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OMRON CORPORATION
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Claims

1. A current detection unit comprising:
 - an annular core (30) having an air gap (31);
 - a case (10, 20) having a compartment (11, 21) in which said annular core is disposed, and a hole (15) in said case disposed in a position corresponding to said air gap in said annular core;
 - a circuit board (40) mounted on one side of said case, said circuit board having a magnetic-to-electric converter element disposed thereon, said magnetic-to-electric converter being inserted into said air gap of said annular core through said hole in said case; and
 - a coil (36) wound on said annular core, characterized in that
 - said case is comprised of two symmetrical halves (10, 20) adapted to be fitted together, each said half (10, 20) defining an annular compartment (11; 21), said annular compartments forming, as said compartment (11, 21), an annular chamber enclosing said core (30).
2. A current detection unit as claimed in claim 1, wherein said case halves (10, 20) are identical.

CURRENT DETECTION UNIT AND RELAY TERMINAL ARRAYField of The Invention

This invention relates to a current detection unit
for and a relay terminal array capable of detecting failures
and which contains^{ing} a number of current detection units.

Background of The Invention

There are many types of relay terminals, including
relay terminals which are not capable of transmission,
relay terminals with transmitting capability, and I/O
10 relay terminals with, for example, photocoupler input and
transistor output.

Since none of these existing relay terminals is
capable of detecting relay failures (welding of contacts,
faulty contacts, and so on) by themselves, faulty relays
15 are slow to be detected. This delay leads to
inconvenience, such as down time until a new relay can be
installed.

To detect a faulty relay, one could use a logic
circuit which has as its inputs the presence or absence
20 of a load current from the relay and an output signal
from the relay coil. Based on these inputs, the circuit
could judge whether there were a relay fault. With this
proposed circuit however, certain problems can occur:

(1) The range of load current which can be detected
25 is limited;

(2) There are limitations on the shape and
dimensions of the current sensor;

(3) It is difficult to provide adequate isolation
between primary and secondary circuits and among the
30 different poles; and

(4) Such a device cannot be assembled efficiently.

A current detection unit according to the
preamble of claim 1 is known from GB-A-2 279 864.

Summary of The Invention

In light of the problems listed above, this invention has the advantage of providing a ^{current detection unit} ~~relay terminal~~ which is compact and easy to assemble ~~as well as being~~
 5 ~~capable of detecting failures in a compact current~~
~~detection unit~~.

The current detection unit of this invention ^{is as} ~~has an~~
^{defined in claim 1.} ~~annular core with a gap; a case which has a compartment~~
~~to hold the annular core and a hole which corresponds to~~
 10 the location of the air gap in the annular core contained
 in the compartment; a circuit board which is mounted on
 one side of the case and has a magnetic-to-electric
 converter element on it which is inserted into the air
 gap of the annular core through the hole in the case; and
 15 a coil which is wound on the core compartment of the
 case.

The relay terminal array of this invention has a
 housing unit with an open top to hold electronic
 circuitry; a number of current detection units supported
 20 adjacent to each other within the housing unit, each of
 which has an annular core with a gap; a case which has a
 compartment to hold the annular core and a hole which
 corresponds to the location of the air gap in the annular
 core contained in the compartment, a circuit board which
 25 is mounted on one side of the case and has a magnetic-to-
 electric converter element on it which is inserted into
 the air gap of the annular core through the hole in the
 case, and a coil which is wound on the core compartment
 of the case; and an upper case which has terminals to
 30 which one end of each of the coils found on the
 corresponding current detection unit are connected and
 terminals to which the other ends are connected. This
 upper case covers the opening on the top of the housing
 unit and includes a relay installation containing a
 35 ~~number of relays. In summary, the relay terminal array~~

~~of this invention comprises a housing unit, a number of current detection units, and an upper case.~~

The current detection unit operates as follows. When a current flows through the coil wound on the core compartment of the case, lines of magnetic force are generated in the core contained in the compartment. These lines of magnetic force are detected by the magnetic-to-electric converter element placed in the air gap in the core. The magnetic field which is detected is converted to an electrical signal and is output as a signal indicating the presence of a current. When there is no current flowing through the coil, no lines of magnetic force are generated in the core. The magnetic-to-electric converter element does not detect a magnetic field, so a signal indicating the absence of a current is output.

This current detection unit has a core in a compartment provided in a case and a coil which is wound on that compartment. A circuit board which has a current detection circuit featuring a magnetic-to-electric converter element is mounted on one side of the case. The case is comprised of two halves which fit together symmetrically, so it can be assembled merely by joining the halves.

If a relay remains on in the relay terminal array when it should be off, because of a failure such as contact welding or faulty contact, a current will continue to flow in the coil in the current detection unit, and the magnetic field generated in the core will be detected by the magnetic-to-electric converter element as described above. If a relay goes off due to a failure when it should be on, no current will flow in the coil, and the magnetic-to-electric converter element will not detect a magnetic field in the core. The output signal from the magnetic-to-electric converter element in these circumstances is used by a logic circuit to determine,

based on this signal and the on/off state of the relay, that a relay has failed. This result is transmitted to external circuitry.

~~In this relay terminal array, the housing unit~~
5 contains the electronic circuitry as well as a number of the current detection units. The opening on the top of the housing unit is covered by the upper case. Inside the housing unit, a vertical spacer is provided which has vertical partitions between each of at least two current
10 detection units. This provides sufficient isolation of the different poles from one unit to the next, and it prevents external devices from interfering with the
~~current detection units.~~

The current detection unit of this invention
15 achieves the following advantages:

(1) The current flowing through a circuit flows through a coil so that it can be detected as a magnetic field by a magnetic-to-electric converter element. This scheme insures that the current in the coil will be
20 detected reliably. ^{When} ~~Since~~ this detection device is built into a relay terminal array, failures of relays can be detected reliably by a logic circuit;

(2) The spatial relationship between the magnetic-to-electric converter element and the core is firmly
25 fixed during assembly;

(3) Sufficient isolation is provided between the primary and secondary elements;

(4) The device can be assembled efficiently. Since the case is composed of two symmetrical halves, it can be
30 assembled merely by fitting two pieces together, a highly efficient mode of assembly; and

(5) The configuration of this invention allows the unit to be assembled easily and enables it to be made more compact.

~~The relay terminal array of this invention contains~~
a number of the current detection units and provides the following advantages:

- 5 (1) A logic circuit swiftly and reliably detects the failure of a relay based on the presence or absence of a current detected by the current detection unit, and on the on/off status of the relay. This allows a failure to be responded to quickly;
- (2) Each current detection unit, and indeed the
10 entire device, is easy to assemble;
- (3) Since all components are arranged compactly, the terminal unit itself is compact;
- (4) The partitions in the spacer ensure that there is adequate isolation between different poles of adjacent
15 current detection units; and
- (5) The partitions in the spacer prevent interference from external sources from reaching the
~~current detection units.~~

Brief Description of The Drawings

20 Fig. 1 is a partial exploded perspective view of the current detection unit of this invention; and

Fig. 2 is a partial exploded perspective view of the current detection unit pictured in Fig. 1x.

~~Fig. 3 is a perspective view of the exterior of the~~
25 relay terminal array of this invention;

Fig. 4 is a perspective view of the exterior of the housing unit on the relay terminal array pictured in Fig. 3;

Fig. 5 is a partial exploded perspective view
30 focusing on the spacers in the relay terminal array pictured in Fig. 3;

Fig. 6 is a partial exploded perspective view focusing on the current detection units in the relay
~~terminal array pictured in Fig. 3; and~~

~~Fig. 7 is a partial exploded perspective view focusing on the upper case in the relay terminal array pictured in Fig. 3.~~

Detailed Description Of The Invention

5 An example of a current detection unit is shown in exterior oblique view in Fig. 1 and in partial exploded oblique view in Fig. 2 . Current detection unit 1 has two bobbins (half cases) 10, 20. Bobbins 10, 20 fit together symmetrically and contain core compartments 11, 10 21, respectively. Compartments 11, 21 form an annular chamber into which the core is inserted. The top halves of the compartments protrude from bobbins 10, 20. Annular core 30, which is contained in compartments 11, 15 21, has a partially isolating air gap 31 in it.

15 The inner side of bobbin 10 has a snap fitting 12 and a boss 13 on it. Bobbin 20 has a depression 22 which corresponds to snap fitting 12 and a hole 23 into which boss 13 fits.

20 Circuit board 40 is mounted to the outside of bobbin 10 by means of self-tapping screws 42 which are inserted through holes 43 in circuit board 40 and holes 14, 24 in bobbins 10, 20. A single Hall element 41 is mounted on the inside of circuit board 40, the side facing the bobbin. This is the magnetic-to-electric converter 25 element which detects the magnetic field generated in core 30 and converts it to an electrical signal. Since circuit board 40 is mounted on the outer side of bobbin 10, Hall element 41 can pass through hole 15, through air gap 31 in core 30, and partially penetrate hole 25 in 30 bobbin 20. This configuration allows Hall element 41 to detect with certainty the lines of magnetic force generated in core 30. On the front of circuit board 40 is the current detection circuit, which comprises various electronic components. In the relay terminal array,

circuit board 40 is connected to another circuit board 40
(see Fig. 6) through connectors 45.

Magnet wire 35 is wound a predetermined number of
turns on compartments 11, 21 of bobbins 10, 20 to produce
5 coil 36. In one aspect of the invention, coil 36 is
wound starting from the top and ending at the top, so
that both halves are wound in the same direction.

In a current detection unit 1 configured in this
way, core 30 is enclosed in compartments 11, 21 of
10 bobbins 10, 20. When bobbins 10, 20 are joined, snap
fitting 12 on bobbin 10 engages with depression 22 on
bobbin 20 and boss 13 on bobbin 10 goes into hole 23 in
bobbin 20. In this way bobbins 10, 20 are formed into an
integral unit. Circuit board 40 is mounted on the side
15 of bobbin 10. When coil 36 is wound and placed in
compartments 11, 21, the assembly is complete.

In the configuration described above, Hall element
41 is easily and reliably positioned in air gap 31 of
core 30 at the time of assembly. This insures that the
20 spatial relationship between Hall element 41 and core 30
will remain fixed. It also guarantees a sufficient
isolation distance between the primary and secondary
circuits and improves the efficiency of the entire
assembly process.

25 The operation of current detection unit 1 is
described below. When a current flows through coil 36,
lines of magnetic force are generated in core 30 inside
compartments 11, 21. These lines of magnetic force are
detected by Hall element 41 in air gap 31 and converted
30 to an electrical signal. A signal indicating the
presence of a current is output by the current detection
circuit. When there is no current flowing through coil
36, no magnetic field is generated in core 30. Hall
element 41 does not detect a magnetic field, and a signal
35 indicating the absence of a current is output.