(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 726 553 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
14.08.1996 Bulletin 1996/33

(51) Int Cl.6: **G08B 29/10**, H01L 33/00

(21) Application number: **96300682.0**

(22) Date of filing: **31.01.1996**

(84) Designated Contracting States:
DE ES FR GB IT

(30) Priority: **10.02.1995 GB 9502602**

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(54) Indicator having fault detection

(57) An indicator having fault detection may be used as a display for a vehicle system. The indicator comprises first and second lanes, each of which comprises a lane controller (12, 20, 22), a light source (4, 6) and a photodetector (8, 10). The photodetector (8, 10) of each lane is responsive to light produced by the light source (4, 6) of the other lane. The lane controllers (12, 20, 22) actuate each light source (4, 6) in turn and produce a fault indication if the photodetectors (8, 10) produce outputs indicating that the actuated light source (4, 6) is not producing sufficient light.

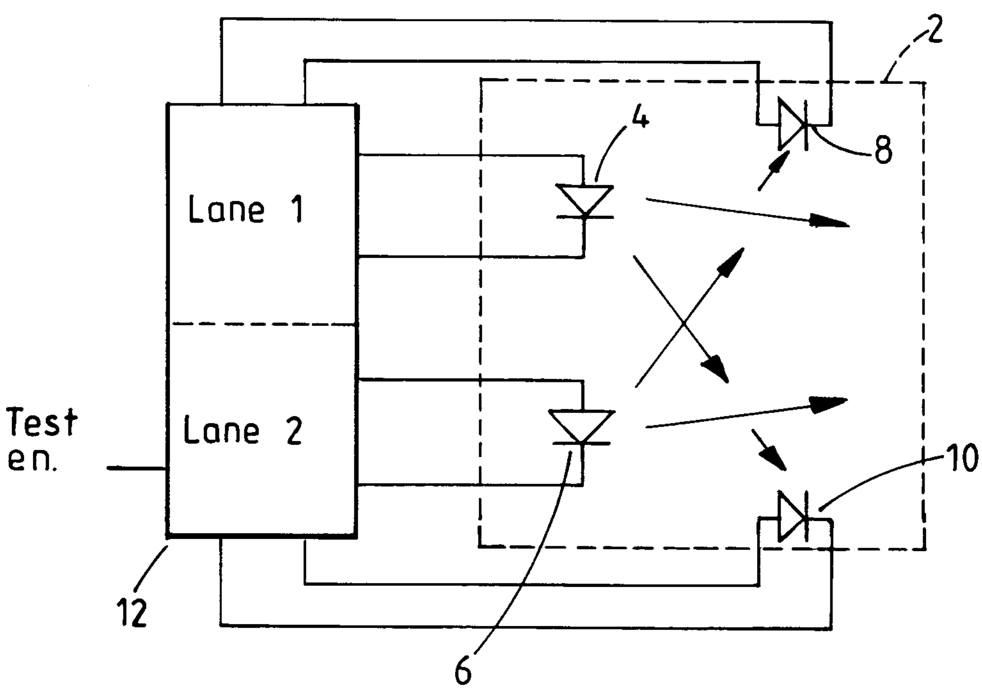


FIG.1.

EP 0 726 553 A1

Description

The present invention relates to an indicator having fault detection. Such an indicator is suitable for use as a display in safety critical systems and/or for warning of the presence of a fault.

Electronic control systems for vehicles, such as aircraft and road vehicles, are frequently equipped with one or more malfunction indicator lights or "MILs". A malfunction indicator light is used to indicate to an operator that a fault has been detected in an electronic controller, a sensor, an actuator, or a part or parts of the vehicle monitored or influenced by the control system. In some circumstances it may be necessary to change the operation of the vehicle in order to reduce a risk to the vehicle, to the environment or to the occupants of the vehicle. This change in operation of the vehicle may require intervention by a human operator. As an example, a malfunction indicator light in an automotive safety system may indicate that only one sub-system of a redundant pair remains available. Upon illumination of the malfunction indicator light, the driver ought to investigate the problem and, if appropriate, continue driving but at a reduced speed. Although it would be possible in some cases for the system designers to prevent or restrict further use of the vehicle, this may not be appropriate since only the driver can be fully aware of the vehicle environment at the instant of failure and of the risks posed by not using the vehicle, such as exposure to extreme climatic conditions.

It is essential that the malfunction indicator lights are functioning properly. It is customary to have a malfunction indicator light lamp-test facility in order to check the operation of the malfunction indicator lamps. This is usually initiated during the starting sequence of the vehicle and causes all of the malfunction indicator lights to be switched on so that the operator has an opportunity to note whether they are lit or not. However, it is believed that in many cases users do not notice when a malfunction indicator light has failed to illuminate. This may occur because the users do not recollect exactly which malfunction indicator lights should be lit, or because they do not pay attention to the control panel during the test sequence.

Manufacturers have attempted to mitigate the risks of malfunction indicator light failure by providing lights having two or more sources within a single indicator. Failure of one source may not be noticed by the user and consequently such an indicator may have a dormant fault therein while outwardly appearing to operate correctly.

DE-A-3 630 372 discloses a light emitting diode having a built in photodetector for monitoring the operation of the light emitting diode. The photodetector is located behind a filter selected such that the photodetector is only sensitive to light having a wavelength similar to the wavelength emitted by the light emitting diode. A further filter is provided around the periphery of the light emitting diode so as to screen ambient light from the photodetector.

According to a first aspect of the invention, there is provided an indicator as defined in the appended Claim 1.

Preferred embodiments of the invention are defined in the other appended claims.

According to a second aspect of the present invention, there is provided an indicator having fault detection, the indicator comprising at least first and second lanes, each lane comprising a lane controller, at least one light source and at least one photodetector responsive to light produced by a light source of the or at least one other lane, each of the controllers being arranged to co-operate in an indicator test sequence in which each controller operates its respective at least one light source in a predetermined pattern, monitors the output of its respective photodetector to determine the output of the or at least one other lane, compares the output of the or at least one other lane with the predetermined pattern and indicates a result of the comparison.

It is thus possible to check the operation of each light source within the indicator so that a failure of one or more light sources does not go undetected.

Each light source may be an incandescent filament lamp, but preferably each light source is a light emitting diode (LED). LEDs generally have longer lives than filament lamps and also tend to suffer a gradual degradation in performance rather than a catastrophic failure. Furthermore, LEDs are light sensitive and a non-illuminated LED can be used as a photodetector. Thus each LED can act both as a light source and as a photodetector. For example, the photo-current induced within a single LED within a Hewlett-Packard HLMP 2685 GaAsP LED light bar due to light emanating from a neighbouring LED operating at full power is easily measured. The photo-current is, however, about one hundred times less than the photocurrent induced by exposure of the device to sun light. However, the current due to a neighbouring LED can be distinguished from the current induced by ambient illumination so as to confirm the correct operation of the LEDs. Furthermore, this device is not optimised for optical cross-coupling between neighbouring LEDs so further signal strength improvements are attainable due to improvements in optical coupling.

The controllers of the at least first and second lanes may be implemented independently of one another. Alternatively, the controllers of one or more lanes may be implemented within a single controller unit.

The light sources are arranged such that most of the light emitted by each source is directed towards a viewing region, i.e. where an operator is expected to be positioned. However, a portion of the light emitted from each light source is arranged to be incident on at least a photodetector of the or at least one other lane.

Preferably the controllers are arranged such that the or each light source in each lane is actuated in turn. Preferably when the or each light source of one lane is actuated, the or each light source of the or each other lane is not actuated. If the controller of one lane suspects that the or any of the lanes that it is monitoring are faulty, the controller may send a "fail" signal and/or may enter a warning mode so as to indicate to the user that a fault has been detected within the indicator. The warning mode may be indicated by a low frequency flashing of the light source of the lane signalling a fault.

Advantageously the test sequence is initiated at vehicle start up. Thus a fault can be detected before the vehicle has moved. In one embodiment of the present invention, the indicator comprises two lanes, each of which has a controller arranged to control a respective LED and uses its LED to monitor the operation of the other lane. The first lane compares a measurement of the illumination arriving at its LED in a first period when the LED of the second lane is unilluminated with the illumination arriving at its LED in a second period when the LED of the second lane is illuminated. Advantageously the first and second periods are of equal duration. The comparison reveals whether or not the second LED was illuminated and sufficiently bright in the second period. The first period represents a measurement of the ambient light, whereas the second period represents a measurement of the sum of the ambient light and the light produced by the second LED. Advantageously a measurement of ambient light in a third period following the expiry of the second period may also be made to improve the measurement of the ambient light level.

It should be noted that the LEDs acting as photodetectors respond more quickly to changes in illumination than does the human eye. Consequently, when the ambient light is provided by an artificial light source such as a street light or a cabin light, the measurement of ambient light made by the LED may vary, for example, due to the source of ambient light being driven from an alternating power supply, while the human eye may observe a constant ambient light level. The indicator test function can be made substantially immune to repetitive variations in the ambient light by making repeated measurements and actuating the LED under test with a repetition frequency which is not a multiple of the power supply frequency used to drive the ambient light source.

Typically the mains frequencies in the USA and the European countries are either 50 Hz or 60 Hz. A convenient repetition frequency for driving the LED in each lane is 270 Hz as this is not a multiple of 50 or 60Hz.

The controllers of each lane may communicate with each other via a dedicated communications link so as to maintain synchronism. Alternatively, each controller may be electrically isolated from each other controller and one controller may be arranged to act as a master and the or each other controller may be arranged to optically monitor the operation of the master controller and to maintain synchronism with it.

The controllers may also be arranged to perform intermittent tests at times other than during a vehicle start-up sequence. The controllers may be arranged to operate their respective light sources with only a small duty cycle such that the illumination generated by each light source is substantially imperceptible to the human eye during the test sequence.

It is thus possible to provide an indicator with a built in test facility such that redundant failures in duplicated channels are identified and a warning is issued.

The present invention will further be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram of a two lane indicator lamp having separate light sources and photodetectors, and constituting a first embodiment of the present invention;

Figure 2 is a schematic diagram of a two lane indicator constituting a second embodiment of the present invention;

Figure 3 is a timing diagram illustrating the operation of the indicator shown in Figure 2;

Figure 4 is a schematic diagram illustrating part of a controller for determining the intensity of the light emitted by a light source of another lane;

Figure 5 is a schematic diagram illustrating an arrangement for switching a LED between use as a light source and use as a photodetector;

Figure 6 is a timing diagram illustrating operation of a three lane indicator constituting an embodiment of the present invention;

Figures 7 to 9 schematically illustrate parts of first, second and third controllers, respectively, within a three lane system;

Figure 10 is a schematic diagram schematically illustrating components for optically coupling first and second controllers in order to keep the controllers synchronized with one another; and

Figure 11 is a comparison of the drive waveforms supplied to a LED during a start-up test and during an intermittent test.

Like parts will be referred to using like reference numbers.

The indicator illustrated in Figure 1 has an indicator element 2 containing first and second LEDs 4 and 6, respectively, and first and second photodetectors 8 and 10, respectively. The indicator 2 is controlled by a controller 12 which is divided into first and second lanes. The first LED 4 and the first photodetector 8 are connected to the first lane whereas the second LED 6 and the second photodetector 10 are connected to the second lane. The first photodetector 8 is arranged to receive light emitted by the second LED 6 and the second photodetector 10 is arranged to receive light emitted by the first LED 4. The LEDs may be arranged to become illuminated to signal the same fault condition or they may signal different fault conditions and appear to the user to be separate indicators.

The controller 12 is responsive to a test enable signal, TESTEN, to perform a test sequence. The test enable signal is asserted during a vehicle start up sequence of the vehicle having the indicator, or when manually invoked by the operator.

Figure 2 shows an indicator 2 in which a first light emitting diode 4 is controlled by a first controller 20, and a second light emitting diode 6 is controlled by a second controller 22. The first and second controllers 20 and 22 are responsive to a test enable signal TESTEN in order to commence a test sequence. The first LED 4 is also arranged to act as a photodetector during those periods when it is not acting as a light source. Similarly, the second LED 6 is also arranged to act as a photodetector when not being used as a light source. The first and second controllers 20 and 22 may be synchronized via an electrical connection (not shown) or optically via the LEDs 4 and 6 as will be described hereinafter.

Figure 3 schematically illustrates a sequence of operation of the embodiments as shown in Figure 1 or Figure 2. During the test sequence, each controller cyclically repeats a test pattern comprising four equal periods P1 to P4. The test pattern repetition frequency is 270 Hz, and each period lasts 1/1080 seconds. The light source 4 of the first lane is illuminated during each first period P1. The light source 6 of the second lane is illuminated during each third period P3. The photodetector 8 of the first lane, which can be the LED 4 in the embodiment shown in Figure 2, measures the light incident on it during the second to fourth periods P2-P4. Similarly, the second photodetector 10, which can be the LED 6 in the embodiment as shown in Figure 2, measures the light incident on it in the periods P4, P1 and P2.

The measurements of light made by the first photodetector 8, 4 during the second to fourth periods are indicated by α_{12}, α_{13} and α_{14}, respectively. The measurements of the light incident on the second photodetector 10, 6 during the periods P4, P1 and P2 are denoted by α_{24}, α_{21} and α_{22}, respectively. For the first photodetector, the measurements α_{12} and α_{14} are measurements of the ambient lighting levels, while α_{13} is the measurement of the sum of the ambient lighting level and the light arriving at the first photodetector from the second light source 6. The light emitted from the second light source 6 can be deduced by subtracting α_{12} from α_{13}. More advantageously, the light emitted from the second source can be calculated by finding the difference between α_{13} and the average of α_{12} and α_{14}. Each measurement α_{12} to α_{14} may comprise an average of a plurality of measurements in a sampled data processing system, or may be an average or an integral formed in an analogue processing element having a low pass or integrating transfer function.

Figure 4 schematically illustrates a processing circuit within each controller 12, 20, 22 for estimating the amount of light produced by the light source of the other lane. The circuit will be described as implemented in the first controller 20, but the corresponding circuit in the other controller is identical except that it receives different input data.

The circuit comprises a first summer 30 which sums the values α_{12} and α_{14} to form a sum of the ambient light during the second and fourth periods P2 and P4. An output of the first summer 30 is provided to an input of a divide by two stage 32. An output of the divide by two stage 32 is provided to a subtracting input of a second summer 34. An adding input of the second summer 34 receives the value α_{13}. An output of the second summer 34, which represents the light produced by the LED 6, is provided to an input of an averaging element 36. The averaging element 36 forms an average of the measurements conducted over a plurality of cycles so as to improve the reliability of the test. An output of the averaging element 36 is provided to an inverting input of a comparator 38. A reference value 40 is provided to the non-inverting input of the comparator 38. If the average value of the measured light output of the second light source 6 is greater than the reference value, the output of the comparator 38 remains "low" (Logic 0) signalling that the second light source 6 is functioning correctly. Otherwise, the comparator 38 signals that a fault has occurred in lane 2.

Figure 5 schematically illustrates the first lane controller 20 of Figure 2 in greater detail. The LED 4 is connected to a power supply 50 via a current limiting resistor 52 and an electronically controllable two-pole two-way ganged switch 54. The switch 54 is switchable between a first position, as illustrated in Figure 5, in which the anode of the LED 4 is connected to the supply 50 via the resistor 52 and the cathode of the LED 4 is connected to ground, and a second mode in which the anode of the LED 4 is connected to ground and the cathode of the LED 4 is connected to an input of a charge amplifier 56. A monitoring and control circuit 58 controls the operation of the switch 54 and the charge amplifier 56. The circuit 58 also monitors the voltage of the supply to the LED 4. The circuit 58 switches the switch 54 to the position shown in Figure 5 to illuminate the LED 4 during the first periods P1. The switch 54 is switched to its other position during the periods P2 to P4 so that the LED 4 is not illuminated and can be used as a photodetector. Light falling on the LED 4 causes a photo-current to be induced therein. The photo current is amplified and integrated by the charge amplifier 56. At the end of each of the second, third and fourth periods P2 to P4, the output of the charge amplifier 56 is read by the circuit 58 and then the charge amplifier 56 is reset in response to a reset signal issued by the circuit 58. A similar arrangement is provided within the lane controller 22 of the second lane. The lane controllers may be kept in synchronism by an electronic communications link (not shown). The stored outputs of the charge amplifier 56 corresponds to the signals α_{12} to α_{14} shown in Figures 3 and 4.

The operation of the two lane system has been described with reference to a four phase measurement scheme. In general, for a multi-lane system having N lanes where N is an integer, the minimum number of discrete time periods within each measurement cycle is equal to (N + 1) but greater accuracy can be achieved with more measurement periods.

If either controller cannot verify the correct functioning of the other lane, the controller repeatedly operates the switch 54 to cause the LED 4 to flash on and off at a relatively low frequency so as to attract the user's attention.

Figure 6 schematically illustrates a timing diagram for an indicator having three lanes. The timing diagram is an extension to that shown in Figure 3. Each measurement cycle is divided into six periods P1 to P6. The light source of the first lane LED 1 is actuated during each first period, the light source of the second lane LED 2 is actuated during each third period and the light source of the third lane LED 3 is actuated during each fifth period.

Figure 6 illustrates the wave forms for a complete first cycle and a partially complete second cycle. Measurements made by the first lane sensor (sensor 1) during the periods P2 to P6 of the first cycle are designated α_{12} to α_{16}, respectively, whereas the corresponding measurements in the second cycle are designated α'_{12} to α'_{16}. A similar nomenclature is used with respect to measurements made by the sensors of the second and third lanes within each period.

Figures 7 to 9 illustrate the signal processing arrangements within the first, second and third lanes, respectively. The processing arrangements are very similar so only the processing arrangement of the first lane, as illustrated in Figure 7, will be described in detail. The signal processing arrangement comprises a first summer 30, a divide by two 32, a second summer 34 and an averaging element 36 as described with reference to Figure 4. An output of the averaging element 36 is applied to a comparator 70 whose output is a logic 1 when the output of the averager 36 is below a predetermined threshold, and a logic 0 when the output of the averager 36 is above the predetermined threshold. The first summer 30 receives the signals α_{12} and α_{14} and forms a sum thereof. This sum is divided by two to form an average of α_{12} and α_{14}. The second summer 34 receives the signals α_{13} and an average of α_{12} and α_{14} and forms a difference between these signals. An output of the comparator 70 is supplied to a first input of an OR gate 72.

The components 30, 32, 34, 36 and 70 are duplicated by a third summer 74, a second divide by two 36, a fourth summer 78, a second averager 80, and a second comparator 82, arranged in a similar manner. An output of the second comparator 82 is supplied to a second input of the OR gate 72. The third summer 74 receives the signals α_{14} and α_{16} whereas the fourth summer 78 receives the signals α_{15} and an average of the signals α_{14} and α_{16}. The components 30, 32, 34, 36 and 70 monitor the performance of the second lane, whereas the components 74 to 82 monitor the performance of the third lane.

If either lane is suspected to have failed, an output of the relevant comparator 70 or 82 goes high and a "fail" signal is asserted at an output of the OR gate 72. The output of the OR gate 72 is connected to a lane 1 flash circuit 86 via an electronically controllable switch 84 which is closed during the test sequence. The lane 1 flash circuit 86 causes the LED of lane 1 to be flashed after the completion of the test sequence if a failure has been detected. A similar arrangement is provided in the second and third lanes as illustrated in Figures 8 and 9. Each lane may assert a "fail" signal to be communicate to other systems.

The test sequences rely on the controllers being kept in synchronism, but it may be desirable to keep the controllers of each lane electrically isolated from the or each other lane so as to lessen the risk that a fault in one controller causes a failure in another controller. This may be done using an optical path provided by the sources and photo detectors, as will be explained with reference to the two lane controller illustrated in Figure 2. When the indicator test is controlled through more than one controller, confusion may arise between the orderly end of the test and a genuine lane failure unless both lanes finish the test together.

In order to overcome this problem one controller is arranged as a master controller and the other controller is arranged to adjust its operation to become synchronised with the master controller. The second controller can detect its relative phase with respect to the first controller by comparing the ambient light measurements made during the fourth and subsequent second periods. If more light is consistently measured during the fourth period than the following second period, this indicates that the first lane light source is coming on somewhat early or much too late with respect to the second lane. In either case, the second lane advances the start of its cycle a small amount in proportion to the light level measured in the fourth period minus the light level measured in the second period. Thus the second lane controller can catch up with the first lane controller over a number of measurement cycles, say 16 to 64. In order to achieve this, the result of α_{24} minus α'_{22} as determined by a subtracter 90 is supplied to the input of a loop compensator 92, for example, a lead-lag network. An output of the compensator 92 is supplied to a circuit 94 for adjusting the start of the cycle of the second lane. An output of the compensator 92 is also provided to a synchronism detector 96 which enables the test sequence to be performed when the first and second lanes are synchronised.

The first lane is arranged to monitor the second lane to determine when the lanes are synchronised. A subtracter 100 forms the difference between the signals α_{12} and α_{14}. An output of the subtracter 100 is supplied via a low pass filter 102 to a synchronism detection circuit 104 similar to the detector 96. The circuit 104 only allows the measurement of the lane 2 output to be performed once the first and second lanes have become synchronised. If the lanes are unable to become synchronised within a predetermined period, each lane assumes that the other is at fault and enters a low flash rate mode. Since one lane will have failed and will be incapable of emitting light, the driver will only see the flashing provided by the working lane.

Confusion between the proper end of the test sequence and failure of one of the lanes can be avoided if the lanes are required to complete their test sequence within a period of say 1 to 3 seconds, but continue to produce the pattern of illumination for a further period of say 1 to 2 seconds. This obviates the risk of a mistaken "failed" diagnosis due to a variation between the controllers in the starting instant and duration of the test.

In the event that the indicator is required to display that a system has failed, it may be illuminated continuously.

It is possible that a light source may fail after the test sequence has been performed but while the vehicle is still in operation. To ensure that an indicator fault does not remain dormant until revealed by the next test during a start up sequence, the indicator may be arranged to undergo a periodic test or a continuous further test in which the light sources of each lane are pulsed on very briefly, for say one microsecond, such that their illumination is substantially imperceptible. The sequence illustrated in Figure 3 may be modified to that illustrated in Figure 11 in which the illumination during the period P1 is reduced to two short pulses at the beginning and the end of the period P1. Such an arrangement still enables the processing circuits illustrated in Figures 4, 5 and 7 to 9 to detect the correct operation of the light sources, albeit with a requirement to average a larger number of measurements in order to maintain reliability.

The first, second and any further light sources need not be arranged to indicate the same failure but may be in adjacent malfunction indicator lamps provided that light from one lamp is detectable within the or each other lamp.

It is thus possible to provide an indicator lamp in which dormant faults are detected. It is further possible use light emitting diodes both as light sources and photo detectors, thereby reducing the number of optical elements required.

Claims

1. An indicator having fault detection, comprising a first lane which comprises a first lane controller (12, 20) and a first light source (4), characterised by a second lane comprising a second lane controller (12, 22) and a second photodetector (10, 6) responsive to light produced by first light source (4), the first lane controller (12, 20) being arranged to actuate the first light source (4) for a first test period (P1) and the second lane controller (12, 22) being arranged to monitor an output of the second photodetector (10, 6) during the first test period (P1) and to produce a first fault signal when the light produced by the first light source (4) is less than a first predetermined value.

2. An indicator as claimed in Claim 1, characterised in that the second lane comprises a second light source (6).

3. An indicator as claimed in Claim 2, characterised in that the second photodetector comprises the second light source (6).

4. An indicator as claimed in Claim 2 or 3, characterised in that the second light source (6) is a light emitting diode.

5. An indicator as claimed in any one of Claims 2 to 4, characterised in that the second lane controller (12, 22) is arranged to actuate the second light source (6) in response to the first fault signal.

6. An indicator as claimed in any one of the preceding claims, characterised in that the second lane controller (12, 22) is arranged to monitor the output of the second photodetector (10, 6) outside the first test period (P1) to form a measure of ambient illumination of the second photodetector (10, 6).

7. An indicator as claimed in Claim 6, characterised in that the second lane controller (12, 22) is arranged to form a measure of illumination during the first test period (P1) and to subtract therefrom the measure of ambient illumination of the second photodetector (10, 6) so as to form a measure of light output of the first light source (4).

8. An indicator as claimed in any one of Claims 2 to 5 or in Claim 6 or 7 when dependent on Claim 2, characterised in that the first lane comprises a first photodetector (8, 4) responsive to light produced by the second light source (6), in that the second lane controller (12, 22) is arranged to actuate the second light source (6) for a second test period (P3), and in that the first lane controller (12, 20) is arranged to monitor an output of the first photodetector (8, 4) during the second test period (P3) to produce a second fault signal when the light produced by the second light source (6) is less than a second predeter-

mined value.

9. An indicator as claimed in Claim 8, characterised in that the first light source (4) constitutes the first photodetector.

10. An indicator as claimed in Claim 9, characterised in that the first light source (4) is a light emitting diode.

11. An indicator as claimed in any one of Claims 8 to 10, characterised in that the first lane controller (12, 20) is arranged to actuate the first light source (4) in response to the second fault signal.

12. An indicator as claimed in any one of Claims 8 to 11, characterised in that the first and second test periods (P1, P3) do not overlap.

13. An indicator as claimed in any one of Claims 8 to 12, characterised in that the first lane controller (12, 20) is arranged to monitor the output of the first photodetector (8, 4) outside the second test period (P3) to form a measure of ambient illumination of the first photodetector (8, 9).

14. An indicator as claimed in Claim 13, characterised in that the first lane controller (12, 20) is arranged to form a measure of illumination during the second test period (P3) and to subtract therefrom the measure of ambient illumination of the first photodetector (8, 4) so as to form a measure of light output of the second light source (6).

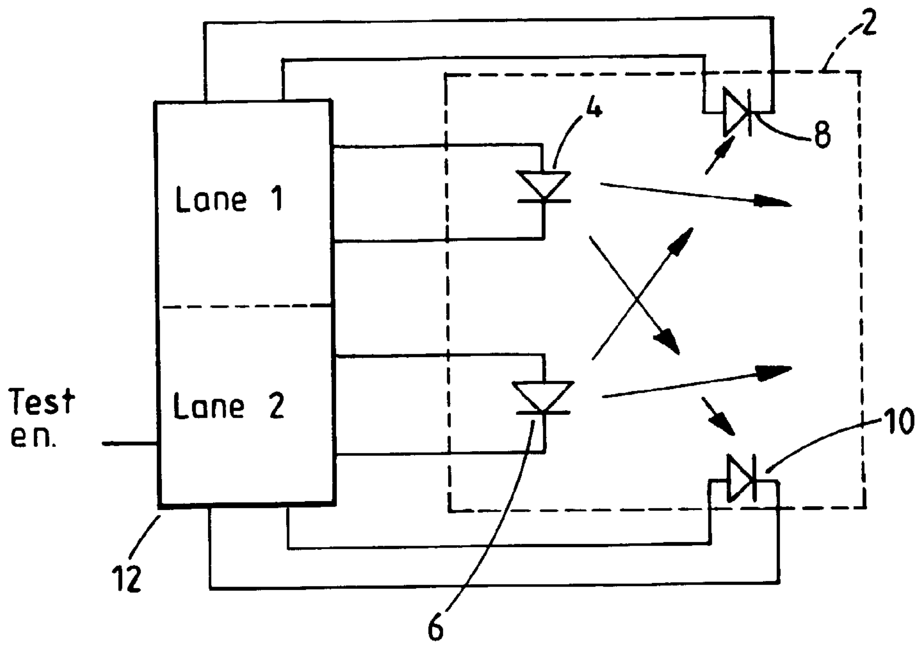

2
4
8
Lane 1
Lane 2
Test en.
10
12
6

FIG.1.

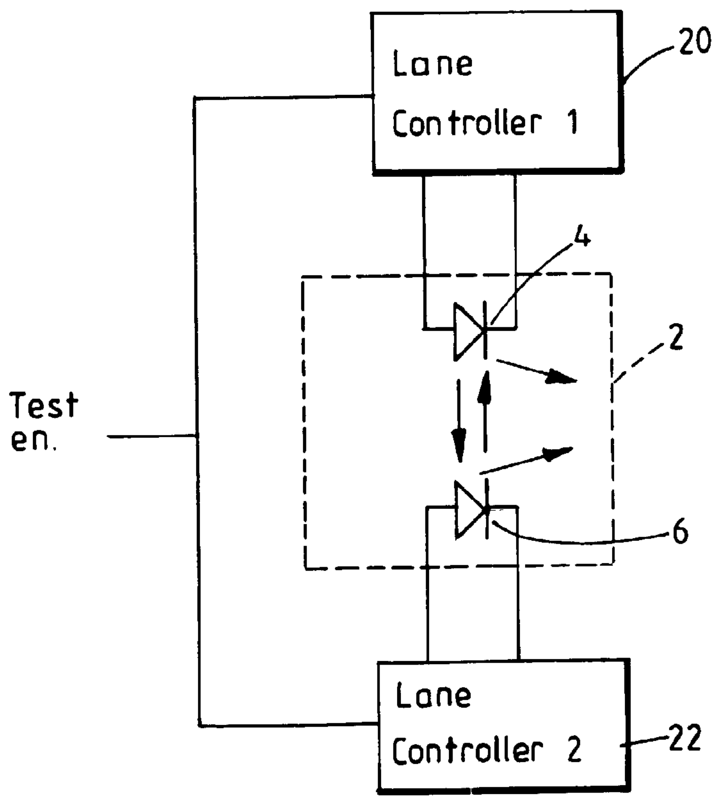

Lane Controller 1
20
4
2
Test en.
6
Lane Controller 2
22

FIG.2.

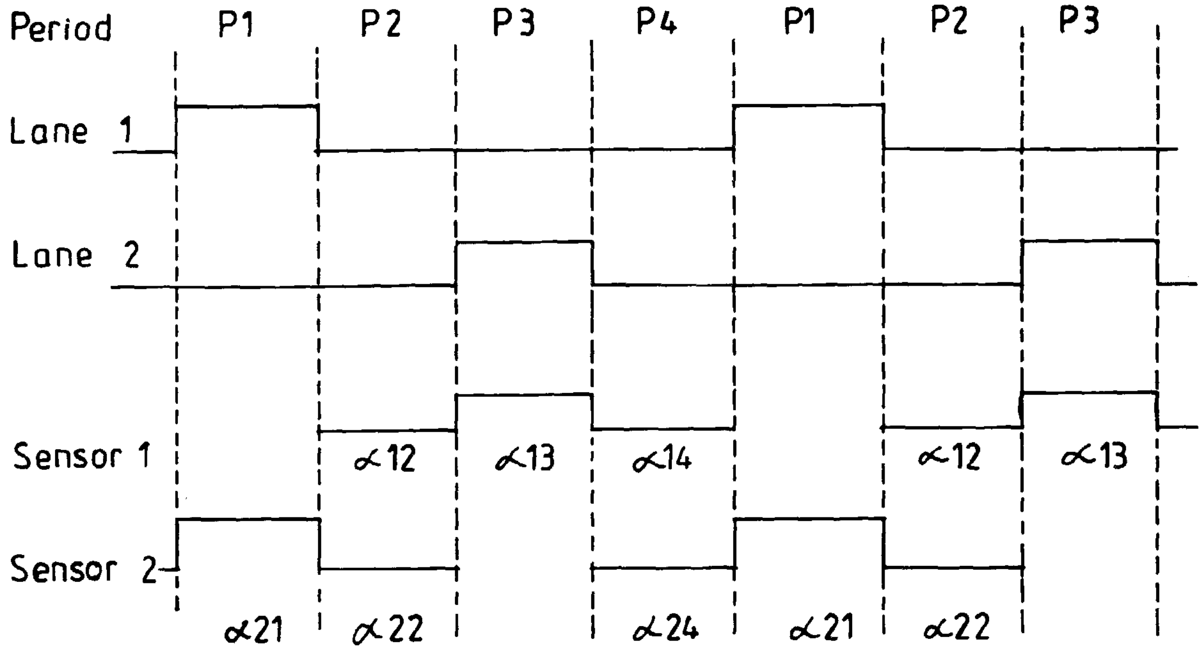

Period
P1
P2
P3
P4
P1
P2
P3
Lane 1
Lane 2
Sensor 1
α12
α13
α14
α12
α13
Sensor 2
α21
α22
α24
α21
α22

FIG.3.

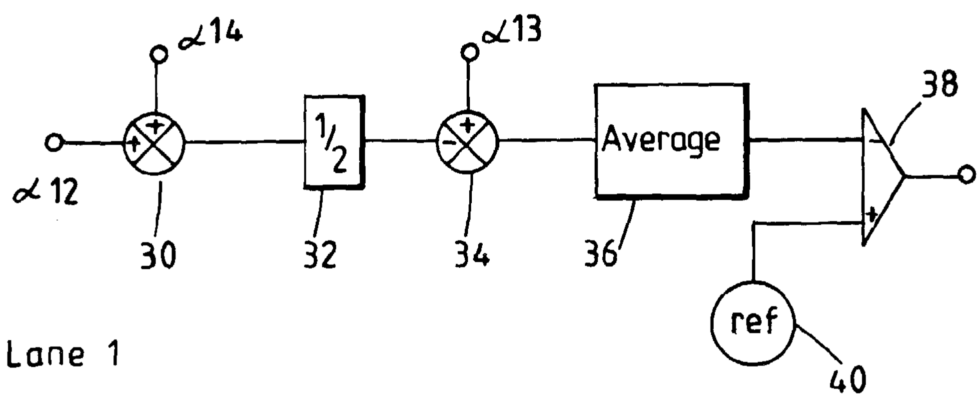

α14
α13
38
α12
1/2
Average
30
32
34
36
ref
40
Lane 1

FIG. 4.

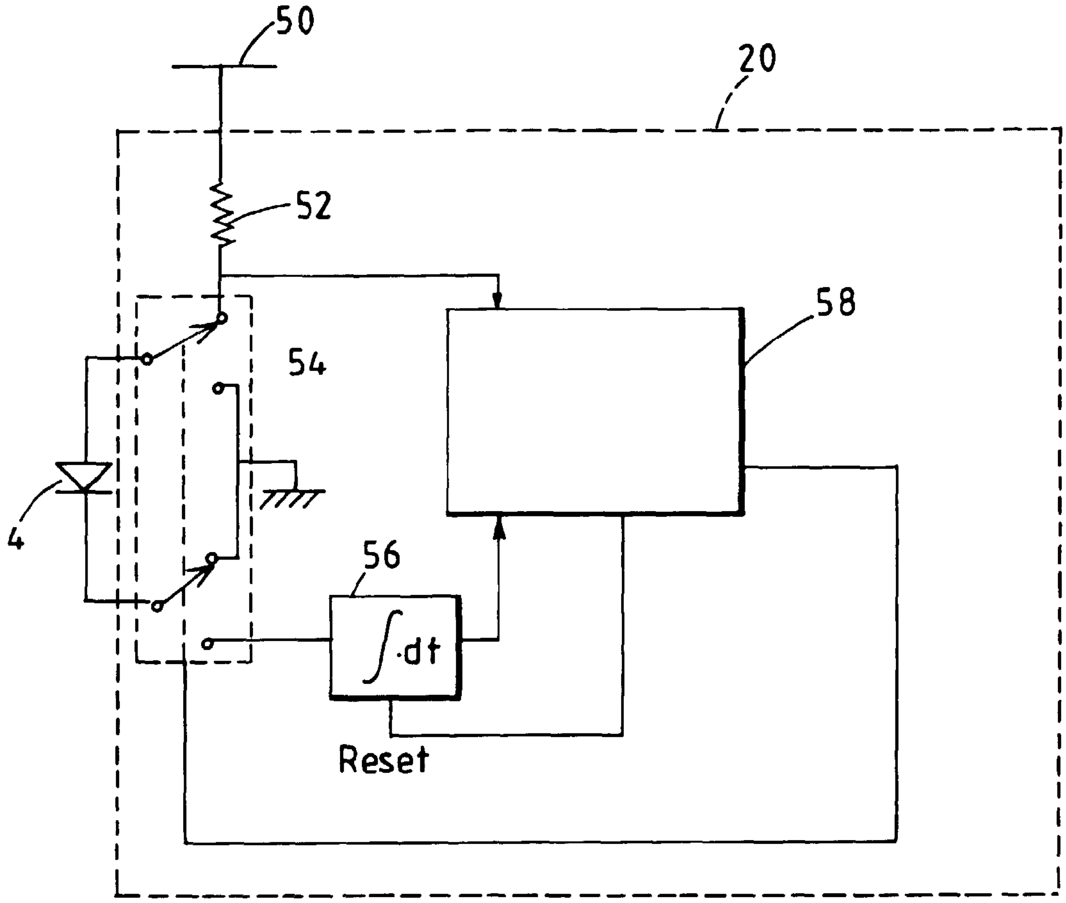


FIG.5.

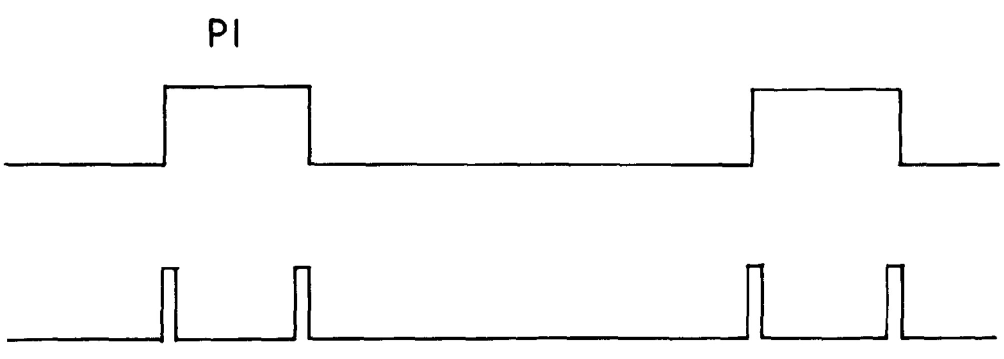
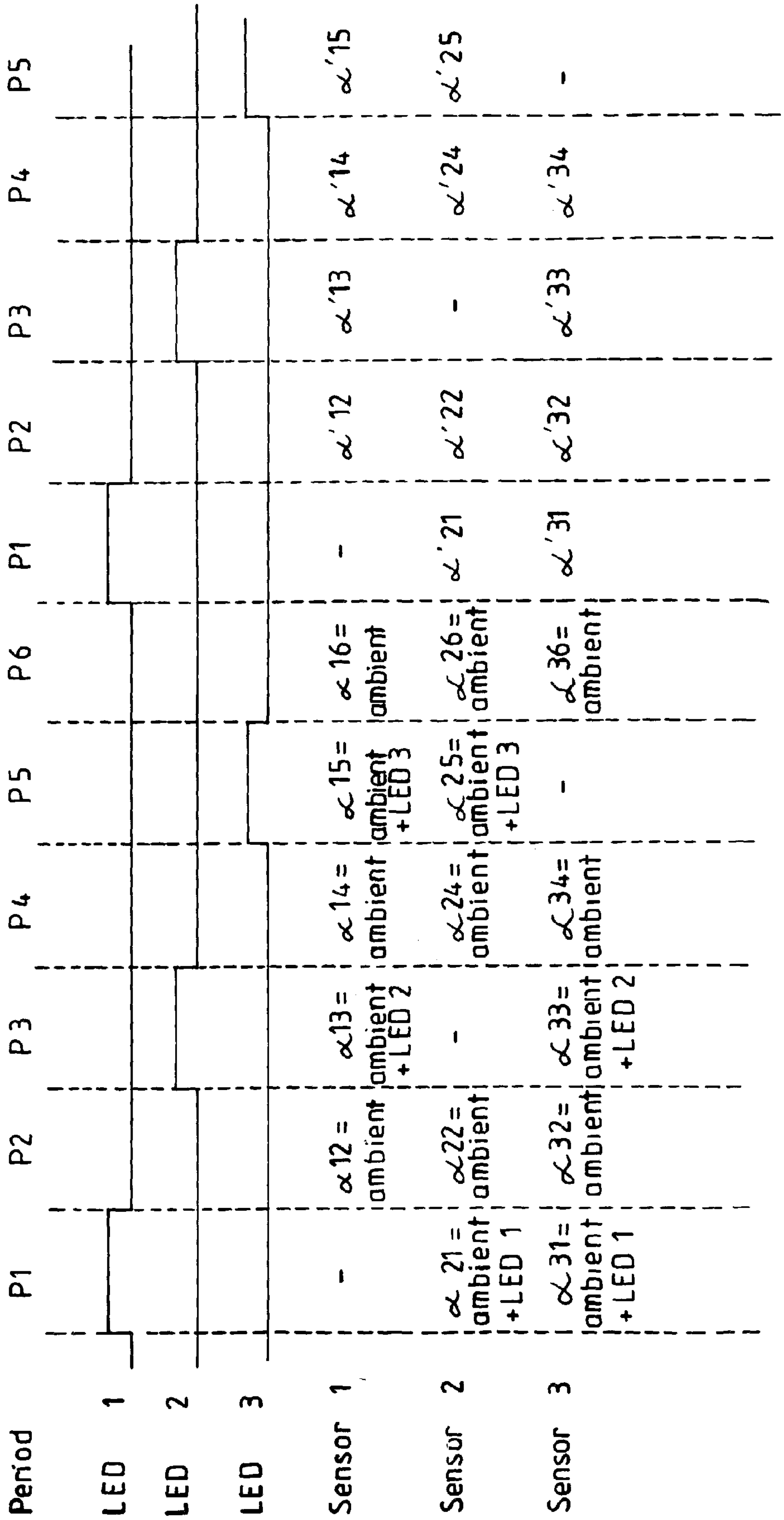


FIG.11.


Period
LED 1
LED 2
LED 3
Sensor 1
Sensor 2
Sensor 3
P1
P2
P3
P4
P5
P6
P1
P2
P3
P4
P5
α 21 = ambient +LED 1
α 31 = ambient +LED 1
α 12 = ambient
α 22 = ambient
α 32 = ambient
α 13 = ambient +LED 2
α 33 = ambient +LED 2
α 14 = ambient
α 24 = ambient
α 34 = ambient
α 15 = ambient +LED 3
α 25 = ambient +LED 3
α 16 = ambient
α 26 = ambient
α 36 = ambient
α'21
α'31
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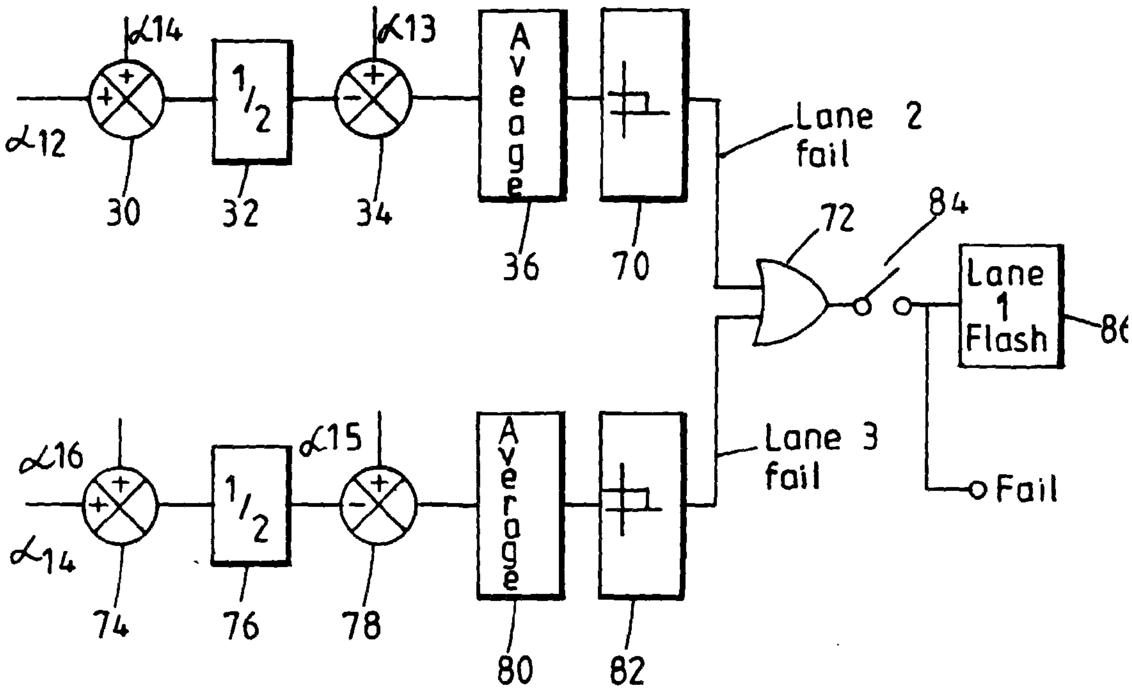
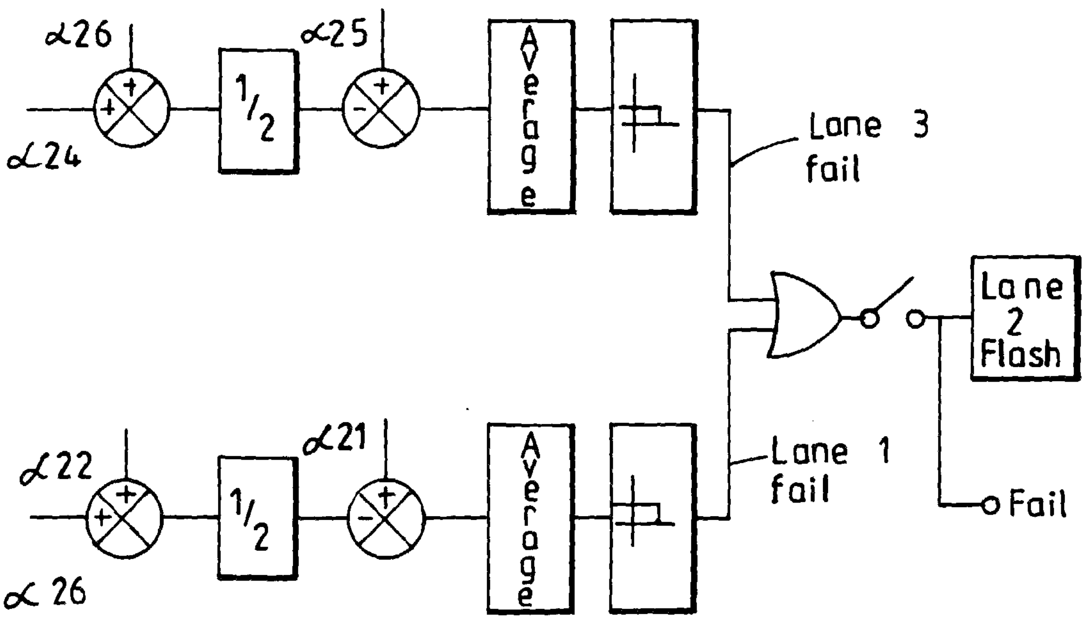
α'15
α'25

FIG.6.



α14
α13
α12
1/2
Average
Lane 2 fail
30
32
34
36
70
72
84
Lane 1 Flash
86
α16
α15
α14
1/2
Average
Lane 3 fail
Fail
74
76
78
80
82

FIG. 7.



α26
α25
α24
1/2
Average
Lane 3 fail
Lane 2 Flash
α22
α21
α26
1/2
Average
Lane 1 fail
Fail

FIG. 8.

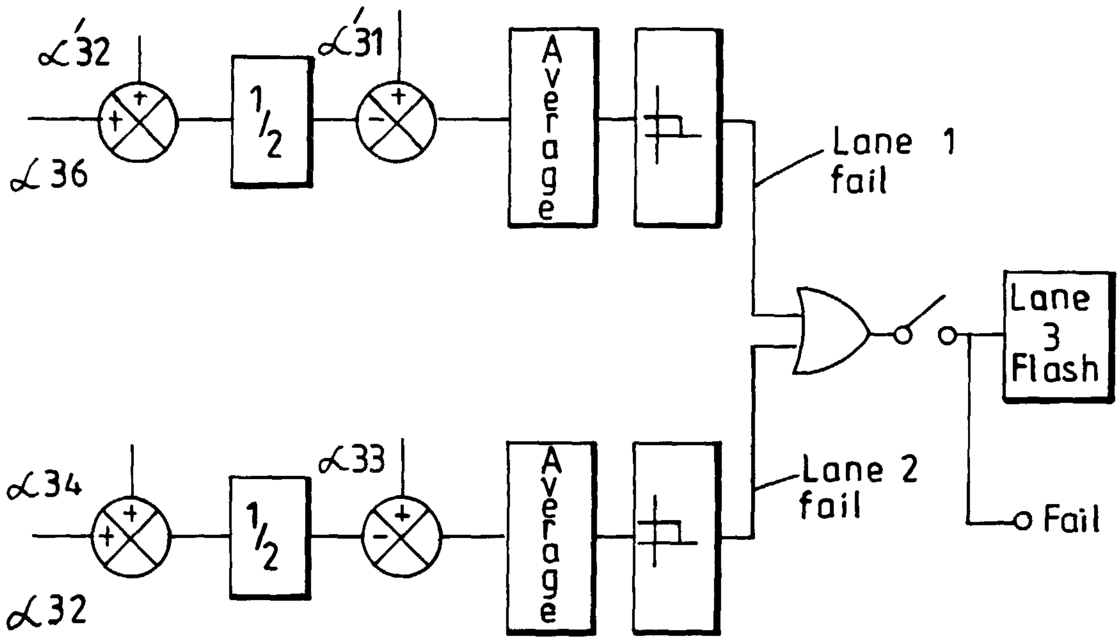

α32'
α36
1/2
α31'
Average
Lane 1 fail
α34
α32
1/2
α33
Average
Lane 2 fail
Lane 3 Flash
Fail

FIG.9.

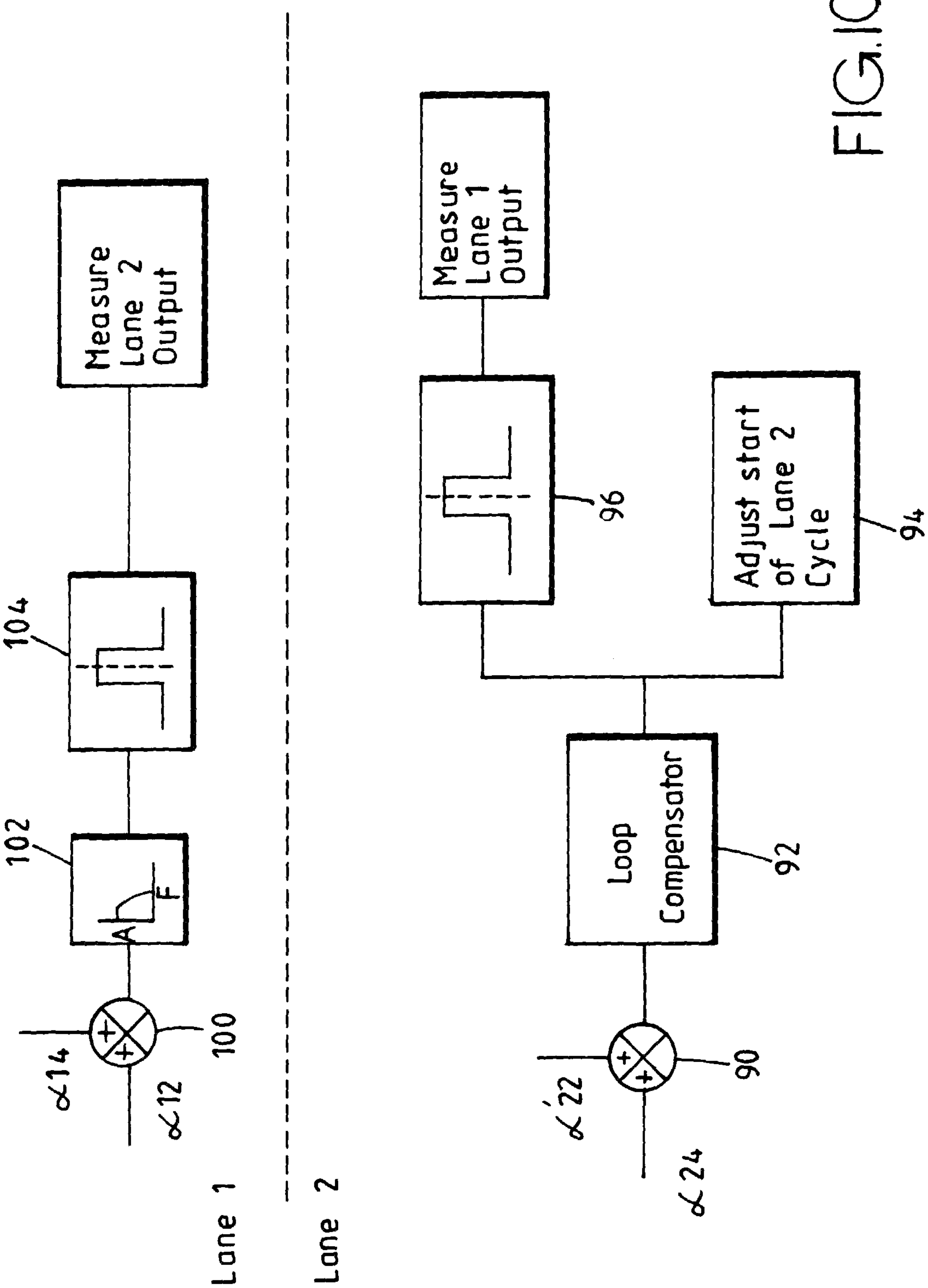

Lane 1
Lane 2
∝14
∝12
100
102
A
F
104
Measure
Lane 2
Output
∝'22
∝24
90
Loop
Compensator
92
96
Measure
Lane 1
Output
Adjust start
of Lane 2
Cycle
94

FIG.10.

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 30 0682

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	US-A-4 588 896 (D. ABBAS) * column 2, line 5 - line 30; figure 1 * ---	1-14	G08B29/10 H01L33/00
A,D	DE-A-36 30 372 (SIEMENS) * abstract * ---	1	
A	US-A-4 990 896 (W. GRAY) * abstract * -----	1	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			G08B H01L H05B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	17 May 1996	Sgura, S

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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