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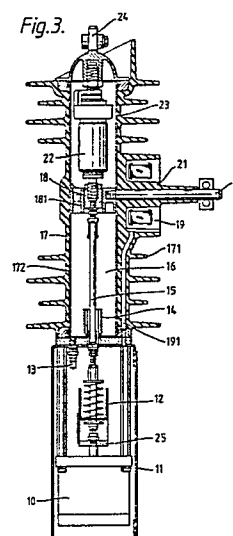
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64 **A bistable magnetic actuator and a circuit breaker.**

67 A circuit breaker comprises a circuit interrupter connected between two external terminals, a bistable magnetic actuator, having a permanent magnet for maintaining its state, connected via a mechanical linkage to operate the circuit interrupter, a capacitive charge store connected to power the actuator, means for recharging the charge store, and electronic control means connected to control the operation of the actuator in response to the current flowing between the terminals, at least the actuator, the charge store and the control means being housed in a common housing.

A bistable magnetic actuator with an axially polarised magnet carried by the armature comprises two interlinked magnetic yokes, outer limbs of which constitute magnetic pole pieces, and inner limbs of which are mechanically connected.



## Description

### A Bistable Magnetic Actuator and a Circuit Breaker

This invention relates to a bistable magnetic actuator, and to an electric circuit breaker.

In an electric circuit breaker, whether it is a switch, an isolator, an autorecloser or some other device, it is necessary to have a mechanism that will open and close contacts in order to interrupt or close an electric circuit.

Conventional high-voltage circuit breakers include a complex, mechanical system for closing and tripping the switch contacts, and the need has arisen for an alternative mechanism capable of opening or closing the switch contacts on receipt of an electrical pulse, and in its static state of firmly holding the contacts in either of the set positions.

According to a first aspect, the invention provides a circuit-breaker comprising a circuit interrupter connected between two external terminals, a bistable magnetic actuator, having a permanent magnet for maintaining its state, connected via a mechanical linkage to operate the circuit interrupter, a capacitive charge store connected to power the actuator, means for recharging the charge store, and electronic control means connected to control the operation of the actuator in response to the current flowing between the terminals, at least the actuator, the charge store and the control means being housed in a common housing. In this way, the actuator for the circuit breaker may be totally self-contained, and may even share the same gas-filled enclosure as the interrupter, which is preferably a vacuum interrupter. The state of the interrupter is maintained by the permanent magnet, and the charge store preferably maintains for an appreciable time its capacity to power the magnetic actuator to change its state; preferably it maintains sufficient charge to permit several changes of state.

The store may be recharged by a long-life cell which will need replacement at intervals; preferably, however, it is recharged from the current flowing between the terminals, for example by a transformer connected to one of the terminals.

According to a second aspect of the invention, a bistable magnetic actuator comprises: a housing defined by two interlinked magnetic yokes, outer limbs of which constitute magnetic pole pieces, and inner limbs of which are mechanically connected; an armature axially reciprocable within the housing between the pole pieces and through the inner limbs on an axis passing through both limbs of both yokes, between two stable positions at each of which it forms a magnetic circuit with a respective magnetic pole piece and breaks the corresponding magnetic circuit with the other magnetic pole piece; an axially polarised magnet carried by the armature for generating the magnetic flux in the said magnetic circuits to hold the armature at one or other of the stable positions; and means for generating a transient magnetic field, in response to an actuation signal, simultaneously to reduce the flux in the said magnetic circuit without reducing significantly the flux within the permanent magnet, thereby to

destabilise the armature without promoting demagnetisation of the permanent magnet, and to increase the flux between the armature and the other pole piece to attract the armature to that other pole piece.

An actuating member connected to the armature can then be caused to change position by the transient magnetic field, which may be generated by a stationary electromagnet coupled magnetically to the armature and to the pole pieces which preferably is activated by a capacitor-discharge circuit triggered by the actuation signal.

Movement of the actuating member may be imparted to a member to be operated, for example the moving contact of a circuit breaker, through any convenient form of mechanical link.

Preferred forms of this aspect of the invention are described in the accompanying claims.

A circuit breaker in accordance with the first aspect of the invention, including a magnetic actuator embodying the second aspect of the invention, will now be described by way of example with reference to the accompanying drawings, of which:-

Figure 1 is an end view of an actuator,

Figure 2 is a sectional view of the actuator along the line A-A of Figure 1; and

Figure 3 is a section taken along the vertical axis of a circuit breaker.

Referring first to Figures 1 and 2, the actuator incorporates an armature AR comprising two cylindrical soft iron armature pieces 1, 2 having a permanent magnet 3 of disc form sandwiched between them, the armature being mounted coaxially at one end of a drive rod 4. The drive rod 4 has a threaded end which serves to secure the elements 1, 2, 3 of the armature together. The armature AR is contained within a housing formed by two interlinking yokes 5, 6 in the form of rectangular frames disposed at right angles to each other, the two inner, or linked limbs IL of the yokes 5, 6 being pierced by openings O which form bearings for the moving armature AR. A tube 7 of non-magnetic material extends between the two inner limbs IL of the yokes around the central region of the armature, and serves to secure the yokes together. The yokes 5, 6 are positioned so that the magnet 3 lies between the linked limbs IL of the yokes whether it is in one or other of its two terminal positions, with either one or other of the soft iron pole pieces 1, 2 in contact with the opposite, outer limb OL of the respective yoke.

The magnet 3 is magnetically polarised in the axial, longitudinal direction parallel to the reciprocating motion of the armature between end stops provided by the outer limbs OL.

With the armature AR in the position shown, the yoke 5 and the armature form a low reluctance magnetic circuit, so that the magnet 3 will produce a strong flux to hold the armature piece 1 against a fixed abutment face or end stop provided by the outer limb OL of the yoke 5. There will be virtually no attractive force tending to move the armature

piece 2 towards the fixed abutment face provided by the outer limb OL of the other yoke 6, as the air gap gives that flux path a very high reluctance.

Coils 8, 9 are disposed coaxially around respective ends of the armature AR, and if the coil 9 is energised to a level such that it will produce sufficient flux across the gap between the armature piece 2 and the outer limb OL of the yoke 6, and in a direction such that it assists the permanent magnet 3, then the outer limb OL of the yoke 5 will be starved of flux and the plunger P will transfer from left to right with no magnetic damage occurring to the permanent magnet 3, so that a strong retaining force will now hold the plunger at the right hand end of the actuator after the coil has been de-energised.

The process can be reversed by suitably energising the coil 8, and can be repeated indefinitely.

A relatively short pulse of current in the appropriate direction through the appropriate coil 8 or 9, as the case may be, will be sufficient to cause the plunger to move from one position to the other.

This short current pulse is provided by a capacitor-discharge circuit of conventional design, triggered by an electrical actuation signal from an external control circuit.

The drive arm 4 can be connected to the actuating mechanism of a circuit breaker for example to produce an opening or closing movement of the breaker contacts, depending upon the direction of movement of the plunger. However an actuator as above described can have a wide variety of other applications.

With reference to Figure 3, an auto-recloser circuit breaker, principally for outdoor use but optionally for indoor applications, comprises, for each of three phases, a vacuum interrupter 22 housed in an EPDM rubber body 17. A single kiosk 11 houses a bistable magnetic actuator 10 of the type described above, which operates all three vacuum interrupters 22 by way of a cross beam 25; in an alternative embodiment (not shown), the cross beam 25 is omitted and there is a magnetic actuator 10 for each phase.

The kiosk may rest on the ground, or else it may be mounted on a plinth or even a pole.

The interrupter contacts are maintained in either the closed or the open position by the magnetic actuator. The fixed contact is connected to an upper line terminal 24 integral with a support casing, and the movable contact to an axially reciprocable transfer contact 18 which slides within a ring-shaped fixed contact 181 connected to a side-mounted terminal 20. The side terminal 20 consists of a rod projecting transversely from an insulating bushing 21 forming part of the rubber body 17. The body 17 has a number of rain sheds 171 moulded onto its outer surface to increase external creepage and flashover distances across the interrupter and from the interrupter 22 to the supporting kiosk 11 which is at earth potential. The inner surface of the EPDM rubber body 17 is lined by a reinforced plastics tube 172 which provides mechanical strength and separates the EPDM rubber from a dielectric liquid or gaseous insulating medium 16 in which the internal parts are immersed. In this example, the medium 16 is SF<sub>6</sub> gas, supplied through a filling valve 13.

A protective current transformer core and toroidally wound secondary winding 19 surround the side-mounted line terminal 20, and are encapsulated in the bushing 21 integral with the rubber body 17. The output from the current transformer is connected by a line 191, encapsulated in the rubber body 17, to the actuator assembly 10. A single phase voltage transformer (not shown) is connected between the line terminal 20 and earth, or between the same line terminal 20 in different phases, and its output is used to supply power to charge storage capacitors in a pulsing unit (not shown) forming part of the magnetic actuator assembly 10, and an electronic control unit (not shown) for the actuator and pulsing unit which is also contained in the magnetic actuator assembly 10. However, the control unit could be powered by a long-life cell. The entire actuator may be immersed in an insulating gas to protect it from corrosive atmospheres.

The actuator 10 is coaxial with the vacuum interrupter, which it drives by way of a purely mechanical, direct linkage. The linkage comprises an axial, insulating rod 15 connected at its upper end to the sliding contact 18 and at its lower end, via a lost motion device 12, to the actuator shaft. The rod extends axially through the base of the rubber body 17 and through the roof of the kiosk 11, which is sealed against the underside of the base of the rubber body 17. A sealing bellows 14 surrounds the lower portion of the rod 15 within the rubber body 17, but the bellows 14 is not required if the actuator is immersed in insulating gas.

Where the drive rod 15 and interrupter 22 are insulated by a gas, the space within the kiosk may communicate with that within the rubber body 17, avoiding the need for the potentially leaky mechanical gas seals.

The control unit responds to a signal from the current transformer 19 indicative of either an over-current condition, a short circuit or an earth fault, to send an appropriate short pulse to activate the actuator. The control unit includes a sequence timer for the auto-reclose function, which causes the interrupter contacts to reclose after a predetermined interval following circuit interruption. If the fault is not cured and the circuit is interrupted a second time, the circuit recloses after a longer predetermined interval; and so on, with progressively increasing intervals.

## Claims

1. A circuit-breaker comprising a circuit interrupter (22) connected between two external terminals (20, 24), characterised by a bistable magnetic actuator (10), having a permanent magnet (3) for maintaining its state, connected via a mechanical linkage (15) to operate the circuit interrupter, a capacitive charge store connected to power the actuator, means for recharging the charge store, and electronic control means connected to control the operation of the actuator (10) in response to the current flowing between the terminals (20,

24), at least the actuator, the charge store and the control means being housed in a common housing.

2. A circuit-breaker according to Claim 1, in which the circuit interrupter (22) is a vacuum interrupter.

3. A circuit-breaker according to Claim 1, in which the mechanical linkage comprises a drive rod (15) housed with the circuit interrupter (22) in an insulating housing (17).

4. A bistable magnetic actuator (10) characterized by: a housing defined by two interlinked magnetic yokes (5, 6), outer limbs (OL) of which constitute magnetic pole pieces, and inner limbs (IL) of which are mechanically connected; an armature (AR) axially reciprocable within the housing between the pole pieces and through the inner limbs on an axis passing through both limbs of both yokes, between two stable positions at each of which it forms a magnetic circuit with a respective magnetic pole piece and breaks the corresponding magnetic circuit with the other magnetic pole piece; an axially polarised magnet (3) carried by the armature for generating the magnetic flux in the said magnetic circuits to hold the armature at one or

other of the stable positions; and means (8, 9) for generating a transient magnetic field, in response to an actuation signal, simultaneously to reduce the flux in the said magnetic circuit without reducing significantly the flux within the permanent magnet, thereby to destabilise the armature without promoting demagnetisation of the permanent magnet, and to increase the flux between the armature and the other pole piece to attract the armature to that other pole piece.

5. An actuator according to Claim 4, in which the means for generating a transient magnetic field comprises at least one stationary electromagnet (8) coupled magnetically to the armature (AR) and to the pole piece.

6. An actuator according to Claim 4 or 5, in which the permanent magnet (3) is disk-shaped.

7. An actuator according to Claim 6, in which the said transient magnetic field is generated in the direction of reciprocating motion of the armature within the armature irrespective of the position of the armature.

8. An electric circuit breaker in which the operating mechanism comprises a bistable magnetic actuator according to Claim 4.

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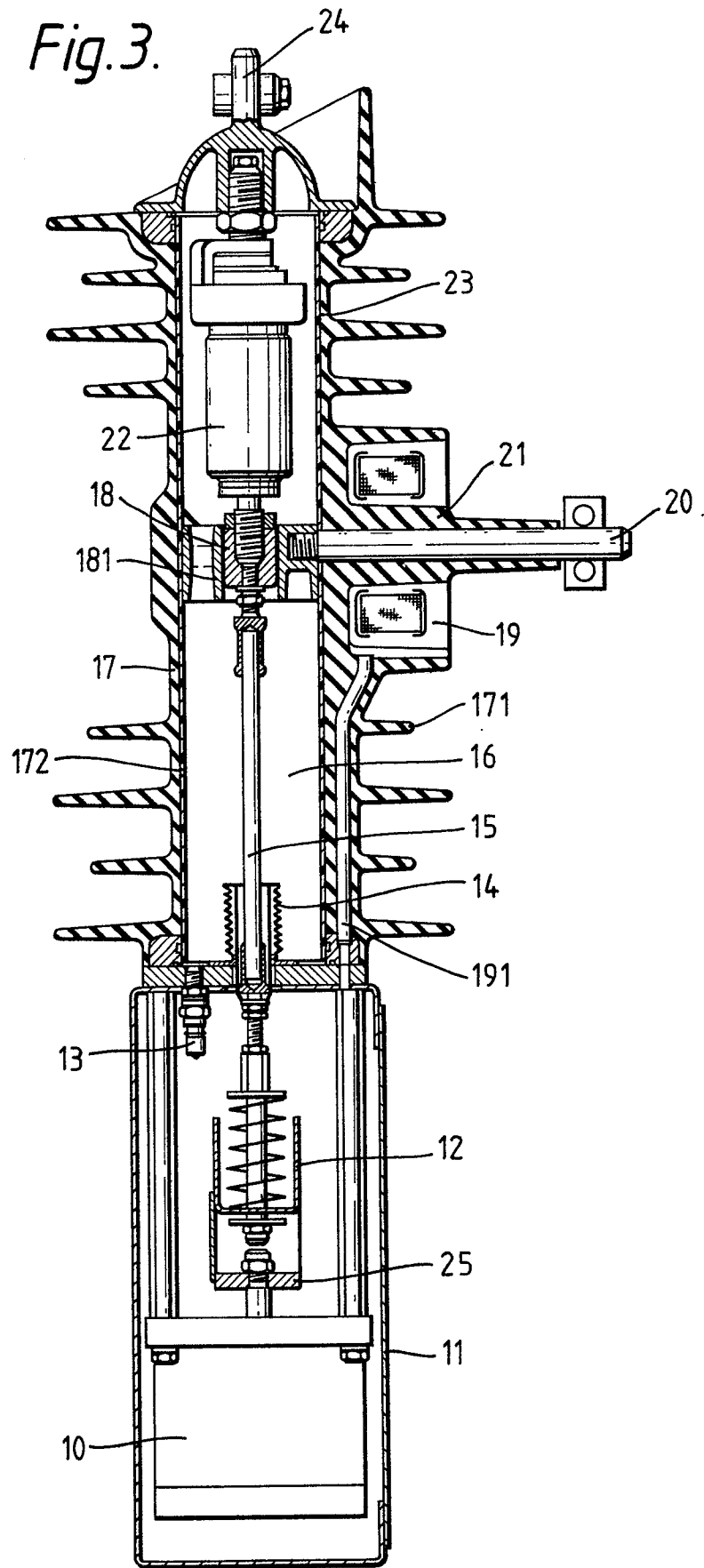
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Fig.3.





EP 89 30 8171

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	GB-A-1196418 (THE ENGLISH ELECTRIC COMPANY) * page 2, lines 6 - 42 * ---	1-3, 8	H01H33/66 H01H51/22 H01F7/16
Y	US-A-4086645 (ELECTRIC POWER RESEARCH INSTITUTE) * column 3, lines 26 - 50 * ---	1-3	
A	US-A-4568804 (JOSLYN MFG. AND SUPPLY CO.) * column 5, lines 4 - 39 * * column 12, lines 9 - 21 * ---	1-3	
Y	FR-A-2141956 (SPERRY RAND LIMITED) * page 5, line 27 - page 6, line 5; figure 4 * ---	4-7	
Y	DE-A-3341625 (AISIN SEIKI K.K.) * page 13, paragraph 2 - page 15, paragraph 1 * -----	4-8	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			H01H H01F
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 22 NOVEMBER 1989	Examiner LIBBERECHT L.A.
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