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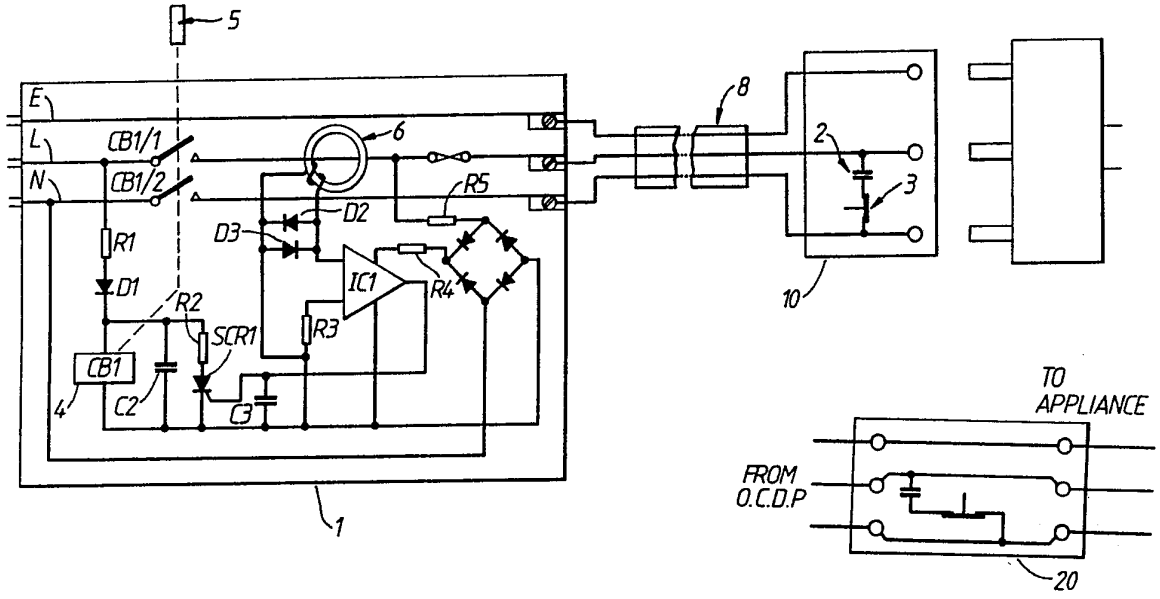
(54) Title: IMPROVEMENTS IN OR RELATED TO CIRCUIT BREAKERS USED WITH ELECTRICAL APPARATUS



(57) Abstract

A protection device (1, 10) for connection between an electrical supply and electrical apparatus includes a circuit breaker to interrupt the supply when an open neutral or live conductor is detected. The protection device includes means (2) for maintaining current flow in the live and neutral conductors, when the protecting device is connected to an electrical supply, whether or not connected electrical apparatus is drawing current. The protection device also includes a current transformer (6) arranged to detect current flow in the live or neutral conductor and a circuit breaker (CB1) adapted in use to interrupt the supply of electricity to the live and neutral conductors when the current transformer detects substantially zero current flow (i.e. open circuit). The protection device can incorporate or be used in conjunction with a residual current circuit breaker.

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Improvements in or Related to Circuit Breakers used with Electrical Apparatus

The present invention relates to circuit breakers used in conjunction with electrical apparatus connectable to a supply via a supply cable. In particular the invention concerns protection devices adapted to disconnect the power supply from a cable supplying a device in the event of the cable being severed.

Each year a number of people suffer electrocution as a result of picking up the severed end of a supply cable for an electrical device when power is still being supplied to the cable. Various devices are available designed to protect against such accidents. Probably the simplest protection device is a fuse located in the plug on the supply cable of an electrical device. Should the supply cable become severed and the live and neutral conductors contact each other then the resulting current would be sufficient to "blow" the fuse. More recently, protection devices known variously as earth leakage circuit breakers (ELCBs), residual current circuit breakers (RCCBs) or residual current devices (RCDs) have been developed. RCCBs are designed to "trip" on the detection of earth leakage and they are often provided in the plug or an adapter attached to a supply cable of an electrical device or within an in-line-connector on the supply cable. In the event of the supply cable becoming severed and the live conductor contacting the earth conductor the RCCB

would operate.

However, in the case of the cable to an appliance being severed without the live conductor contacting the neutral conductor or earth, neither the circuit fuse or the RCCB will operate (trip), the user is then likely to pick up the severed ends of the live cable and receive a shock between live and neutral. The current through the human body will be insufficient to rupture most fuses and unless the user provides a current path to earth, the RCCB will not operate.

The present invention provides a protection device including trip means operable on detection of the severance of the live conductor or of the neutral conductor when a cable on the load side of the protection device is severed.

The protection device according to the present invention may be provided within a plug or adapter attachable to the supply cable of an electrical appliance which may also be protected by a separate RCCB. Alternatively a composite device may be produced incorporating both the open circuit detection components and an RCCB.

Features and advantages of the present invention will become clear from the following description of embodiments thereof, given by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a diagram showing the electrical components of a first embodiment of the invention in which the open circuit detection components are located in a plug connectable between an RCCB and the supply cable of a portable appliance,

Figure 1a shows the first embodiment used with a capacitor, housed in a socket on the supply cable, for maintaining current in the live and neutral conductors, and

Figure 1b shows an in-line connector which provides an alternative housing for the capacitor for maintaining current in the live and neutral conductors, for use in conjunction with the plug of Figure 1a;

Figure 2 is a circuit diagram of a modification of the first embodiment in which a relay is used in place of a circuit breaker, and an integrated circuit is used in place of an operational amplifier;

Figure 3 is a circuit diagram of a second embodiment of the invention incorporating both the open circuit detection components and RCCB components; and

Figure 4 is a circuit diagram of a modification of the second embodiment in which an integrated circuit is used in place of operational amplifiers.

Referring to Figure 1 it can be seen that the protection device according to a first embodiment of the invention consists of two parts, one part being a plug (1) housing the open-circuit detection circuits and the second part being an appliance socket (10) (shown in Fig. 1a), or in-line connector (20) (shown in Fig. 1b), containing a suitably rated capacitor (2) connected between live and neutral for ensuring that current flows in the live and neutral conductors regardless of whether or not the appliance is energised.

The plug (1) may be plugged directly into a mains supply socket, but preferably is to be plugged into a socket/adapter housing an RCCB which itself is supplied from the mains. The plug (1) shown in Figure 1 is directly connected to one end of the appliance supply cable 8 but could easily be made as an adapter into which a plug attached to the supply cable would be plugged.

The appliance socket (10), or in-line connector (20), is located on the supply cable towards the appliance end so as to enable the detection of severance of the length of cable between the plug (1) and

the appliance socket (10), or in-line connector (20). The capacitor (2) housed in the appliance socket (10), or in-line connector (20), can be replaced for d.c. applications by a resistor or other device, but with a.c. supplies the capacitor is more suitable as it will not require to dissipate heat.

The socket (10) or connector (20) may also incorporate a test device (3) if required, which disconnects the capacitor when pressed and causes this current flow to cease. This can be used to test the protection device while the user is close to it, and before he connects it to his appliance.

Alternatively the test device can be incorporated in the plug (1), but in this case it will be required to carry the full load current of 13 amps and may even be called onto interrupts the full load current, thus it will be a more rugged and costly device.

The plug (or adapter) (1) contains the circuit breaker and detection circuits.

The circuit breaker CB1 consists of a holding coil (4), two normally open contacts CB1/1 and CB1/2 and a push button (5). When the push button (5) is pressed the armature of CB1 is mechanically actuated to the operated position and held by the magnetic flux produced by the current flowing in coil (4), this current is not sufficient to energise the armature to the operated position without mechanical assistance. The push button incorporates a spring loaded member which closes the contacts CB1/1 and CB1/2 when the push button is released.

As the circuit breaker is designed so that the contacts CB1/1 and CB1/2 can only remain closed while the coil (4) is energised and the spring loaded member is holding them closed, interruption of the supply to coil (4) or a short circuit across coil (4) will cause its armature to release and actuate the

spring loaded member, opening the contacts CB1/1 and CB1/2.

A latched circuit breaker could be substituted but the following circuit would require to be reversed such that the circuit breaker coil is energised under trip conditions.

The appliance socket (10), or the connector (20), is permanently wired to the plug (1), and when plugged into a live supply socket current will flow in the live and neutral wires of the appliance cable, the live (or neutral) conductor carrying this current is arranged to flow through a transformer (6) having a secondary winding whose output is connected to the inverting input of an operational amplifier IC1, thus all the time current is flowing to the appliance the operational amplifier output is low and the SCR1 does not trigger.

When the user severs his cable, all current flowing through the transformer will cease and the output of IC1 will go high, triggering the SCR1, shorting the coil of CB1 and releasing the circuit breaker, opening the contacts CB1/1 and CB1/2 isolating the damaged cable.

It should be noted that the circuit breaker CB1 will only energise and hold its contacts closed while current is flowing through this transformer (6).

A modification of the first embodiment is illustrated in Figure 2 where a relay is utilised in place of a circuit breaker.

The relay RL1 is energised when the reset button PB1 is operated transferring the charge of capacitor C1 to the coil of RL1, which energises and closes contacts RL1/1 and RL1/2 enabling current to flow in the live and thus through the transformer (6) either enabling an operational amplifier to trigger an SCR1 or the SCR direct, maintaining current in the

relay RL1 until the cable is severed. When the cable is severed the transformer (6) will no longer have a current flowing through it and thus will cease to cause triggering of the SCR. Since the SCR is conductive for alternate half-cycles only it will switch off, releasing the relay.

A composite device incorporating the open circuit detector and an RCCB is illustrated in Figure 3. It can be seen that the device comprises a conventional RCCB (with a second transformer 7 which acts as a core balance to detect an out of balance current) and open-circuit detection circuit and socket (10), or connector (20), as described for Figure 1.

A further variation is shown in Figure 4 where a custom designed integrated circuit is used incorporating operational amplifiers and diodes of Figure 3.

From the foregoing, it can be seen that personal safety when using portable appliances has been increased many times over the conventional RCCB, covering all cases of cable damage except that of the cable being shaved, exposing both live and neutral conductors which must be grasped at the same time to receive a shock, and may prove fatal if the user is not in contact with earth. This circumstance is considered to be remote and protection against a fatal shock when using protection devices according to the invention approaches 100%.

In a modified embodiment, the capacitor (2), resistor or other device may be incorporated within the appliance (not shown) and in parallel with the appliance switch by Original Equipment Manufacture (O.E.M.), thereby maintaining current at all times power is present. Such an appliance would be suitable for use with or without an O.C.D.P. protection device, and would be able to plug directly into an adaptor provided on plug (1).

CLAIMS:

1. Protection device for connection between an electrical supply and an electrical load, comprising trip means operable on detection of the severance of the live conductor or the neutral conductor on the load side of the protection device.

2. Protection device according to claim 1, and further comprising current maintenance means adapted for connection between a live and a neutral conductor for maintaining current flow in the live and neutral conductors between an electrical supply and the current maintenance means when the protection device is connected to the electrical supply; and detector means adapted for conenction to the live and neutral conductors between the supply and the current maintenance means for detecting current flow in the live and/or the neutral conductor; wherein the trip means is responsive to the output of the detector means for interrupting the supply of electricity to the live and neutral conductors.

3. A protection device according to claim 2, wherein the current maintenance means comprises a capacitor adapted for connection between the live and neutral conductors.

4. A protection device according to claim 2 or 3, wherein the detector means comprises a current transformer arranged either to detect current in the live conductor or to detect current in the neutral conductor.

5. A protection device according to claim 4, wherein the detector means is adapted to output a high signal

when substantially zero current flow is detected, and the interrupting means comprises a silicon controlled rectifier, receiving at its gate the output of the detector means, adapted to conduct when the output of the detector means is said high signal.

6. A protection device according to claim 5, wherein the detector means further comprises an operational amplifier arranged to receive at its inverting input the output from the current transformer.

7. A protection device according to claim 5, wherein the detector means further comprises an integrated circuit arranged to receive the output from the current transformer.

8. A protection device according to claim 5, wherein the interrupting means comprises a circuit breaker arranged to interrupt the supply of electricity from the electrical supply to the live and neutral conductors when the silicon controlled rectifier conducts.

9. A protection device according to claim 5, wherein the interrupting means comprises a relay arranged to interrupt the supply of electricity from the electrical supply to the live and neutral conductors when the silicon controlled rectifier conducts.

10. A protection device according to any one of the preceding claims, and further comprising a residual current circuit breaker.

11. A protection device according to claim 5, wherein the detector means further comprises a core balance transformer adapted to detect an imbalance in the current

flows in the live and neutral conductors, and an or a further operational amplifier arranged to receive the output of the core balance transformer, wherein the output of the detector means is further adapted to output a high signal when an imbalance in the current flows in the live and neutral conductors is detected by the core balance transformer.

12. A protection device according to any one of the preceding claims, and further comprising test means manually actuatable to interrupt current flow in the live and neutralconductors when the protection device is connected to the electrical supply.

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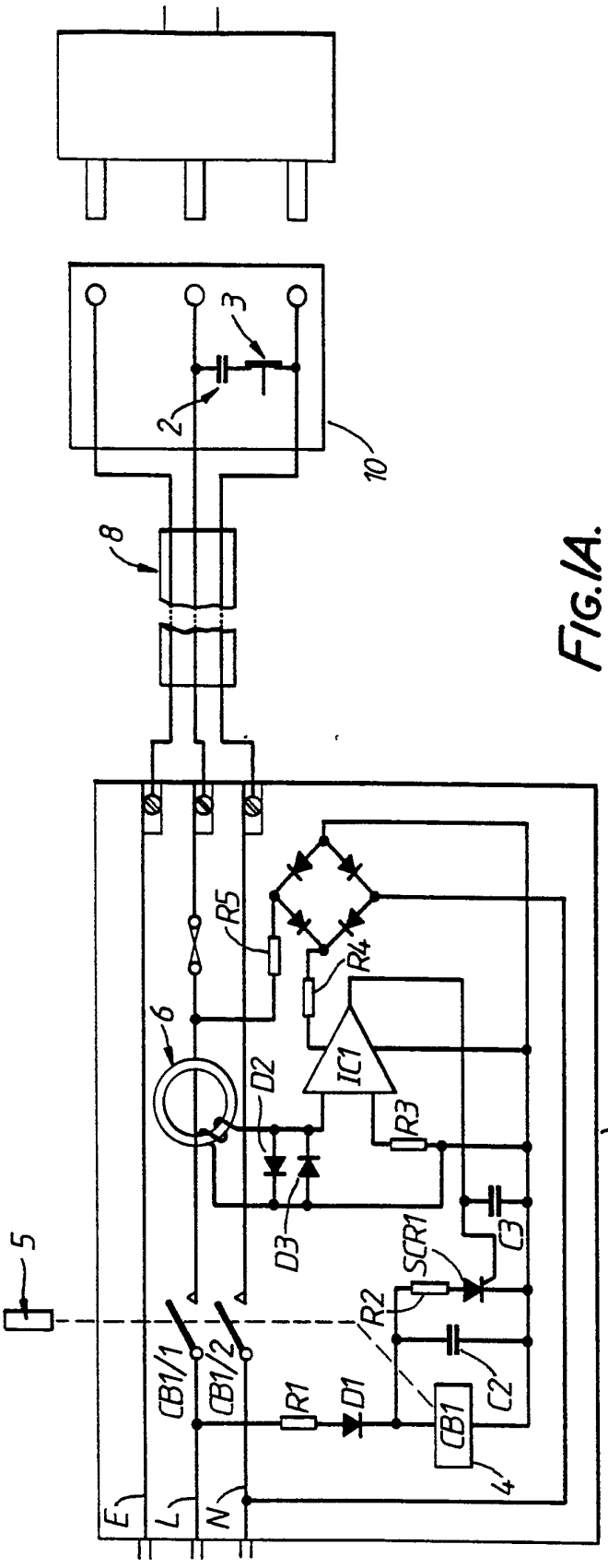

FIG.1A.

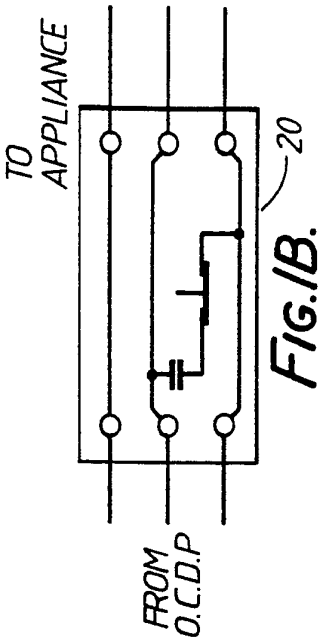

FIG.1B.

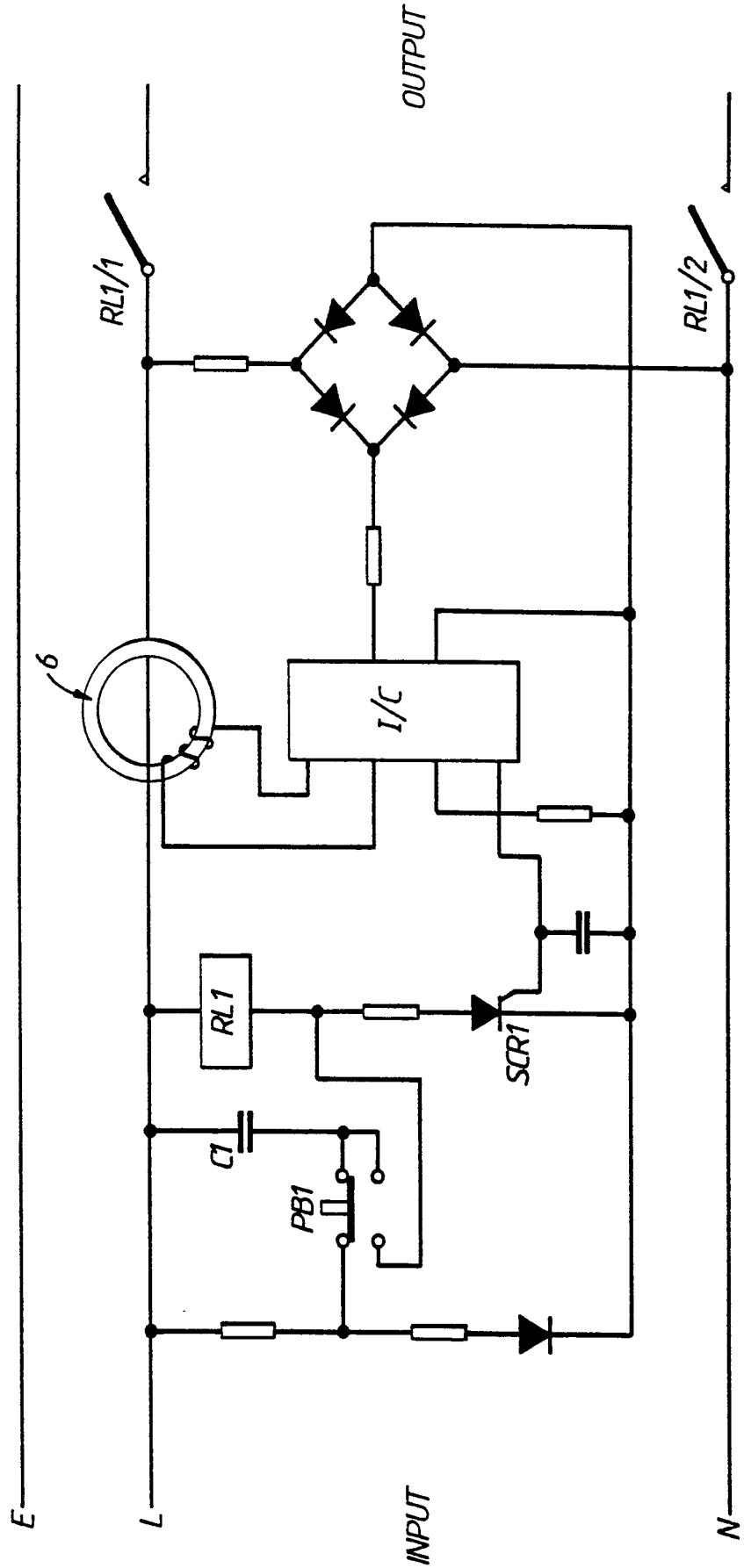

FIG. 2.

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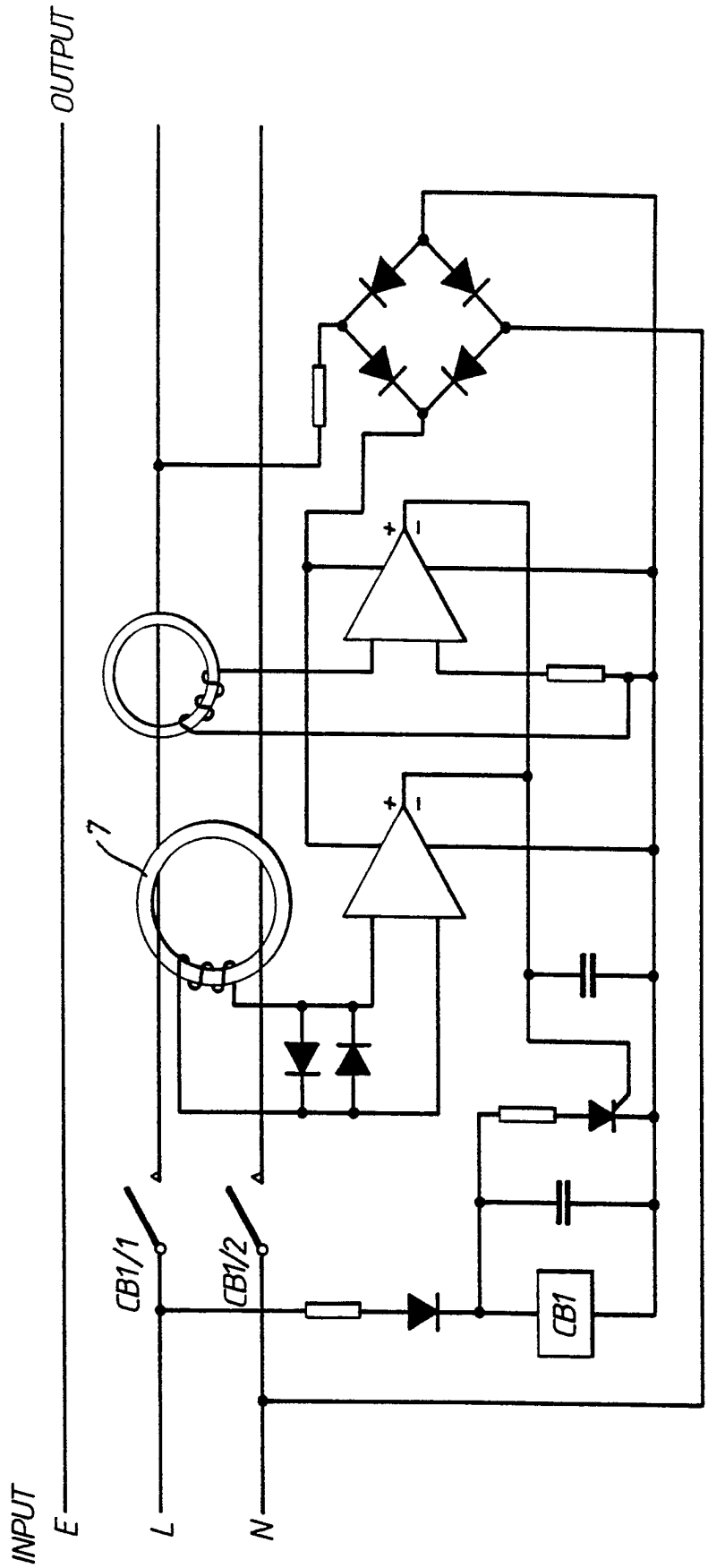

FIG. 3.

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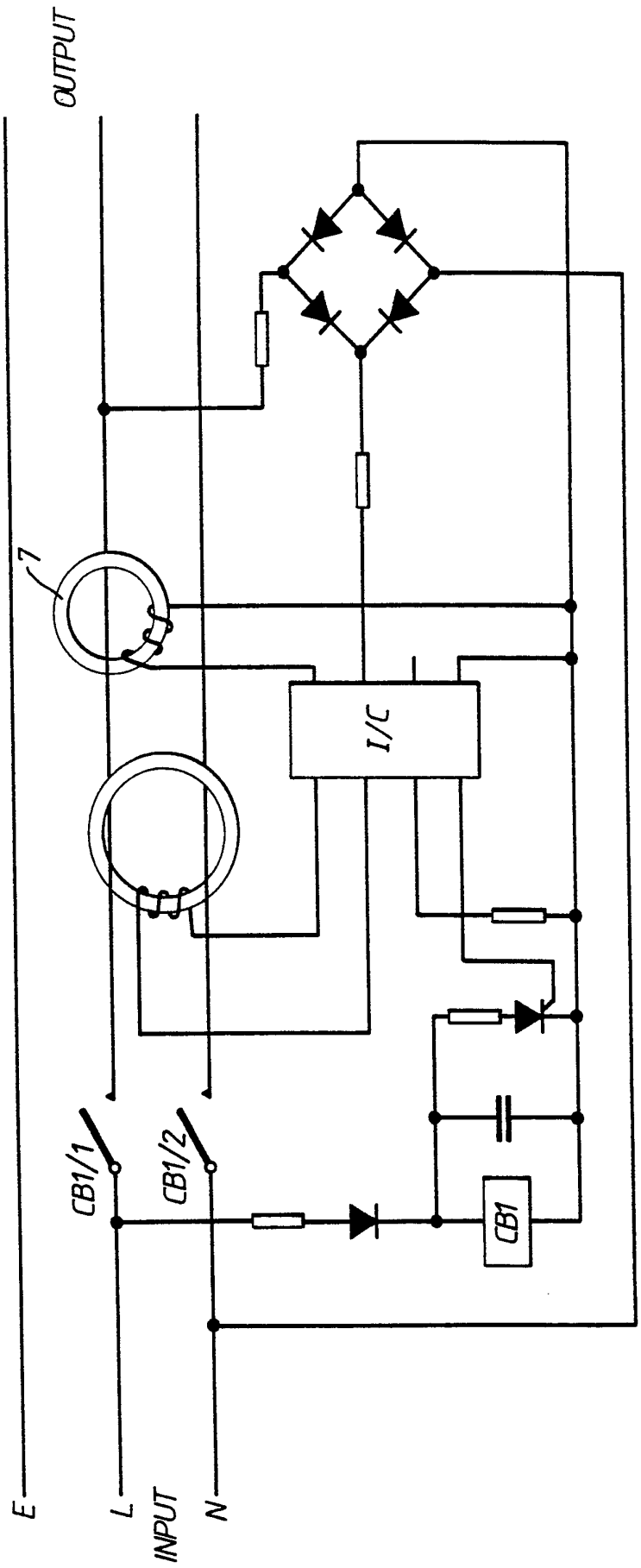

FIG. 4.

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 89/00148

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 H02H5/10

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	H02H ; G01R

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
X	GB,A,2200001 (DURAPLUG ELECTRICALS) 20 July 1988 see page 6, lines 23 - 34	1, 2
Y		3, 12
Y	US,A,4639719 (GENERAL SIGNAL CORPORATION) 27 January 1987 see column 5, lines 12 - 26	3, 12
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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
04 OCTOBER 1989	07. 11. 89
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ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

SA 27485

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB-A-2200001	20-07-88	None	
US-A-4639719	27-01-87	CA-A- 1235458	19-04-88
US-A-4389694	21-06-83	None	