invention relates to space alarms to warn against an intruder, and relates more particularly to an optical space alarm.

Space alarms which respond to the motion of an intruder in a protected space are already known. Some employ ultrasonic sound, and some employ radar. Ultrasonic sound has the disadvantage of false alarms resulting from air turbulence (for example, in a warehouse using space heaters). Radar has the disadvantage that it penetrates walls, and thus a truck passing along a street just outside the protected space, may produce a false alarm. This situation has, of course, been suggested many years ago, but was unsuccessful for a number of reasons. The general object of the present invention is to overcome such reasons and difficulties, and to provide an improved space alarm based on the use of light. The light used may be either visible light, or infra red, or other portions of the electromagnetic spectrum.

The present invention solves the problem of distinguishing between a false alarm caused by time variations in the infrared spectrum caused by clouds or an automobile headlight, etc., the system being largely independent of such ambient illumination. The modulation may be quite simple, as by using a single half wave rectifier to suppress alternate half waves of ordinary AC current. This would give a sixty cycle modulation of the light. The further object of the present invention is to emphasize the effect of motion of an intruder. For this purpose I provide zones of opposite phase through which an intruder moves. Preferably the space alarm camera is provided with a mosaic of photocells in its focal plane, alternate ones of which are reversed in phase connection. This doubles the relative or apparent change in mosaic output when there is motion, and it has the further incidental but advantageous result of balancing the effect of changes in ambient light, thus additionally guarding against false alarm resulting from a change in the modulated ambient light such as would be caused by voltage fluctuations in the lighting system.

The photocells usually are not linear in response. A further object of the invention is to linearize the photocells so that a large change in the value of ambient light will not change the sensitivity of the system to the modulated light used for illuminating the protected area. A change in modulation envelope caused by motion of a body through the light zones passes through a tuned or selective amplifier (tuned to sixty cycles in this case) and reaches a phase detector to produce a direct current which operates an alarm, preferably a relay. For optimum results the system may be made independent of the absolute value of the reference level or voltage, and dependent only on its rate of change at the detector output. This is done by using a differentiating circuit which responds to rate of change. A fast or a moderately slow change in DC level will set off the alarm, but neither the absolute level of the DC voltage from the phase detector, nor an extremely slow change in that level will do so, thereby making the system independent of both a gradual change in reference level, and the absolute reference level.

The alarm relay employed is a normally energized relay, and thus may be tripped if the power supply fails momentarily. A further object of the present invention is to avoid false alarm resulting from such a momentary power failure, and for this purpose I provide a delay means to bridge an interruption which is only momentary. Difficulty also may be caused by radio frequency resulting from switching transients. These may intermodulate in the tuned amplifier, which is a high gain amplifier. Still another object is to avoid such difficulty.

A further object of the present invention is to make the system independent of variations in power supply voltage, as by use of a Zener diode, without however drawing the large current usually required by such a diode.

To accomplish the foregoing objects, and other more specific objects which will hereinafter appear, my invention resides in the optical space alarm system and the elements thereof, as are hereinafter more particularly described in the following specification. The specification is accompanied by drawings in which:

FIG. 1 is a block diagram explanatory of the invention;
FIG. 2 is a circuit diagram for the same; and
FIG. 3 shows zones of oppositely phased illumination.

Referring to the drawing, and more particularly to FIG. 1, the system is shown applied to a room or space 12, and comprises means 14 to illuminate the space, and a camera 20 having photosensors 30. There is also means 18 to modulate the illumination at a characteristic frequency different from that produced by ordinary AC current, and a means 34 to select that output of the photosensors which has the characteristic frequency. More specifically, in the present invention the means 18 is a single wave rectifier, so that a lamp at 14 is modulated at sixty instead of 120 cycles, and the means 34 is an amplifier selective to the sixty cycle frequency. It substantially rejects the effects of other illumination, and so reduces spurious response caused by changes in ordinary AC illumination or by changes in DC illumination. The amplifier is a tuned amplifier, but resonant LC circuits are not used because of the low frequency.

The rectifier 18 may be a silicon diode rectifier. The lamp at 14 may be an ordinary lamp, but is energized solely by alternate half waves of the AC supply. In one embodiment the lamp is disposed in one corner of the room, and is directed toward the remote walls 22 and 24. The camera 20 is a wide angle camera which is disposed in another part of the room 12, and is directed toward the same illuminated walls.

The camera has a row of closely adjacent photosensors in its focal plane, in this case six photosensors 30, and the alternating sensors are connected in reverse polarity relative to the intermediate sensors. The output is supplied to a low pass filter 32, followed by the selective amplifier 34, the output of which is received by a detector 36, which in turn leads through a differentiating circuit 38, to a normally energized relay circuit 40 which in turn controls an alarm 44. The detector is preferably a balanced or push-pull phase detector, which is sensitive at the balance point, that is the point at which the AC signal coming from the camera approaches zero, as it is at points substantially removed from zero, because phase detection linearizes the response. The linearizing the response causes a given change of AC value to produce the same change in the detected DC, regardless of the absolute value of the AC or the resultant detected DC voltage.

The light source 14 may be one lamp or multiple...
lamps. One lamp is here assumed for simplicity, but in practice is usually more than one. The lamp can receive the standard 120 volts, or the system may be provided with lower voltages lamps fed from a step-down transformer. The diode rectifier is in series with the lamp and provides alternate half waves to the lamp filament. This causes the filament to heat and cool sixty times a second, modulating its light output perhaps 40%, depending on the thermal inertia of the particular filament. Only the light which is modulated at sixty cycles is employed to detect an intruder.

Even though the system is insensitive to 120 cycles, the lamp (unless at a very remote distance) preferably should not be in the line of sight of the camera, because too much light coming from a single point may saturate the system. All that is necessary for proper protection is light that has been diffused by reflection from the walls and other objects in the protected area.

As an example, three 6 watt, 24 volt lamps operated from a 24 volt transformer through a single rectifier supplied sufficient illumination to provide "one step" sensitivity anywhere in a protected area which was 25 feet long by 16 feet wide, and which had walnut colored, wood panelled walls. One step sensitivity means detection of a person taking a single step. The specific light and camera pattern for best protection depends on the area to be protected. In small areas it is best to illuminate a far wall with the modulated light, and to look at that wall with the camera (or cameras) from the other side of the enclosure.

The rectifier is shown in a separate rectangle in Fig. 1. In practice a silicon diode rectifier may be used, and is so small that it may be housed in the lamp socket itself.

The camera consists of a lens which focuses the image of the protected area on six silicon photodetectors in its focal plane, suggested at 30 in Fig. 1. These photodetectors are so connected that the outputs of alternate cells are 180 degrees out of phase, as shown at the upper left of Fig. 2, and thereby tend to cancel each other. The series voltage output of three cells (cells 1, 3 and 5 in Fig. 2) is substantially balanced against the other three cells (cells 2, 4 and 6) by means of a variable potentiometer 52. Any resultant output or further unbalance of the system is fed through a shielded cable (suggested by loop 53) to a detachable connector 55 to the control cabinet. In order to linearize the system, each photocell is shunted individually by a resistor 54. Linearizing the system helps keep the sensitivity independent of variations in ambient light intensity.

As described later, a slight unbalance of the system may be desirable because in that case the resulting voltage on the phase detector may indicate a meter relay connected across the detector that the entire system is functioning properly, so that any loss in sensitivity due to the failure of a component will cause this voltage to disappear. This slight unbalance can be obtained in several ways, one being by a slight shift of camera angle.

The control unit is housed within a small compact control cabinet. It contains the low pass filter 32 (Fig. 1); an input stage and the low-noise sixty cycle amplifier 34; the balanced phase detector 36 which senses the variations in phase and amplitude of the incoming signal and converts it into a corresponding direct current; the differentiating amplifier 38, 49; the pushpull amplifier (very low frequency) in box 42 to amplify the fluctuation of this direct current, and a normally energized relay also at 42, controlling alarm 44.

There is also circuitry described later to protect against false alarm in case of momentary power failure. This makes it possible for the power to be restored on momentary power failure, serve to energize the relay to hold the relay energized for a few seconds after the power failure until the power has been restored. After power restoration it keeps the relay energized until all transients due to the power failure are dissipated out of the amplifier circuit. The relay then is switched back to the intruder sensing system.

The circuit

The circuit may be described in greater detail with reference to Fig. 2 of the drawing. In this description I mention the quantitative values of many of the components, but it should be understood that these values are given solely by way of example, and are not intended to be in limitation of the invention.

Referring to the circuit diagram, the camera has six photocells 1, 3, 5, 6, 4, 2 in a series backing arrangement, balanced by a 3K ohm potentiometer 52. Each photocell is shunted by a fixed 200 ohm resistor 54. The output of the camera is capacity coupled through a 10 microfarad capacitor 56 into the first amplifier stage, which is not selective. It consists of a noise-selected silicon planar NPN transistor TR1 in a conventional grounded-emitter amplifier circuit. Its output is by-passed by a 0.02 mf capacitor 58 to eliminate the higher frequency components, and is capacity coupled by means of a 2 mf, coupling capacitor 60 and a 100 ohm resistor 62 into a three-stage selective direct-coupled amplifier.

This main amplifier is a high gain (say 100 db) amplifier selective to sixty cycles, and has three stages TR2, TR3, and TR4. Its input section consists of an NPN silicon noise-selected planar transistor TR2. The second stage centers about transistor TR3. The output of the third stage TR4 of this amplifier is fed back through a 180 degree phase-shift network to the base of the first stage TR2.

The phase-shift network consists of the three 0.1 mf, condensers 66 and a variable 25K resistor 68. The phase shift network is shunted by a variable 300K resistor 70 which receives feed back the same original input signal in phase. The value of this variable resistor 70 is so adjusted that at sixty cycles its signal completely blocks out the signal from the phase shift network which has been shifted 180 degrees. At sixty cycles therefore, there is complete cancellation in the feed-back network, and no amplifier degeneration results. However, at frequencies different from sixty cycles this cancellation does not occur.

There then is a negative feedback which greatly decreases the amplification. The amplifier is thereby tuned or made sixty cycles selective, by some 20 db per octave.

This amplifier is also a temperature stabilizing feedback network consisting of the 12K resistor 72 and 2.2K resistor 74 making a voltage divider which supplies the bias to the first stage of the amplifier through a 4.7K base resistor 76. The voltage drop across the resistor 74 is by-passed by a 500 mf capacitor 78 so that only the very low frequencies associated with temperature changes are fed back. This stabilizes the amplifier against such temperature changes.

The terminals marked 80 are normally soldered together, but are broken for the initial adjustment of the shunted phase shift network which is adjusted to cancel the sixty cycles. The terminals are then re-connected, and the variable resistors fixed in position. The output of this amplifier, basically sixty cycles, is then fed to a phase detector system.

This consists of two phase detectors, each in bridge form and coupled by ten microfarad capacitors 82, 84, one detector providing a positive DC voltage when there is a sixty cycle input in phase with its control signal, and the other detector providing negative DC voltage under the same condition. This provides a pushpull DC output which follows the amplitude and phase of the sixty cycle signals provided by the camera. It has the important advantage that it is capable of supplying circuitry through zero to opposite polarity. It reverses DC polarity in response to a sixty cycle input of phase of the AC. Most important, it does not at all respond to a 120 cycle signal, that is, to ordinary AC lamps.

Specifically, the upper of the two phase detectors works
as follows: the two 3K resistors 86, 88 and the two diodes 90, 92 form a bridge circuit. The diodes are so connected that unless there is a voltage from the synchronous six volt transformer source 242 the diodes are non-conducting and there is no DC output. When there is AC voltage applied from the six volt source, the diodes become conducting every other half cycle, although because of the bridge circuit none of the six volts is reflected into the opposite legs of the bridge which are the input side. However, during the half wave that the diodes are conducting, the input signal from the capacitor 82 is short circuited. During the other half wave of that same input no short circuit exists because the diodes are non-conducting, since the voltage from the six volt source has also reversed itself. Thus either the positive or negative phase of the input signal remains, and gives a resulting DC voltage depending on its phase relationship to the six volt driving voltage. This results in a positive or negative push-pull DC output from the phase detector.

The phase detector will detect sixty cycle signals. It will also give some reduced detection of the odd harmonics of sixty cycle but this can be neglected. The even harmonics are not detected at all. The normal 120 cycle flicker in lighting systems, in or outside of the protected area, is therefore not detected by the phase detector, even if some of the 120 cycles passes through the selective amplifier.

The lower of the two bridge circuits works in the same way but in opposite polarity, because transformer secondary 244 is reversed. The bridge components are all like.

The outputs of the two phase detectors are connected through the two 5.6K resistors 94, 96 and 50 mf filter capacitors 98, 100 to filter out any of the remaining sixty cycles, and the resulting slow DC fluctuations are capacitor coupled by means of the 200 mf capacitors 102, 104 into a stage consisting of transistors TR5 and TR6. The differentiating circuit previously referred to (and shown at 38, 40 in FIG. 1) consists of capacitors 102 and 104 and resistors 178 and 180, the latter having a floating center connection. Differently expressed, the power supply of the amplifier stage (TR5, TR6) is made to float in respect to the power supply of the previous amplifier (TR2, TR3, TR4). For that reason any low frequency signal which may not be detected by the phase detector stage comes through alike to the bases of both transistors TR5 and TR6. Because of the floating power supply, transistors TR5 and TR6 will respond only to a differential signal, and so low frequency pulses not coming in differentially do not get into the pushpull stage.

However, because of the nature of the phase detectors, any modulations of the sixty cycle input on the camera are detected differentially (in a push-pull manner).

The modulations envelope (the slow fluctuations in the sixty cycles from the camera due to a moving intruder) are fed through the capacitors 102, 104, and are amplified differentially by stages TR5 and TR6. The DC output of TR5 and TR6 is balanced by means of the 2K potentiometer 106 in their collector supply circuit, so that with no input signal there is no voltage difference between the collectors of TR5 and TR6. The potentiometer 106 then is fixed in position. The output (pushpull) of the two collectors then is fed to a bridge circuit consisting of two 15K resistors 105, 110 and two diodes 112, 114 each shunted by a 47K resistor 116, 118. The output of this bridge is connected between the base and emitter of the PNP transistor TR7, in such a way that any unbalanced signal between the collectors in either direction (plus or minus) makes the base negative in respect to the emitter, and a collector current is generated in TR7.

The TR7 collector current provides a base current for transistor TR8 which in turn gives an amplified collector current. The collector current through TR8 produces a voltage drop in the 15K resistor 120 in series with it. Thus if TR8 is fully conducting, almost the entire voltage is across the resistor 120, and only about 0.1 volt is across TR8. The voltage drop across TR8 supplies the bias for the emitter-follower transistor TR9, whose emitter in series with the 100 ohm protective resistor 11 supplies the output relay 124. The relay in turn is shunted by a small microfarad 15 volt capacitor 126 to AC voltage applied from the line. In this way the occasional surges of the collector resistor 120 in series with TR8 is also shunted by a 50 mf capacitor 128 to hold over during a polarity reversal on the bases of transistors TR5 and TR6. Such polarity reversals occur because the capacitors 102, 104 feeding TR5 and TR6 can pass only AC fluctuations which must have polarity reversals.

Thus, if any false alarm indication due to momentary interruptions in the power line, the circuit centering on transistor TR10 is included. This circuit is in the power supply for the relay circuit and partially consists of the normal power supply circuit containing the 12 volt secondary 130, a rectifying diode 132, and a 50 mf. filter capacitor 134. Under normal conditions this circuit supplies the power for the pushpull amplifier and relay. However, it also charges a thousand mf capacitor 136 through a bridge circuit consisting of 1K resistor 138 and 4.7K resistor 140 in series, as well as two silicon diodes 142, 144 in series in a bucking arrangement, which diodes also shunt the two legs of the bridge. The junction of the two resistors is connected to the base of transistor TR10, and the junction of the two diodes is connected to the emitter of transistor TR10.

Any change in the line potential causes, in turn, a change in the DC across the capacitor 134 in the power supply. This change in voltage tends to charge or discharge the capacitor 136. During the charging or discharging of this capacitor 136 there is a potential drop across the aforementioned bridge feeding the capacitor. When this potential drop exceeds the voltage necessary for one of the diodes 142, 144 to conduct, it provides a base current for TR10. This occurs, typically, during a momentary line failure or the instant the power comes on again, but does not occur during normal line voltage fluctuations because such fluctuations do not exceed the threshold potential of the diodes.

When transistor TR10 conducts, it provides base current for transistor TR9, keeping the relay 124 energized during the transient condition caused by the power failure, and keeping it energized long enough after restoration of the power until all signals generated in the amplifier by the failure have dissipated themselves. The diode 146 between transistors TR8 and TR9 effectively disconnects transistor TR9 from TR8 when TR10 is momentarily supplying the base voltage to TR9. At all other times the diode 146 conducts, causing transistor TR9 to respond to the intruder. Because of the functions, the relay 124 is normally energized during no alarm, and becomes de-energized and drops out during an alarm condition.

Low pass filters at the input (upper left) part of the diagram eliminate radio frequency caused by switching transients, which might otherwise interfere in the amplifier. The 220 ohm resistor 150 and the capacitor 58 act as one low pass filter. Similarly the 220 ohm resistor 152 and the 0.02 mf. capacitor 154 act as another low pass filter.

A Zener diode 160 maintains constant potential regardless of current through it. If the Zener diode were used alone it would need large current to provide sufficient voltage regulation. The present circuit adds a transistor TR11 and draws only small current. The resistors 162, 164 and 166 are 220 ohm, 100 ohm, and 10K ohm respectively. The resulting circuit maintains the potential of the base of transistor TR11 relative to the negative power supply. The emitter of TR11 supplies the amplifier circuit, and follows the base potential, and is kept constant despite changes in power supply voltage.

A meter relay is indicated at 236, connected across the detector test terminals T1 and T2. It is shown in dotted lines because it is optional. When used, the camera out-
put is intentionally unbalanced slightly, to provide a response at meter relay 230, to show that the system is functioning. A lack of response would alert an inspector to the fact that the system is not functioning.

The main power supply transformer has a primary 300 controlled by switch 301. A pilot light is indicated at 304. Transformer secondary 240 delivers 24 volts; transformer secondaries 242 and 244 deliver 6 volts, and transformer secondary 130 delivers 12 volts.

The sensors 1-6 are silicon photocells or so-called solar cells.

Some additional component values may be given as follows: The resistors 170, 172, 174, 176, 178, 180, 182, 184, 186 and 188 all have a value of 4.7K ohms. The resistor 190 is 22K ohms and the resistor 192 is 2.2K ohms. Resistors 194-195 are 1K ohms. Resistors 196, 198 and 200 are 5.6K ohms. Resistors 202 and 204 are 15K ohms. Resistor 206 is 220 ohms. Resistors 208 and 210 are 1K ohms. Resistor 212 is 18K ohms. Resistor 214 is 1.8K ohms. Resistor 216 is 470 ohms. Resistor 218 is 10K ohms. Resistor 220 is 47K ohms. Resistors 87 and 89, like resistors 86 and 88 in the companion bridge, are 3.3K ohms. Resistor 222 is 100K ohms.

The capacitor 224 is 100 mf, at 6 volts, and the same applies to capacitor 226. Capacitor 228 is 0.1 mf. Capacitor 230 is 100 mf, at 15 volts. Capacitor 232 is 0.5 mf. Zener diode 160 carries 5 watts at 13 volts. Capacitors 234 and 235 are 0.5 mf each.

It would be understood that the foregoing specific component values have been given solely by way of example, and are not intended to be in limitation of the invention.

General matter

The cameras preferably are mounted on the side of an enclosure that does not face any windows. In small areas it is the wall or walls opposite the cameras that are illuminated by the light source. Usually the light source consists of tungsten filament lamps connected in parallel and having filament whose filament current preferably should not exceed 0.50 ampere. The lamps are connected to a power source in series with a silicon rectifier rated for the proper current. This power source may be the standard AC line, or for lower voltage lamps may be a transformer of the same voltage as the rated voltage of the lamps. With a larger room, and for the indirect operation described above, the lamps may be about four feet from the wall which is being illuminated, and about six feet apart, and are preferably provided with reflectors to illuminate the wall, and not the floor. A very large room, the lamps do not aim light at the cameras. The cameras preferably are mounted on swivels and turned in a direction facing the area to be protected. The cameras then are connected in parallel to the control unit.

The camera cable should be a two-wire shielded cable, shielded by aluminum foil or equivalent so as to be 100% electrostatically shielded. The camera cable should be kept at least six inches away from power lines, and should be as short as possible.

After the system is installed a voltmeter may be connected between the two test terminals T1 and T2 (FIG. 2) connected to the capacitors 82, 84 in the phase detector circuit. The DC voltage between these test points indicates whether the light falling on the photocells in the cameras is properly balanced for efficient operation. If they are too far off balance there is a danger that the sixty cycles per second on the camera may be strong enough to saturate the amplifier and reduce the sensitivity of the system. This saturated condition can be avoided by turning the cameras slightly in the horizontal plane. When the system is properly balanced the volt meter should read less than 0.5 volt. If the voltage across T1 and T2 is intended to more than 2.0 and 0.5 volt, After the system has been balanced the volt meter should be removed, and its scale set so as to conveniently read 15 volts, and connected across the relay coil 124 by connection to test points T3 and T4. The no alarm voltage is approximately 12 volts. The alarm voltage approaches zero volt.

As so far described the protected space may be considered to be effectively divided into zones of opposite phase, because of the opposite phasing of the sensors, and motion by an intruder from one zone to the next zone produces an increased output which is detected by the system. However, zones of opposite phase may be produced by illuminating successive zones with lamps energized in opposite phase. This is particularly valuable for the protection of a large area, say several hundred feet long. In that case an array of lamps may be placed at the far wall, looking directly into the camera. Adjacent lamps may be alternately phasing by connecting them in series with rectifiers which are alternately oppositely poled, so that when one lamp filament heats, the adjacent lamp filament cools. A moving intruder sequentially blocking the individual light beams from these lamps alternately might produce positive and then negative voltages to appear in the phase detector, even though the image of the entire array of lamps may fall on only one photocell in the focal plane of the camera, because of the extreme distance of the lamps from the camera.

Referring to FIG. 3, assume a lengthy space between walls 320 and 322, which are say two or three hundred feet apart. This might be a long corridor, or a long warehouse aisle. Camera 324 responds primarily to illumination from a series of lamps 326, 328, 330 and 332. These are energized from a sixty cycle supply 334, but through silicon diode rectifiers which are oppositely phased in alternation, as is indicated at 336, 338, 340 and 342. The lamps may be disposed at a spacing of say five feet, more or less.

A single sensor in the camera 324 may subtend or span an arc of say 10°, and face all of the lamps. A moving intruder, say at 344, might affect only one sensor, but phase reversals would be produced while moving from one illuminated zone to the next illuminated zone, the illuminating being reversed in phase.

Of course, with the camera equipped with a series or mosaic of cells, detection could be produced in either of two fashions. An intruder near the camera may produce phase reversals resulting from the zones of illumination, and would in any case produce phase reversals in moving from sensor to sensor. Thus, the zones of opposite phase may be produced by the sensors, or by the illumination, or by both. In general, for a small protected space the camera sensors alone are sufficient to provide the zones of opposite phase; for a long distance and narrow space the illumination alone by means of a series of oppositely phased lamps could be used to produce the zones of opposite phase; and for a large space the multiple lamps and the mosaic of camera sensors preferably are both employed to provide the desired zones of opposite phase.

Any overlapping of the illumination from adjacent lamps does not detract from the operation described above because the area of shadow that is subtended by the intruder grows larger as the intruder moves toward the camera. A response is said to be obtained, though not as great a response as that resulting from the phase reversal which occurs when an intruder crosses from zone to zone.

With a single sensor it would not be essential that it be located in the focal plane of the camera, but an array of sensors as above described should be in the focal plane, for precise differentiation between one sensor and the next.

Reverting to FIG. 3, when the walls 320 and 322 are
far apart as shown, they preferably are both provided with cameras and lamps, and thus, the complete system may include the additional camera 360 on wall 322, and the lamps 346, 348, 350 and 352 provided on the wall 320. Here again alternate lamps are oppositely phased, as is indicated by the rectifiers in series with the lamps. This dual system further insures detection of an intruder.

The protected space may be divided into zones without the alternate zones being operated in opposite electrical phase. Modulated illumination may be provided through rectifiers, and the amplifier following the camera may be tuned to the modulation, all as previously described, while using sensors connected in like phase instead of alternately in opposite phase. For this purpose the spacing between the successive sensors is preferably increased, so that the protected space is divided into live zones with relatively dense spaces therebetween. The motion of an intruder then causes changes in the amplitude of the output from the phase detector. Such an arrangement is entirely feasible, although I do not consider it as good as my preferred arrangement, in which the zones are oppositely phased.

By analogy the spaced zones of like phase may be paraded by special illumination, instead of (or in addition to) the camera all in analogy to Fig. 3 described above. For this purpose the lamps which are very remote from and are directed at the camera may have reflectors which produce narrow beams, with unilluminated or dark spaces between the beams. The lamps are modulated in like phase. The intruder then produces a detector output when moving across the zones, even though the lamps are in phase. The illumination may be invisible or visible.

It is believed that my improved space alarm and the method of operation of the same, as well as the advantages thereof, will be apparent from the foregoing detailed description. The alarm system is an optical device. It is designed to indicate motion in a given area by means of near infra red light. Its signal is confined within the protected premises. It is unaffected by air turbulence. Neither motion outside the protected area nor air turbulence will give false alarms. It also has the advantage of being relatively insensitive to ambient light changes, because it sees only its own modulated light, and light other than from an external lamp shining directly into the lens of its camera and focused at its focal plane, does not seriously affect it. It therefore is insensitive to such changes as might occur when a headlight is turned on through a window, or a cloud passes beneath the sun.

The alarm when installed is capable of monitoring a large or small area against an intruder. The camera looks into the area to be protected and when a person moves within this protected area, his movement causes a change in the light pattern at the focal plane of the camera. The camera is sensitive to the modulated light provided for the system, because the modulation is like a signal which the camera recognizes. Other ambient lights do not carry such a signal and the camera does not recognize their existence. The system avoids spurious response to momentary power failure or to radio frequency waves caused by switching transients, and is independent of gradual changes in voltages reference level or the absolute value of the reference level.

It will be understood that while I have shown and described the invention in preferred forms, changes may be made therein without departing from the invention, as sought to be defined in the following claims.

I claim:

1. A system for detecting a moving intruder in a protected space with the aid of illumination and photosensors, comprising means to illuminate the space, means to modulate the illumination at a characteristic frequency different from that of ordinary AC, means to divide the protected space into zones which are successively of opposite electrical phase, a tuned amplifier acting as a selector means to select the output of a photosensor to the aforesaid characteristic modulation frequency and thereby rejecting the effect of other illumination, said output from the selector means being modulated in response to motion of an intruder from one zone to a next zone, and a phase amplitude detector to demodulate the said selector output and said detector being a balanced detector providing a pull pull output, a very low frequency low pass filtered amplifier, capacitors for capacity coupling the said detector to the said low pass filtered amplifier, a full wave rectifier for rectifying the output of the low pass filtered amplifier in order to provide a DC output in response to motion of an intruder, and an alarm circuitry responsive to the said DC output.

2. An optical space alarm system as defined in claim 1 in which the zones of opposite electrical phase are produced by an array of four or more photosensors disposed in the focal plane of a camera, the alternate sensors being connected in reverse polarity relative to the intermediate sensors.

3. An optical space alarm system as defined in claim 1 in which the zones of opposite electrical phase are produced by an array of four or more lamps energized from a conventional AC source through half wave rectifiers, alternate lamps being energized through a half wave rectifier by alternate half waves, and the intermediate lamps being energized through an oppositely polarized half wave rectifier by the other half waves.

4. An optical space alarm system as defined in claim 1 in which the zones of opposite electrical phase are produced by an array of photosensors disposed in the focal plane of a camera, the alternate sensors being connected in reverse polarity relative to the intermediate sensors, and in which additional zones of opposite phase are produced by an array of lamps energized from a conventional AC source through half wave rectifiers, alternate lamps being energized through a half wave rectifier by alternate half waves, and the intermediate lamps being energized through an oppositely polarized rectifier by the other half waves.

5. An optical space alarm system for protecting a space, said system comprising a half wave rectifier and a lamp energized from a conventional AC source by alternate half waves from said rectifier, a space alarm camera having a row of four or more photosensors, the successive photosensors being exposed to successive illuminated zones of the space to be protected, whereby the output is modulated by motion of a body such as that of an intruder from zone to zone, the output of the rectifier then being switched to an amplifier which is tuned to be selective to the lamp modulation frequency, and to reject illumination of different frequency, and a phase amplitude detector to demodulate the said selector output and said detector being a balanced detector providing a push pull output, a very low frequency low pass filtered amplifier, capacitors for capacity coupling the said detector to the said low pass filtered amplifier, a full wave rectifier for rectifying the output of the low pass filtered amplifier in order to provide a DC output in response to motion of an intruder, and an alarm circuitry responsive to the said DC output.

6. An optical space alarm system for protecting a space, said system comprising a rectifier and a lamp energized from a conventional AC source by alternate half waves from said rectifier, a space alarm camera having a row of four or more photosensors, means connecting alternate sensors in reverse polarity relative to the intermediate sensors, the successive photosensors being exposed to successive illuminated zones of the space to be protected, whereby the output is modulated by motion of a body such as that of an intruder from zone to zone, a low pass filter receiving the output of the sensors to eliminate the effect of switching transients, an amplifier following the low pass filter which amplifier is tuned to be selective to
the lamp modulation frequency, and to reject illumination of different frequency, and a phase amplitude detector to demodulate the said selector output and said detector being a balanced detector providing a push pull output, a very low frequency low pass filtered amplifier, capacitors for capacity coupling the said detector to the said low pass filtered amplifier, a full wave rectifier for rectifying the output of the low pass filtered amplifier in order to provide a DC output in response to motion of an intruder, and an alarm circuitry responsive to the said DC output.

7. An optical space alarm system as defined in claim 6 in which there is a differentiating circuit following the phase amplitude detector which differentiating circuit responds to rate of change, and the components of which are so selected that a fast change or a moderately slow change will operate the alarm, but an extremely slow change or absolute value will not, thereby making the system independent of a gradual change in reference level or the reference level itself.

8. An optical space alarm system as defined in claim 6 in which the photosensors are provided with means to linearize their response, in order to maintain constant sensitivity despite changes in the intensity of the ambient illumination.

9. An optical space alarm system as defined in claim 6 in which the reverse polarity sensors are intentionally unbalanced slightly, and in which a meter relay is connected for response to the output of the detector, whereby a response of the meter relay indicates that the system is functioning, and a failure of response at the meter relay warns that the system is not functioning.

10. An optical space alarm system for protecting a space, said system comprising a rectifier and a lamp energized from a conventional AC source by half waves from said rectifier, said lamp being directed toward the remote walls, a space alarm camera directed toward the same illuminated walls, said camera having a row of four or more photosensors, means connecting alternate sensors in reverse polarity relative to the intermediate sensors, the successive photosensors being exposed to successive illuminated zones of the space to be protected, whereby the output is modulated by motion of a body such as that of an intruder from zone to zone, a low pass filter receiving the output of the sensors to eliminate the effect of switching transients, an amplifier following the low pass filter and which amplifier is tuned to be selective to the lamp modulation frequency, and to reject illumination of different frequency, and a phase amplitude detector to demodulate the said selector output and said detector being a balanced detector providing a push pull output, a very low frequency low pass filtered amplifier, capacitors for capacity coupling the said detector to the said low pass filtered amplifier, a full wave rectifier for rectifying the output of the low pass filtered amplifier in order to provide a DC output in response to motion of an intruder, and an alarm circuitry responsive to the said DC output.

11. An optical space alarm system for protecting a space, said system comprising a silicon diode rectifier and a lamp energized from a conventional AC source by alternate half waves from said rectifier, a wide angle space alarm camera having a row of four or more adjacent photosensors disposed in the focal plane of the camera, means connecting alternate sensors in reverse polarity relative to the intermediate sensors, the successive photosensors being exposed to successive illuminated zones of the space to be protected, whereby the output is modulated by motion of a body such as that of an intruder from zone to zone, an amplifier selective to the lamp modulation frequency, and to reject illumination of different frequency, and a phase amplitude detector providing a push pull output, a very low frequency low pass filtered amplifier, capacitors for capacity coupling the said detector to the said low pass filtered amplifier, a full wave rectifier for rectifying the output of the low pass filtered amplifier in order to provide a DC output in response to motion of an intruder, and an alarm circuitry responsive to the said DC output.

12. An optical space alarm system as defined in claim 11 in which there is a differentiating circuit following the phase amplitude detector which differentiating circuit responds to rate of change, and the components of which are so selected that a fast change or a moderately slow change will operate the alarm, but an extremely slow change or absolute value will not, thereby making the system independent of a gradual change in reference level or the reference level itself.

13. An optical space alarm system as defined in claim 11 in which the photosensors are provided with means to linearize their response, in order to maintain constant sensitivity despite changes in the intensity of the ambient illumination.

14. An optical space alarm system as defined in claim 11 in which the reverse polarity sensors are intentionally unbalanced slightly, and in which a meter relay is connected for response to the output of the detector, whereby a response of the meter relay indicates that the system is functioning, and a failure of response at the meter relay warns that the system is not functioning.

15. A system for detecting a moving intruder in a protected space with the aid of illumination and photosensors, comprising means to illuminate the space, means to modulate the illumination at a characteristic frequency different from that of ordinary AC, means to divide the protected space into zones which are successively of opposite electrical phase, the zones of opposite electrical phase being produced by an array of photosensors disposed in the focal plane of a camera, the alternate sensors being connected in reverse polarity relative to the intermediate sensors, and the aforesaid illumination being produced by an array of lamps energized from a conventional AC source through half wave rectifiers, alternate lamps being energized through a half wave rectifier by alternating half waves, the intermediate lamps being energized through an oppositely polarized rectifier by the other half waves to provide zones of opposite phase, a tuned amplifier acting as a selector means to select the output of a photosensor to the aforesaid characteristic modulation frequency and thereby rejecting the effect of other illumination, said output from the selector means being modulated in response to motion of an intruder from one zone to the next zone, and means to demodulate the said output to operate an alarm.

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