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(54) **Electromagnetic actuator arrangement.**

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Description

The present invention relates to electromagnetic actuator arrangements and relates particularly but not exclusively to residual current circuit breakers.

It is necessary for residual current circuit breakers in particular to trip very quickly, e.g. in less than 20 milliseconds. In order to meet this requirement, it has been necessary to provide a very powerful biasing spring which trips the actuator when the actuator is de-energised. A correspondingly powerful and bulky electromagnet has been reauired to overcome the spring bias in the energised condition.

German patent number 532028 discloses a single-pole switching circuit breaker with a switch 12 biased by a spring 14 towards its open position but, in use, held closed by an armature 18 which is held against legs 16 of an electromagnetic core 15. The circuit breaker is for use with D.C. sources only, and if any excess current is detected, a coil 22 reduces the magnetic strength of the core 15. The spring 14 is then able to pull the armature 18 away from the core 15, thereby opening the switch 12.

U.S. patent number 4,063,299 discloses a ground fault circuit interrupter in which a torroidal sensing coil 22 is used to detect any disparity between the live 12 and neutral 14 power lines in order to indicate a ground fault. In normal operating conditions, no disparity is detected and so the remanent magnetic latching relay 80 remains unmagnetised. The armature is biassed by a spring away from the latching relay pole 90 and holds switches 86,88 closed. As soon as the sensing coil 22 detects a ground fault, the latching relay is activated, pulling the armature 92 and opening the switches 86,88.

An object of the present invention is to provide an electromagnetic actuator arrangement which is faster-acting and/or requires a less powerful electromagnet than comparable conventional actuator arrangements.

According to the present invention, an electromagnetic actuator arrangement comprises an electromagnetic actuator, including at least one operating member of magnetically soft material which cooperates with biasing means and is magnetised when said electromagnetic actuator is energised characterised in that the actuator arrangement further comprises means for reversing the magnetising force acting on said operating member when the said electromagnetic actuator is de-energised.

The invention is applicable particularly but not exclusively to circuit breakers and relays, which incorporate two such operating members, namely a fixed yoke and a movable armature. By reversing the magnetising force on de-energising an electromagnetic actuator of this type, the residual magnetic flux in the armature is opposed by the reversed magnetic field and the normal tendency of the armature to stick to the yoke immediately after the winding has been de-energised is avoided.

In fact during the brief period in which the residual magnetic flux in the armature maintains its original polarity, the armature is repelled by the reversed magnetic field arising from the reversed magnetising force and thus the biasing force is briefly augmented at the instant of de-energising the winding. Accordingly the invention is also applicable for example to solenoids and other devices which incorporate only a single "operating member" of magnetically soft material.

In typical preferred embodiments, particularly of relay and circuit-breaker arrangements, the armature will be removed from the magnetic field of the winding by the biasing means by the time that the residual magnetic flux in the armature has been reversed by the reversal of magnetising force on de-energising the actuator. The resulting force of attraction acting on the armature will accordingly be very weak in comparison with the opposing biasing force and the tripping time will not be adversely affected.

A particularly convenient way of limiting the reverse magnetisation is to reverse the magnetising force by means of a capacitor (which may for example by connected in parallel with the winding) which is arranged to discharge through the winding on de-energisation of the actuator. Preferably the discharge is oscillatory so that the residual magnetisation of the armature is thereby reduced to a very low level.

In a preferred embodiment the winding of the electromagnetic actuator is energised from a current force (preferably a substantially constant current source) and a gate-controlled semi-conductor switching device is arranged both to bypass current from said current source in response to a control signal applied to the gate of said device on de-energising said electromagnetic actuator, and to conduct the current which is discharged by said capacitor through said winding.

A preferred embodiment of the invention is described below by way of example only with reference to the accompanying drawing, Figure 1, which is a circuit diagram of a residual current circuit breaker in accordance with the invention.

The circuit shown in Figure 1 comprises live (L) and neutral (N) mains input terminals which are connected via a two-pole switch SW1 to mains output terminals, which may in turn be connected to an electrical appliance (not shown). Switch SW1 is controlled by an electromagnetic actuator comprising a movable armature AR1 and a yoke Y1 which is provided with a winding L1. Armature AR1 is mechanically linked to switch SWl and the latter is biased open by a tension spring SP which acts on the armature. Armature AR1 and yoke Y1 are composed of magnetically soft iron and contact one another when switch SW1 is closed.

In use, switch SW1 is closed manually and ener-

gised by a rectified constant current source comprising a series-connected diode D1, resistors R3, R4 and R5 and R6 and capacitor C6 (which are connected between the mains conductors) and resistor R2 (which is connected between the junction of R3 and C6 and one end of winding L1).

The other end of winding L1 is connected to pin 6 of an RA3783 integrated circuit IC1 ad thence via pin 4 thereof to the free terminal of smoothing capacitor C6. Accordingly winding L1 is energised and maintains switch SW1 ON.

A ferrite-core transformer T1 is coupled to the mains conductors and its output is fed to pins 2 and 3 of IC1.

The potential difference across pins 2 and 3 is monitored by IC1 and in the event that it exceeds a predetermined threshold value (as a result of an inbalance in the forward and return currents in the mains conductors due to a potentially dangereous leakage of current to earth) an output voltage is generated at pin 5. A series-corrected discharge capacitator C1 and thyristor SCR1 are corrected in parallel with winding L1 and the gate of SCR1 is connected to pin 5. The cathode of thyristor SCR1 is also connected to the negative terminal of capacitor C6 so that thyristor SCR1 bypasses the output current of the current source as well as providing a discharge path for capacitor C1 through winding L1. The current from R2 is sufficient to hold SCR1 ON whilst capacitor C1 is discharging.

Accordingly, when an earth leakage current is detected, a voltage appears at terminal 5 of IC1 which fires thyristor SCR1, thereby bypassing the forward current from resistor R2 of the current source and allowing capacitor C1 to send a brief reverse discharge current through winding L1 which generates a reverse magnetising force which opposes the residual flux in armature AR1 and yoke Y1. Accordingly, armature AR1 is immediately repelled from yoke Y1 and is rapidly removed from the yoke by biasing spring SP. By this time, the current in winding L1 has fallen to zero. Thus switch SW1 breaks the mains circuit very rapidly.

When safe conditions have been restored, the circuit may be re-set by depressing switch SW1 manually.

A pair of test contacts TC are connected in series with a resistor R7 between the neutral output terminal and a live input terminal of the mains conductors to enable a residual current to be generated artificially in order to test the circuit.

The sensitivity of the circuit can be adjusted by altering the value of a resistor R8 which is connected across the winding of T1 or the value of resistor R1 which is connected between terminals 1 and 7 of IC1. It is by-passed by a noise suppression capacitor C4 and an additional noise-suppression capacitor C3 is connected between pins 1 and 8 of IC1. Resistor R8 is by-passed by a noise-suppression capacitor C5 and a noise-suppression capacitor C2 is also connected between the gate and cathode of thyristor SCR1.

It should be noted that the circuit automatically switches switch SW1 OFF in the event of loss of mains supply.

Claims

1. An electromagnetic actuator arrangement comprising an electromagnetic actuator, including at least one operating member (AR1) of magnetically soft material which cooperates with biasing means (SP) and is magnetised when said electromagnetic actuator is energised characterised in that the actuator arrangement further comprises means (SCR1, C1, L1) for reversing the magnetising force acting on said operating member (AR1) when the said electromagnetic actuator is de-energised.

2. An electromagnetic actuator arrangement as claimed in claim 1 characterised in that the actuator arrangement further comprises two operating members (AR1, Y1) of magnetically soft material which are mutually attracted when said electromagnetic actuator is energised, said operating members (AR1,Y1) being relatively movable and being biased apart by said biasing means (SP) which operates said electromagnetic actuator when it is de-energised.

3. An electromagnetic actuator arrangement as claimed in claim 1 or claim 2 characterised in that said magnetising force reversing means comprises means (SCR1, C1) for reversing the flow of current in a winding (L1) which is magnetically coupled to said operating member(s).

4. An electromagnetic actuator arrangement as claimed in claim 3 characterised in that said current flow reversing means includes a capacitor (C1) which discharges through said winding (L1) on de-energising said electromagnetic actuator.

5. An electromagnetic actuator arrangement as claimed in any preceding claim characterised in that a said operating member (AR1,Y1) is arranged to be removed by said biasing means (SP) from a magnetic field of the electromagnetic actuator on reversing said magnetising force.

6. An electromagnetic actuator arrangement as claimed in any preceding claim characterised in that said electromagnetic actuator is arranged to operate at least one pair of electric contacts

(SW1).

7. An electromagnetic actuator arrangement as claimed in claim 6 characterised in that said electromagnetic actuator is a main circuit breaker.

8. An electromagnetic actuator arrangement as claimed in claim 7 which is a residual current circuit breaker and comprises means (T1) for detecting residual current in a mains circuit and means (IC1) responsive to said residual current to de-energise said electromagnetic actuator, said electric contacts (SW1) being arranged to break said mains circuit on de-energising said electromagnetic actuator.

9. An electromagnetic actuator arrangement as claimed in claim 4 or any of claims 5 to 8 as dependent on claim 4 characterised in that said winding (L1) is energised from a current source, and a gate-controlled semi-conductor switching device (SCR1) is arranged both to bypass current from said current source in response to a control signal applied to the gate of said device (SCR1) on de-energising said electromagnetic actuator, and to conduct the current which is discharged by said capacitor (C1) through said winding (L1).

10. A residual current circuit breaker as claimed in claim 8 which comprises a transformer which is coupled to both conductors of said mains circuit and to circuit means (IC1) arranged to generate a control signal which de-energises said electromagnetic actuator when the output of said transformer (T1) exceeds a predetermined value.

11. A residual current circuit breaker as claimed in claim 10 characterised in that a winding (L1) of said electromagnetic actuator is connected in series with a gate-controlled semiconductor switching device and a capacitor (C1), said capacitor (C1) being charged when said winding (L1) is energised, and said circuit means is arranged to apply said control signal to the gate of said semi-conductor switching device to discharge said capacitor (C1) through said winding (L1) and through said semiconductor switching device.

Patentansprüche

1. Elektromagnetische Betätigungsanordnung mit einem elektromagnetischen Betätigungselement, welches zumindest ein Arbeitselement (AR1) aus magnetisch weichem Material beinhaltet, welches mit Vorspannelementen (SP) in Verbindung steht und magnetisiert wird, wenn das elektromagnetische Betätigungselement aktiviert wird,
dadurch gekennzeichnet,
daß die Betätigungsanordnung weitere Mittel (SCR1, C1, L1) zur Umkehrung der auf besagtes Arbeitselement (AR1) wirkenden magnetischen Kraft beinhaltet, wenn das elektromagnetische Element deaktiviert wird.

2. Elektromagnetische Betätigungsanordnung nach Anspruch 1,
dadurch gekennzeichnet,
daß die Betätigungsanordnung desweiteren zwei Arbeitselemente (AR1, Y1) aus magnetisch weichem Material beinhaltet, die beide angezogen werden, wenn das besagte elektromagnetische Betätigungselement aktiviert wird, wobei die besagten Arbeitselemente (AR1, Y1) relativ zueinander bewegbar sind und von besagten Vorspannungsmitteln (SP), die das besagte elektromagnetische Betätigungselement betätigen, wenn es deaktiviert ist, auseinander gespannt werden.

3. Elektromagnetische Betätigungsanordnung nach Anspruch 1 oder 2,
dadurch gekennzeichnet,
daß besagte Mittel zur Umkehrung der magnetischen Kraft Mittel (SCR1, C1) zur Umkehrung des Stromflusses in einer Windung (L1) beinhaltet, die mit besagtem Arbeitselement bzw. besagten Arbeitselementen magnetisch verbunden ist.

4. Elektromagnetische Betätigungsanordnung nach Anspruch 3,
dadurch gekennzeichnet,
daß besagte Mittel zur Umkehrung des Stromflusses einen Kondensator (C1) beinhalten, welcher sich durch besagte Windung (L1) beim Deaktivieren des besagten elektromagnetischen Betätigungselements entlädt.

5. Elektromagnetische Betätigungsanordnung nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet,
daß eines der besagten Arbeitselemente (AR1, Y1) dazu angeordnet ist, durch besagte Vorspannungsmittel (SP) aus einem magnetischen Feld des elektromagnetischen Betätigungselements bei Umkehrung besagter Magnetkraft entfernt zu werden.

6. Elektromagnetische Betätigungsanordnung nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet,
daß das besagte elektromagnetische Betätigungselement zur Betätigung von wenigstens einem Paar von elektrischen Kontakten (SW1) angeordnet ist.

7. Elektromagnetische Betätigungsanordnung nach Anspruch 6,
dadurch gekennzeichnet,
daß das elektromagnetische Betätigungselement eine Vorrichtung zur Unterbrechung der Hauptleitung ist.

8. Elektromagnetische Betätigungsanordnung nach Anspruch 7,
dadurch gekennzeichnet,
daß die elektromagnetische Betätigungsanordnung einen Reststrom-Leitungsunterbrecher darstellt und Mittel (T1) zur Feststellung des Reststroms in einer Hauptleitung aufweist sowie Mittel (IC1) aufweist, die auf besagten Reststrom ansprechen, um das besagte elektromagnetische Betätigungselement zu deaktivieren, wobei besagte elektrische Kontakte (SW1) dazu angeordnet sind, den besagten Hauptstromkreis beim Deaktivieren des besagten elektromagnetischen Betätigungselements zu unterbrechen.

9. Elektromagnetische Betätigungsanordnung nach Anspruch 4 oder einem der Ansprüche 5 - 8 in Abhängigkeit von Anspruch 4,
dadurch gekennzeichnet,
daß besagte Windung (L1) von einer Stromquelle aktiviert wird und eine eingangskontrollierte Halbleiterschaltvorrichtung (SCR1) dazu angeordnet ist, sowohl den Strom von besagter Stromquelle in Erwiderung eines Kontrollsignals umzuleiten, welches an den Eingang besagter Halbleiterschaltvorrichtung (SCR1) bei der Deaktivierung des besagten elektromagnetischer Betätigungselements angelegt wird und um den Strom, der durch den besagten Kondensator (C1) durch besagte Windung (L1) entladen wird, zu leiten.

10. Reststrom-Leitungsunterbrecher nach Anspruch 8,
dadurch gekennzeichnet,
daß der Reststrom-Leitungsunterbrecher einen Transformator (T1) beinhaltet, der sowohl mit den Leitungen des besagten Hauptkreises als auch mit Leitungsmitteln (IC1) verbunden ist, die zur Erzeugung eines Kontrollsignals zugeordnet sind, welches das besagte elektromagnetische Betätigungselement deaktiviert, wenn die Ausgangsgröße des besagten Transformators (T1) einen vorherbestimmten Wert überschreitet.

11. Reststrom-Leitungsunterbrecher nach Anspruch 10,
dadurch gekennzeichnet,
daß eine Windung (L1) des besagten elektromagnetischen Betätigungselements in Reihe mit einer eingangskontrollierten Halbleiterschaltvorrichtung und einem Kondensator (C1) verbunden ist, wobei besagter Kondensator (C1) geladen wird, wenn besagte Windung (L1) aktiviert wird und wobei besagte Leitungsmittel dazu angeordnet sind, das besagte Kontrollsignal an den Eingang der besagten Halbleiterschaltvorrichtung anzulegen, um besagten Kondensator (C1) über besagte Windung (L1) und über besagte Halbleiterschaltvorrichtung zu entladen.

Revendications

1. Dispositif électromagnétique comprenant un actionneur électromagnétique constitué d'au moins un élément actif (AR1) formé à partir d'un matériau magnétique doux qui coopère avec un moyen de rappel (SP) et est magnétisé lorsque ledit actionneur électromagnétique est activé, caractérisé en ce qu'il comprend en outre des moyens (SCR1, C1, L1) pour inverser la force magnétique agissant sur ledit élément actif (AR1) lorsque l'actionneur électromagnétique est désactivé.

2. Dispositif électromagnétique selon la revendication 1, caractérisé en ce qu'il comprend en outre deux éléments actifs (AR1, Y1) formés à partir d'un matériau magnétique doux qui s'attirent mutuellement lorsque l'actionneur électromagnétique est activé, lesdits éléments actifs (AR1, Y1) étant mobiles l'un par rapport à l'autre et rappelés séparément par le moyen de rappel (SP) qui commande l'actionneur électromagnétique lorsqu'il est désactivé.

3. Dispositif électromagnétique selon l'une quelconque des revendications 1 ou 2, caractérisé en ce que le moyen inversant la force magnétique comprend des moyens (SCR1, C1) pour inverser le sens du courant dans un enroulement (L1) magnétiquement couplé au(x) dit(s) élément(s) actif(s).

4. Dispositif électromagnétique selon la revendication 3, caractérisé en ce que le moyen inversant le sens du courant comprend un condensateur (C1) qui se décharge à travers l'enroulement (L1) en désactivant l'actionneur électromagnétique.

5. Dispositif électromagnétique selon l'une quelconque des revendications précédentes, caractérisé en ce que l'un des éléments actifs (AR1, Y1) est soustrait à l'action d'un champ magnétique produit par l'actionneur électromagnétique par le biais du moyen de polarisation (SP) qui inverse la force de magnétisation.

6. Dispositif électromagnétique selon l'une quelconque des revendications précédentes, caractérisé en ce que l'actionneur électromagnétique est prévu pour commander au moins une paire de contacts électriques (SW1).

7. Dispositif électromagnétique selon la revendication 6, caractérisé en ce que l'actionneur électromagnétique est un sectionneur de réseau.

8. Dispositif électromagnétique selon la revendication 7, qui est un coupe-circuit pour courant résiduel et comprend un moyen (T1) pour détecter un courant résiduel dans l'alimentation du réseau et un moyen (IC1) sensible audit courant résiduel pour désactiver l'actionneur électromagnétique, les contacts (SW1) coupant l'alimentation du réseau en désactivant l'actionneur électromagnétique.

9. Dispositif électromagnétique selon la revendication 4 ou l'une quelconque des revendications 5 à 8 en dépendance de la revendication 4, caractérisé en ce que l'enroulement (L1) est alimenté depuis une source de courant et en ce qu'un dispositif de commutation à semi-conducteur à tension de grille contrôlée (SCR1) est prévu à la fois pour dériver le courant produit par ladite source de courant en réponse à un signal de contrôle appliqué à la grille du dispositif (SCR1) lors de la désactivation de l'actionneur électromagnétique et laisser passer le courant qui provient de la décharge du condensateur (C1) à travers l'enroulement (L1).

10. Coupe-circuit pour courant résiduel selon la revendication 8, comprenant un transformateur simultanément relié aux conducteurs du réseau de distribution et au moyen (IC1) du circuit prévu pour produire un signal de contrôle qui provoque la désactivation de l'actionneur électromagnétique lorsque la sortie du transformateur (T1) dépasse une valeur prédéterminée.

11. Coupe-circuit pour courant résiduel selon la revendication 10, caractérisé en ce qu'un enroulement (L1) de l'actionneur électromagnétique est relié en série avec un dispositif de commutation à semi-conducteur à tension de grille contrôlée et un condensateur (C1), ledit condensateur (C1) étant chargé lorsque l'enroulement (L1) est activé, l'élément de circuit étant prévu pour appliquer le signal de contrôle sur la grille du dispositif de commutation à semi-conducteur afin de provoquer la décharge du condensateur (C1) à travers l'enroulement (L1) et le dispositif de commutation à semi-conducteur.

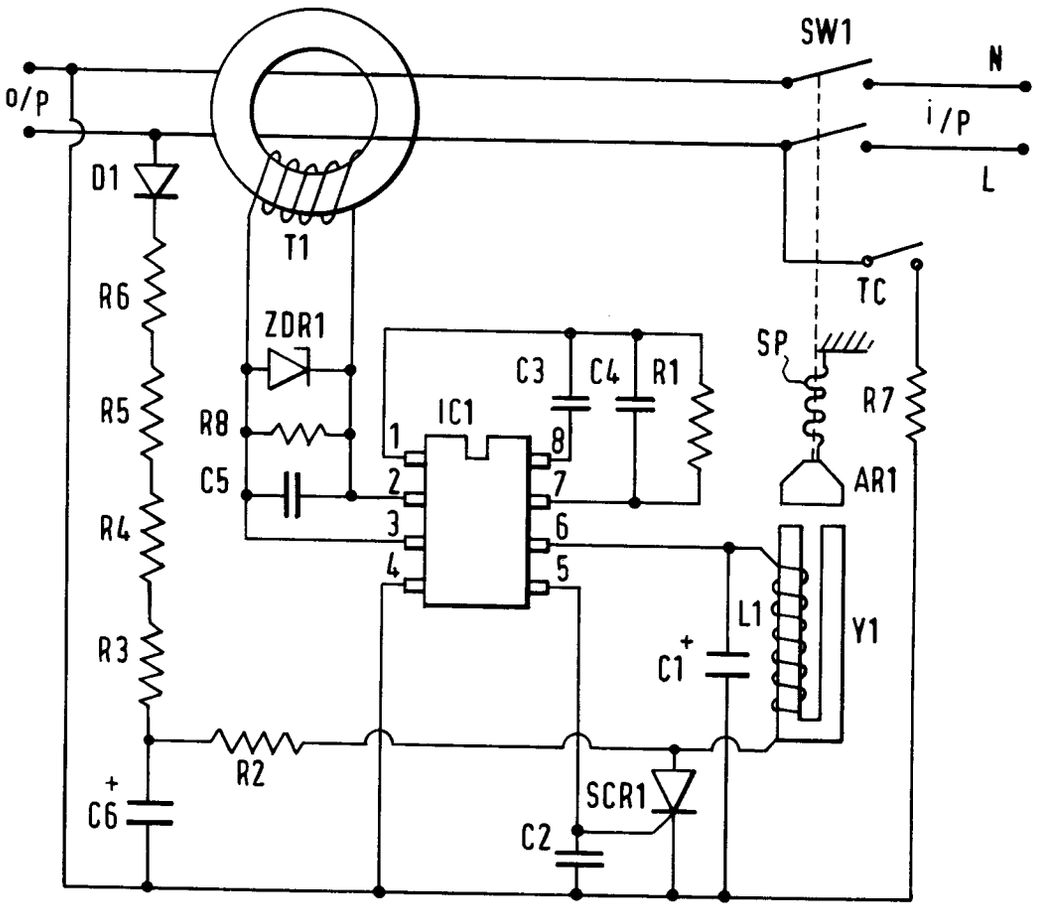

SW1
N
o/P
i/P
L
D1
T1
TC
R6
ZDR1
SP
C3
C4
R1
R7
R5
R8
IC1
1
8
C5
2
7
AR1
R4
3
6
4
5
L1
Y1
R3
C1
R2
SCR1
C6
C2

Fig.1.