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(54) Optical barrier for detecting moving objects.

(57) A barrier (1) comprising a transmitting unit (4) set up on one side of a path and having a number of infrared-emitting diodes (5) multiplexed and modulated at a predetermined frequency; a receiving unit (6) set up on the opposite side of the path and having a number of infrared photoreceivers (7); and electronic equipment (8) for controlling the electric signals generated by the photoreceivers (7). The electronic equipment (8) comprises an electronic processing unit (14) for automatically determining a reference value (Vf) for each of the photoreceivers (7); for comparing the signals generated by the photoreceivers (7) with the reference value (Vf); and for checking the comparison and so indicating the status, clear or engaged, of the barrier.

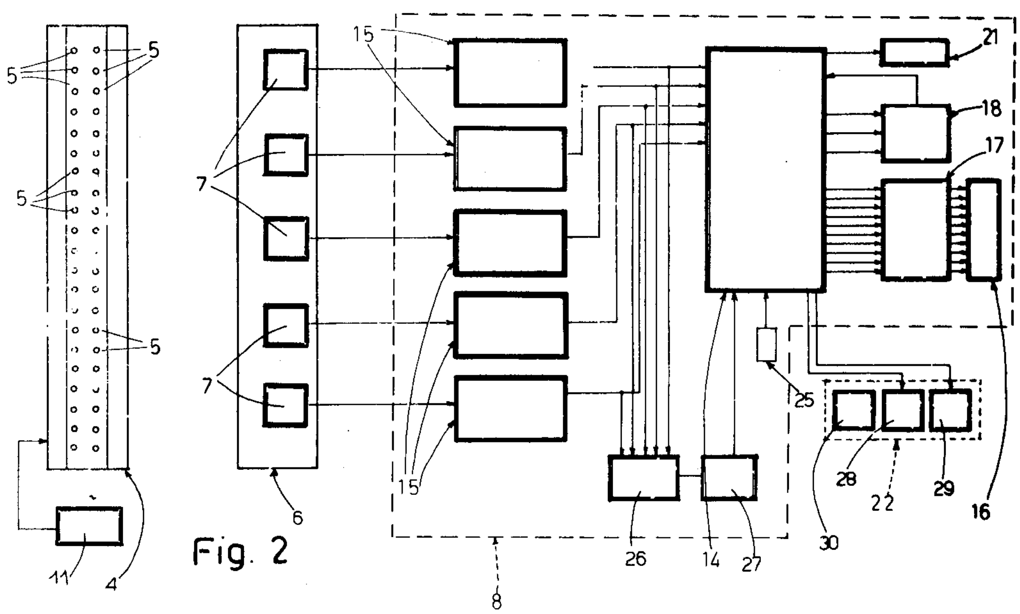

Fig. 2

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The present invention relates to an optical barrier for detecting moving objects, particularly vehicles in transit, and which also detects the continuity of the vehicle, in the sense that a tractor and trailer combination is considered a single vehicle.

Barriers of the aforementioned type are known to comprise two posts set up facing each other on either side of a given vehicle path. One of the posts is fitted with a transmitting unit featuring a number of infrared-emitting diodes multiplexed and modulated at a given frequency, and the other with a receiving unit featuring a number of infrared photoreceivers. The barrier is also fitted with electronic equipment for indicating whether the path is engaged or clear.

Optical barriers of the aforementioned type present several drawbacks.

Foremost of these is the need for calibrating, manually at present, the amplitude of the signal of each photoreceiver, to offset any difference in the electrical characteristics of the photoreceivers, and whenever any change occurs in atmospheric conditions. In other words, each photoreceiver must be so calibrated as to receive a signal of a given reference value or higher, and to exclude reception of any signals below the reference value, i.e. signals originating from sources other than the emitters, or signals resulting from reflection of the beam by an object between the posts. As the photon signal from the emitters is constant while that supplied to the photoreceivers varies as a function of atmospheric conditions, the signal converted by the photoreceiver is subject to a certain amount of variation, which is further compounded by the relative position of the photoreceivers and emitters.

What is more, in the event of a breakdown or operating defect involving any one of the transmitters or photoreceivers, known barriers indicate engagement of the path even when this is clear. Failure of the operator to detect the fault immediately thus results in false data - the consequences of which are obvious, for example, in the case of turnpike applications - and in the path being put out of service until the fault is rectified.

It is an object of the present invention to provide an optical barrier for detecting moving objects, designed to overcome the aforementioned drawbacks.

According to the present invention, there is provided an optical barrier for detecting moving objects, particularly vehicles traveling along a given path, and comprising:

a transmitting unit set up on one side of said path and presenting a number of infrared-emitting diodes multiplexed and modulated at a predetermined frequency;

a receiving unit set up on the opposite side of said path and presenting a number of infrared photoreceivers; and

electronic equipment for controlling the electric signals generated by said photoreceivers;

characterized by the fact that said equipment comprises an electronic processing unit for automatically determining, for each said photoreceiver, a respective first reference value; for comparing the signals generated by said photoreceivers with said first reference value; and for checking said comparison and indicating the status, clear or engaged, of said barrier.

A preferred non-limiting embodiment of the present invention will be described by way of example with reference to the accompanying drawings, in which:

Fig.1 shows a view in perspective of an optical barrier in accordance with the teachings of the present invention;

Fig.2 shows a block diagram of the electronic section of the Fig.1 barrier;

Fig.s 3, 4 and 5 show operational flow charts of the Fig.1 barrier;

Fig.6 shows the electric circuit of a device in Fig.2.

Number 1 in Fig.1 indicates an optical barrier for detecting moving objects, in particular vehicles in transit, and which also detects the continuity of tractor and trailer vehicles. Barrier 1 comprises two posts 2 and 3 set up facing each other on either side of a given vehicle path, perpendicular to the traveling direction of the vehicle, and each presenting a vertical slot 9 on the surface facing the other post.

As shown in Fig.2, post 2 houses a transmitting unit 4 presenting, at slot 9, a number of pairs of infrared-emitting diodes 5 multiplexed and modulated at a predetermined frequency and equally spaced along the axis of slot 9; barrier 1 comprises a block 11 for electrically supplying unit 4 and housed in a box 12; and post 3 houses a receiving unit 6 presenting a number of infrared photoreceivers 7 arranged along the axis of slot 9 and smaller in number than diodes 5. Barrier 1 preferably presents five photoreceivers 7 and fifty pairs of transmitting diodes 5. Barrier 1 also presents electronic equipment 8 housed in a box 13 and which provides for controlling the signals generated by photoreceivers 7; and an electronic block 22 connected to equipment 8 and which, normally installed in the operating booth, provides for indicating engagement of the vehicle path and any malfunctioning of units 4 and 6.

With reference to Fig.2, equipment 8 comprises:

a control and data processing unit 14;

a number of signal rectifying blocks 15 between respective photoreceivers 7 and unit 14;

a block 16 consisting of a number of known indicator lights (LED's) not shown;

an interface block 17 connecting unit 14 and block 16;

a digital-analog converter 18 for generating a first electric reference signal adjustable via a program in unit 14;

an alarm block 21;

a pushbutton 25 connected to unit 14;

an adding block 26 connected to and for adding the output signals of all the rectifying blocks 15; and

a comparing block 27 for comparing the value of the output signal from adding block 26 with a second electric reference signal set by the operator.

As shown in Fig.6, each photoreceiver 7 may consist of a photodiode 23, and an amplifier 24 for selecting only signals of a predetermined frequency.

Diodes 5 are multiplexed and modulated at a predetermined frequency, i.e. one pair of diodes 5 at a time emits an infrared light beam of a given frequency and for duration T; and one photoreceiver 7 at a time is enabled to receive the beam for as long as it takes to effect a complete scan of unit 4. The scatter angle of the beam generated by each pair of diodes 5 is such as to impinge simultaneously on all the photoreceivers 7, each of which is subjected to a different light intensity, even in the absence of any kind of object between posts 2 and 3. More specifically, the photoreceiver 7 closest to the pair of diodes 5 by which the beam is emitted receives the maximum light intensity. In the presence of an object between posts 2 and 3, one or more of photoreceivers 7 are dimmed, that is, receive a lower light intensity due to reflection by both the object and the road surface. In the event of fouling, e.g. by mud, or malfunctioning of one or more of diodes 5 by which a beam should have been emitted, photoreceivers 7 are all dimmed.

The photoreceiver 7 enabled by unit 14 to receive the beam converts this into an electric signal proportional to the light intensity; block 15 connected to photoreceiver 7 detects the peak of the electric signal and supplies it to unit 14; and unit 14 compares the peak value, converted into a digital signal, with a reference value Vf typical of each photoreceiver 7. If the peak value is greater than Vf, this means the photoreceiver 7 in question is not dimmed and that, for that particular photoreceiver 7, barrier 1 is clear. Conversely, photoreceiver 7 is considered dimmed and barrier 1 engaged by an object. When the peak value of all the photoreceivers 7 is greater than Vf, barrier 1 is considered clear, i.e. no object between posts 2 and 3. Conversely, in the event of an object coming between posts 2 and 3 at any time during scanning of photoreceivers 7, at least one of these will be dimmed, thus indicating engagement of barrier 1.

Block 16 comprises a number of indicator lights (LED's), one for each photoreceiver 7 plus another two: one for indicating barrier 1 engaged, and the other for indicating malfunctioning of unit 6. In actual use, unit 14 provides for de-activating and activating electrical supply to the non-dimmed and dimmed photoreceiver indicators respectively. In the event of even one of photoreceivers 7 being dimmed, i.e. indicating barrier 1 is engaged, unit 14 activates the engaged barrier indicator in block 16. In the event of a fault on any one of photoreceivers 7, unit 14 provides for flashing the respective photoreceiver indicator, and for flashing the unit 6 malfunction indicator in block 16. Block 22 consists of three elements 28, 29 and 30, for respectively indicating engagement of the vehicle path, and malfunctioning of units 6 and 4. Elements 28, 29 and 30 are activated by unit 14, and may each consist of an indicator light (LED). In the event of only one photoreceiver 7 being considered operative, unit 14 activates sound alarm block 21 for indicating total malfunctioning of unit 6.

With reference to Fig.s 3 and 4, the following is a description of the operating phase of barrier 1 wherein value Vf for each photoreceiver 7 is determined in the first operating cycle and each time pushbutton 25 is pressed. As shown in Fig.3, start block 51 goes on to block 52 wherein unit 14 counts the number of photoreceivers 7 connected to it and considered usable, as described in more detail later on. If only one photoreceiver 7 is connected, block 52 goes on to block 53 wherein unit 14 activates sound alarm block 21 for indicating total malfunctioning of unit 6. Conversely, if a number of photoreceivers 7 are usable, block 52 goes on to block 54 wherein unit 14 determines whether the current cycle is the first. If it is, block 54 goes on to block 55 and from there to block 56; if it is not, block 54 goes directly to block 56. While ensuring barrier 1 is maintained clear, block 55 of unit 14 determines the Vf value of each photoreceiver 7, i.e. calibrates each photoreceiver automatically. In block 56, unit 14 determines whether pushbutton 25 is pressed. If it is, block 56 goes back to block 55; if it is not, block 56 goes on to block 57 wherein unit 14 determines whether all the photoreceivers counted are clear, i.e. not dimmed by an object between posts 2 and 3, by comparing the electric signals generated by photoreceivers 7, and converted into digital signals, with the respective Vf value. If photoreceivers 7 are all clear, block 57 goes on to block 58 and back to block 57; conversely, block 57 goes on to block 61.

In block 58, unit 14 controls the clear barrier indicators, i.e. disables the indicator lights (photoreceiver and engaged barrier LED's) in block 16 and the indicator light of element 28. In block 61, unit 14 determines whether any one of the photoreceivers 7 counted in block 52 is dimmed, i.e. whether the digital-converted peak value of the signal generated by any one of photoreceivers 7 is below the Vf value. In the event of a positive response, block 61 goes on to block 62 and then back to block 52; conversely, block 61 goes on to block 63. In block 62, unit 14 enables an internal timer to determine whether photoreceiver 7 is dimmed in excess of a predetermined time period over and above that required for a complete scan of diodes 5. In the event of a positive response, this obviously indicates a fault on the photoreceiver, which cannot possibly remain dimmed, without being cleared at least once, throughout a complete scan of diodes 5. Accordingly, block 62 of unit 14 performs a series of operations wherein the dimmed photoreceiver 7 is considered out of order, and the number of photoreceivers to be considered by block 52 is reduced by one unit, so that the blocks downstream from block 52 operate solely on the remaining photoreceivers. In block 62, unit 14 also provides for flashing the respective faulty photoreceiver LED in block 16; for flashing the LED indicating impaired operation of barrier 1; and, finally, for enabling element 29 (consisting, for example, of a flashing LED) for indicating impaired operation of unit 6. In the event the faulty photoreceiver is replaced, this is taken into account by a procedure in block 52, which provides for updating the number of operative photoreceivers.

In block 63, unit 14 determines whether more than one of the photoreceivers still in use is dimmed, i.e. whether an object is interposed between posts 2 and 3. In the event of a positive response, block 63 goes on to block 64 and then back to block 52; conversely, block 63 goes directly to block 52. In block 64, unit 14 provides for a series of indications, such as constant electric supply to the dimmed photoreceiver and engaged barrier LED's in block 16, and for enabling element 28, which, as stated, informs the operator that barrier 1 is engaged by an object.

For each complete scan of diodes 5, block 26 provides for adding the output signals from blocks 15 and for supplying the total to block 27, which in turn compares the signal total with said second reference signal. If the signal total is less than the second reference signal, block 27 supplies unit 14 with a request signal to interrupt the operating phase of barrier 1 described above with reference to Fig.3, and to commence the Fig.5 phase wherein the dimming time of all photoreceivers 7 is determined. As shown in Fig.5, start block 34 goes on to block 35, which provides for a predetermined wait time depending on the scanning speed of diodes 5, and on a predetermined maximum number of faulty or impaired diodes 5, e.g. fouled by mud and so prevented from transmitting light, which number is entered into unit 14 by the operator. Over and above said maximum number of diodes 5, barrier 1 is considered totally impaired.

Block 35 then goes on to block 36, which determines whether all the photoreceivers are still dimmed at the end of said wait time. In the event of a positive response, block 36 returns to the Fig.3 phase, in that dimming of all the photoreceivers for a period exceeding at least twice the time required for a complete scan of diodes 5 indicates an object, e.g. a vehicle, interposed between posts 2 and 3. In the event the infrared beam from one or more pairs of diodes 5 fails to be transmitted correctly, photoreceivers 7 are only dimmed for the operating time of said pairs of diodes 5, so that, in the event of a negative response in block 36, this goes on to block 37 and then back to the Fig.3 operating phase. Block 37 provides for activating element 30 and block 16 for respectively indicating impaired operation of unit 4 and barrier 1. Unit 14 also features a procedure for resetting block 37 after a predetermined number of complete scans of diodes 5, and so disabling the signals indicating impaired operation of unit 4 and barrier 1 in the event operation of diodes 5 is restored (e.g. by cleaning the diodes).

With reference to Fig. 4, block 55 comprises a block 71 wherein unit 14 is enabled to receive, for each photoreceiver 7, a number of analog signals at least equal to the number of pairs of diodes 5, and which, via block 18, are all converted by unit 14 into digital signals. In the first cycle, this conversion is effected by selecting one of a number of Vref values predetermined on the basis of experience and stored in a memory block of unit 14, which then computes, for each photoreceiver 7, the mean value Sm of all the signals supplied by the photoreceiver and converted into digital signals. Finally, unit 14 then computes the mean value Stm of all the Sm values of photoreceivers 7, so as to define a range of values extending, for example, between a maximum ratio Stm/100 and a minimum ratio Stm/200. The Vref value is so selected that the Stm value ranges between 1/2 and 2/3 of the full scale value of block 18. Block 71 goes on to block 72, which determines whether the Sm values of photoreceivers 7 are within the range processed in block 71. If all the Sm values are within said range, block 72 goes on to block 73 and from there to block 56; conversely, block 72 goes on to block 74.

In block 73, unit 14 determines value Vf for each photoreceiver 7, which value Vf is a percentage value normally set, on the basis of experience, to between ten and twenty percent of the Sm value. In block 74, unit 14 determines whether the Sm values outside said range are above the maximum or below the minimum range value, in which case, block 74 goes on to block 75 or block 76 respectively. Both blocks 75 and 76 go back to block 72, and provide respectively for selecting, from said predetermined number of stored Vref values, a new Vref value respectively greater and lower than that selected in block 71. On the basis of the new Vref value, blocks 75 and 76 provide for analog-digital conversion of the signals of each photoreceiver; for computing new Sm and Stm values; and for computing new maximum and minimum range values. The Vref value is varied until, in block 72, all the Sm values of photoreceivers 7 are within said range. In the event of a change in atmospheric conditions, or dust depositing on photodiodes 23, operation of pushbutton 25 on the part of the operator provides for re-calibrating all of photoreceivers 7, in which case, the Vref value selected in block 71 is that computed in the foregoing operating phase.

The advantages of the present invention will be clear from the foregoing description.

In particular, barrier 1 features a system for automatically calibrating photoreceivers 7, with no need for assistance on the part of the operator, and which undoubtedly provides for more accurate calibration than that performed manually. What is more, calibration of photoreceivers 7 may be requested at any time by simply pressing pushbutton 25, thus ensuring correct operation of barrier 1 under any atmospheric conditions (rain, fog, mist, etc.) and regardless of atmospheric agents, dust or vehicle exhaust gas depositing on photodiodes 23.

Moreover, barrier 1 remains operative even in the event of impaired operation of transmitting and receiving units 4 and 6, providing, of course, that at least one photoreceiver 7 and a certain number of diodes 5 remain operative. As such, the engaged barrier indication holds true even in the event of impaired operation, thus enabling continued operation of barrier 1. Equipment 8 provides for indicating various conditions of assistance to both the operator and maintenance personnel. The operator in fact is informed directly in the booth of engagement of barrier 1 or impaired operation of barrier 1 or unit 4; and by an alarm when unit 6 presents only one fully operative photoreceiver 7. Blocks 16 and 22, on the other hand, may be said to provide for self-diagnosis functions for assisting maintenance personnel in checking engagement and/or impaired operation of barrier 1, locating faulty photoreceivers 7, checking impaired operation of unit 4, and so keeping a visual check of the operation of barrier 1 for speeding up repairs and reducing downtime.

To those skilled in the art it will be clear that changes may be made to the optical barrier described and illustrated herein without, however, departing from the scope of the present invention.

Claims

1. An optical barrier for detecting moving objects, particularly vehicles traveling along a given path, and comprising:

a transmitting unit (4) set up on one side of said path and presenting a number of infrared-emitting diodes (5) multiplexed and modulated at a predetermined frequency;

a receiving unit (6) set up on the opposite side of said path and presenting a number of infrared photoreceivers (7); and

electronic equipment (8) for controlling the electric signals generated by said photoreceivers (7);

characterized by the fact that said equipment (8) comprises an electronic processing unit (14) for automatically determining, for each said photoreceiver (7), a respective first reference value (Vf); for comparing the signals generated by said photoreceivers (7) with said first reference value (Vf); and for checking said comparison and indicating the status, clear or engaged, of said barrier.

2. A barrier as claimed in Claim 1, characterized by the fact that said processing unit (14) comprises:

first means for each said photoreceiver (7) for enabling reception of a number of analog signals at least equal in number to said diodes (5);

second means (18) for converting said analog signals into digital signals on the basis of a second reference value (Vref) selected from a number of predetermined second values (Vref) stored in a memory block of said processing unit (14);

third means (71) for computing, for each said photoreceiver (7), a third value (Sm) defined by the mean of all said signals supplied and converted into digital signals; for computing a fourth value (Stm) defined by the mean of all said third values (Sm); and for computing, by means of said fourth value (Stm), the maximum and minimum values of a range of fifth values;

fourth means (72) for determining whether said third values (Sm) are within said range processed by said third means (72);

fifth means (73) for computing said first value (Vf) for each said photoreceiver (7), said first value (Vf) being defined by a percentage value of the corresponding third value (Sm); and

sixth means (74, 75, 76) for selecting a new second value (Vref) in the event at least one of said third values (Sm) is outside said range of fifth values; for converting said analog signals into digital signals, on the basis of said new second value (Vref); for computing, for each said photoreceiver (7), a new third value (Sm) defined by the mean of all said signals supplied and converted into digital signals; for computing a new fourth value (Stm) defined by the mean of all said new third values (Sm); and for computing, by means of said new fourth value (Stm), a new maximum and minimum value of said range of fifth values.

3. A barrier as claimed in Claim 2, characterized by the fact that said processing unit (14) comprises seventh means (54) which, in the case of a first operating cycle, provides for automatically determining said first reference value (Vf) of each said photoreceiver (7).

4. A barrier as claimed in Claim 2 and/or 3, characterized by the fact that said equipment (8) comprises manually operated eighth means (25) for controlling said processing unit (14) and automatically determining said first reference value (Vf) of each said photoreceiver (7).

5. A barrier as claimed in at least one of the foregoing Claims, characterized by the fact that said processing unit (14) comprises ninth means (52) for computing how many of said photoreceivers (7) are operative; tenth means (61) for determining whether any one of said photoreceivers (7) is faulty, by virtue of generating, in excess of a predetermined time period, a signal whose value is constantly below a predetermined value; and eleventh means (62) for excluding said faulty photoreceiver (7) from the computation performed by said ninth means (52), so that said equipment (8) may function even in the event of impaired operation of said receiving unit (6), in the sense that the number of operative photoreceivers (7) is less than the number of photoreceivers (7) actually installed in said receiving unit (6).

6. A barrier as claimed in Claim 5, characterized by the fact that said equipment (8) comprises:

a first electric block (16) having a number of first indicator lights, one for each said photoreceiver (7); a second indicator light for indicating the barrier is engaged, i.e. for indicating the presence of an object along said path; and a third indicator light for indicating impaired operation of said receiving unit (6); and

twelfth means (64) for providing a number of indications, such as constant electrical supply of said first indicator lights corresponding to said photoreceivers (7) dimmed for less than said predetermined time and so indicating the presence of an object along said path; and electrical supply of said second indicator light; said third indicator light being activated by said eleventh means (62).

7. A barrier as claimed in Claim 6, characterized by the fact that said twelfth means provide for flashing said first indicator lights relative to said faulty photoreceivers (7) excluded from the count performed by said ninth means (52).

8. A barrier as claimed in Claim 7, characterized by the fact that it comprises a second electric block (22) connected to said equipment (8) and preferably remote from the same for enabling viewing by an operator; said second block (22) presenting a first element (28), activated by said twelfth means (64), for indicating the barrier is engaged, and a second element (29), activated by said eleventh means (62), for indicating impaired operation of said receiving unit (6).

9. A barrier as claimed in Claim 8, characterized by the fact that said equipment (8) comprises a sound alarm (21) activated by said ninth means (52) upon said ninth means (52) determining that only one of said photoreceivers (7) is operative.

10. A barrier as claimed in at least one of the foregoing Claims, characterized by the fact that said equipment (8) comprises thirteenth means (26, 27) for evaluating impaired operation of said transmitting unit (4) as a function of the signals generated by said receiving unit (6); a third element (30), activated by said evaluating means (26, 27), for indicating impaired operation of said transmitting unit (4); and a block, activated by said evaluating means (26, 27), for indicating impaired operation of said barrier.

11. A barrier as claimed in Claim 10, characterized by the fact that said evaluating means comprise:

an adding block (26) for adding the signals generated by said photoreceivers (7) in the course of a complete scan of said diodes (5);

a comparing block (27), which, depending on the total of the signals generated by said photoreceivers (7), provides for comparing the value of the output signal from said adding block (26) with a predetermined electric reference signal;

a block (36) for checking whether all of said photoreceivers (7) are dimmed;

a wait block (35) for activating said check block (36) after a predetermined wait time; and

a block (37) for indicating impaired operation of said transmitting unit (4) and said barrier, in the event said check block (36) determines said photoreceivers (7) are all dimmed for less than said predetermined wait time.

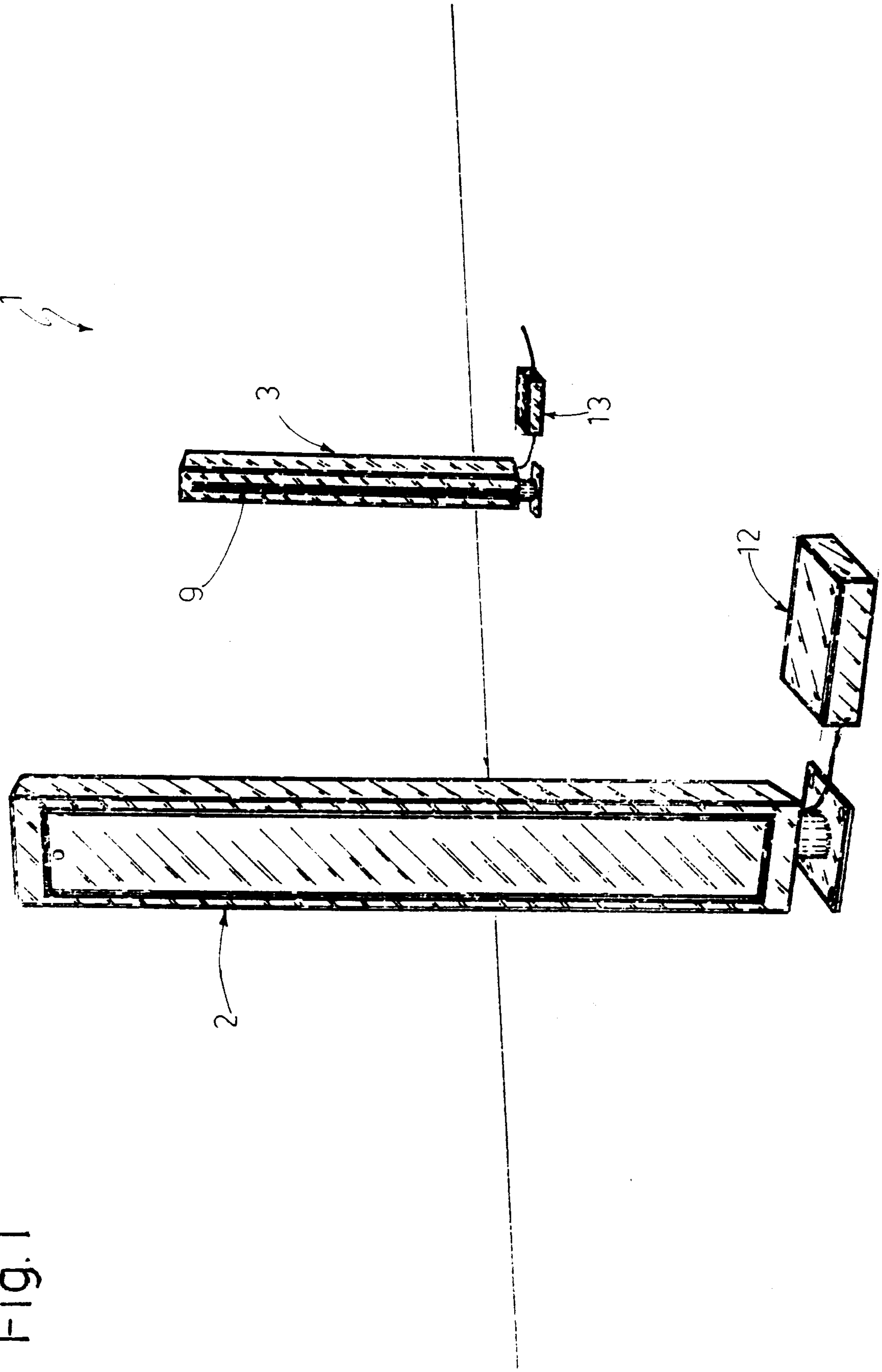

Fig.1

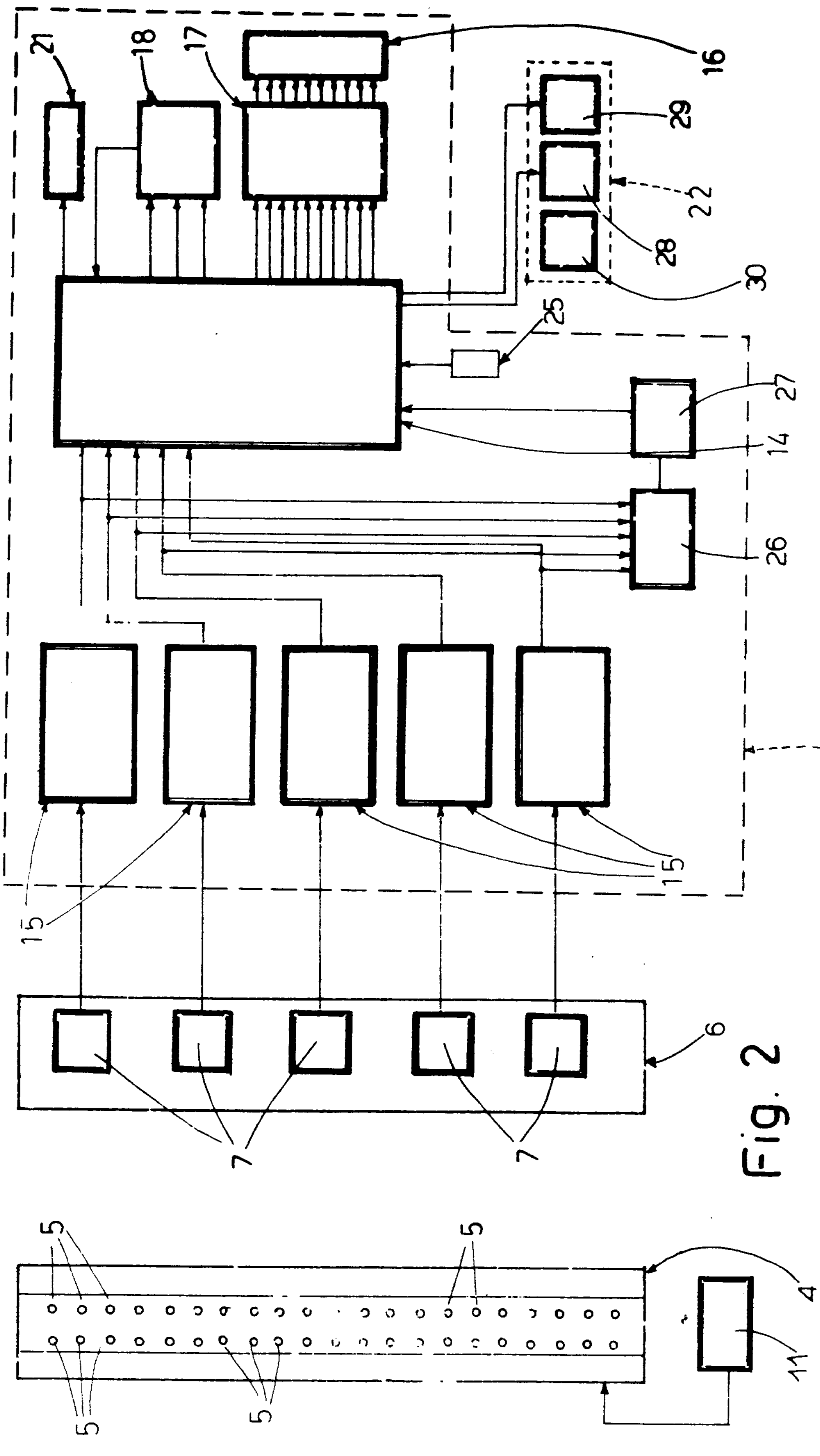

Fig. 2

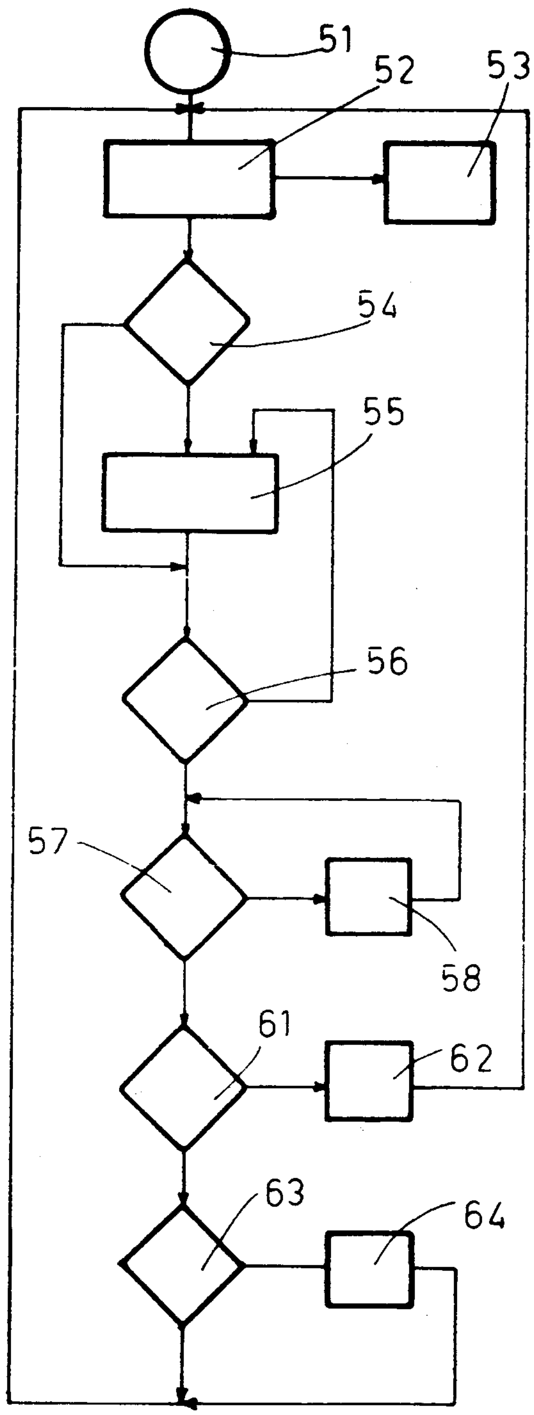

Fig.3

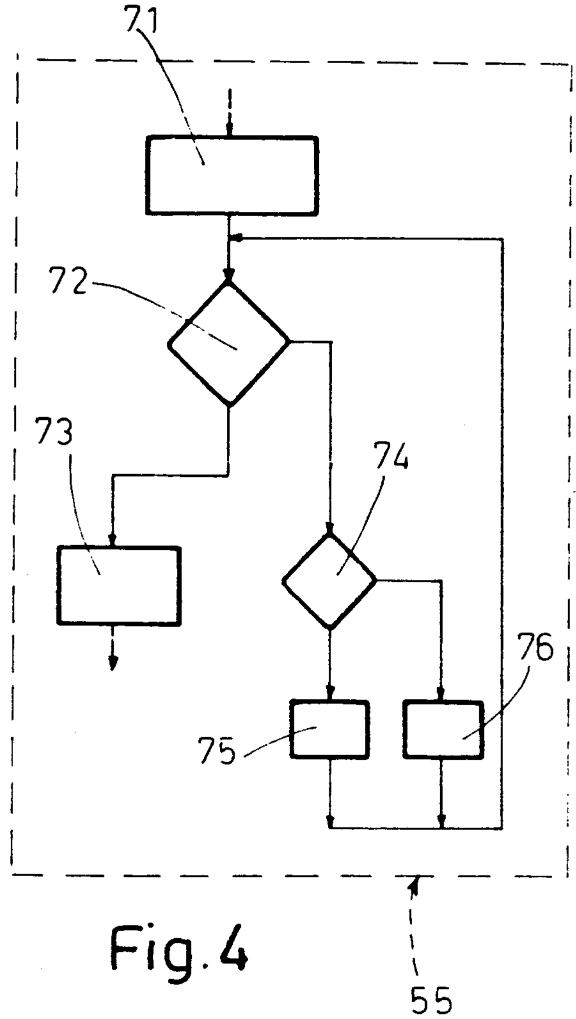

Fig.4

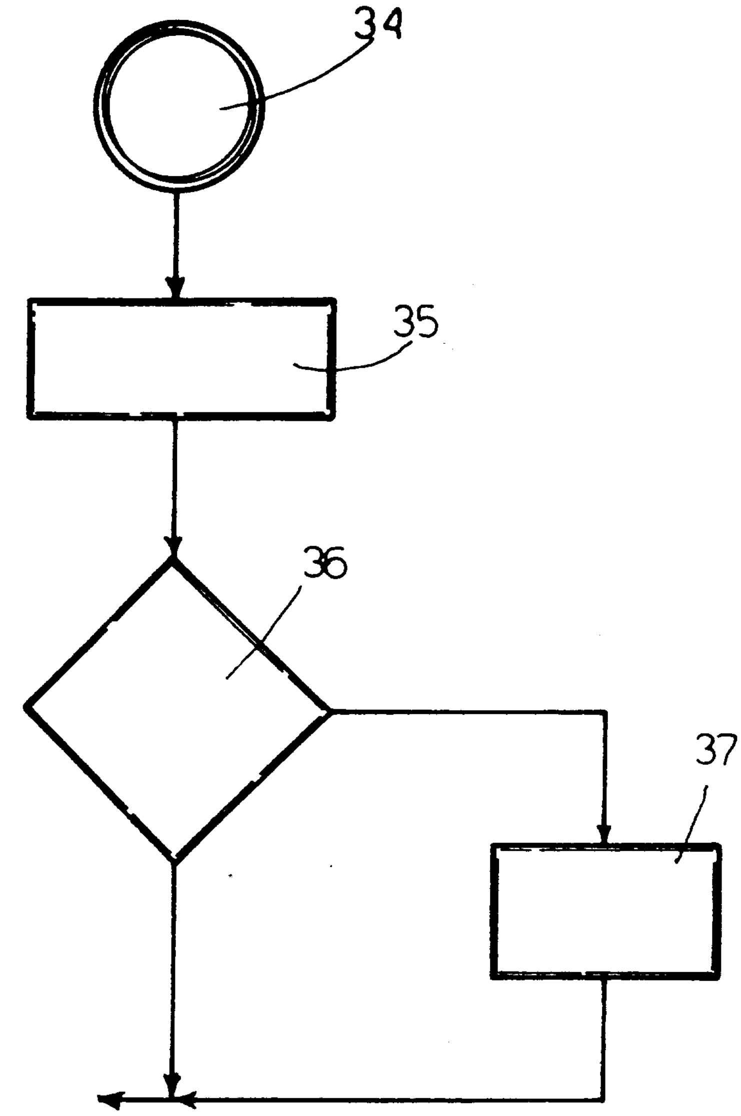

Fig.5

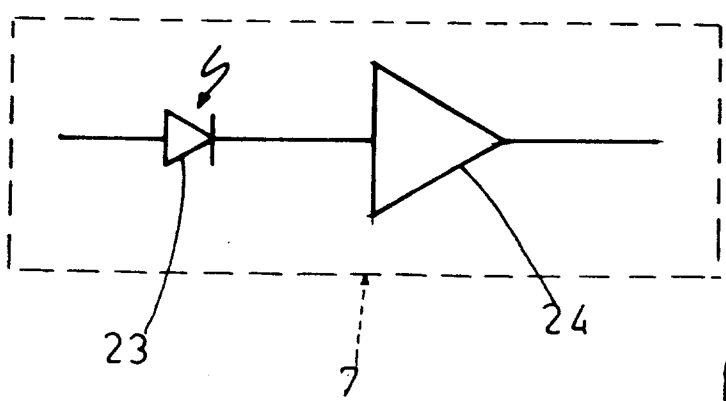

Fig.6