FAIL-SAFE DETECTOR

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Filed: May 19, 1971

Appl. No.: 144,726

U.S. Cl. 187/29 R, 318/480
Int. Cl. B66h 1/36
Field of Search 187/29; 318/480; 307/117

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UNITED STATES PATENTS

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ABSTRACT

A fail-safe position detector in which a pulsed light source induces corresponding electrical pulses in a light responsive receiver circuit when the components are in a desired relative position. The pulses generated in the receiver circuit are effective to operate a translating device through an isolation transformer. Threshold devices at critical junctures in the circuit eliminate marginal operation. The components are selected so that failure of one component or a combination of components will not cause false triggering of the translating device.

12 Claims, 5 Drawing Figures
FAIL-SAFE DETECTOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to detector devices for detecting the relative positions of objects and is illustrated as applied to detecting the location of an elevator car relative to the landings in a hoistway.

2. The Prior Art

Various schemes and devices have been utilized to detect the position of an elevator car relative to the landings in the hoistway. The simplest such device is a cam operated mechanical switch. Such devices are subject to mechanical wear and misadjustment.

Another widely used device is the inductor relay. The inductor relay is an electromechanical relay in which the armature is not displaced upon energization of the coil until a magnetic circuit is completed by a separate magnetically permeable member. Usually the coil is mounted on the car and a vane of the magnetically permeable material is mounted in the hoistway at a point where it will complete the magnetic circuit of the relay as the car passes in close proximity in the vane. Such devices eliminate the problem of mechanical wear, however, they lack the ability of precisely locating the position of the car.

Inductor systems which are capable of generating a continuously variable signal indicative of the displacement of the car from a landing are also in use for bringing the car rapidly and accurately to a landing. Such a system is disclosed in U.S. Pat. No. 2,874,806 and an improvement is shown in U.S. Pat. No. 3,207,265. Electrostatic devices have also been used to a limited extent for controlling the operation of the car as a function of the relative position of the car.

In addition, visible light beams have been used in conjunction with phototubes to accurately establish the position of elevator cars relative to the landings. In U.S. Pat. No. 3,138,223, a beam of light generated by an incandescent bulb energizes a phototube through a slot in a vane mounted on the wall of the hoistway when the car is level with the landing. The device is also used to indicate when the car is within a predetermined distance of the landing during slowdown so that door opening may be initiated. Incandescent lamps and photoresistors are also in wide spread use for determining when passengers are in the path of automatically operated elevator doors to prevent the doors from closing on passengers and for purpose of monitoring passenger transfers.

The photoelectric detecting devices utilized to date are responsive to a continuous light signal and are therefore subject to false triggering by random light sources. In addition, neither the incandescent light sources nor the photoresistive devices can be operated at any significant pulse rate which would be useful in reducing the incident of false triggering caused by random light sources.

SUMMARY OF THE INVENTION

According to the invention, a pulsed source of radiant energy, preferably visible light or infrared light, triggers a photoresponsive device in a receiver circuit when two objects are in a desired relative position with respect to each other. Corresponding electrical pulses generated in a receiver circuit operate a translating device, which may take the form of an electromagnetic relay, through an alternating current (hereinafter referred to as A.C.) coupling device.

Preferably, the pulsed source of radiant energy is in the form of a light emitting diode which may be pulsed at a frequency in the kilohertz range. In the preferred embodiment of the invention, the A.C. coupling device is an isolation transformer which couples signals in the kilohertz range applied through the primary to the secondary. By pulsing the radiant energy source and coupling the translating device to the receiver through an A.C. coupling device tuned to the frequency of the radiant energy source, misoperation caused by stray radiant energy or failure of a component in the receiver circuit in an activated condition is minimized.

In order to further improve the reliability of the detector, a threshold device compares the amplitude of the electrical pulses generated by the photoresponsive device to a reference signal and only passes pulses of a predetermined amplitude to the isolation transformer. In the embodiment of the invention disclosed in detail, the threshold device includes an operational amplifier utilized as a comparator and a Zener diode having a breakdown voltage selected such that pulses pass through the Zener only when they have a value with respect to the reference signal which is determined by the predetermined breakdown voltage of the Zener diode and the transfer function of the operational amplifier.

The operational amplifier is an uncompensated microcircuit operational amplifier which has a natural frequency in the megahertz range so that oscillations due to failure of the operational amplifier will not be passed through the isolation transformer to the translating device. If the translating device is to be located remotely from the receiver, a line driver and a line receiver may be utilized in conjunction with an A.C. coupled transmission line between the threshold device and the isolation transformer to reduce the possibility of noise interference.

For detecting a desired relative position between two objects, the transmitter may be mounted on one object and the receiver on the other or both the transmitter and receiver may be mounted on the same object with a control element on the other object to control the flow of pulses from the transmitter to the receiver. The control element may either interrupt or complete the flow of pulses between the transmitter and the receiver. In the latter case, it may take the form of a reflective surface. In the embodiment of the invention described in detail, the control device is in the form of a vane which projects from one object perpendicular to the direction of the relative motion of the two objects. The pulses of radiant energy are focused into a beam which intersects the line of sight of the receiver in the plane of the reflective surface. To further increase the reliability of the device, a non-reflective surface is placed in the line of sight of the receiver at a point beyond the plane of the reflective surface to protect the receiver from stray radiation. More than one transmitter-receiver combination can be used on separate channels to determine the direction of approach of the object to a desired position. The device may also be used to monitor passenger transfers between the elevator car and the landing by locating the transmitter and receiver so that a passenger passing through the doorway will interrupt the light pulses.
BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of a detector device according to the invention;
FIG. 2 is a schematic diagram of an elevator system incorporating the invention;
FIG. 3 is an enlarged sectional view of a portion of FIG. 2; and
FIG. 4 is a schematic circuit diagram of a detector according to the invention; and
FIG. 5 is a plan view in section of another application of the invention to an elevator system.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 illustrates in block diagram form the general organization of the invention. A function generator 1 generates a repetitive electrical signal which drives a light-emitting diode 2. A light-emitting diode which emits light in the visible spectrum can be utilized, however, a General Electric infrared light emitting diode, SSL-5C, has been utilized in the preferred embodiment of the invention. The infrared light-emitting diode was selected because its emissions can be reflected by a metallic surface which is advantageous as will be seen below. It should be understood that any control device which can emit electromagnetic radiation having a wavelength in the range of approximately 2,000 to 10,000 A could be utilized. The light-emitting diode has the advantage of long life and can be pulsed at frequencies in the megahertz range for the state of the art light-emitting diodes. Incandescent light sources on the other hand have limited life and cannot be pulsed at any significant pulse rate due to residual incandescence.

A function generator which generates any repetitive electrical signal could be utilized for the function generator 1, however, a square wave generator which generates a signal having a frequency of 4 kilohertz was selected for the preferred embodiment. The light-emitting diode 2 (hereinafter referred to as LED) therefore emits pulses of infrared radiation having a frequency of 4 kilohertz. It is unlikely that there would be stray radiation modulated at the same frequency in the environment in which the device is to be utilized.

The pulses of infrared energy 3 may be aimed directly at a phototransistor 4 or may be reflected from a reflective surface 5. As mentioned above, the infrared energy may be easily reflected from a polished metallic surface.

The phototransistor 4 is operative to generate electric pulses having a frequency corresponding to that of the pulses of infrared energy 3 triggering it. The phototransistor is capable of generating pulses in the kilohertz range unlike the photoresistor which is commonly referred to as the photocell.

A first threshold device 6 passes along the electrical pulses generated by the phototransistor only when they exceed a predetermined value. This adds to the reliability of the detector by rejecting electrical pulses generated by stray or reflected infrared energy. Signals which exceed the threshold of the threshold device 6 are amplified by the amplifier 7. The output of the amplifier 7 is applied to the translating device 14 through an A.C. coupler 13. In a preferred embodiment of the invention, the A.C. coupler 13 is in the form of an isolation transformer which is operative only to couple signals in the kilohertz range. If the translating device and coupling device are located remotely from the amplifier 7, a transmission line 9 having a line driver 8, a high pass filter 10, a second threshold device 11 and an additional amplifier 12 are provided to assure the delivery of a reliable signal to the A.C. coupler 13.

FIG. 2 illustrates an elevator system incorporating the invention. An elevator car 15 is suspended by a wire rope 16 in a hoistway 17. The wire rope 16 passes over a drive sheave 18 and supports a counterweight 19 in the conventional manner. The elevator car 15 is caused to move up and down in the hoistway 17 to serve three landings by a motor and control system 19 which acts through the shaft 20 supporting a drive sheave 18.

The transmitter and receiver of the position detector are mounted in a unit 21 on the side of the car. The flow of the pulses of infrared energy between the transmitter and receiver are controlled by vanes 22 mounted at each landing. These vanes may be the vanes associated with the inductor landing system described in U.S. Pat. No. 3,207,265 mentioned above. Strips of metallic material 23, or other materials which reflect infrared rays, are fastened to the vanes 22 to provide a reflective surface for the pulses of infrared energy. In the arrangement shown, pulses of infrared energy will be reflected by the strips 23 when the elevator car 15 is a predetermined distance above or below each landing. It is clear that various other arrangements of the reflective strips can be arranged to indicate any desired position of the car in the hoistway such as when it is in exact registry with each landing. The indication that the car is within a given distance above or below a landing can be used for various elevator control functions such as the preopening of the door as the car approaches a landing and for leveling purposes. By using pairs of transmitters and receivers and additional strips of reflective materials, a plurality of channels can be provided. The information provided by the various channels can be combined in any number of ways to perform desired logic functions. Suitable materials for the reflective strips 23 include chromium plated plastic or metal, polished copper etc. Gold and silver polyester tape sold under the trade name of Mylar have been found suitable for reflecting infrared radiation. Mylar tape has the advantage that it can be easily cut to the desired dimensions and is provided with an adhesive backing for easy installation.

If the translating device is to be located in the control 19 located in the penthouse, the transmission line 9 shown in the block diagram of FIG. 1 can be routed to a junction box 24 on the car and then through the traveling cable 25 to the junction 26 in the hoistway. The transmission line 9 can then form part of the cable 27 which connects the junction box 26 with the control 19.

FIG. 3 shows an enlarged plan view of the section of the elevator system shown in FIG. 2. The detector unit 21 fastened to the car 15 mounts the transmitter 2 so that the beam of pulses formed by the lens or focusing device 28 intersects the metallic strip 23 on the vane 22 mounted on the wall of the hoistway 17 when the car is adjacent to the landing. The beam of pulses reflected from the metallic strip 23 are focused by the lens 29 on the photoresistor 4. A shield 30 projecting from the car 15 in the line of sight of the receiver 4 protects the receiver from random or reflected infrared radiation.
when the car is not adjacent the landing. It can be appreciated that when the car is not adjacent a vane the beam of pulses generated by the transmitter 2 will not be reflected into the line of sight of the phototransistor 4.

FIG. 4 is a schematic circuit diagram of a preferred embodiment of the invention. A supply voltage of plus 125 volts D.C. is applied between buses 30 and 31 with the bus 30 being held at ground potential. The Zener diode ZD1 cooperates with the resistor R4 to provide a 30 volt supply for the squarewave generator portion of the circuit. Although any conventional squarewave generator could be utilized, the squarewave generator utilized in the circuit of FIG. 4 comprises the programmable unijunction transistor PU and the conventional J-K flip-flop F-F. The programmable unijunction transistor PU is a solid state device which has a characteristic that it will block the passage of current from its anode A to its cathode K until its anode to cathode voltage exceeds, by a small predetermined amount, the voltage between its gate electrode G and the cathode. When this occurs the device exhibits a negative resistance characteristic much as an ordinary unijunction transistor exhibits. The voltage at which the device will conduct is determined by the voltage applied between the gate and the cathode, hence the origin of the term programmable.

As used in the circuit of FIG. 4, the voltage at which the programmable unijunction transistor PU will fire is determined by the voltage divider comprising the resistors R2 and R3. The anode to cathode voltage of PU is determined by the voltage on a capacitor C1 as it is charged through the resistor R1. Until the charge on a capacitor C1 reaches the predetermined value, the voltage determined by the voltage divider R2 and R3 is applied to the input 32 of the flip-flop F-F. When the charge on the capacitor reaches the predetermined firing voltage, the programmable unijunction transistor PU fires to rapidly discharge the capacitor C1 through the current limiting resistor R26. Since the value of the resistor R26 is very small, the input to the flip-flop F-F goes to essentially ground potential. When the capacitor C1 has discharged, the programmable unijunction transistor is reset and the input voltage to the flip-flop F-F is again the voltage determined by the resistors R2 and R3 while the capacitor C1 recharges. It can be seen then that the potential applied to the input 32 of the flip-flop F-F alternates between essentially zero voltage and some predetermined positive value.

The flip-flop F-F is the conventional J-K type of flip-flop in which a signal appears on the output 33 upon alternate applications of a signal to the input 32. In such flip-flops the state of the output signal remains constant despite the removal of the input signal until another input signal is applied. Assume that the output 33 of F-F goes to some positive value while the capacitor C1 is charging. When PU fires so that the input to flip-flop F-F goes to zero, the signal at the output 33 remains equal to one. When the capacitor C1 has discharged and the signal applied to the input 32 again goes to some positive value, the output signal at 33 goes to zero and remains at zero when PU again fires. This time when C1 has discharged and PU is again reset so that a positive signal is applied to the input 32, the output 33 returns to the original positive value. Thus it can be seen that the output 33 of the flip-flop F-F alternates between zero volts and some positive value with the frequency of the pulses being determined by the cycle time of the programmable unijunction transistor PU.

The Zener diode ZD2 and the resistor R5 combine to sharpen the waveform of the signal developed at 33. The squarewave signal thus generated is amplified by the two stage emitter follower amplifier comprising NPN transistors Q1 and Q2 which serve to control the light-emitting diode LED. When the output 33 is at zero so that transistors Q1 and Q2 are turned off, LED receives current through resistors R10 and R9 and a diode D1 and emits light in the infrared range. When a positive signal appears at the output 33 of F-F, transistor Q1 is turned on. The base current thus supplied to Q2 saturates this transistor. In this state, the collector to emitter impedance of Q2 drops to essentially zero thereby shorting LED and terminating its emission of infrared light. The diode D1 having a forward drop which exceeds the collector to emitter impedance of Q2 when it is in saturation assures that LED is cut-off under these circumstances. It is seen then that the LED generates pulses of infrared radiation as a function of the squarewave signal appearing at the output of the flip-flop 33.

The receiver circuit includes phototransistor PT and a threshold device which includes the operational amplifier OA operated as a comparator and a Zener diode resistor combination ZD5 and R19. The Zener diode ZD4 cooperates with resistor R11 to establish a supply voltage of 30 volts for the phototransistor PT and the operational amplifier OA. Zener diode ZD3 cooperates with resistors R11 and R12 to establish a reference voltage which is applied to inputs A and B of the operational amplifier through resistors R13 and R14 respectively. The resistor R15 which is a large compared with resistors R13 and 14 biases the potential at input A to be slightly negative with respect to the potential at input B of the operational amplifier. The incidence of infrared radiation upon the phototransistor PT causes additional current to pass through resistor R15 thereby making the potential of the input A of the operational amplifier positive with respect to the input B. This results in a positive potential at the output of OA. When this potential exceeds the Zener breakdown voltage of the Zener diode ZDS, base current is supplied to the transistor Q3 which turns this transistor on.

The transistor Q3 controls the line driver which includes the transistor Q4. With Q3 cut-off, Q4 of the line driver is turned on to supply current through resistor R17, transmission line 9, resistor R21, Zener diode ZD6 and the base to emitter circuit of transistor Q5 to charge the capacitor C2 of the high pass filter comprising capacitor C2 and resistor R21. In this state the transistor Q5 can be turned on by the base current applied through the resistors R32 and R23. The transistor Q4 is biased to the on condition by the resistor R18 so that the line driver will supply current to maintain C2 in the charged state despite the introduction of negative splices on the line.

With the transistor Q5 turned on, transistor Q6 is turned off so that no current passes through the primary of the transformer T1. When the transistor Q3 is turned on by a voltage which exceeds the Zener breakdown voltage of the Zener diode ZDS, the base of transistor Q4 goes to essentially zero volts to turn Q4 off. The capacitor C2 will then discharge through the circuit formed by resistor R17, diode D2, the collector to emitter circuit of transistor Q3, bus 30, diode D3,
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Zener diode ZD6 and resistor R21 as long as the charge on the capacitor exceeds the Zener breakdown voltage of ZD6. This causes the base of transistor Q5 to go negative with respect to the emitter which turns off Q5. The diodes D2 and D3 complete the discharge path and protect the emitter to base circuit of the transistors Q4 and Q5 respectively by limiting reverse bias to the forward drop of the diodes.

With transistor Q5 turned off, transistor Q6 is turned on to complete a circuit for the energization of the primary of the transformer T1. A build-up of the magnetic field in the primary T1 induces current in the secondaries which is rectified by the full wave rectifier bridge circuit B1 which supplies direct current to the coil of the relay R. The capacitor C4 serves as a filter for the bridge circuit. When the transistor Q6 is again turned off by the turning on of the transistor Q5, the collapse of the field in the primary T1 again induces a pulse in the secondary. Continued pulsing of the transformer T1 generates sufficient direct current to maintain the relay R in the energized state. The capacitor C3 is provided to protect the transistor Q6 from spikes caused by the discontinuities of the current in the primary of the transformer T1.

It can be seen that the relay R will be energized only as long as the photo transistor is subjected to pulses of infrared radiation emitted by the light emitting diode LED. The strength of the incident infrared radiation must be sufficient to drive the A input of OA sufficiently positive with respect to the B input so that the output of OA exceeds the Zener breakdown voltage of ZDS. The value of the electrical signals generated by the phototransistor must exceed the reference voltage by an amount which is a function of the breakdown voltage of the Zener diode and the transfer function of OA. If the voltage output of OA does not exceed the breakdown voltage of ZDS, Q3 will not be turned on and no pulses will therefore be induced in the primary of the transformer T1. As mentioned previously the line driver which includes transistor Q4 cooperates with the capacitor C2 to assure that spikes on the line will not erroneously generate pulses in the primary of T1. The Zener diode ZD6 assures that the pulses which will be passed to the translating device must be above a certain threshold to eliminate false triggering by stray signals induced in the transmission line. The A.C. coupling provided by the transformer T1 precludes false energization of the relay R due to failure of a component such as Q6 in the activated condition. Furthermore, T1 is an isolation transformer which is constructed so that only signals in the kilohertz range applied to the primary will induce current in the secondary. This further improves the reliability of the system by precluding false triggering by stray signals in other frequency ranges.

The operational amplifier OA is a high gain uncompensated operational amplifier which is operated in an open loop configuration to preclude false triggering of the relay R should the operational amplifier fail in the oscillating state. As a further precaution, OA is a micocircuit operational amplifier which has a natural frequency above one megahertz so that failure of the operational amplifier in this state will not be effective to induce current in the secondary of the transformer T1. The Fairchild Camera and Instrument Corporation Micro-Circuit Operational Amplifier μA709 has been found to be satisfactory for this purpose. The circuit of FIG. 4 is so designed that failure of a single component or a combination of components will not falsely energize the relay R. This is a highly desirable feature in a passenger transportation system where fail-safe operation has high priority.

FIG. 5 illustrates how the detector according to the invention can be utilized in place of the present light detectors used to control the automatic operation of elevator car doors 32. In this arrangement, the transmitter may be placed on one side of the entranceway 33 so as to project pulses of infrared energy across the entranceway to the receiver 4 mounted on the other side of the entranceway. One of the units could even be mounted to the door as is shown in FIG. 5. In this configuration, the relay R will be energized as long as no one is in the doorway, but will be dropped out when the beam of pulses of infrared energy is interrupted by a person or an object in the doorway.

It is apparent from the above discussion that the invention could be utilized in many applications where it is desirable to have a reliable fail-safe detector. The light emitting diodes have an advantage over the use of incandescent lamps not only in the fact that they can be pulsed at high frequencies thereby reducing the possibility of false indications due to stray radiation, but also in their exceptionally long life as compared with incandescent light sources.

We claim as our invention:

1. A fail-safe position detector for determining when two objects are in a desired relative position with respect to each other comprising:
   - electrical energy means,
   - a transmitter connected to said electrical energy means, said transmitter being operative to generate a beam of pulses of electromagnetic radiation,
   - a receiver connected to said electrical energy means, said receiver being responsive to electromagnetic radiation of the wavelength generated by the transmitter and operative to generate corresponding pulses of electrical energy when the two objects are in a relative position such that the beam of pulses generated by the transmitter impinges upon the receiver;
   - translating means operative from a first to a second condition when energized; and
   - coupling means connected between the receiver and the translating means for energizing the translating means only with the pulses of electrical energy generated by the receiver, said coupling means completely isolating said translating means from said electrical energy means, preventing operation of said translating means from said electrical energy means due to component failure.

2. The detector of claim 1 including a threshold device comprising:
   - a comparator having two inputs and an output; and
   - a reference signal source for generating a reference signal having a predetermined value;
   - said receiver being connected to one input of the comparator, the reference signal source being connected to the other input and the coupling means being connected to the output,
   - said comparator being operative to deliver the pulses generated by the receiver to the coupling means only when they reach a predetermined value with respect to the reference signal.

3. The detector of claim 2
wherein said transmitter includes a function generator operative to generate a repetitive electrical signal having a frequency in the kilohertz range and a light emitting diode energized by said function generator and operative to emit pulses of light at the frequency of said repetitive electrical signal, wherein said receiver includes a photoresponsive device responsive to the pulses of light emitted by the light emitting diode and operative to generate pulses of electrical energy of a corresponding frequency, and

wherein the coupling means is an isolation transformer having a primary connected to the output of said comparator and a secondary connected to said translating device and operative to couple only signals in the kilohertz range between the primary and the secondary.

4. A fail-safe position detector for determining when two objects are in a desired relative position with respect to each other comprising:

a transmitter operative to generate a beam of pulses of electromagnetic radiation having a wavelength between approximately 2,000 and 10,000A, said transmitter including a function generator operative to generate a repetitive electrical signal having a frequency in the kilohertz range and a light emitting diode energized by said function generator and operative to emit pulses of light at the frequency of said repetitive electrical signal, a receiver responsive to electromagnetic radiation of the wavelength generated by the transmitter and operative to generate corresponding pulses of electrical energy when the two objects are in a relative position such that the beam of pulses generated by the transmitter impinges upon the receiver, said receiver including a photoresponsive device responsive to the pulses of light emitted by the light emitting diode and operative to generate pulses of electrical energy of a corresponding frequency, a translating device operative from a first to a second condition when energized, an A.C. coupling device connected between the receiver and the translating device for energizing the translating device with the pulses of electrical energy generated by the receiver, said A.C. coupling device being an isolation transformer having a primary connected to the output of said comparator and a secondary connected to said translating device and operative to couple only signals in the kilohertz range between the primary and the secondary, and a threshold device including a comparator having two inputs and an output and a reference signal source for generating a reference signal having a predetermined value, said receiver being connected to one input of the comparator, the reference signal source being connected to the other input and the A.C. coupling device being connected to the output, said comparator being operative to deliver the pulses generated by the receiver to the A.C. coupling device only when they reach a predetermined value with respect to the reference signal, said comparator including an operational amplifier having two inputs and one output with said receiver connected to one input and said reference signal source connected to the other, and a Zener diode having a breakdown voltage of a predetermined threshold value and an impedance device connected in series to the output of said operational amplifier, whereby the comparator will generate an output only when the pulses generated by the receiver have a value with respect to the reference signal which is determined by the breakdown voltage of the Zener diode and the transfer function of the operational amplifier.

5. The detector of claim 4 wherein the operational amplifier is an uncompensated micrcircuit operational amplifier having a natural frequency in the megahertz range, whereby the oscillations due to failure of the operational amplifier cannot be passed through the isolation transformer to energize the translating device.

6. The detector of claim 1 including said mounting means for mounting both the transmitter and the receiver on a first one of the objects and guiding means for guiding the relative movement of the two objects such that the second object intersects the beam of pulses of the electromagnetic radiation between the transmitter and receiver when the two objects are in the desired position.

7. The detector of claim 1 including the mounting means includes means for mounting both the transmitter and the receiver on a first one of the objects and a control device mounted on the other object for controlling the flow of said pulses of electromagnetic radiation between the transmitter and the receiver.

8. The detector of claim 7 wherein the control device incorporates a reflective surface effective to reflect the pulses of electromagnetic radiation generated by the transmitter, wherein said transmitter includes focusing means to direct said pulses into a beam along a line of sight, and wherein said receiver includes focusing means making the receiver responsive only to pulses striking it along a predetermined line of sight, said focusing means being oriented such that the beam of pulses from the transmitter is reflected by the control device along the predetermined line of sight of the receiver only when the two objects are in the desired relative position with respect to each other.

9. A fail-safe position detector for determining when two objects are in a desired relative position with respect to each other comprising:

a transmitter operative to generate a beam of pulses of electromagnetic radiation having a wavelength between approximately 2,000 and 10,000A, said transmitter including focusing means to direct said pulses into a beam along a line of sight, a receiver responsive to electromagnetic radiation of the wavelength generated by the transmitter and operative to generate corresponding pulses of electrical energy when the two objects are in a relative position such that the beam of pulses generated by the transmitter impinges upon the receiver, said receiver including focusing means making the receiver responsive only to pulses striking it along a predetermined line of sight, a translating device operative from a first to a second condition when energized,
an A.C. coupling device connected between the receiver and the translating device for energizing the translating device with the pulses of electrical energy generated by the receiver, mounting means for mounting both the transmitter and the receiver on a first one of the objects, a control device mounted on the other object for controlling the flow of said pulses of electromagnetic radiation between the transmitter and the receiver, said control device incorporating a reflective surface effective to reflect the pulses of electromagnetic radiation generated by the transmitter, said control device being a vane projecting perpendicular to the direction of relative movement of the two objects with the plane of the reflective surface oriented parallel to said direction of relative movement, and wherein the mounting means includes means to mount the transmitter and receiver on said first object such that their lines of sight intersect at a point in the plane of said reflective surface, said focusing means of the transmitter and receiver being oriented such that the beam of pulses from the transmitter is reflected by the control device along the predetermined line of sight of the receiver only when the two objects are in the desired relative position with respect to each other.

10. The detector of claim 9 including a non-reflective shield mounted on said first object blocking the line of sight of said receiver at a point beyond the point at which the reflective surface of said vane intersects said line of sight when said objects are in the desired position, whereby the receiver is protected from stray radiation.

11. In a transportation system including a structure having a plurality of landings and a vehicle mounted for movement relative to the structure to serve the landings, a detector system for detecting the position of the vehicle relative to a selected landing and including:

- a transmitter including a light emitting diode and a pulse generator operative to pulse said light emitting diode at a predetermined frequency,
- a receiver including photosensitive means responsive to the pulses of light generated by the transmitter and operative to generate electrical pulses at a corresponding frequency in response thereto,
- mounting means for mounting the transmitter and receiver such that the pulses of light generated by the transmitter impinge upon the receiver when the vehicle is in a desired position relative to the selected landing,
- translating means operative from a first to a second condition when energized, and an isolation transformer connected between the receiver and the translating means and operative to energize the translating means only in response to electrical pulses from the receiver.

12. In a transportation system including a structure having a plurality of landings and a vehicle mounted for movement relative to the structure to serve the landings, a detector system for detecting the position of the vehicle relative to a selected landing and including:

- a transmitter including an infrared light emitting diode and a pulse generator operative to pulse said infrared light emitting diode at a frequency in the kilohertz range,
- a receiver including a phototransistor responsive to the pulses of infrared light generated by the transmitter and operative to generate electrical pulses at a corresponding frequency in response thereto,
- mounting means for mounting the transmitter and receiver such that the pulses of infrared light generated by the transmitter impinge upon the receiver when the vehicle is in a desired position relative to the selected landing,
- a translating device operative from a first to a second condition when energized, and an isolation transformer connected between the receiver and the translating device and operative to energize the translating device only in response to electrical pulses from the receiver having a frequency in the kilohertz range,
- a vane having a metallic surface effective to reflect infrared light, said mounting means including means for mounting said vane to said structure adjacent the selected landing and means for mounting the transmitter and receiver on said vehicle such that the beam of pulses of infrared light transmitted by the receiver is reflected by the metallic surface of said vane to impinge upon said receiver only when said vehicle is in the desired position relative to the selected landing.