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

(11) Publication number: **0 623 943 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **94105339.9**

(51) Int. Cl.^{5}: **H01H 47/00**

(22) Date of filing: **06.04.94**

(30) Priority: **06.04.93 JP 78441/93**

(43) Date of publication of application:
09.11.94 Bulletin 94/45

(84) Designated Contracting States:
DE FR GB IT

(71) Applicant: **OMRON CORPORATION**
10, Tsuchido-cho
Hanazono
Ukyo-ku
Kyoto 616 (JP)

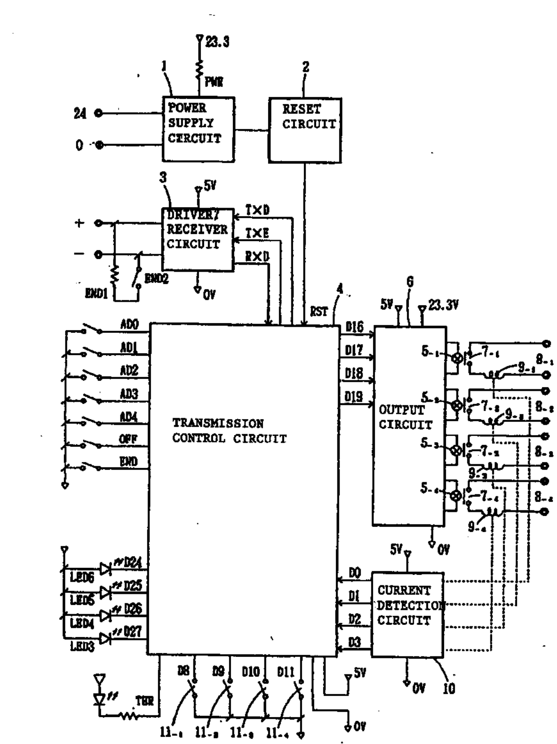
(72) Inventor: **Fujiwara, Teruhiko, c/o Omron Corp.**
Intellectual Prop. Ctr,
20, Igadera,
Shimokaiinji
Nagaokakyo-shi, Kyoto 617 (JP)

(74) Representative: **WILHELMS, KILIAN &**
PARTNER Patentanwälte
Eduard-Schmid-Strasse 2
D-81541 München (DE)

(54) Relay terminal array with malfunction detection and transmission functions.

(57) This invention is a relay terminal which can accurately detect malfunctions of relays. Detection coils are connected in series to relay contacts on load circuits. By detecting the magnetic flux generated in the coils, a current detection circuit, which contains a Hall element, determines if a current is flowing in the load circuits. Detection signals, which indicate the presence or absence of a current, and outputs from the relay coils are processed in a transmission control circuit. A malfunction detection signal indicating whether or not a malfunction has occurred is transmitted to a programmable controller via a driver/receiver circuit. If a malfunction has occurred, display means flash on and off.

FIG. 1



EP 0 623 943 A1

FIELD OF THE INVENTION

This invention concerns a relay terminal which is capable of transmitting detection signals when malfunctions are detected in the relay load circuits.

BACKGROUND OF THE INVENTION

A conventional relay terminal array consists of a number of relays whose contacts are connected to load circuits. Each load circuit is switched on or off in accordance with the contact state of the relay coil. Some conventional relay terminals are not able to transmit signals whether or not there is contact while other conventional relay terminals can. Conventional relay terminals of the type described above, however, cannot detect malfunctions. When such a relay becomes fused or a contact becomes intermittent, the malfunction cannot be immediately detected in the control center. The delay in detecting the malfunctioning relay causes down time and other problems.

This application is related to copending application Serial No. 94103624.6, filed March 9, 1994, which discloses a current detection unit and relay terminal array without a transmission function.

SUMMARY OF THE INVENTION

This invention considers the problem described above. One advantage of this invention that the relay terminal array is capable of detecting malfunctions and transmitting the status of the relay terminal to the main control unit.

This invention provides a number of other advantages. This invention uses a magneto-electric converter element to detect the presence or absence of current in a load circuit. Thus, an advantage of this invention is that a determination whether or not a malfunction has occurred is made based on the logic state of a current detection circuit and the result of processing performed on an output indicating the state of a relay coil.

Other advantages are that a wide range of currents can be detected and that signal indicating that a relay has malfunctioned can be transmitted to a programmable controller or other device. Another advantage of this invention is that a malfunction of a relay can be reported on site without increasing the number of components required.

The malfunction detection function of this invention can be disabled. Thus, a further advantage of this invention is that the user can enable or disable the detection function, as needed, in response to the load being used.

The relay terminal array of this invention comprises a number of relays in which the excitation of the relay coil of each relay causes the relay contact, which is connected to a load circuit, to be made or broken. Each of the relays has a current detection unit comprising a detection coil serially connected to its associated load circuit; a magneto-electric converter element to detect the presence of magnetic flux which is generated by an electric current flowing through the detection coil; and a current detection circuit which outputs a signal representing a logic state. By performing logic processing on the output of the magneto-electric converter element and the excitation of the relay coil, the current detection unit can detect a malfunction in any of the relays. If a malfunction is detected, the current detection unit outputs a signal indicating that a malfunction has occurred. The relay terminal array also has a transmitting unit to transmit the state of the relay whether a malfunction has occurred. The transmitting unit receives the output of the current detection unit and outputs an output signal to, for example, a monitoring center for the system.

When current is flowing in the load circuit for any relay, a magnetic flux is generated in the detection coil serially connected to that load circuit. When no current is flowing, no flux is generated. The presence or absence of this magnetic flux is detected by the magneto-electric converter element in the current detection circuit, and the result is output as a signal representing a logic state. The signal output by the current detection circuit and the state of the relay coil are processed by the logic processing device. If, for example, the state of the relay coil is "1", indicating that the relay is on, and the output of the current circuit is "0", indicating that the load circuit is open, the processor will conclude that a malfunction has occurred. If the state of the relay coil is "1" and the output of the current detection circuit is also "1", meaning that current is flowing in the load circuit, the processor will conclude that the load circuit is normal. A signal indicating that a malfunction has or has not occurred is transmitted to the exterior, for example, to a programmable controller.

BRIEF DESCRIPTION OF THE FIGURES

Fig. 1 is a block diagram showing a relay terminal array of this invention;

Fig. 2 is a circuit diagram showing a circuit used as the current detection unit in the relay terminal array;

Figs. 3a-3d are a timing chart illustrating the operation of the smoothing circuit of the current detection unit;

Fig. 4 is a timing chart illustrating the operation of the relay terminal array in its normal ON state;

Fig. 5 is a timing chart illustrating the operation of the relay terminal array in its normal OFF state;

Fig. 6 is a timing chart illustrating the operation of the relay terminal array when the circuits are open and the open circuit detection switches are on;

Fig. 7 is a timing chart illustrating the operation of the relay terminal array when the circuits are open and the open circuit detection switches are off;

Figs. 8a-8d show various waveforms illustrating the operation of the relay terminal array when the circuits are open and the open circuit detection switches are switched on while detection is occurring;

Figs. 9a-9c show various waveforms illustrating the operation of the relay terminal array when the load circuit is shorted; and

Fig. 10 is a chart showing the state of the display for normal operation and malfunction for every relay coil state and load current in the relay terminal array.

DETAILED DESCRIPTION OF THE INVENTION

The invention will be described with references to the accompanying drawings, Figs. 1-10. Fig. 1 is a block diagram showing a relay terminal array of this invention. This relay terminal array comprises power supply circuit 1; reset circuit 2; driver/receiver circuit 3, which sends data to and receives data from a programmable controller; transmission control circuit 4; output circuit 6, which receives relay coil outputs D_{16}, D_{17}, D_{18} and D_{19} from transmission control circuit 4 and transmits them to relay coils 5_1, 5_2, 5_3, and 5_4, respectively; current detection coils 9_1, 9_2, 9_3, and 9_4, which are connected in series with relay contacts 7_1, 7_2, 7_3, and 7_4 and connected to load circuits 8_1, 8_2, 8_3, and 8_4, respectively; current detection circuit 10, which detects the magnetic flux generated in detection coils 9_1, 9_2, 9_3, and 9_4 and outputs signals D_0, D_1, D_2, and D_3 to indicate the presence or absence of a current in load circuits 8_1, 8_2, 8_3, and 8_4; LEDs (LED3, LED4, LED5, and LED6) which display the states of the four relays; and switches 11_1, 11_2, 11_3, and 11_4, which can be switched to a mode in which an "Open" state is not to be detected. Current detection circuit 10 comprises four independent circuits corresponding to detection coils 9_1, 9_2, 9_3, and 9_4, which are connected in series with their corresponding load circuits. Transmission control circuit 4 receives the signals representing the presence or absence of current in the load circuits which are output by current detection circuit 10. It processes these signals together with the state of the relay coils to determine whether or not a malfunction has occurred. When a malfunctioning relay is detected, its corresponding display means, one of LED3, LED4, LED5, and LED6, will flash on and off, and a signal indicating that the relay is malfunctioning (its corresponding flag) will be transmitted to the programmable controller via driver/receiver 3.

Fig. 2 is a circuit diagram of an example of a circuit for the current detection circuit 10. This circuit comprises magnetic flux detection circuit 21, which contains Hall element HE to detect magnetic flux in detection coil 9; constant voltage circuit 22, which provides drive voltage to Hall element HE at a constant level of 1V; amplifier circuit 23, which amplifies the output of Hall element HE; comparator circuit 24, which compares the amplified signal with a reference voltage and whose output is "HIGH" in the presence of a current and is "LOW" in the absence of a circuit; and smoothing circuit 25, which smooths the output signal when an AC load is being used.

Detection coil 9, which is connected to load circuit 8 serially, is wound on a ring core with a gap. When a current is flowing in detection coil 9, Hall element HE in magnetic flux detection circuit 21 measures the magnetic flux generated by the current outputs the voltage generated by the load current.

Constant-voltage circuit 22 comprises transistor Q_1, whose emitter is connected to Hall element HE and whose collector is connected to the +5V power supply; resistor R_1, one of whose terminals is connected to the +5V power supply; and resistor R_2, one of whose terminals is connected to the other terminal of resistor R_1 at the connection point for the base of transistor Q_1, and the other of whose terminals is connected to the power supply at the 0V level. The ratio for resistors R_1 and R_2 is set so that a voltage of 1V is applied to Hall element HE.

Amplifier circuit 23 has a differential amplifier unit 27 comprising resistors R_3, R_4, R_5, and R_6, operational amplifier 26; and operational amplifier 28. The output terminal of operational amplifier 28 and the inverting input terminal are connected to form a voltage follower, which is connected to one of the terminals of resistor R_6. The output voltage V_{OP} of amplifier circuit 23 can be obtained by solving $V_{OP} = AV_H + V_C$, where the output of Hall element HE is V_H, the differential amplification factor is A, and the constant voltage output by voltage follower 29 is V_C.

Comparator circuit 24 comprises the series circuit comprising resistors R_7, R_8, R_9, and R_{10}, connected to the power supply between the +5V and 0V levels, which supply reference voltages VR_1, and VR_2; operational amplifier 30, whose non-inverting input terminal is connected the output of amplifier circuit 23 and whose inverting input terminal is connected the common connection point of resistors R_7 and R_8, the reference voltage VR_1; operational amplifier 31, whose non-inverting input terminal is connected the connection points of resistors R_9 and R_{10}, the reference voltage VR_2 ($VR_1 > VR_2$) and whose inverting input terminal is connected the output of amplifier circuit 23; and OR circuit 32, which receives as input the outputs of operational amplifiers 31 and 32.

When the output V_{OP} of amplifier circuit 23 is greater than VR_1 ($V_{OP} > VR_1$), the output of operational amplifier 30 is "HIGH" and the output of operational amplifier 31 is "LOW". In this case, the output of OR circuit 32 is "HIGH", indicating that a current has been detected.

When the output V_{OP} of amplifier circuit 23 is greater than VR_1, but less than VR_2 ($VR_2 > V_{OP} > VR_1$), the output of both operational amplifiers 30 and 31 are "LOW". In this case, the output of OR circuit 32 is "LOW", indicating the absence of a current.

When the output V_{OP} of amplifier circuit 23 is less than VR_2 ($V_{OP} < VR_2$), the output of operational amplifier 30 is "LOW" and the output of operational amplifier 31 is "HIGH". In this case, the output of OR circuit 32 is "HIGH", indicating the presence of a current.

Smoothing circuit 25 comprises resistor R_{12} connected in series with a parallel circuit of diode d and resistor R_{11} between the input terminal which receives the output V_I of comparator circuit 24 and output terminal D_i (i = 0, 1, 2, 3). Resistor R_{13} is connected between the input terminal and 0V. Capacitor C_1 is connected between the output terminal and 0V.

Let us assume that the load current in smoothing circuit 25 is AC and the output of Hall element HE is the signal pictured in Fig. 3a. This signal is amplified by amplifier circuit 23, superposed on the 2.5V DC reference voltage, and output. The result is that the output V_{OP} of amplifier circuit 23 has a waveform like that shown in Fig. 3b. Comparator circuit 24 compares output V_{OP} to reference voltages VR_1 and VR_2. If $V_{OP} > VR_1$ or $V_{OP} < VR_2$, the output of comparator circuit 24 is "HIGH". In this case, the output V_I of comparator circuit 24 assumes the waveform shown in Fig. 3c. This pulse-type output waveform V_I is smoothed by smoothing circuit 25 and output as signal D_O shown in Fig. 3d to indicate that a current has been detected.

When the output V_I of comparator circuit 24 is "HIGH", capacitor C_1 is charged via diode d and resistor R_{12}. Since the time constants of R_{12} and C_1 are small, the charging will occur rapidly. When the output V_I of comparator circuit 24 is "LOW", the voltage charged in capacitor C_1 is discharged through resistors R_{12}, R_{11}, and R_{13}. In this case, the time constant ($R_{11} + R_{12} + R_{13}$) with capacitor C_1 is large, resulting in a smoothing effect. The smoothing circuit does not operative when a DC current flows in the load circuit, since it is not needed.

The output of current detection circuit 10, achieved as described above, comprises signals D_0, D_1, D_2, and D_3, which indicate the presence or absence of a current in load circuits 8_1, 8_2, 8_3, and 8_4. These signals are input into transmission control circuit 4. In transmission control circuit 4, logic processing is performed on signals D_0, D_1, D_2, and D_3 received from circuit detection circuit 10 and on relay coil outputs D_{16}, D_{17}, D_{18}, and D_{19}, which are output to the various relays via output circuit 6. This processing determines whether a malfunction has occurred.

A brief explanation of determination of a malfunction follows. If a relay is ON, that is, if the output signal from the relay coil is "LOW", and the current detection signal (the load current) is positive (i.e., greater than 0.5A), the relay is in its normal ON state, and its LED will stay lit continuously. Waveforms for this case are shown in Fig. 4.

In the normal OFF state, the output signals D_{16}, D_{17}, D_{18}, and D_{19} from the relay coils are "HIGH". The current detection signal is negative (i.e., less than 0.5A), and LED3, LED4, LED5, and LED6 will be off. The waveforms for this case arc shown in Fig. 5.

When the relays are in the normal OFF state, all malfunction flags will be set to "0", and a malfunction flag "0" will be transmitted to the programmable controller.

When any of the load circuits of the relays are open, and detection switches 11_1, 11_2, 11_3, and 11_4 are on, the output signals from the relay coils are "LOW", indicating that the relays ore on, but the current detection signals will be negative. In this case, the LED drive signal will pulse, and LED3, LED4, LED5, and LED6 will flash on and off to indicate a malfunction. The malfunction flag will be set to "1". Fig. 6 shows the waveforms for this case.

Normally, the current flowing in the load circuit which is made or broken by the relays is relatively large. However, conditions set by the user, such as having a load which is only the display means, may cause the current to be very small. If this happens, the current detection circuit may output a "negative" signal, even though the load current is normal. An open relay malfunction is then detected when conditions are in fact normal. This embodiment has a feature which allows the user to prevent such false positives. When open relay detection switches 11_1, 11_2, 11_3, and 11_4 are on, the detection of open relay malfunctions will be prevented.

When the load circuits of the relays are open and switches 11_1, 11_2, 11_3, and 11_4 are off, the output signals from the relay coils will be "LOW" (to indicate that the relays are on). Because switches 11_1, 11_2, 11_3, and 11_4 are off, the LEDs will remain lit even if the current detection signal is negative, and the malfunction flag will be "0". Waveforms for this case are shown in Fig. 7.

When the relays are open and switches 11_1, 11_2, 11_3, and 11_4 are switched on, while detection is occurring, LED3, LED4, LED5, and LED6 will enter detection phase and light up. The LEDs will begin flashing when the switches are activated. Figs. 8a-8d shown the waveforms for this case.

When the load circuit is shorted, the output signal from the relay coils are "HIGH", indicating that the relays ire off. Since the current detection signal is positive, the LED drive signal will pulse, as shown in Fig. 9c. The LEDs (LED3, LED4, LED5, and LED6) will flash to indicate a malfunction, and the malfunction flag will be "1". Fig. 9 shows the waveforms for the case in which the circuit is shorted.

A summary of the relationship of the relays, the load current, the open relay detection switches, the LEDs, and the malfunction flags is shown in Fig. 10 for each condition discussed above.

Claims

1. A relay terminal array having a plurality of relays, each of said plurality of relays having a relay coil such that excitation of said relay coil causes a relay contact, said relay terminal comprising:

a current detection circuit detecting the presence or absence of a current in a load circuit of said relay and to output detection signals, and

a transmission control circuit for comparing said detection signals from said current detection circuit with a state signal from each of said relay coils, to determine if a malfunction has occurred in said relays, said transmission control circuit outputting a malfunction detection signal when a malfunction has occurred.

2. A relay terminal array as claimed in claim 1, wherein said current detection circuit comprises:

a magnetic flux detection circuit detecting magnetic flux generated by said current in said load circuit and to output a magnetic flux detection signal;

a constant-voltage circuit providing a constant drive voltage to said magnetic flux detection circuit;

an amplifier circuit amplifying said magnetic flux detection signal from said magnetic flux detection circuit and to output an amplified detection signal; and

a comparator circuit for comparing said amplified detection signal from said amplifier circuit with a reference voltage to determine the presence or absence of said current in said load circuit and to output a current detection signal,

wherein said detection signals comprise said magnetic flux detection signal, said amplified detection signal, and said current detection signal.

3. A relay terminal array as claimed in claim 2, wherein said magnetic flux detection circuit comprises:

a detection coil connected serially to said load circuit of said relay; and

a magneto-electric converter element for detecting magnetic flux generated by said current in said load circuit.

4. A relay terminal array as claimed in claim 2, said relay terminal array further comprising a smoothing circuit to smooth said current detection signal outputted by said comparator circuit.

5. A relay terminal array as claimed in claim 1, said relay terminal array further comprising a plurality of display means corresponding to said plurality of relays for displaying whether a malfunction has occurred in each of said relays, said display means being activated by said malfunction detection signal from said said transmission control circuit.

6. A relay terminal array as claimed in claim 1, said relay terminal array further comprising an open relay detection switch for preventing said transmission control circuit detection from outputting said malfunction signal.

7. A relay terminal array as claimed in claim 1, said relay terminal array further comprising a driver-receiver circuit transmitting said malfunction detection signal to a monitoring center.

FIG. 1

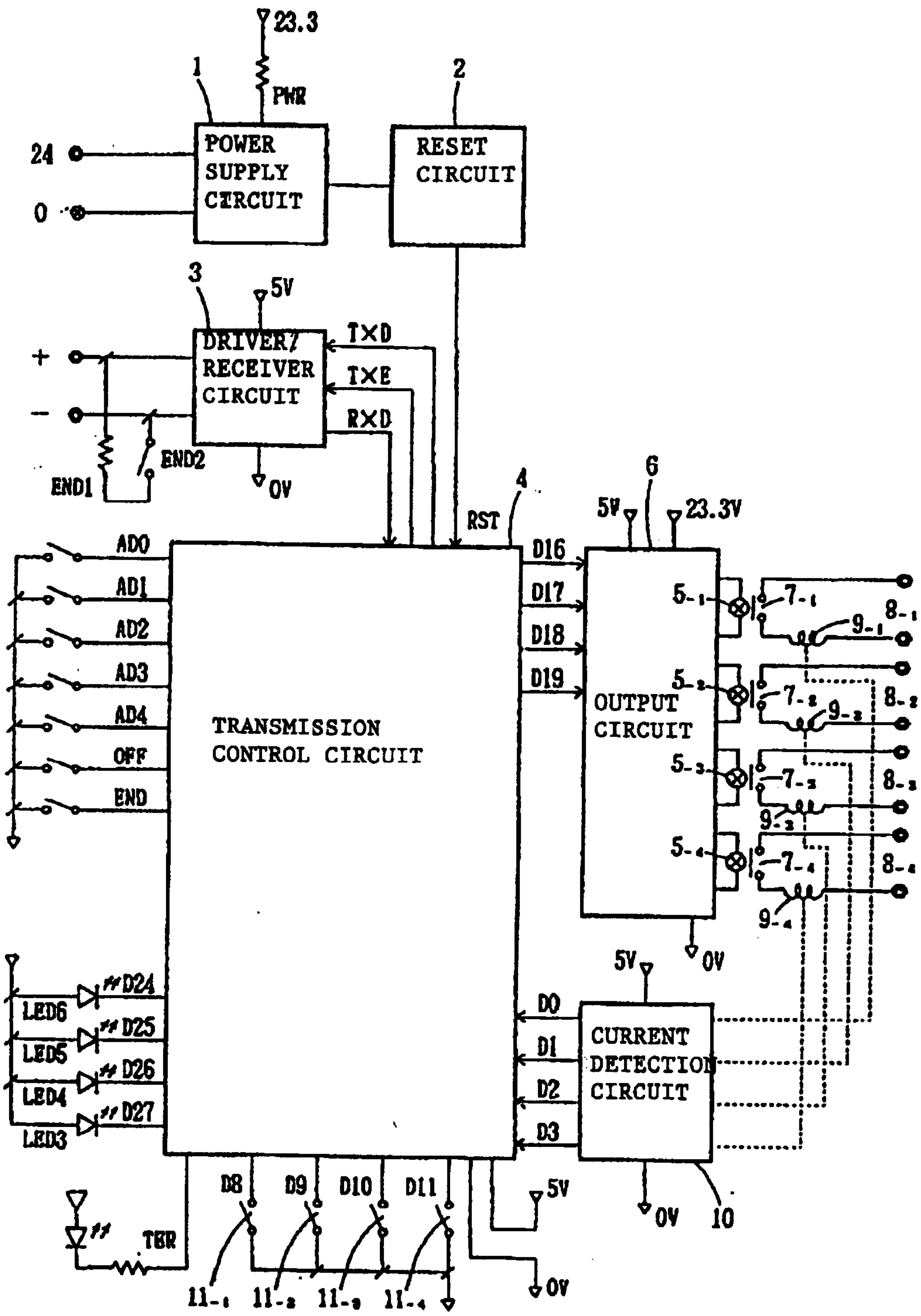

23.3
1
PWR
2
24
0
POWER
SUPPLY
CIRCUIT
RESET
CIRCUIT
3
5V
DRIVER/
RECEIVER
CIRCUIT
TXD
TXE
RXD
+
−
END1
END2
0V
4
RST
6
5V
23.3V
AD0
AD1
AD2
AD3
AD4
OFF
END
TRANSMISSION
CONTROL CIRCUIT
D16
D17
D18
D19
OUTPUT
CIRCUIT
0V
5V
D0
D1
D2
D3
CURRENT
DETECTION
CIRCUIT
LED6
LED5
LED4
LED3
D24
D25
D26
D27
TER
D8
D9
D10
D11
5V
0V
0V
10

FIG. 2

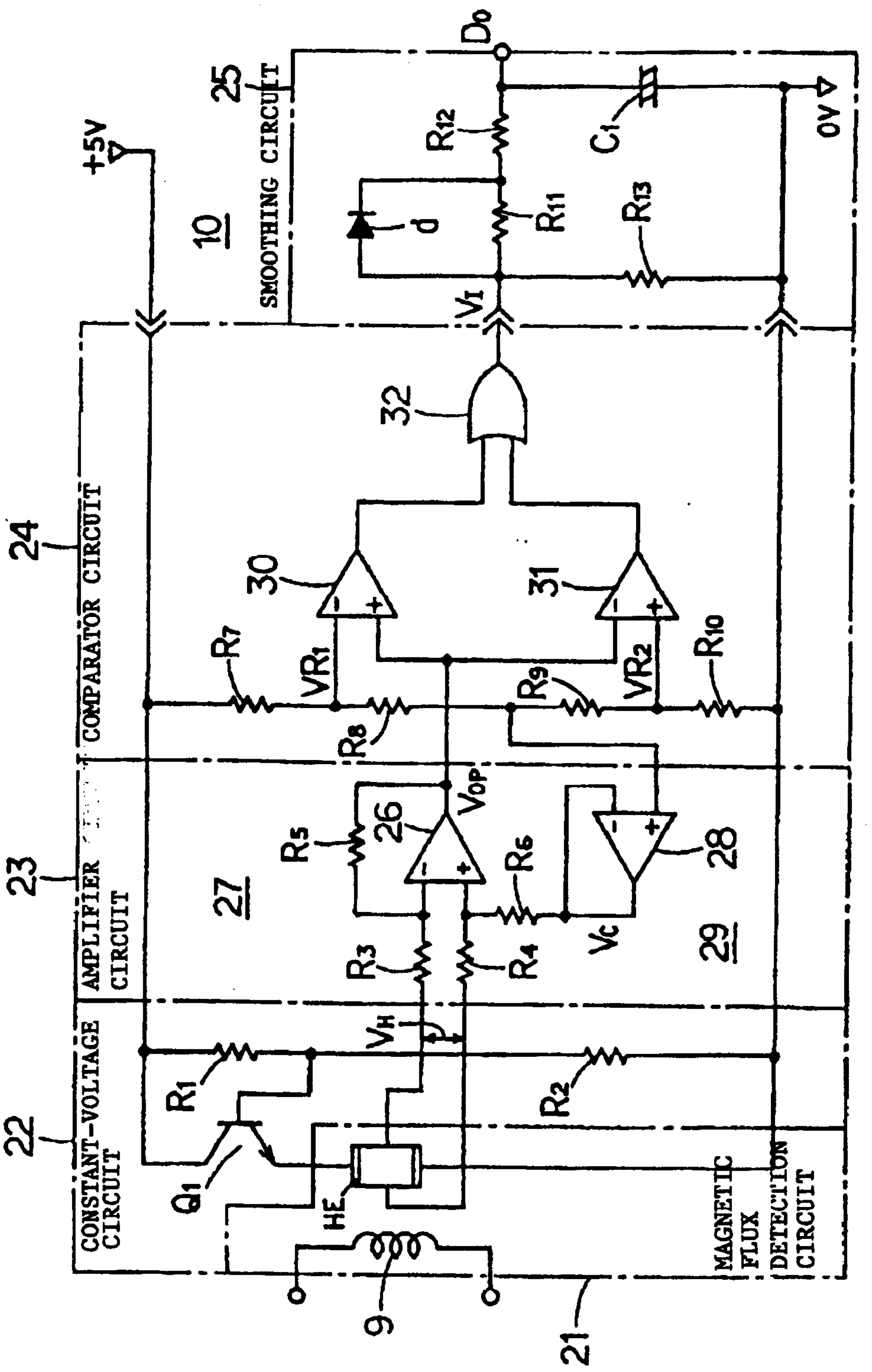

+5V
Do
0V
SMOOTHING CIRCUIT
COMPARATOR CIRCUIT
AMPLIFIER CIRCUIT
CONSTANT-VOLTAGE CIRCUIT
MAGNETIC FLUX DETECTION CIRCUIT
10
21
22
23
24
25
26
27
28
29
30
31
32
9
HE
Q1
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13
C1
d
VR1
VR2
VOP
Vc
VH
VI

FIG. 3a

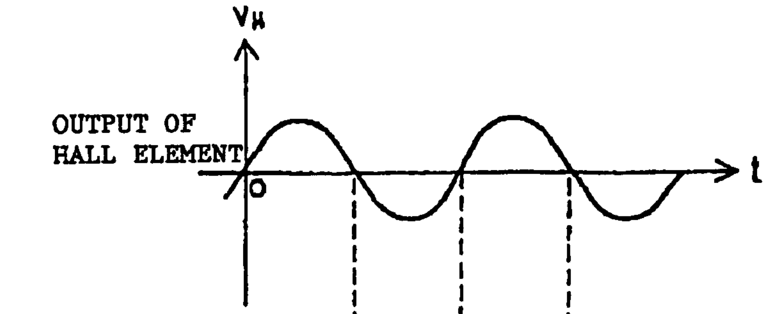


FIG. 3b

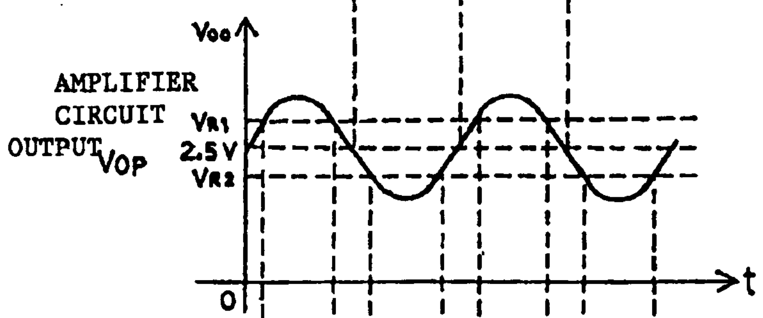


FIG. 3c

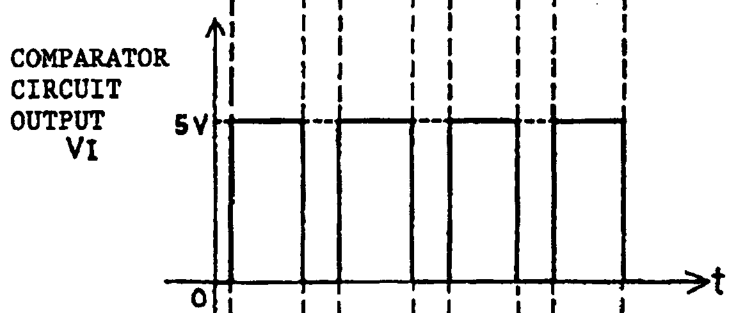


FIG. 3d

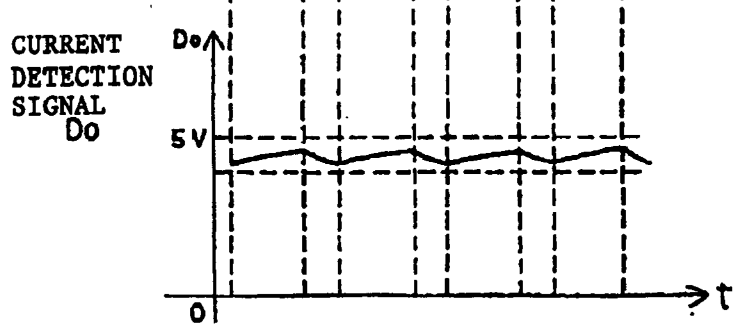


FIG. 4

NORMAL ON STATE

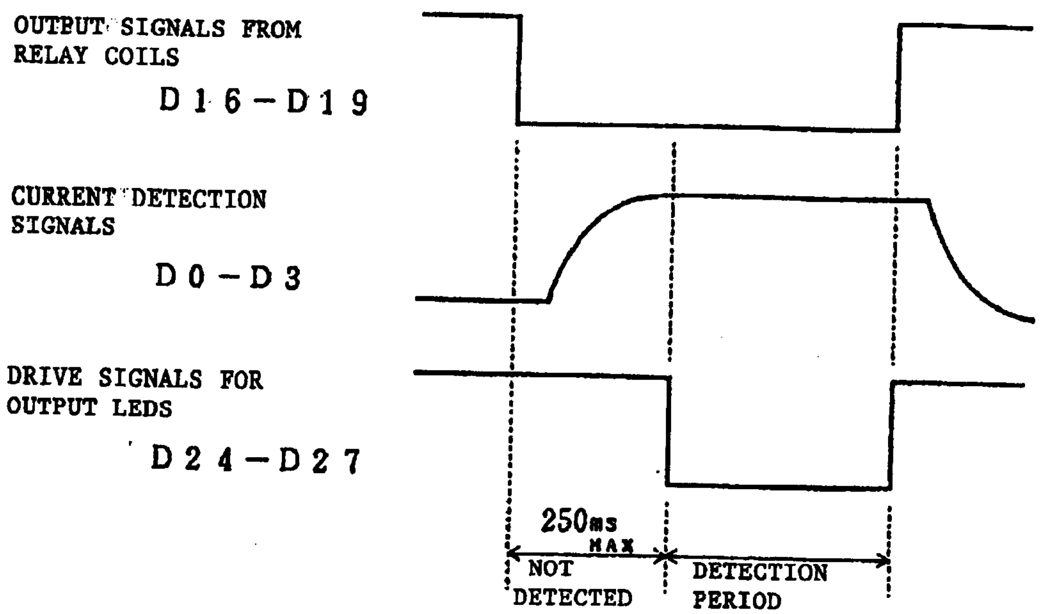


FIG. 5

NROMAL OFF STATE

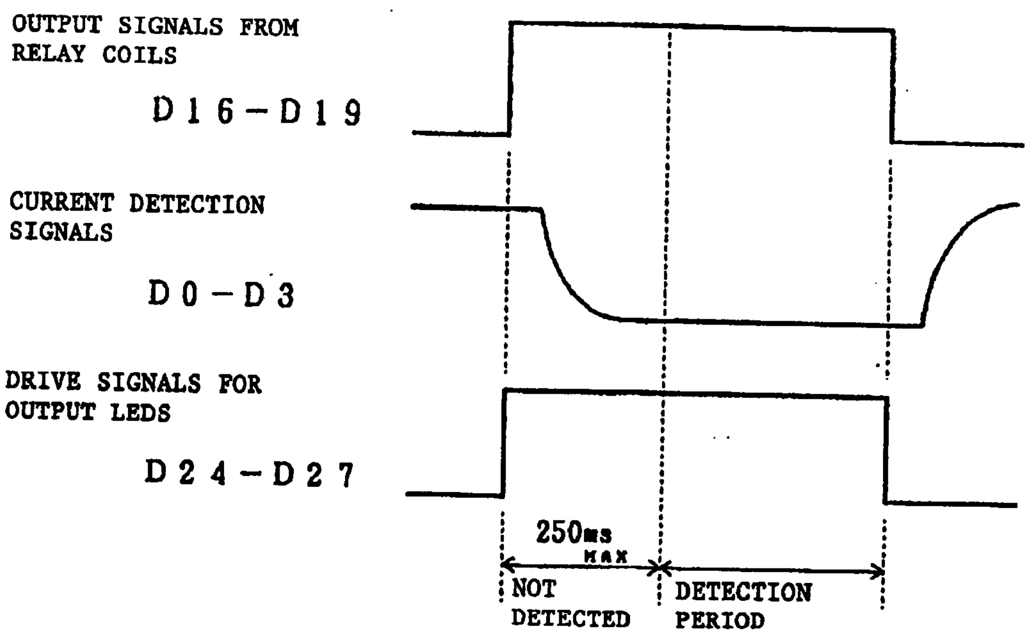


FIG. 6

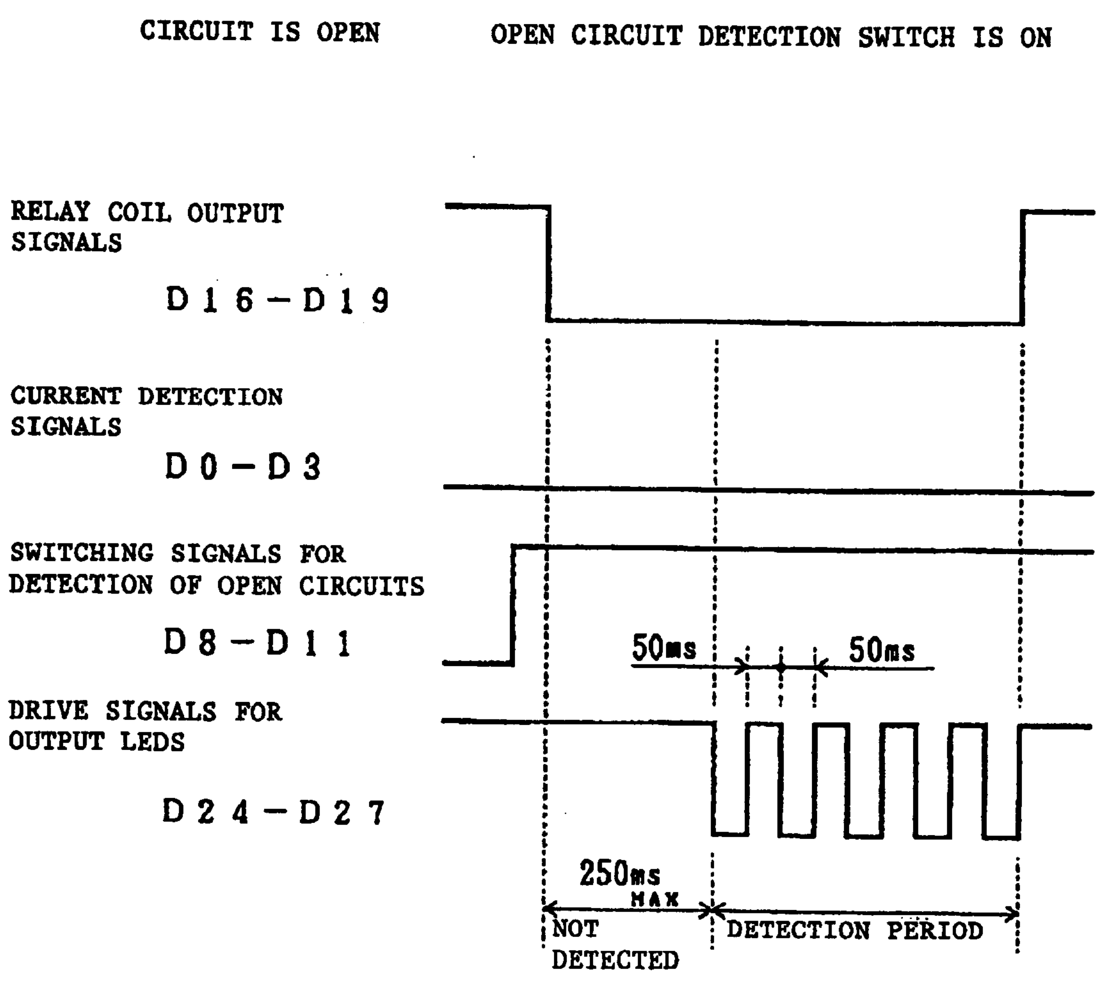
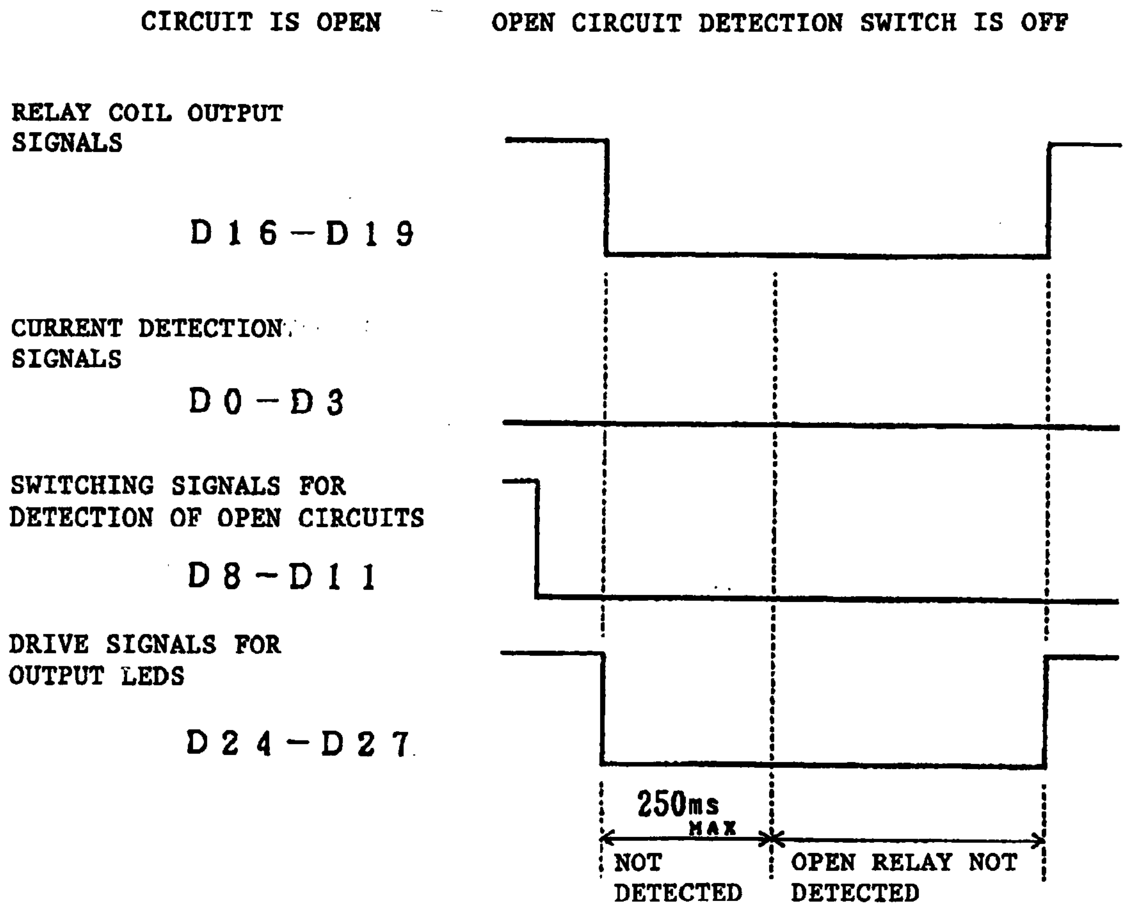

CIRCUIT IS OPEN
OPEN CIRCUIT DETECTION SWITCH IS ON
RELAY COIL OUTPUT SIGNALS
D16－D19
CURRENT DETECTION SIGNALS
D0－D3
SWITCHING SIGNALS FOR DETECTION OF OPEN CIRCUITS
D8－D11
DRIVE SIGNALS FOR OUTPUT LEDS
D24－D27
50ms
50ms
250ms MAX
NOT DETECTED
DETECTION PERIOD

FIG. 7


CIRCUIT IS OPEN – OPEN CIRCUIT DETECTION SWITCH IS OFF
RELAY COIL OUTPUT SIGNALS
D16–D19
CURRENT DETECTION SIGNALS
D0–D3
SWITCHING SIGNALS FOR DETECTION OF OPEN CIRCUITS
D8–D11
DRIVE SIGNALS FOR OUTPUT LEDS
D24–D27
250ms MAX
NOT DETECTED
OPEN RELAY NOT DETECTED

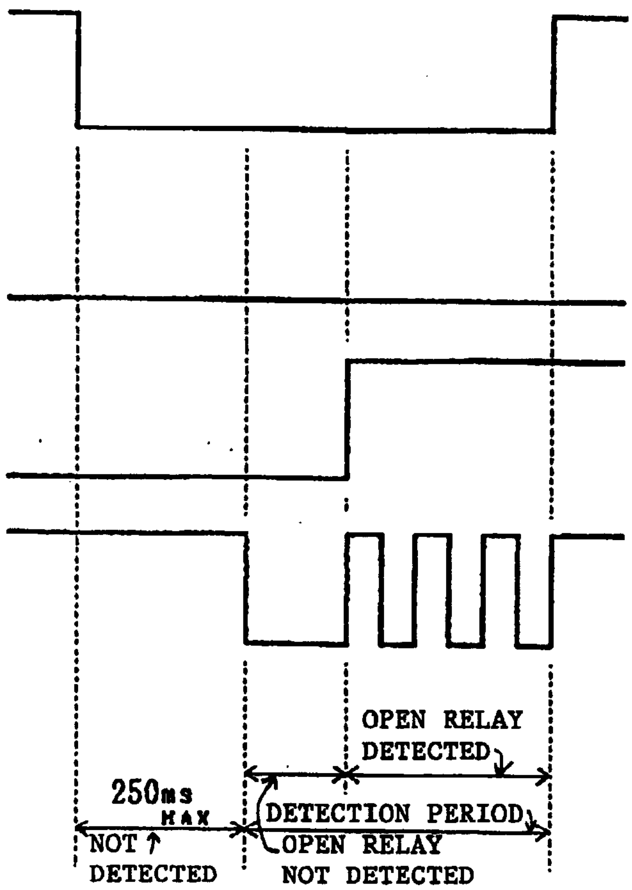
CIRCUIT IS OPEN, DETECTION SWITCH THROWN DURING DETECTION PERIOD

FIG. 8a
RELAY COIL OUTPUT SIGNALS
D16-D19

FIG. 8b
CURRENT DETECTION SIGNALS
D0-D3

FIG. 8c
SWITCHING SIGNALS FOR OPEN CIRCUIT DETECTION
D8-D11

FIG.8d
DRIVE SIGNALS FOR OUTPUT LEDS
D24-D27



CIRCUIT IS SHORTED

FIG. 9a
RELAY COIL OUTPUT SIGNALS
D16-D19

FIG. 9b
CURRENT DETECTION SIGNALS
D0-D3

FIG. 9c
DRIVE SIGNALS FOR OUTPUT LEDS
D24-D27

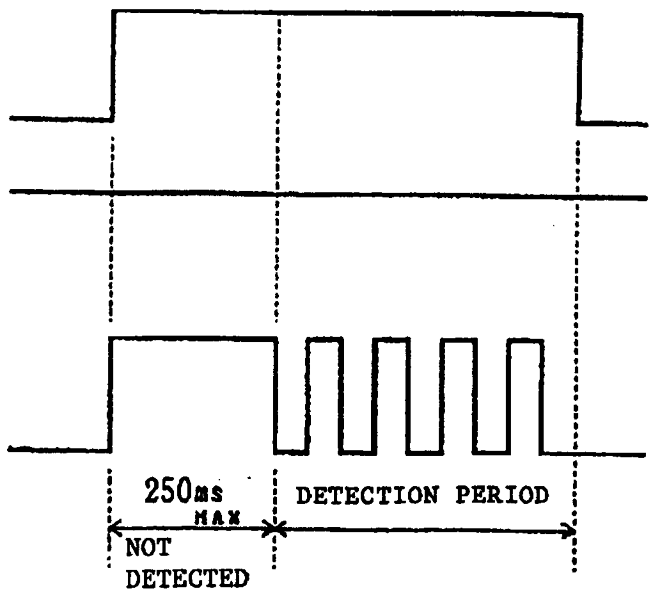


FIG. 10

RELAY	LOAD CURRENT	DETECTION SWITCH FOR OPENING CIRCUIT	LED DISPLAY	MALFUNCTION FLAG
ON	> 0.5A	※	ON	0
OFF	< 0.5A	※	OFF	0
ON	< 0.5A	ON	FLASHING	1
ON	< 0.5A	OFF	ON	0
OFF	> 0.5A	※	FLASHING	1

※ DON'T CARE

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 10 5339

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
Y	DE-U-91 13 081 (SIEMENS) * page 1, line 11 - line 23; claim 9; figures *	1,2	H01H47/00
Y	EP-A-0 359 566 (MATSUSHITA ELECTRIC WORKS) * column 6, line 26 - column 7, line 4; figures 1,4,5 *	1,2	
A	EP-A-0 157 054 (DURAPLUG ELECTRICALS LIMITED) * page 5, line 38 - page 6, line 3; figures *	2	
A	FR-A-2 565 430 (SHINKOH ELECTRIC) * page 3, line 8 - line 32; figures 1-4 *	1,2	
A	DE-A-41 12 996 (BOSCH) * abstract; figure 7 *	1,2	
A	GB-A-2 157 903 (THE PLESSEY COMPANY PLC.) * page 1, line 73 - line 102; figure *	1,2,7	

TECHNICAL FIELDS SEARCHED (Int.Cl.5)

H01H
H02J
H05B
G01R
H02H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	15 July 1994	Kempen, P

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)