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⑤④ **Residual current devices.**

⑤⑦ An RCD comprises a current-monitoring system or device including an electro-mechanical release means adapted to actuate a circuit-breaking mechanism upon current imbalance. The electro-mechanical release means comprises a re-setting motor, whereof the rotary output shaft is provided with a cam or ramp surface to engage with a release flag adapted to act on a latch to release a switch mechanism of the RCD. Stationary poles of the re-setting motor are formed with an extension having an aperture through which conductors connecting a power supply to a load can pass.

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RESIDUAL CURRENT DEVICES

This invention relates to residual current devices (hereinafter and in the claims for convenience called "RCD"), an example of which is a residual current circuit breaker.

An RCD, as is well known to those skilled in the art, incorporates a current-monitoring system or device which monitors the currents passing through a plurality of conductors connecting a power supply to a load. Provided the currents passing through an RCD, in closed circuit condition, are in balance then the current-monitoring system or device is inoperative. An imbalance of currents in an RCD causes the current-monitoring system or device to operate an electro-mechanical release means to render the RCD into a circuit-breaking condition. The present invention is particularly concerned with such release means.

The current differential in an RCD necessary to attain the circuit-breaking condition is extremely small as is well known, say 20 to 30 milli-Amps for example, with a balanced current of the order of 100 Amps for example.

The current monitoring system or device of an RCD generally comprises a toroidal core with a primary winding formed by the main circuit conductors and a secondary winding providing a signal to the electro-mechanical release means. This electro-mechanical release means is generally a form of relay, the armature of which is normally held closed by the magnetic flux from a permanent magnet. When the signal from the current-monitoring system or device exceeds a predetermined level it causes the flux to be diverted other than through the armature which is then released and moves to an open position under the action of a spring. This movement is utilised to operate a latch to release a switch mechanism thereby opening the contacts of the RCD.

The use of a separate toroidal core with windings connected to a release relay suffers from a number of disadvantages. These are:-

1. The winding process for toroidal components is difficult and expensive; this may apply both to the toroid itself and to the relay.

2. It is not always easy to obtain a sufficiently accurate match between the output impedance of the toroid and the input impedance of the relay. Consequently the transfer of energy between the two components is inefficient.

3. The form of output energy to the toroidal current monitoring device is electrical while the desired output is mechanical. It is not very efficient to convert energy from electrical to magnetic, back to electrical, and then to magnetic again, before finally converting to mechanical as occurs with

most present current monitoring devices. Each time energy is converted from one form to another losses occur and efficiency is reduced. It must also be borne in mind that the amount of energy which can be readily extracted from the small imbalance current of, say, 20 to 30 mA which it is desired to detect is very low.

4. In conventional RCDs where a wound toroid drives an electro mechanical release, the current monitoring system or device is inherently sensitive only to alternating currents and special measures have to be taken to produce a satisfactory response to any form of direct current such as smooth d.c. or pulsating d.c. obtained from rectification of alternating current. This latter condition can occur with certain types of equipment containing semi-conductor devices.

It is a general object of the present invention to obviate or mitigate these disadvantages.

Before defining and describing an RCD according to the present invention we draw attention to our pending PCT application No. GB88/00210 file March 18, 1988 which describes and claims an RCD, in particular a residual current circuit breaker (hereinafter for convenience called "RCCB"). In said PCT application there is disclosed an RCB comprising a current-monitoring system or device including an electro-mechanical release means adapted to actuate a circuit-breaking operating mechanism upon current imbalance, the electro-mechanical release means being a re-setting motor, the rotary output shaft of which is provided with a cam or ramp surface to engage with a release flag which acts on a latch to release the switch mechanism of the RCCB.

It is a specific object of the present invention to provide an RCD employing a re-setting motor as its electro-mechanical release means and which is more economic and simpler to manufacture than the RCCB of our aforesaid PCT application.

According to the present invention there is provided an RCD comprising a current-monitoring system or device including an electro-mechanical release means adapted to actuate a circuit-breaking mechanism upon current imbalance and comprising a re-setting motor, whereof the rotary output shaft is provided with a cam or ramp surface to engage with a release flag adapted to act on a latch to release a switch mechanism of the RCD, stationary poles of the re-setting motor being formed with an extension having an aperture through which conductors connecting a power supply to a load can pass.

Preferably the stationary poles are spaced axially along the re-setting motor shaft on which is

mounted a rotor disc of permanent magnet material having alternate North, South magnetic poles on the faces of the disc, and so arranged that the presence of an axial magnetic flux between the stationary poles cause the disc to align in a stable relationship to the stationary poles.

Preferably the axial flux is provided by a permanent magnet located at the opposite side of the aperture for the main conductors from the motor shaft and the pole pieces are spaced apart by a non-magnetic spacer to prevent excessive flux leakage.

Preferably also each pole extension has regions of reduced cross section carrying magnetic flux due to the imbalance current in the conductors and is so arranged that when the magnetic flux in them is sufficient to cause them to saturate, the re-setting motor is effectively cut off magnetically from the permanent magnet, and the rotor disc can move to take up a position such that the magnetic poles on its disc rotor lie in a position of least reluctance.

Preferably the pole extensions have a portion at right angles to that containing the apertures so that the permanent magnet may seat thereon, each right angled part extending axially in opposite directions.

Preferably, the arrangement of re-setting motor, brackets and spacer are enclosed in a two-part electrically insulated casing apertured for passage of the current-carrying conductors and configured to provide a seat for the magnet below the said arrangement at the diametrically-opposed side of the apertures through which the current-carrying conductors extend.

Preferably, the magnet is provided with a slot, or other female or male formation, exposed by an opening in the casing to permit the magnet to be rotated by a screwdriver, or other convenient tool or manually, to adjust the release point or trip level of the RCD.

The present invention is also the electro-mechanical release means for an RCD as defined in the preceding paragraphs.

An embodiment of the present invention will now be described, by way of example, with reference to the accompanying drawing which is an exploded view of the electro-mechanical release means for an RCD.

The electro-mechanical release means for the RCD comprises a two part moulded insulated casing, the parts being designated 10 and 11.

Each casing part 10 or 11 is provided with a generally centrally disposed circular aperture 12. Above each aperture 12 there is provided a circular recessed region 13 formed with a central circular aperture 14.

Below each aperture 12 each casing part 10 or

11 is provided with a semi-cylindrical seating region 15.

The casing parts 10, 11 are provided with appropriate interengaging formations 17 and screw or bolt holes 18 to permit the casing parts 10, 11 to be secured together.

Within the assembled casing 10, 11 there is suitably mounted above the seating regions 15 an arrangement of a re-setting motor, magnetic brackets and a non-magnetic spacer which arrangement is indicated by the general reference 19.

The re-setting motor is housed in the circular recessed regions 13 and comprises a rotor disc 20 of permanent magnet material having magnetic poles on each rotor disc surface arranged N,S,N,S and preferably disposed so that each N is opposite an S on the other face of the rotor disc 20 which mounts in a centre piece 21, an output shaft 22 which extends out of aperture 14.

The rotor disc 20 is disposed above a non-magnetic spacer 23.

At each side of the non-magnetic spacer 23 there is disposed an L-shaped bracket 24 of permeable magnetic material at the top of which is incorporated a multiple pole assembly 25 of the re-setting motor. Each bracket 24 has apertures 26 so disposed that the remaining section 24A. of permeable magnetic material is capable of being saturated by the combination of magnetic fields due to a permanent magnet 27 and the imbalance of conductors 28 which pass through the apertures 26.

The brackets 24, spacer 23 and re-setting motor components are suitably clamped together, bearing inserts 30 being fitted within the multiple pole assemblies.

The output shaft 22 at one end is provided with a ramp or cam surface 22A as indicated.

The spacer 23 is formed with a generally centrally located circular aperture 29 which, together with apertures 26, are aligned with the apertures 12 in the casing parts 10, 11.

The horizontal limbs 24B of the brackets 24 extend in opposite directions and lie above the semi-cylindrical seating regions 15 which in the assembled casing 10, 11 form a cylindrical seating and receive and locate the permanent magnet 27 which is formed with a slot 32. The slot 32 is exposed through an opening in the bottom of the assembled casing 10, 11.

The slot 32 can be engaged by a screwdriver to adjust the release point or trip level of the RCD of which the electro-mechanical release means forms part.

The RCD has not been illustrated or described in detail other than the references in the opening paragraphs of the specification since the construction and functioning of RCDs are well known to

those skilled in the art.

In the detail views of the drawing, however, there is shown the output shaft 22 of the re-setting motor which is indicated in these views at 33, the cam or ramp surface of the shaft 22 being indicated as aforesaid, at 22A.

The cammed or ramped end 22A of the output shaft 22 cooperates with a release flag 34 of generally quadrant shape which is pivoted on a spindle 35 secured to a support plate (not shown).

The release flag 34 has a curved peripheral side formed with a release detent 36 with which the end 22A of the output shaft 22 co-acts.

The release flag 34 at its pivot end has an actuating and release surface 37 for co-acting with a release lever 38.

A spring 39 supported by the spindle 34 has an active arm 40 engaging the release flag 34 to urge the latter against the end 28 of the output shaft 22.

The conductors 28 carry the current to be monitored and connect a power output to a load, and these pass through the aligned apertures 12, 26 and 29 of the electro-mechanical release means.

When the current flowing through the conductors 28 is in-balance the electro-mechanical release means is inactive.

When however a signal from the current monitoring system of the RCD exceeds a predetermined level the resulting flux together with that from the magnet 27, through the intermediary of the magnetic brackets 24, causes one or more of the regions 24A adjacent to the apertures 26 to saturate thus effectively cutting off the rotor disc 20 from the action of the permanent magnet 27 thus causing it to "step" rotationally to align the ramp or cam face 22A of the shaft 22 with the release detent 36 which allows the release flag 34 to pivot, under spring action, against the cam or ramp face 28 thus causing the actuating and reset surface 37 to urge the release lever 38 from position A to position B which, as usual, causes the contacts (not shown) of the RCD to be thrown to the "off" position.

The electro-mechanical release means of the present invention has a low manufacturing cost and is simple to construct in that it does not involve the provision of any windings, thus simplifying the assembly. It is also responsive not only to alternating current but to direct current.

Claims

1. An RCD comprising a current-monitoring system or device including an electro-mechanical release means adapted to actuate a circuit-break-

ing mechanism upon current imbalance and comprising a re-setting motor, whereof the rotary output shaft is provided with a cam or ramp surface to engage with a release flag adapted to act on a latch to release a switch mechanism of the RCD, stationary poles of the re-setting motor being formed with an extension having an aperture through which conductors connecting a power supply to a load can pass.

2. An RCD as claimed in claim 1, in which the stationary poles are spaced axially along the re-setting motor shaft on which is mounted a rotor disc of permanent magnet material having alternate North, South magnetic poles on the faces of the disc, and so arranged that the presence of an axial magnetic flux between the stationary poles cause the disc to align in a stable relationship to the stationary poles.

3. An RCD as claimed in claim 2, in which the axial flux is provided by a permanent magnet located at the opposite side of the aperture for the main conductors from the motor shaft and the pole pieces are spaced apart by a non-magnetic spacer to prevent excessive flux leakage.

4. An RCD as claimed in any one of claims 1 to 3, in which each pole extension has regions of reduced cross section carrying magnetic flux due to the imbalance current in the conductors and is so arranged that when the magnetic flux in them is sufficient to cause them to saturate, the re-setting motor is effectively cut off magnetically from the permanent magnet, and the rotor disc can move to take up a position such that the magnetic poles on its disc rotor lie in a position of least reluctance.

5. An RCD as claimed in claim 3 or 4, in which the pole extensions have a portion at right angles to that containing the apertures so that the permanent magnet may seat thereon, each right angled part extending axially in opposite directions.

6. An RCD as claimed in any one of claims 3 to 5, in which the arrangement of re-setting motor, brackets and spacer are enclosed in a two-part electrically insulated casing apertured for passage of the current-carrying conductors and configured to provide a seat for the magnet below the said arrangement at the diametrically-opposed side of the apertures through which the current-carrying conductors extend.

7. An RCD as claimed in any one of claims 3 to 6, in which the magnet is provided with a slot, or other female or male formation, exposed by an opening in the casing to permit the magnet to be rotated by a screwdriver, or other convenient tool or manually, to adjust the release point or trip level of the RCD.

8. An electro-mechanical release means for an RCD comprising a current-monitoring system or device and a circuit-breaking mechanism adapted

to be actuated by the electro-mechanical release means upon occurrence of a current imbalance within the RCD, the electro-mechanical release means comprising a re-setting motor, whereof the rotary output shaft is provided with a cam or ramp surface adapted to engage with a release flag adapted to act on a latch to release a switch mechanism of the RCD, stationary poles of the re-setting motor being formed with an extension having an aperture through which conductors connecting a power supply to a load can pass.

9. An electro-mechanical release means as claimed in claim 8, in which the stationary poles are spaced axially along the re-setting motor shaft on which is mounted a rotor disc of permanent magnet material having alternate North, South magnetic poles on the faces of the disc, and so arranged that the presence of an axial magnetic flux between the stationary poles cause the disc to align in a stable relationship to the stationary poles.

10. An electro-mechanical release means as claimed in claim 9, in which the axial flux is provided by a permanent magnet located at the opposite side of the aperture for the main conductors from the motor shaft and the pole pieces are spaced apart by a non-magnetic spacer to prevent excessive flux leakage.

11. An electro-mechanical release means as claimed in any one of claims 8 to 10, in which each pole extension has regions of reduced cross section carrying magnetic flux due to the imbalance current in the conductors and is so arranged that when the magnetic flux in them is sufficient to cause them to saturate, the re-setting motor is effectively cut off magnetically from the permanent magnet, and the rotor disc can move to take up a position such that the magnetic poles on its disc rotor lie in a position of least reluctance.

12. An electro-mechanical release means as claimed in claim 10 or 11, in which the pole extensions have a portion at right angles to that containing the apertures so that the permanent magnet may seat thereon, each right angled part extending axially in opposite directions.

13. An electro-mechanical release means as claimed in any one of claims 10 to 12 in which the arrangement of re-setting motor, brackets and spacer are enclosed in a two-part electrically insulated casing apertured for passage of the current-carrying conductors and configured to provide a seat for the magnet below the said arrangement at the diametrically-opposed side of the apertures through which the current-carrying conductors extend.

14. An electro-mechanical release means as claimed in claims 10 to 13 in which the magnet is provided with a slot, or other female or male formation, exposed by an opening in the casing to permit

the magnet to be rotated by a screwdriver, or other convenient tool or manually, to adjust the release point or trip level of the RCD.

