

An apparatus and method for testing circuit breakers

The present invention relates to an apparatus and method for testing circuit breakers, and in particular, for testing Residual Current Devices (RCD's), otherwise known as Residual Current Circuit Breakers (RCCB's) or "safety switches".

5 BACKGROUND OF THE INVENTION

Residual current circuit breakers operate to disconnect their circuit when they detect that current leaking out of the circuit, such as current leaking to earth through a ground fault for example, exceeds safety limits. Such devices are intended to operate quickly so that when a person contacts a live wire, the circuit is isolated
10 before electric shock can drive the heart into ventricular fibrillation, the most common cause of death in such circumstances. Most RCD's are designed to trip when a current of 30 mA (milliamps) over 300 ms (milliseconds) is detected.

Because RCD's are important in saving people's lives, their integrity is required to be tested on a regular basis. Typically, RCD's have inbuilt testing circuits.
15 These generally require that a user push and hold a button on the RCD which bleeds off 30 mA either over the period of time the button is pressed or until the circuit is tripped. In Australia, RCD manufacturers typically require that this "push-button" test be performed monthly in the case of fixed equipment and in the case of portable equipment, each time the equipment is used. Australian Occupational Health and
20 Safety (OH&S) Regulations recommend that the "push-button" test be performed every 6 months. In other jurisdictions around the world, recommendations and regulations may differ.

Although the inbuilt "push-button" test is effective in 'trip' testing the RCD, it does not incorporate a 'no trip' test which is a test often performed in the industry to
25 ensure that an RCD does not trip when a current below 30 mA is detected. Currently, there exists portable test equipment capable of performing both of these tests, however, there are a number of drawbacks associated with such equipment, including the following:

- The 'trip' and 'no trip' tests on existing test equipment need to be performed
30 separately, requiring a manual changeover.
- Existing test equipment is currently designed and adapted for use in multiple jurisdictions around the world, and are quite large and cumbersome units.

- They incorporate selections and tests that are not appropriate in individual jurisdictions, such as those required only in Australia and New Zealand for example. This unnecessarily increases the size of the equipment, and increases its complexity and cost. An operator may mistakenly or ignorantly use the equipment on the wrong scale or even perform the wrong test;
- Existing test equipment is known to be quite inaccurate, particularly in situations where the test current varies. For example, such equipment is typically designed for use at 240 V (volts). When dealing with voltages higher or lower than 240 V, such as 220 V or 250 V as is the case in some countries, the current through the test equipment is different and the equipment therefore becomes inaccurate. A similar situation results when multiple tests are performed in a row. The resistor heats up and the resistance changes the test current. Therefore, existing test equipment which is susceptible to thermal change often produce inaccurate test results also; and
- Existing test equipment lack the versatility of being able to test a RCD of any current rating on the same unit. Also, existing test equipment lack the capability to test the actual tripping current of the RCD.

It is therefore an object of the present invention to provide an apparatus and method for testing a circuit breaker such as an RCD which overcomes at least some of the aforementioned problems or provides the public with a useful alternative.

SUMMARY OF THE INVENTION

Therefore in one form of the invention there is proposed an apparatus for testing a circuit breaker connected to a circuit having at least an active and an earth, said apparatus including:

a means to perform a first test and a second test on the circuit breaker, said first test being to determine whether the circuit breaker will trip when a first predetermined current is leaked from active to earth and said second test being to determine whether the circuit breaker will trip when a second predetermined current is leaked from active to earth, whereby said first and second tests are carried out in sequence, and wherein the circuit breaker does not trip during the first test, the said second test is automatically initiated.

In preference said first predetermined current is below a predetermined safety threshold, and said second predetermined current is equivalent to the predetermined safety threshold.

In preference said apparatus includes a means to perform a third test, whereby said third test being to determine the actual tripping current required to trip said circuit breaker when the actual tripping current is leaked from active to earth.

In preference said apparatus includes a means to select said predetermined current independent of said predetermined safety threshold.

Therefore the apparatus is configured to perform a first test on a circuit breaker to determine whether it will trip prematurely, that is, when current leaking out of the circuit is at a level below a known safety threshold, and a second test to determine whether the circuit breaker will trip when required, that is, when current leaking out of the circuit is at a level equivalent to a known safety threshold.

Preferably the predetermined safety threshold is 30 milliamps.

Preferably the apparatus is adapted to be connected to active, neutral and earth of the circuit at a point downstream of the circuit breaker.

In preference said first test is carried out over a first predetermined period of time.

Preferably said first predetermined level of current is 15 milliamps and said first predetermined period of time is 1 second.

In preference the apparatus includes a display means adapted to display information associated with said first test, second test, third test and said selected predetermined current.

Preferably if the circuit breaker trips during the first test, the time taken for the circuit breaker to trip is displayed on the display means.

In preference said second test is carried out over a second predetermined period of time.

Preferably the second predetermined level of current is 30 milliamps and said second predetermined period of time is 1 second.

In preference if the circuit breaker does trip within 300 milliseconds, the test passes and this indicates that the circuit breaker is functioning correctly and the time taken for the circuit breaker to trip is displayed on the display means.

5 Preferably if the circuit breaker does not trip within 300 milliseconds, the test fails.

In preference if the circuit breaker trips between 300 milliseconds and 1 second, the test fails and the time taken for the circuit breaker to trip is displayed on the display means.

10 Preferably if the circuit breaker does not trip after 1 second, the apparatus is automatically deactivated.

In a further form of the invention there is proposed a method of testing a circuit breaker of the type adapted to be tripped when a threshold current leaks from an associated circuit having an active, a neutral and an earth, said method comprising the following steps:

- 15 (a) performing a first test wherein a first predetermined level of current is leaked from active to earth, said first predetermined level of current being less than the threshold current adapted to trip the circuit breaker;
- (b) performing a second test wherein a second predetermined level of current is leaked from active to earth, said second predetermined level of current being
- 20 equivalent to the threshold current adapted to trip the circuit breaker.

In a yet further form of the invention there is proposed a method of testing a residual current circuit breaker of the type adapted to be tripped when it detects a current of approximately 30 milliamps leaking from active to earth in the circuit, said method comprising the following steps:

- 25 (a) performing a first test wherein a 15 milliamp test current is leaked from active to earth over 1 second;
- (b) detecting whether the circuit breaker is tripped during the first test;
- (c) if the circuit breaker is tripped during the first test, indicating that the first test has failed and the time taken for the circuit breaker to trip;
- 30 (d) if the circuit breaker is not tripped during the first test, indicating that the first test has passed, and performing a second test wherein a 30 milliamp test current is leaked from active to earth over 1 second;
- (e) detecting whether the circuit breaker is tripped during the second test;

- (f) if the circuit breaker is tripped within 300 milliseconds, indicating that the second test has passed and the time taken for the circuit breaker to trip;
- (g) if the circuit breaker is tripped after 300 milliseconds but before 1 second, indicating that the second test has failed and the time taken for the circuit breaker to trip; and
- (h) if the circuit breaker is not tripped during the second test, indicating that the test has failed.

In a yet further form of the invention there is proposed a method of testing a circuit breaker of the type adapted to be tripped when a threshold current leaks from an associated circuit having an active, a neutral and an earth, said method comprising the following steps:

- (a) performing a third test wherein a test current is leaked from active to earth increasingly until the circuit breaker is tripped;
- (b) the test current stops increasing when the circuit breaker is tripped and is retained for several seconds or until the circuit breaker is reset; and
- (c) the test current retained is displayed on a display means.

In a yet further form of the invention there is proposed a method of testing a residual current circuit breaker of the type adapted to be tripped when it detects a current of approximately the rated current leaking from active to earth in the circuit, said method comprising the following steps:

- (a) selecting a current without tripping the circuit breaker, whereby the selected current is generally the rated current of the circuit breaker
- (b) performing a first test wherein a test current half the selected current is leaked from active to earth over 1 second;
- (c) detecting whether the circuit breaker is tripped during the first test;
- (d) if the circuit breaker is tripped during the first test, indicating that the first test has failed and the time taken for the circuit breaker to trip;
- (e) if the circuit breaker is not tripped during the first test, indicating that the first test has passed, and performing a second test wherein a 30 milliamp test current is leaked from active to earth over 1 second;
- (f) detecting whether the circuit breaker is tripped during the second test;
- (g) if the circuit breaker is tripped within 300 milliseconds, indicating that the second test has passed and the time taken for the circuit breaker to trip;
- (h) if the circuit breaker is tripped after 300 milliseconds but before 1 second,

indicating that the second test has failed and the time taken for the circuit breaker to trip; and

(i) if the circuit breaker is not tripped during the second test, indicating that the test has failed.

5 BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate several implementations of the invention and, together with the description, serve to explain the advantages and principles of the invention. In the drawings:

- 10 Figure 1 illustrates an apparatus for testing circuit breakers in accordance with the present invention, including a standard IEC lead on its front face adapted for use in multiple jurisdictions;
- Figure 2 illustrates an apparatus for testing circuit breakers in accordance with the present invention, including a male 3-pin plug on its front face
15 adapted for use in Australia and New Zealand;
- Figure 3 illustrates a circuit diagram associated with the apparatus of Figures 1 and 2; and
- Figure 4 illustrates a logic diagram associated with the apparatus of Figures 1 and 2.

20 DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following detailed description of the invention refers to the accompanying drawings. Although the description includes exemplary embodiments, other embodiments are possible, and changes may be made to the embodiments described without departing from the spirit and scope of the invention. Wherever
25 possible, the same reference numbers will be used throughout the embodiments and the following description to refer to the same and like parts.

The present invention relates to an apparatus 10 used to perform various integrity tests on a circuit breaker device such as a Residual Current Device (RCD). Many homes across Australia have an installed safety switch device which when
30 tripped, isolates the electrical circuit across the house and prevents the person at risk from being electrocuted. An example in which this may occur is where a person

contacts a live wire downstream of the safety switch. Although the following description specifically refers to RCD's, it is to be understood that the apparatus 10 of the present invention may be used to test other similar circuit breaker devices.

The apparatus 10 is illustrated in Figure 1 and comprises a housing 12 in the shape of a rectangular box including on its upper face 14, a 3-digit digital display 16, three light-emitting diodes (LED's) 18, 20 and 22, a push-button 24, and a rocker switch 25. In a further envisaged embodiment of the invention, the three LED's 18, 20 and 22 could be replaced by a LCD display means or another means of display. Shown in Figure 1 is the rocker switch 25 in position one of four, allowing for the trip and no trip RCD tests to be carried out. The selection means, shown in this embodiment as a rocker switch 25, could have a plurality of positions or include an alternate method of selection. Positions two, three and four allow the actual tripping current to be determined, the tripping time at a preset current and the ability to preset the current. These tests are to be discussed in more detail further in the description.

On the front face 26 of the housing 12 is a male IEC lead 28 comprising active 30, neutral 32 and earth 34 pins. The apparatus 10 is adapted to be connected to mains power through IEC lead 28. As those skilled in the art would be aware, IEC leads are useful in that they are recognised and used across multiple jurisdictions. The apparatus 10 may therefore be connected to a conventional wall socket (not shown) in a particular jurisdiction using a standard connecting cord (not shown) having one end adapted to engage the male IEC lead 28 and an opposed end adapted to engage the wall socket.

Alternatively, the apparatus may be constructed for use in individual countries. For example, the apparatus 34 shown in Figure 2 includes a male 3-pin plug 36 on its front face 26 which is common to Australia and New Zealand, allowing the apparatus 10 to be plugged directly into a wall socket (not shown) in those countries without the use of connecting cords. The components of apparatus 34 shown in Figure 2 that are the same or similar to the components of apparatus 10 in Figure 1 are indicated by the same reference numerals. For example, the active 30, neutral 32 and earth 34 pins of both the IEC lead 28 and the 3-pin male plug 36 are indicated by the same reference numerals.

The apparatus 10 is adapted to be connected to mains power downstream of the RCD (not shown) under test. As can be seen in the circuit diagram of Figure 3, the apparatus 10 comprises two primary circuits, an internal charging circuit 38, and a testing circuit 40 which provides for both the 'no trip' (15 mA) and 'trip' (30 mA)

tests to be carried out in sequence when the rocker switch 25 is in position one. Each test is described below.

The internal charging circuit 38 is used to charge capacitor 42 across active 30 and neutral 32 wires to 5 V so that electronic components such as the digital display 16 and LED's 18, 20 and 22 may be powered. Some of the electrical componentry in Figure 3, such as photorelay 44, fuse 45, octocouplers 46 and 48, and bridge rectifiers 50 and 52 are not described here in any detail in that they are relatively standard components and their function should be well known to those skilled in the art. Although not shown in the perspective views of Figure 1 and Figure 2, the internal charging circuit further includes a phase reversal switch 53 so that measurements involving both positive and negative voltage amplitudes may be performed.

Once the apparatus 10 is connected to mains power, charging of capacitor 42 to 5 V should only take a few seconds and when this is complete, the first LED 18 illuminates indicating a ready condition. Figure 4 shows the logic diagram associated with the apparatus 10 of the present invention where the relationship between electronic components such as LED's 18, 20 and 22, digital display 16 and pushbutton 24 is clearly illustrated. The logic circuit also includes links 55 so as to allow the circuit to be more easily modified to suit a particular application. The links 53 do not affect the operation of the circuit at all. Again, the particulars of the logic diagram of Figure 4 will not be described here in any detail.

To begin testing, the push-button 24 is adapted to be pressed and held down for the duration of the test sequence which will now be described in detail.

As soon as the push-button 24 is pressed, a first test sequence (the 'no trip' test) is initiated which involves bleeding a 15 mA current from active 30 to earth 34 over a period of 1 second, during which time the second LED 20 lights. If the RCD does trip within 1 second, the second LED 20 remains illuminated and the 3-digit display 16 will indicate the time it took for the RCD to trip. If the RCD does not trip, then after the 1-second period, the second LED 20 switches off and the time is reset. If the RCD is functioning correctly, it should not trip during this first test sequence. The 15 mA 'no trip' test is typically undertaken as an industry expectation, and is not currently a legal requirement in Australia.

Immediately following the first test sequence, the 'trip' test is initiated whereby a current of 30 mA is passed to earth and the third LED 22 is illuminated. If the RCD trips at any time within a 1-second period, the time will be displayed on the digital display 16. If the time displayed is within 300 ms, then the RCD is functioning correctly and the test passes. If the trip time is greater than 300 ms but less than 1 second, the RCD has tripped but has taken too long and this indicates a failed test. If after 1 second, the RCD does not trip at all, a zero reading will be displayed and this also indicates a failed test.

Thus, the apparatus 10 of the present invention provides a user with the ability to undertake two integrity tests on a circuit breaker device such as an RCD. A user is simply required to connect the apparatus 10 (by means described above) to mains power downstream of the RCD. When the unit is charged and activated, a first 'no trip' test for testing whether the RCD trips prematurely is initiated, and if that passes, it is followed by a 'trip' test for testing whether the RCD will trip when it is required to do so.

Throughout the first and second test sequences, all displays and data are held either until the apparatus 10 discharges (which usually takes approximately 2 minutes) or when the pushbutton 24 is released. When the pushbutton 24 is released the data is reset to zero but the apparatus 10 does not discharge, thereby reducing the charge time for any subsequent tests.

An advantage the apparatus 10 provides over existing test equipment of this sort is that during each test, the current is maintained constant regardless of voltage or temperature. This not only increases the accuracy of the apparatus 10, but also allows for the addition of extra test stages and the testing of circuit breakers at any desired test current (with a simple change of resistors). This is achieved because the apparatus 10 employs the use of constant current regulators as opposed to standard resistors. It can be seen in the tripping circuit 40 of Figure 3 that the tripping current across active 30 and earth 34 is regulated by the use of a field-effect transistor 54. Similarly, the non-trip circuit uses a voltage regulator 56 and a constant voltage diode 58 associated therewith. A constant voltage diode 58 is used in this instance because it is more accurate than a Zener diode. In using each of the above components, accuracy within $\pm 2\%$ is ensured. The circuit also provides that if the 'trip' test does not pass, the current will be turned off after two seconds so as to prevent overheating of the current regulator, this limiting the power required because a smaller heat sink may be used.

The above trip or no trip tests are carried out whilst the rocker switch 25 is in position one, shown in Figure 4 as switch 60. It can be seen from Figure 4 that if the rocker switch (25 and 60) is in position two, three or four, the variable resistor 62 is activated. Also, some additional circuitry 64 is activated in order to display any
5 information arising from the use of the variable resistor 62 on the apparatus's 10 LCD display 16.

Rocker switch 25 position two allows for the actual tripping current to be measured and indicated on the digital display 16. Moving the switch to position two disconnects the timing circuitry of the apparatus 10 so that the RCD will only trip
10 when a current of sufficient amplitude passes from active to earth. The test current is ramped up, by decreasing the resistance of the variable resistor 62 until the RCD is tripped. The actual tripping current is then held in the apparatus 10, for several seconds or until the RCD is reset, and displayed on the digital display 16.

Rocker switch 25 position four enables the tripping current to be selected
15 from a range of 0 to at least 100mA before being applied to the RCD. This is achieved by altering the resistance of the variable resistor 62, generally using a dial (not shown). Once the desired current is obtained the rocker switch 25 is to be moved to position three so that the RCD being tested is connected and the timing circuit is reinstated. This position allows the apparatus 10 the advantage of testing an
20 RCD with any current rating.

It is to be understood that there need not necessarily be 3 LED's 18, 20 and 22. Any means of providing an appropriate visual indication that the apparatus 10 is charged and ready, that the first test sequence is underway, and finally that the second test sequence is underway, may be used. For example, the apparatus 10
25 may include a tri-colour LED (not shown) which simply designates a different colour to the different stages of operation. Alternatively, the digital display 16 may include such indicia. For example, in the case of the 3-digit display 16, the first digit may be made to illuminate when the apparatus 10 is charged and ready for use, the second digit may illuminate when the first test sequence is initiated, and so on. It is
30 envisaged that the LED's 18, 20 and 22 and the 3-digital display 16 will be incorporated into an LCD display means.

The apparatus 10 of the present invention may well include the following additional features:

- a Liquid Crystal Display (LCD) instead of, or in addition to, the 3-digit digital display 16;
- a data storage means so that information such as the date of a particular test, a location where a test was carried out, the test currents, the trip times, and other relevant information may be stored; and
- a data output means such as an attached printer or computer port. The printer or attached computer could then be used to provide a printout of the stored information.

Those skilled in the art should now appreciate the benefits in using the apparatus 10 of the present invention over existing test equipment. The apparatus 10 is designed to fit in one hand, can easily be carried on a belt clip, involves single pushbutton operation with no complex scale or selector switches, is of robust construction, automatically performs the 'no trip' and 'trip' tests in sequence, and includes constant current regulators instead of simple resistors to give unprecedented accuracy over a wide range of voltages.

Further advantages and improvements may very well be made to the present invention without deviating from its scope. Although the invention has been shown and described in what is conceived to be the most practical and preferred embodiment, it is recognized that departures may be made therefrom within the scope and spirit of the invention, which is not to be limited to the details disclosed herein but is to be accorded the full scope of the claims so as to embrace any and all equivalent devices and apparatus.

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CLAIMS

1. An apparatus for testing a circuit breaker connected to a circuit having at least an active and an earth, said apparatus including:
a means to perform a first test and a second test on the circuit breaker,
5 said first test being to determine whether the circuit breaker will trip when a first predetermined current is leaked from active to earth,
said second test being to determine whether the circuit breaker will trip when a second predetermined current is leaked from active to earth,
whereby said first and second tests are carried out in sequence, and
10 wherein if the circuit breaker does not trip during the first test, the said second test is automatically initiated.
2. An apparatus according to claim 1 wherein said first predetermined current is below a predetermined safety threshold, and said second predetermined current is equivalent to the predetermined safety threshold, wherein said
15 predetermined safety threshold corresponds to the nominal earth leakage trip current of the circuit breaker.
3. An apparatus according to claim 2 wherein the predetermined safety threshold is 30 milliamps.
4. An apparatus according to any one of the preceding claims wherein the
20 apparatus is adapted to be connected to active, neutral and earth of the circuit at a point downstream of the circuit breaker.
5. An apparatus according to any one of the preceding claims wherein said first test is carried out over a first predetermined period of time.
6. An apparatus according to claim 5 wherein said first predetermined current
25 is 15 milliamps and said first predetermined period of time is 1 second.

7. An apparatus according to any one of the preceding claims wherein the apparatus includes a display means adapted to display information associated with said first test and said second test.
- 5 8. An apparatus according to claim 7 whereby if the circuit breaker trips during the first test, the time taken for the circuit breaker to trip is displayed on the display means.
9. An apparatus according to any one of the preceding claims wherein said second test is carried out over a second predetermined period of time.
- 10 10. An apparatus according to claim 9 wherein the second predetermined current is 30 milliamps and said second predetermined period of time is 1 second.
11. An apparatus according to any one of the preceding claims 7 to 10 whereby if the circuit breaker does trip within 300 milliseconds of initiating the second test, the second test passes and this indicates that the circuit
15 breaker is functioning correctly and the time taken for the circuit breaker to trip is displayed on the display means.
12. An apparatus according to any one of the preceding claims whereby if the circuit breaker does not trip within 300 milliseconds of initiating the second test, the second test fails.
- 20 13. An apparatus according to any one of the preceding claims 7 to 10 whereby if the circuit breaker trips between 300 milliseconds and 1 second of initiating the second test, the second test fails and the time taken for the circuit breaker to trip is displayed on the display means.
- 25 14. An apparatus according to any one of the preceding claims whereby if the circuit breaker does not trip after 1 second of initiating the second test, the apparatus is automatically deactivated.

15. A method of testing a circuit breaker of the type adapted to be tripped when a threshold current leaks from an associated circuit having an active, a neutral and an earth, said method comprising the following steps:

5 (a) performing a first test wherein a first predetermined current is leaked from active to earth, said first predetermined current being less than the threshold current adapted to trip the circuit breaker;

(b) performing a second test wherein a second predetermined current is leaked from active to earth, said second predetermined current being equivalent to the threshold current adapted to trip the circuit breaker,

10 wherein if the circuit breaker does not trip during the first test, the second test is automatically initiated.

16. A method of testing a residual current circuit breaker of the type adapted to be tripped when it detects a current of approximately 30 milliamps leaking from active to earth in an associated circuit, said method comprising the

15 following steps:

(a) performing a first test wherein a 15 milliamp test current is leaked from active to earth over 1 second;

(b) detecting whether the circuit breaker is tripped during the first test;

(c) if the circuit breaker is tripped during the first test, indicating that the

20 first test has failed and the time taken for the circuit breaker to trip;

(d) if the circuit breaker is not tripped during the first test, indicating that the first test has passed, and automatically performing a second test wherein a 30 milliamp test current is leaked from active to earth over 1 second;

25 (e) detecting whether the circuit breaker is tripped during the second test;

(f) if the circuit breaker is tripped within 300 milliseconds, indicating that the second test has passed and the time taken for the circuit breaker to trip;

(g) if the circuit breaker is tripped after 300 milliseconds but before 1 second, indicating that the second test has failed and the time taken for the

30 circuit breaker to trip; and

(h) if the circuit breaker is not tripped during the second test, indicating that the test has failed.

17. A method of testing a residual current circuit breaker of the type adapted to be tripped when it detects a current of approximately the rated current
5 leaking from active to earth in an associated circuit, said method comprising the following steps:

(a) performing a first test wherein a test current of half the rated current is leaked from active to earth over 1 second;

(b) detecting whether the circuit breaker is tripped during the first test;

- 10 (c) if the circuit breaker is tripped during the first test, indicating that the first test has failed and the time taken for the circuit breaker to trip;

(d) if the circuit breaker is not tripped during the first test, indicating that the first test has passed, and automatically performing a second test wherein the rated current is leaked from active to earth over 1 second;

- 15 (e) detecting whether the circuit breaker is tripped during the second test;

(f) if the circuit breaker is tripped within 300 milliseconds, indicating that the second test has passed and the time taken for the circuit breaker to trip;

(g) if the circuit breaker is tripped after 300 milliseconds but before 1 second, indicating that the second test has failed and the time taken for the
20 circuit breaker to trip; and

(h) if the circuit breaker is not tripped during the second test, indicating that the test has failed.