

# United States Patent [19]

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Kahl, Jr. et al.

[45] Aug. 14, 1973

[54] **PHOTOELECTRIC INTRUSION DETECTOR**

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[73] Assignee: **Arrowhead Enterprises, Inc.**, Bethel,  
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[22] Filed: **Feb. 4, 1971**

[21] Appl. No.: **112,632**

[52] U.S. Cl. .... **250/340, 356/153, 340/276**

[51] Int. Cl. .... **G01t 1/16**

[58] Field of Search ..... **250/83.3 H, 239;**  
**340/410, 253, 276, 277; 356/153**

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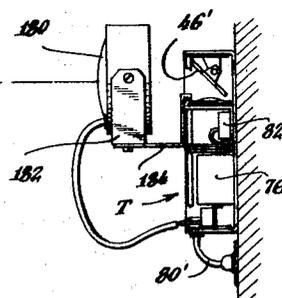
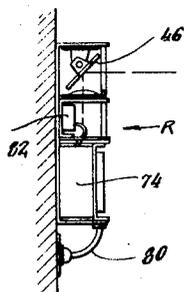
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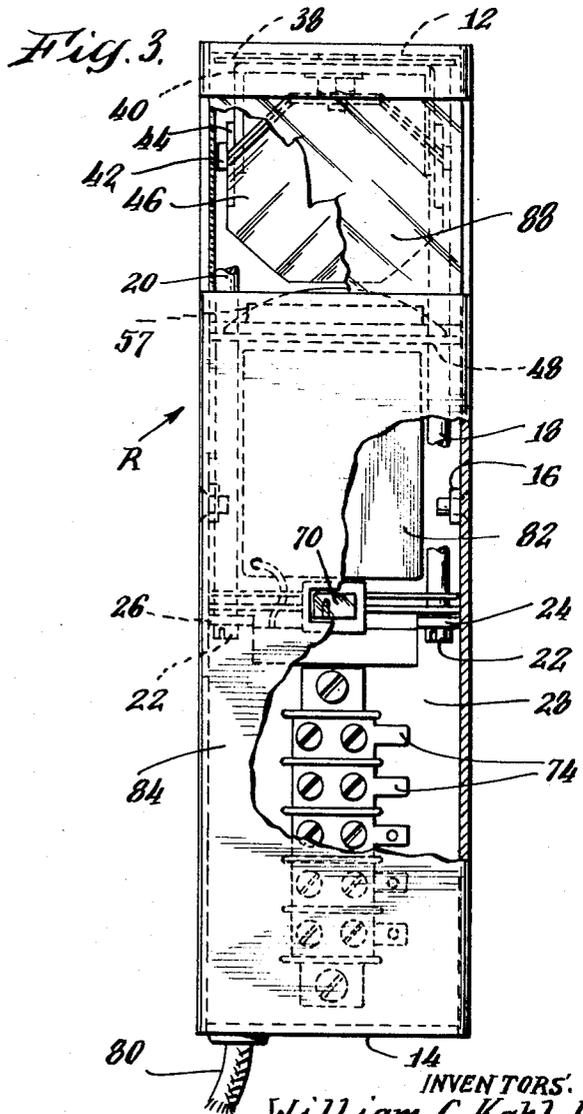
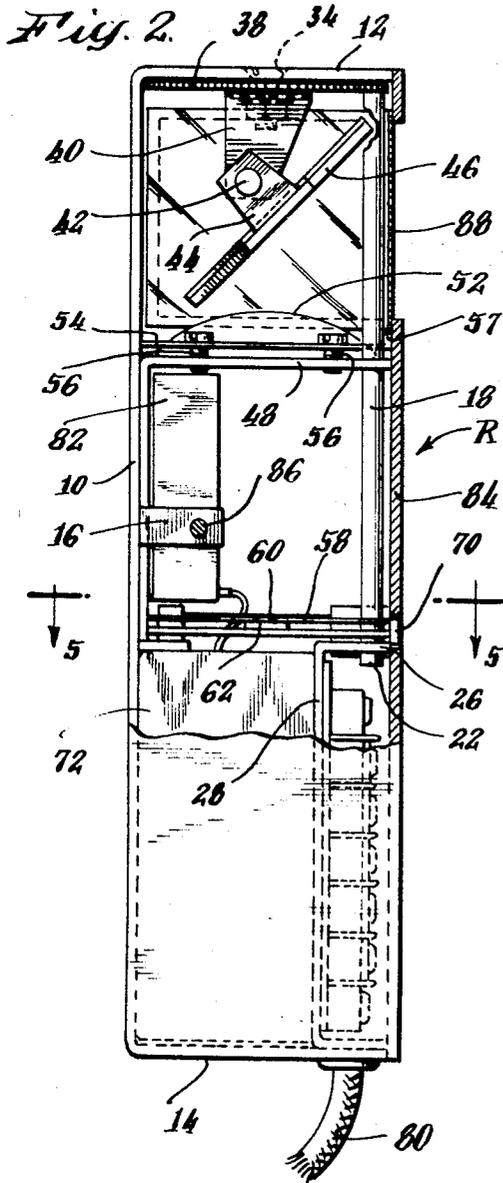
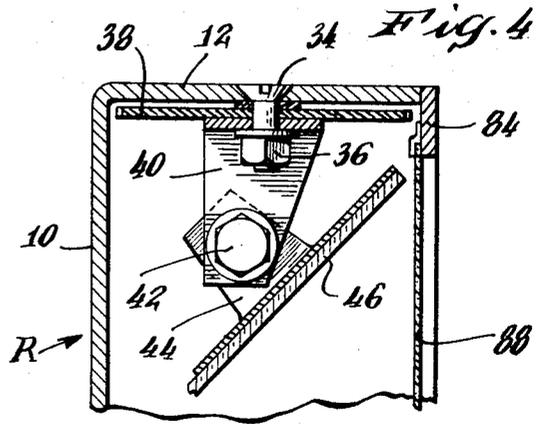
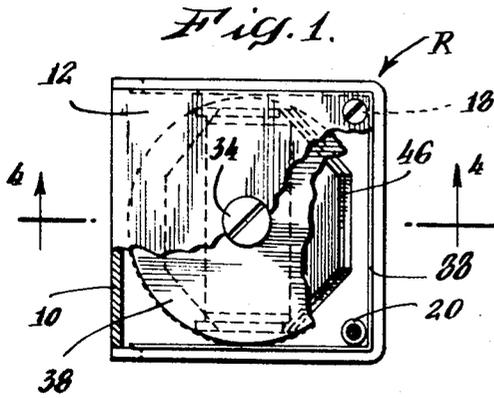
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[57] **ABSTRACT**

There is disclosed a photoelectric intrusion detector comprising a transmitter unit and a receiver unit. Each unit includes a collimating lens and a mirror adjustable about two axes of rotation. The detector employs an infrared beam invisible to the human eye and the mirror of each unit is positioned behind a dark red window, making it extremely difficult to ascertain beam direction. Jamming of the system is prevented by utilizing a pulsed, rather than a steady, beam. This also makes the system substantially insensitive to ambient light. There is also disclosed means for rapid alignment upon installation by method of an external visible light source attachable to each unit in turn, followed by adjustment of the mirror of the other unit.

**1 Claim, 12 Drawing Figures**





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Fig. 5.

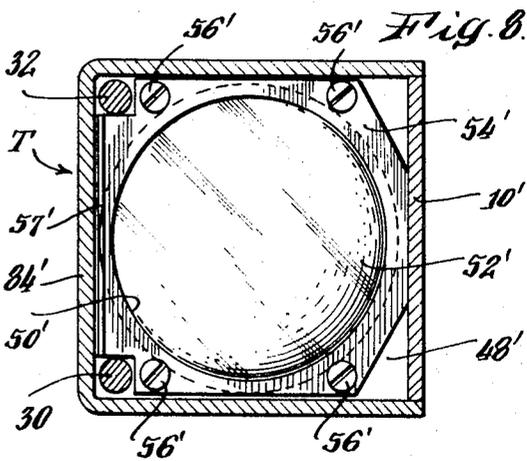
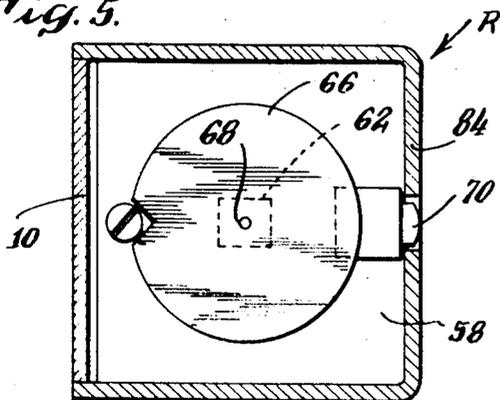


Fig. 6.

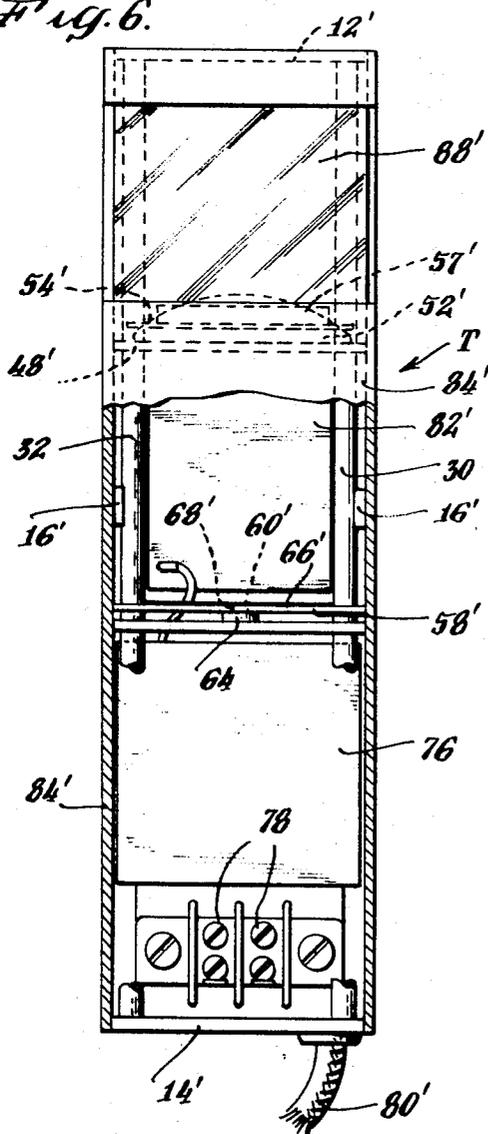
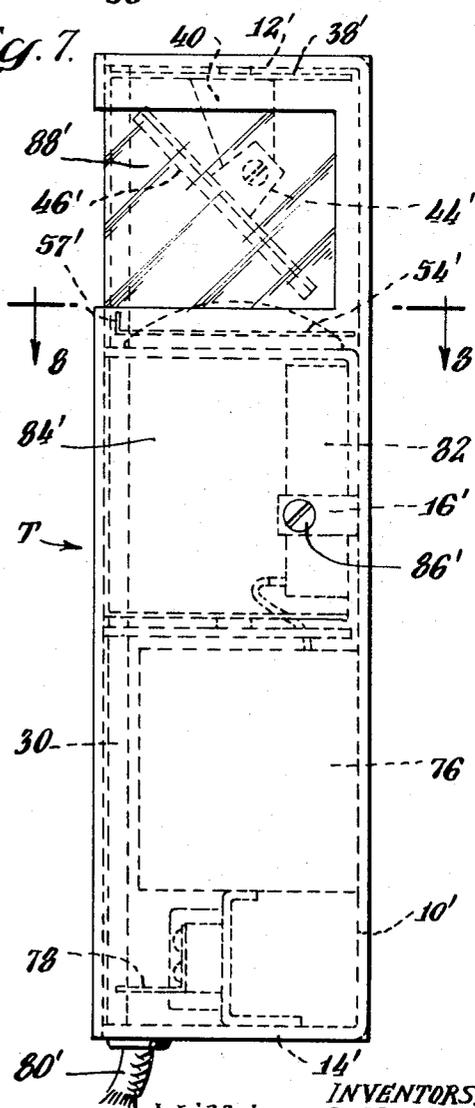


Fig. 7.



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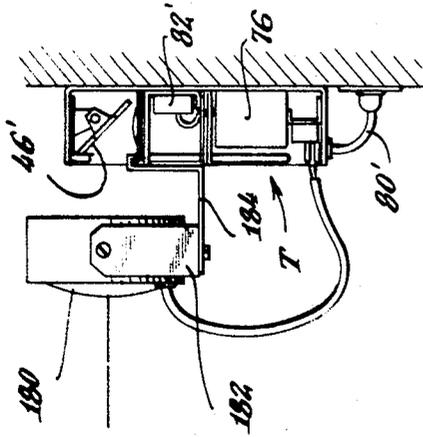


Fig. 9.

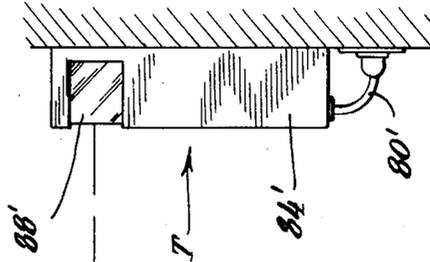


Fig. 10.

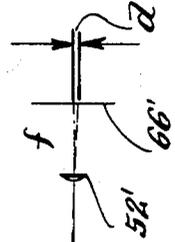
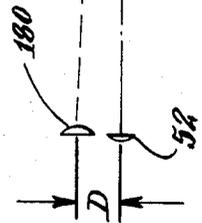
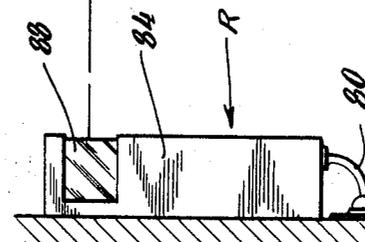
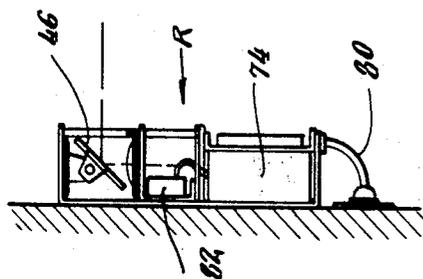


Fig. 11.



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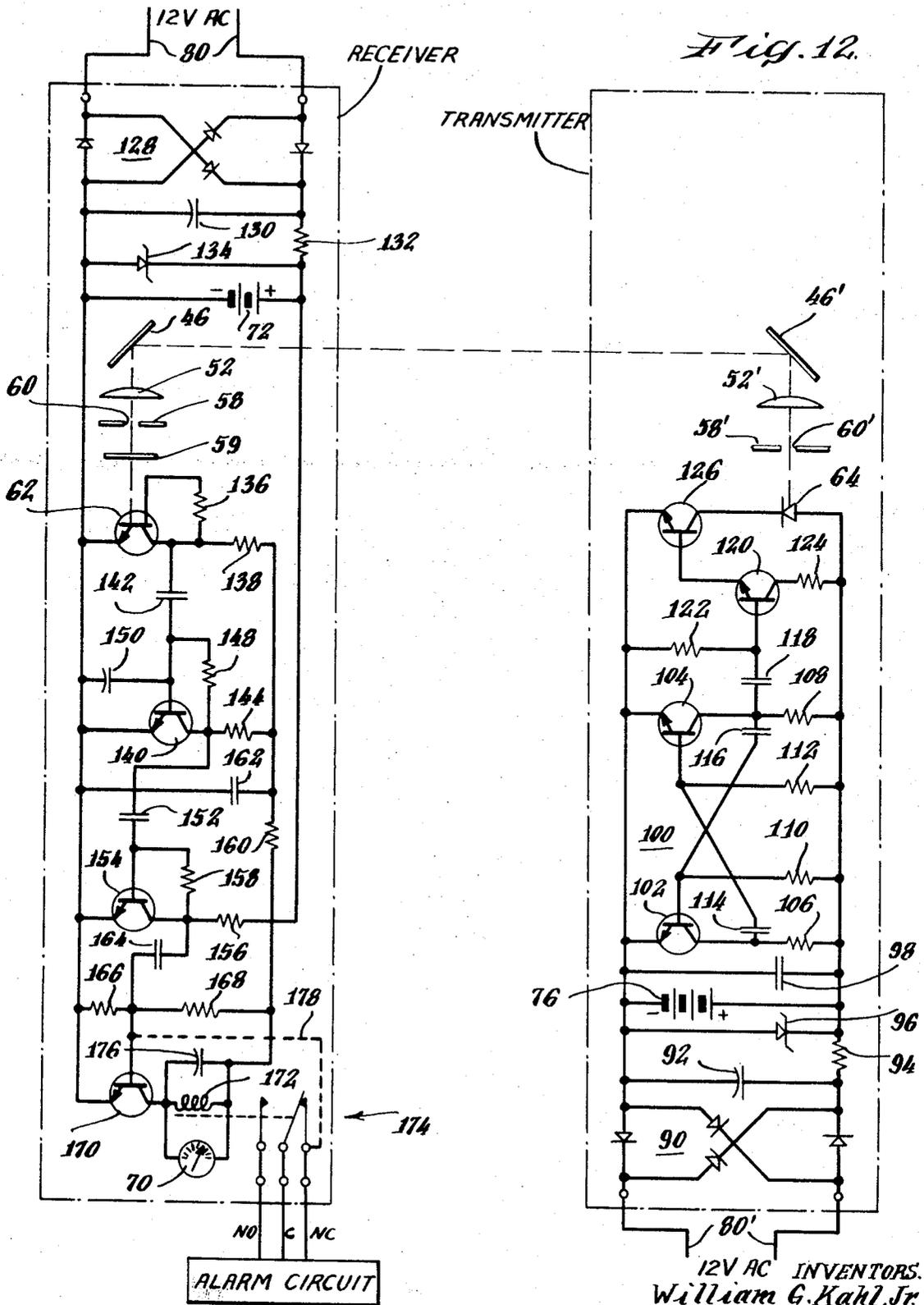


Fig. 12.

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## PHOTOELECTRIC INTRUSION DETECTOR

## BACKGROUND OF THE INVENTION

Photoelectric intrusion detectors are well known in the art. They customarily include a transmitter unit which projects a beam of light, and a receiver unit which activates a signal system if the beam is broken. The light may be either visible or invisible (e.g. infrared). In either case, the requirement of an optical system, such as a collimating lens, often dictates the physical dimensions of such a unit, causing it to project excessively from its mounting location, such as a wall. This makes the unit unduly conspicuous and, if mounted in heavy traffic areas such as aisles, corridors, etc., subjects it to possible damage or misalignment.

Most prior art systems employ steady state light sources. This makes such units defeatable by, for example, shining a flashlight into the receiver. It also renders them susceptible to changes in ambient illumination and outdoor installations of such devices are practically unworkable.

Still another problem with prior art devices is the difficulty of alignment on initial installation. This is particularly pronounced when using invisible radiation, such as infrared, and when a considerable distance separates the transmitter and receiver. It has been customary, when making such installation, to activate the transmitter and then attempt to "catch" the beam at the intended receiver location by manually manipulating a suitably responsive detector. Naturally, this "trial and error" technique is tedious and time consuming.

Accordingly, it is a primary object of the present invention to provide a photoelectric intrusion detection apparatus which is not subject to the foregoing deficiencies. Other objects are to provide such an apparatus which is unobtrusive, easily aligned, has minimum susceptibility to jamming and ambient light, and from which its direction of aim is difficult to ascertain. Other objects, features, and advantages will become apparent from the following description and appended claims.

## SUMMARY OF THE INVENTION

The invention comprises an improvement in a photoelectric intrusion detector system including a radiation transmitter, a radiation receiver, and signalling means responsive to interruption of the radiation therebetween. The transmitter comprises a housing, a source of electromagnetic radiation within the housing, means within the housing for collimating the radiation, and a mirror within the housing selectively positionable about two axes of rotation for directing radiation out of the housing. The receiver comprises a housing, a mirror in the housing selectively positionable about two axes of rotation for receiving and redirecting from the transmitter, means in the housing for focusing the redirected radiation, and means responsive to the focused radiation for actuating the signalling means.

## BRIEF DESCRIPTION OF THE DRAWINGS

The invention may be best understood by reference to the following description and the attached drawings wherein:

FIG. 1 is a plan view of the receiver of this invention, partially broken away to illustrate its internal construction;

FIG. 2 is a side elevation of the receiver of FIG. 1 with the upper portion of the housing broken away;

FIG. 3 is a front elevation of the receiver of FIG. 1 with portions of the housing broken away;

FIG. 4 is an enlarged partial cross section taken substantially along the line 4—4 of FIG. 1;

FIG. 5 is an enlarged cross section taken substantially along the line 5—5 of FIG. 2;

FIG. 6 is a front elevation of the transmitter of this invention, partially broken away to illustrate its internal construction;

FIG. 7 is a side elevation of the transmitter of FIG. 6;

FIG. 8 is an enlarged cross section taken substantially along the line 8—8 of FIG. 7;

FIG. 9 is an illustration of the initial alignment in accordance with the invention;

FIG. 10 is an illustration of the aligned transmitter and receiver in operation;

FIG. 11 is a diagram useful in explaining the initial alignment; and

FIG. 12 is an electrical and optical schematic of the invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

With particular reference to the drawings, there is illustrated in FIGS. 1-5, a receiver R and in FIGS. 6-8, a transmitter T. The mechanical features of these units are quite similar and a number of identical parts are employed. Consequently, the receiver will be first described and, where appropriate, similar elements of the transmitter will be given similar reference numerals, but with a prime attached.

The receiver is vertically elongated and of rectangular cross section. The basic structure is a rectangular back plate 10 with integral forwardly extending top 12 and bottom 14 portions. Also extending forwardly at the sides of back plate 10 are drilled and tapped housing mounting tabs 16. At the forward corners of receiver R vertical rods 18, 20 extend downwardly slightly more than half the length of the unit where they are secured by screws 22 to forwardly extending tabs 24, 26 of terminal board 28. In the transmitter T somewhat similar rods 30, 32 extend the length of the unit from top 12' to bottom 14'.

Mounted to the top 12 of the receiver (and top 12' of the transmitter) by means of bolt 34 and nut 36 is a knurled thumb wheel 38 which is integrally secured to a support bracket 40. Mounted on bracket 40 by means of a bolt 42 is a mirror mount 44 which supports an octagonal mirror 46 at a nominal 45° to the vertical axis. ("Nominal" because the mirror is adjustable about the axis of bolt 42.) It will thus be seen that mirror 46 is rotatable about two axes — namely, the axes of bolts 34 and 42. Also, the mirror serves to bend the optical axis from horizontal to vertical, reducing the depth of the unit and its protrusion from the mounting surface.

Below mirror 46 is a horizontal shelf 48 having a relatively large circular aperture 50 therein (FIG. 8). Seated atop shelf 48 is a plano-convex lens 52 secured by an annular clamping plate 54 and screws 56. The forward edge of clamping plate 54 terminates in an upstanding flange 57, which serves a purpose to be later described.

Mounted below, and in the focal plane of, lens 52 is a horizontal shelf 58 which carries an infrared filter 59 and defines a small central aperture 60. Directly below aperture 60 is mounted a photo-transistor 62. The

transmitter T is similarly constructed but, in place of the photo-transistor, there is mounted alight emitting diode 64. Atop shelf 58 (and 58') there is mounted a white paper disc 66 which defines a small central aperture 68 aligned with aperture 60.

Receiver R includes a small meter 70 for indicating activation of photo-transistor 62 by the light beam. The lower portion of the receiver houses a rechargeable battery 72 and various electrical terminals including 12 volt terminals 74. The transmitter T also encloses a rechargeable battery 76 and is provided with 12 volt terminals 78. Power is provided to each unit through a power cord 80. Various electronic circuit elements are mounted in area 82, 82'. These elements are not individually illustrated but are shown schematically in FIG. 12. Both receiver and transmitter are enclosed by a housing 84 secured to tabs 16 by screws 86. The upper portion of each housing surrounding mirror 46 carries a dark red window 88 which extends across the front and substantially to the rear of each side.

As previously mentioned, the subject invention employs a pulsed infrared beam which makes it quite insensitive to high ambient light levels. The circuit of the transmitter, FIG. 12, comprises a full wave bridge rectifier 90 and a 50 microfarad, 25 volt filtering capacitor 92 connected in parallel across the 12 VAC, 60 Hz source 80'. Connected in series with this combination is a 150 ohm voltage dropping resistor 94. A 6.8 volt zener diode 96, 6.8 volt rechargeable lead dioxide battery 76 and 290 microfarad, 15 volt storage capacitor 98 are connected in parallel to develop 6.8 volts DC, the proper voltage for charging the battery. If the battery is discharged, the storage capacitor 98 stores enough energy to assure proper functioning. This combination supplies an astable multivibrator 100 having an output consisting of a series of positive pulses 50 microseconds wide repeating at the rate of 40 Hz. The multivibrator comprises a pair of 2N 2925 transistors 102, 104; 4.7 K ohm resistors 106, 108; 5 megohm resistor 110; 91 K ohm resistor 112; 0.0018 microfarad capacitor 114; and 0.01 microfarad capacitor 116.

The output pulses from multivibrator 100 are connected through a 0.01 microfarad coupling capacitor 118 to a 2N530B emitter-follower transistor 102 which has its base connected to positive through a 180 K ohm resistor 122 and its collector connected to negative through a 22 ohm resistor 124. The output from emitter-follower 120 is amplified by a D42C2 power transistor 126 in series with S5L5CF infrared light emitting diode 64. The diode acts as a point source from which infrared rays radiate in a cone. The short focal length lens 52' collimates the rays, which are aligned by the adjustable mirror 46'.

The transmitted infrared beam is intercepted by the receiver, which has an identical optical system, the lens 52 focusing the rays on FPT 100 silicon photo-transistor 62. A focal plane filter 58 and spectral filter 59 reject all visible and near infrared light which is of shorter wavelength than that emitted by the diode 64. Longer wavelengths are blocked by the glass lens 52. This serves to: eliminate modulated visible fluorescent light; and reduce ambient light and prevent photo-transistor saturation.

The receiver power supply is similar to that of the transmitter, comprising a rectifier 128, a filter capacitor 130, and a current limiting resistor 132. These elements are substantially identical with the similar ele-

ments of the transmitter and operate in the same manner, together with 4.6 volt zener diode 134, to maintain 4 volt battery 72 in a charged condition.

Photo-transistor 62 is an FPT 100 which is biased in a unique manner to stabilize the gain as the filtered ambient radiation varies from bright daylight to darkness. This ambient radiation level creates one bias and the electrical base connection the other. The base is connected to the collector through a 2.2 megohm resistor 136. The collector is connected to a decoupled 3 VDC source through a 3.6 K ohm resistor 138. As more light falls on the photo-transistor junction, more collector current flows and the collector voltage drops. Due to the lower collector voltage, less base current flows, thereby countering the first effect and stabilizing the total bias condition. In this way, gain stability for the incoming infrared pulses is achieved.

The output pulses from the photo-transistor are coupled to the base of a 2N5308 transistor 140 by a 0.0012 microfarad coupling capacitor 142. Transistor 140 is connected in series with 330 ohm resistor 144. A negative feedback resistor 148 has a value of 2.2 megohms. During this first stage of amplification, extremely high frequency noise is shunted to negative by 0.003 microfarad capacitor 150. The negative feedback resistor 148 tends to block low frequencies more than high frequencies which tend to be phase shifted by the slow transistor.

The signals from the first amplification stage are coupled through a 0.1 microfarad capacitor 152 to the base of 2N2925 transistor 154 which is connected in series with a 6.8 K ohm resistor 156. More negative feedback is provided by 120 K ohm resistor 158 which selectively blocks low frequencies while transmitting the higher frequency components which form the pulse. This

The signals from transistor 154 are coupled through a 0.01 microfarad capacitor 164 to a tap between 13 K ohm resistor 166 and 82 K ohm resistor 168 and to the base of a 2N5308 transistor 170 which serves as a relay driver. Transistor 170 is connected in series with the coil 172 of a 5F-300 LSS relay 174. Coil 172 is connected in parallel with meter 70 and with 50 microfarad capacitor 176. Relay 174 is energized except when the pulse modulated radiation beam is interrupted. An additional "lock in" connection 178 may be added, if desired.

As has been previously explained, one of the most tedious aspects of installing a photoelectric detection system utilizing invisible radiation is the initial alignment. However, the present invention permits rapid visual alignment provided by the unique swivelled mirrors within the units and a blinking sealed beam light. The installer first mounts the receiver R and transmitter T on the desired spaced surfaces as shown in FIG. 9. The installer is provided with a 12 volt sealed beam light 180 having a built in flasher. The light 180 is swivel-mounted on a V-shaped bracket 182 which, in turn, is rotatably secured to a hanger 184. The hanger is suspended from the flange 57 or 57' of one of the units — the transmitter in the FIG. 9 illustration. The leads from light 180 are connected to the 12 volt terminals 78. The light is then aimed at the remote receiver. The installer, or an assistant, now adjusts the mirror 46 on the receiver and observes the flashing white spot on disk 66 formed by lens 52. The mirror 46 is adjusted until the spot falls within aperture 68. The sealed beam

light is then removed from transmitter T and attached to receiver R in a similar fashion. The adjustment is then repeated, this time by movement of mirror 46' on the transmitter T. The units are then completely aligned and the housings 84, 84' are installed, the dark red plastic windows 88, 88' effectively concealing the position of the mirror.

It might be added at this point that the flasher in sealed beam light 180 is not absolutely necessary. However, it is quite useful as a means of identification and prevents the installer from inadvertently aligning a unit with the wrong light source — a bare electric bulb, for example.

Precise alignment of the sealed beam light with the optics of either unit is not necessary. In fact, accurate alignment is achieved, even if light 180, as shown in FIG. 9 is rotated 90° to a receiver along the wall surface. This is illustrated schematically in FIG. 11 wherein the sealed beam light 180 is displaced a distance  $D = 6$  inches from lens 52. A commercial unit which incorporates this invention has a range of 400 feet, and this corresponds to the distance  $L$  separating lenses 52, 52'. The focal length of each lens is 2 inches and this is the distance  $f$  from lens 52' to disk 66'. The expression for displacement  $d$  of the focused spot is

$$d/f = D/L$$

$$d = (fD/L)$$

In the above illustration,

$$d = [2 (6)]/4800$$

$$= 0.0025 \text{ inch,}$$

a value which is considerably less than the diameter of aperture 68.

It is believed that the many advantages of the invention will now be apparent to those skilled in the art. It will also be apparent that many variations and modifications may be made therein without departing from its spirit and scope. Accordingly, the foregoing description is to be construed as illustrative only, rather than limiting. This invention is limited only by the scope of the following claims.

We claim:

1. The method of aligning an optical intrusion detector system including a transmitting unit having an invisible radiation source, an adjustable transmitting mirror and a collimating lens, a receiving unit having an adjustable receiving mirror, a photosensitive receiver and a focusing lens, and an auxiliary visible light source, which comprises: manually positioning said invisible light source adjacent one of said transmitting and receiving units; adjusting the mirror of the other of said units to focus visible light from said light source through its corresponding lens onto its corresponding source or receiver; manually repositioning said visible light source adjacent the other of said transmitting and receiving units; and adjusting the mirror of said one unit to focus visible light from said light source through its corresponding lens onto its corresponding source or receiver. stage of amplification is biased in such a way that large signals tend to drive it from Class A operation toward saturation, thereby limiting the gain to a reasonable value. The resistor 160 has a value of 1.2 K ohm and capacitor 162 has a value of 100 microfarads.

The signals from transistor 154 are coupled through a 0.01 microfarad capacitor 164 to a tap between 13 K

ohm resistor 166 and 82 K ohm resistor 168 and to the base of a 2N5308 transistor 170 which serves as a relay driver. Transistor 170 is connected in series with the coil 172 of a 5F-300 LSS relay 174. Coil 172 is connected in parallel with meter 70 and with 50 microfarad capacitor 176. Relay 174 is energized except when the pulse modulated radiation beam is interrupted. An additional "lock in" connection 178 may be added, if desired.

As has been previously explained, one of the most tedious aspects of installing a photoelectric detection system utilizing invisible radiation is the initial alignment. However, the present invention permits rapid visual alignment provided by the unique swivelled mirrors within the units and a blinking sealed beam light. The installer first mounts the receiver R and transmitter T on the desired spaced surfaces as shown in FIG. 9. The installer is provided with a 12 volt sealed beam light 180 having a built in flasher. The light 180 is swivel-mounted on a V-shaped bracket 182 which, in turn, is rotatably secured to a hanger 184. The hanger is suspended from the flange 57 or 57' of one of the units — the transmitter in the FIG. 9 illustration. The leads from light 180 are then connected to the 12 volt terminals 78. The light is then aimed at the remote receiver. The installer, or an assistant, now adjusts the mirror 46 on the receiver and observes the flashing white spot on disk 66 formed by lens 52. The mirror 46 is adjusted until the spot falls within aperture 68. The sealed beam light is then removed from transmitter T and attached to receiver R in a similar fashion. The adjustment is then repeated, this time by movement of mirror 46' on the transmitter T. The units are then completely aligned and the housings 84, 84' are installed, the dark red plastic windows 88, 88' effectively concealing the position of the mirror.

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It is believed that the many advantages of the invention will now be apparent to those skilled in the art. It will also be apparent that many variations and modifi-

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cations may be made therein without departing from its spirit and scope. Accordingly, the foregoing description is to be construed as illustrative only, rather than limiting. This invention is limited only by the scope of the following claims.

We claim:

1. The method of aligning an optical intrusion detector system including a transmitting unit having an invisible radiation source, an adjustable transmitting mirror and a collimating lens, a receiving unit having an adjustable receiving mirror, a photosensitive receiver and a focusing lens, and an auxiliary visible light source,

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which comprises: manually positioning said invisible light source adjacent one of said transmitting and receiving units; adjusting the mirror of the other of said units to focus visible light from said light source through its corresponding lens onto its corresponding source or receiver; manually repositioning said visible light source adjacent the other of said transmitting and receiving units; and adjusting the mirror of said one unit to focus visible light from said light source through its corresponding lens onto its corresponding source or receiver.

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UNITED STATES PATENT OFFICE  
CERTIFICATE OF CORRECTION

Patent No. 3,752,978 Dated August 14, 1973

Inventor(s) William G. Kahl, Jr., et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 30, "suitabley" should read -- suitably --.  
Column 2, line 8, "illustrates" should read -- illustrate --.  
Column 3, line 2, "alight" should read -- a light --. Column 4, line 36, after "This" insert -- stage of amplification is biased in such a way that large signals tend to drive it from Class A operation toward saturation, thereby limiting the gain to a reasonable value. The resistor 160 has a value of 1.2 K ohm and capacitor 162 has a value of 100 microfarads. --; line 46, "modulcated" should read -- modulated --; line 63, after "are" insert -- then --. Column 5, line 44, beginning with "We claim:" cancel all to and including "the following claims." in column 7, line 5. Column 8, line 1, "invisible" should read -- visible --.  
Column 1, line 54, after "redirecting" insert -- radiation --.  
Signed and sealed this 5th day of February 1974.

(SEAL)  
Attest:

EDWARD M. FLETCHER, JR.  
Attesting Officer

RENE D. TEGTMEYER  
Acting Commissioner of Patents