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Abstract

Bistable magnetic actuator (5) for a medium voltage circuit breaker arrangement, comprising at least one electrical coil (7) for switching a ferromagnetic armature (6) between a first limit position and a second limit position effected by an electromagnetic field, at least one permanent magnet (8) for holding the armature (6) in one of the two limit positions corresponding to an open and a closed electrical switching position respectively of the mechanically connected circuit breaker, wherein the armature (6) comprises an upper plunger (9) resting on a ferromagnetic core element (10) of the one electrical coil (7) for static holding the armature (6) in the first limit position, which is attached to a plunger rod (12) extending through the ferromagnetic core element (10) and through the permanent magnet (8) for mechanically coupling the actuator (5) to the circuit breaker arrangement, wherein the armature (6) comprises a lower plunger (13) unlockable attached on the opposite side of the plunger rod (12) in an axial distance from the core element (10) and movable on the core element (10) in order to shift the armature (6) to the second limit position by reducing the magnetic flux in the upper plunger (9).

See Figure 2a

Patent Claims

1. Bistable magnetic actuator (5) for a medium voltage circuit breaker arrangement, comprising at least one electrical coil (7) for switching a ferromagnetic armature (6) between a first limit position and a second limit position effected by an electromagnetic field, at least one permanent magnet (8) for holding the armature (6) in one of the two limit positions corresponding to an open and a closed electrical switching position respectively of the mechanically connected circuit breaker, wherein the armature (6) comprises an upper plunger (9) resting on a ferromagnetic core element (10) of the one electrical coil (7) for static holding the armature (6) in the first limit position, which is attached to a plunger rod (12) extending through the ferromagnetic core element (10) and through the permanent magnet (8) for mechanically coupling the actuator (5) to the circuit breaker arrangement, **characterized in that** the armature (6) comprises a lower plunger (13) unlockable attached on the opposite side of the plunger rod (12) in an axial distance from the core element (10) and movable on the core element (10) in order to shift the armature (6) to the second limit position by reducing the magnetic flux in the upper plunger (9).

2. Bistable magnetic actuator (5) according to Claim 1,
characterized in that the armature (6) further comprises a ferromagnetic yoke (11) surrounding the electrical coil (7) and the permanent magnet (8) in order to create a magnetic circuit including the upper plunger (9) and to the lower plunger (13).

3. Bistable magnetic actuator (5) according to Claim 1,
characterized in that gravity force or additional spring force is provided for initial movement of the lower plunger (13) to the core element (10) after unlocking it from the plunger rod (12).

4. Bistable magnetic actuator (5) according to Claim 1,
characterized in that the second limit position of the armature (6) is defined by a stop element (14) attached to the plunger rod (12) adjacent to the lower plunger (13).

5. Bistable magnetic actuator (5) according to Claim 1,
characterized in that an intermediate plate (15) of non-magnetic material is arranged between the lower plunger (13) and the core element (10) for controlling the magnetic distance between both parts of the armature (6).

6. Bistable magnetic actuator (5) according to Claim 5,
characterized in that the thickness of the intermediate plate (15) is dimensioned corresponding to the magnitude of the current in the electrical coil (10) that is needed to initiate the shifting operation of the armature (6).

7. Bistable magnetic actuator (5) according to Claim 1,
characterized in that the lower plunger (13) comprises fixing means for fastening or releasing the lower plunger (13) on the plunger rod (12).

8. Bistable magnetic actuator (5) according to Claim 7,
characterized in that the fixing means comprises of two gripper elements (16a, 16b) pivoting attached to lower surface (17) of the lower plunger (13) and corresponding with a groove (18) in the plunger rod (12) for fastening the lower plunger (13) thereon.

9. Bistable magnetic actuator (5) according to Claim 7,
characterized in that the fixing means comprises a spring element (19) for pressing the gripper elements (16a, 16b) against the groove (18) of the plunger rod (12).

10. Bistable magnetic actuator (5) according to Claim 7,
characterized in that the fixing means comprises an actuatable lever arm arrangement (20) for bridging the gripper elements (16a, 16b) in order to release the lower plunger (13) from the plunger rod (12).

11. Bistable magnetic actuator (5) according to Claim 10,
characterized in that a bowden cable (21) is provided for releasing the lever arm arrangement (20) by a low-energy operated electrical actuator in accordance with an electrical control signal.

12. Medium voltage circuit breaker with at least one vacuum interrupter (1) each comprising moving electrical contacts (2, 3) for electrical power interruption, operating via a common jackshaft (4) for mechanically coupling the moving electrical contacts (2, 3) with a bistable magnetic actuator (5) according to one of the preceding Claims.

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ABB TECHNOLOGY AG

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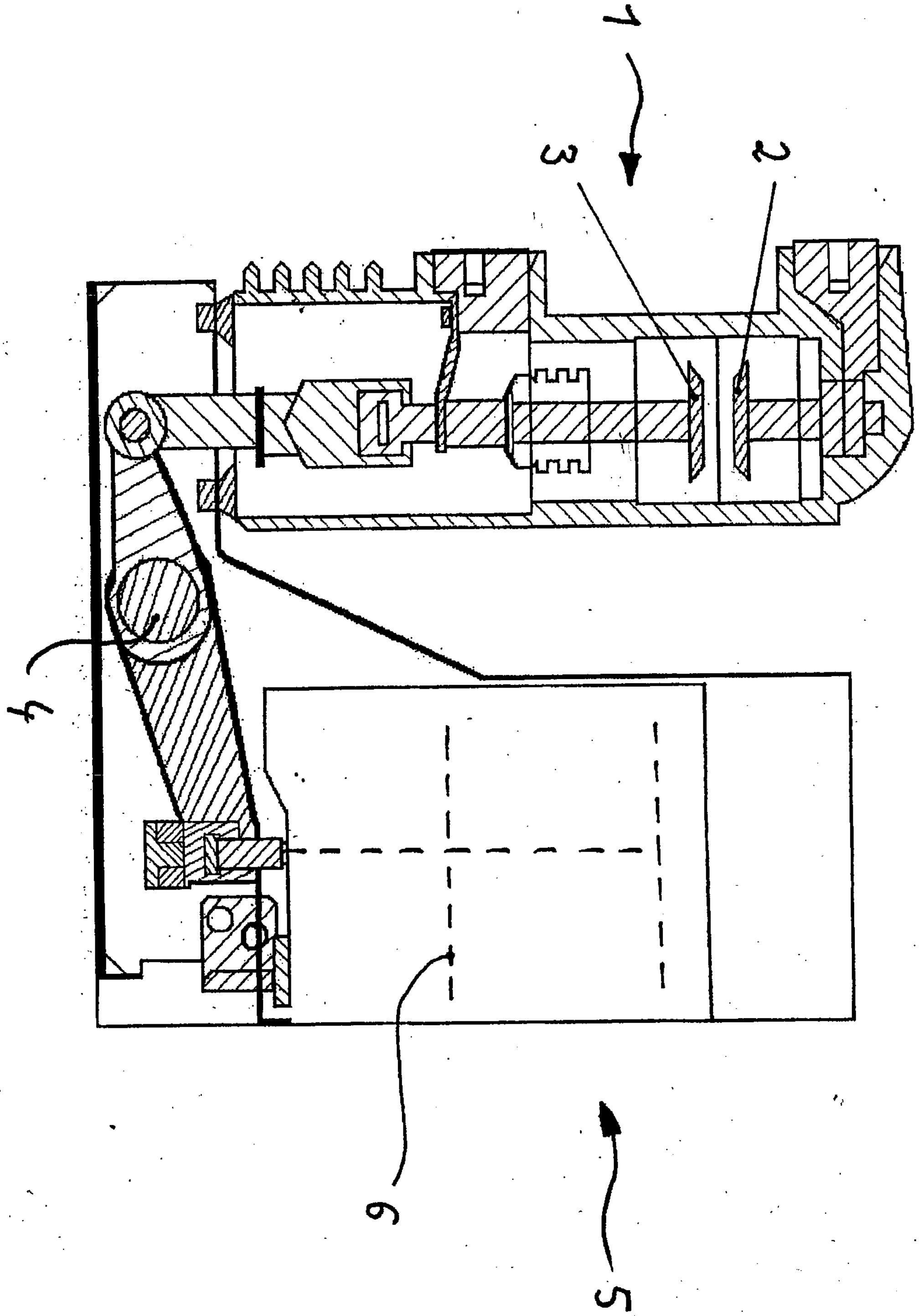

Fig.1

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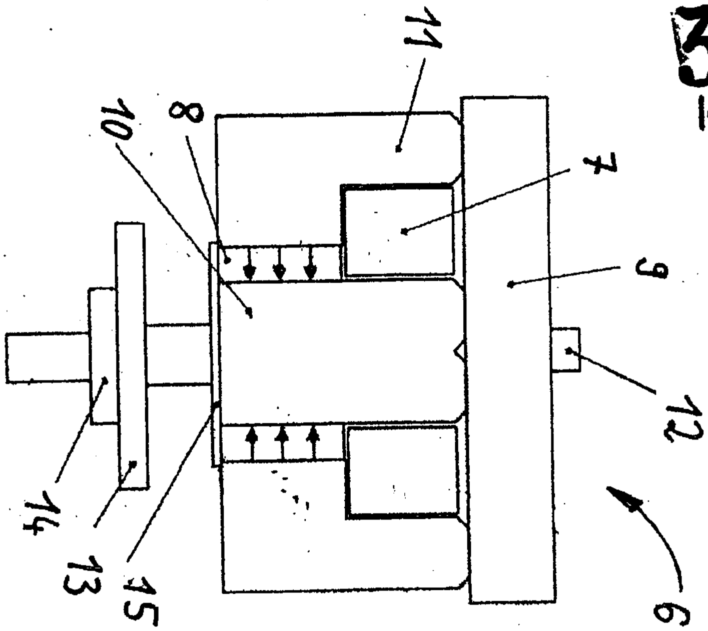

Fig.2a

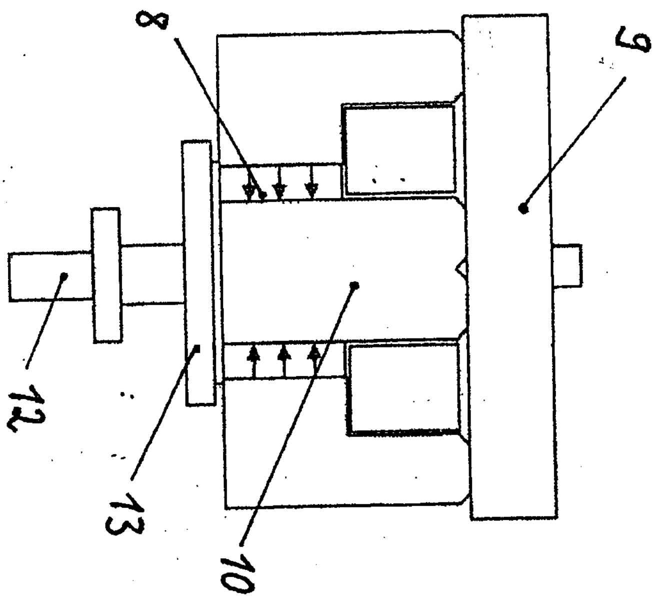

Fig.2b

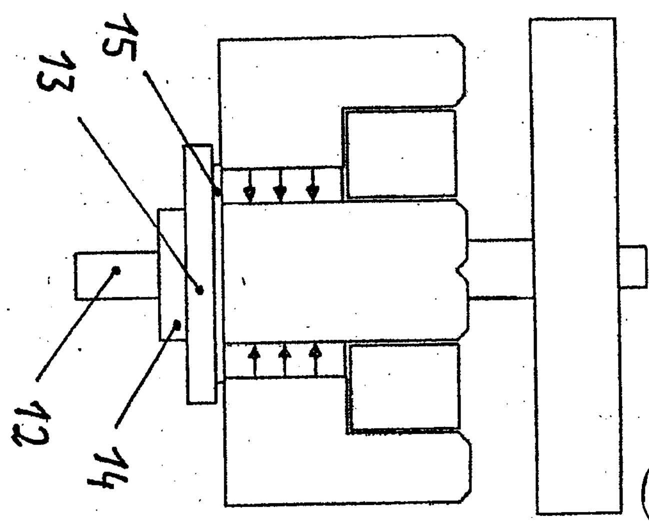

Fig.2c

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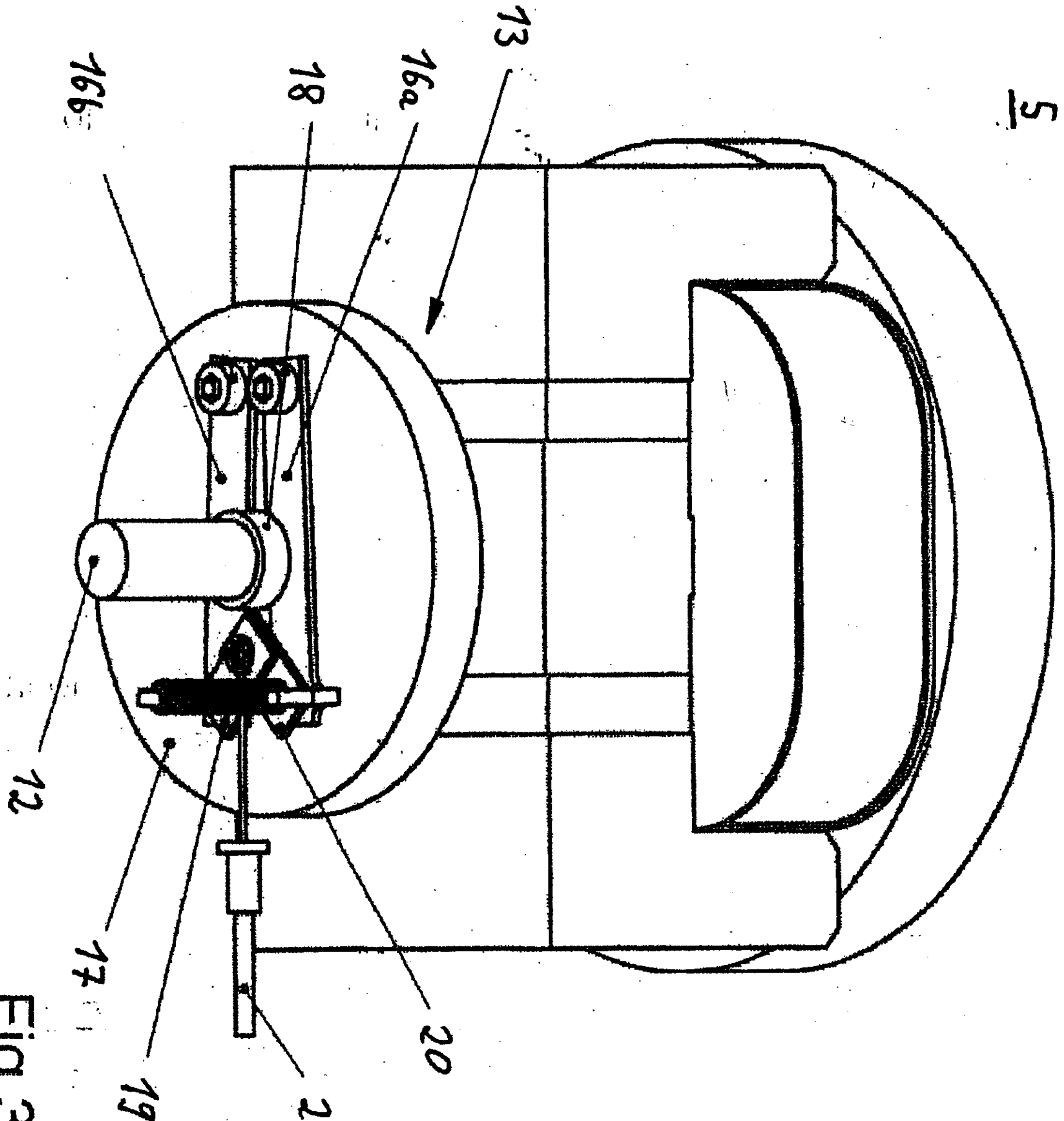

Fig.3

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Bistable Magnetic Actuator for a Medium Voltage Circuit Breaker

Field of the invention

The invention relates to a bistable magnetic actuator for a medium voltage circuit breaker comprising at least one electrical coil for switching a ferromagnetic armature between a first limit position and a second limit position effected by an electromagnetic field, at least one permanent magnet for holding the armature in one of the two limit positions corresponding to an open or a closed electrical switching position of the mechanically connected circuit breaker, wherein the armature comprises an upper plunger resting on a ferromagnetic coil element of the electrical coil for static holding the armature in the first limit position, which is attached to a plunger rod extending through the ferromagnetic coil element and through the permanent magnet for mechanically coupling the actuator with the circuit breaker.

Medium-voltage circuit breaker rated between 1 and 72 kV may be assembled into a metal-enclosed switch gear line ups for indoor use, or may be installed outdoor in a substation. Nowadays, vacuum circuit breakers replaced air-break circuit breakers for indoor applications. The characteristics of medium-voltage breakers are given by international standards. Especially, vacuum circuit breakers rated current up to 300 Ampere. These breakers interrupt the current by creating and extinguishing the arc in vacuum container. These are generally applied for voltages up to about 35,000 V, which corresponds roughly to the medium-voltage range of power systems. Vacuum circuit breakers tend to have longer life expectancies than air circuit breakers.

Nevertheless, the present invention is not only applicable to vacuum circuit breakers, but also to air circuit breakers or modern SF6 circuit breakers having a chamber filled with sulfur hexafluoride gas.

Background of the invention

It is a matter of common knowledge to use magnetic actuator with high force density to operate moving contacts for a purpose of electrical power interruption in the medium-voltage field of technology. Known magnetic actuators have a design with a fixed core in the center of the device, and two moveable plungers, one above and one below the core, that are connected with a plunger rod. Such a device is supposed to generate a high static holding force in the closed position to latch opening and contact springs. The magnitude of this static holding force is the key parameter for the design of the entire circuit breakers and for space and weights reasons it is generally advantageous to generate this force with a small magnetic actuator. In the open position, a lower static holding force is needed to keep the circuit breaker in open position. For bringing the actuator from close to open position feeding the electrical coil of the actuator with electrical energy is needed.

The document EP 0 898 780 B1 describes a magnetic actuator with a ferromagnetic armature which is displaceable linearely between two limit positions and which is mechanically connected to a circuit breaker and which in the limit positions is under the influence of magnetically generated forces. The armature and the ferromagnetic shunt body are arranged in succession in a space between first and second abutment. The abutments are pole surfaces of magnetic circuits which include at least one permanent magnet for generating a holding force for the armature. This known device is as well supposed to operate a vacuum circuit breaker. In the closed position, the ferromagnetic shunt body is apart from the armature. The shunt can now be moved towards the armature to initiate the opening operation of the circuit breaker. The known solution is based on a design that does not use the full potential of the static holding force as the affective area between the moveable armature and the fixed yoke is limited to the area that is inside the coil. The consequence is that the actuator is almost twice as big as needed.

The WO 03/030188 A1 discloses a further magnetic actuator, especially for a vacuum circuit breaker having a big design. Two electrical coils are needed in order to operate the magnetic actuator or bringing a connected circuit breaker from an open to a closed switching position. A first magnetic flux is generated by the armature and the yoke in such a way that the armature is held in one limit position and the electrical coil generates a second magnetic flux that actuates the armature. The permanent magnet is located between the yoke and a fixed magnetic return element, in such a way that the magnetic flux runs via the magnetic return element. In addition, the armature outside the yoke covers a front face of the yoke, said face running perpendiculary to the direction of displacement of the armature. Since the permanent magnet is provided to hold the magnetic armature in one of the two limit positions, neither mechanically latching nor a constant electrical current supply is required.

Also this known solution uses the armature for generating the static holding force in both limit positions. This implies a second magnetic path from the magnets to the armature that is only effective in the open limit position. This second magnetic path increases sizes again and weights of the magnetic actuator. It also requires a closed room around both the armature. The ferromagnetic shunt body forms the two abutments that need to fulfill magnetic functions. This increases the size and weight of the actuator further. The known solution entailes the driving of the ferromagnetic shunt body back to the lower abutment during the opening operation. This driving requires additional energy that is not available for the opening operation, which is the most critical operation of a circuit breaker in case of short circuit switching.

It is an object of the present invention to provide a bistable magnetic actuator for a medium voltage circuit breaker which has small dimensions and which allows a low-energy opening operation.

Summary of the invention

According to the invention a bistable magnetic actuator for a medium voltage circuit breaker is provided comprising at least one electrical coil for switching a ferromagnetic armature between a first limit position and a second limit position effected by an electromagnetic field, at least one permanent magnet for holding the armature in one of the two limit positions corresponding to an open or a closed electrical switching position of the mechanically connected circuit breaker, wherein the armature comprises an upper plunger resting on a ferromagnetic coil element of the one electrical coil for static holding the armature in the first limit position which is attached to a plunger rod extending through the ferromagnetic core element and through the permanent magnet for mechanically coupling the actuator to the circuit breaker, wherein the armature also comprises a lower plunger unlockable attached on the opposite side of the plunger rod in an axial distance from the core element and moveable on the core element in order to shift the armature to the second limit position by reducing the magnetic flux in the upper plunger.

The invention is based on the effect that the fraction of the flux of the at least one permanent magnet will be drained into the lower plunger. The force that is generated by the remaining flux at the transitions from the core element to the upper plunger is no longer sufficient to latch the drive against the opening force of the circuit breaker mechanism, which originates from the one or more contact springs and the one or more opening springs therein. Theses springs are sufficient to press the circuit breaker and the actuator in the open position.

Compared to the prior art the present invention describes the way how the actuator can be brought from close to open position without feeding the coil of the actuator. Therefore, a completely different design of the actuator is required, having less material for the same performance, resulting in a smaller and lighter solution. The full potential of the static holding force can be used, as the effective area between the moveable plunger and the fixed core element is both the area inside the electrical coil and the area of the two legs outside the electrical coil. Dedicated plungers are being used for generating the static holding force in the closed and open position. As the plungers just lay on top or at the bottom of the core element, this principle enables a very compact design. A closed room around all parts of this device is not required for magnetic reasons. A simple plastic cover can protect the magnetic air gap from intrusion of external particles. The lower plunger is sliding freely on the plunger rod during the opening operation and no force is drained from the system for moving the lower plunger and the full force is available to the opening operation of the circuit breaker. The lower plunger is moved away from the permanent magnet, especially back to the position that is normal for a closed circuit breaker, during the normal closing operation of the magnetic actuator.

The armature preferably comprises a ferromagnetic yoke surrounding the electrical coil and the permanent magnet in order to create a magnetic circuit including the upper plunger and the lower plunger.

Preferably, with the help of a small spring or simply by gravity (if the actuator is assembled upside-down inside a circuit breaker), the opening operation could be initiated after unlocking it from the plunger rod before.

In a preferred embodiment of the invention a stop element is provided which is attached to the plunger rod adjacent to the lower plunger in order to define the second limit position of the magnetic actuator.

According to another preferred embodiment of the invention an intermediate plate of non-magnetic material is arranged between the lower plunger and the core element for controlling the magnetic distance between both parts of the armature. This can be used to adjust the actuator's static force in its open position to the needs of the application. At the same time, the thickness of this intermediate plate can be used to adjust the magnitude of current of the electrical coil that is needed to initiate the closing operation, and therewith the amount of energy that is used for the closing operation.

According to a further preferred embodiment of the invention fastening or releasing the lower plunger on the plunger rod can be achieved by fixing means mounted on the lower plunger. Preferably, said fixing means comprise of two gripper elements pivoting attached to the lower surface of the lower plunger and corresponding with a groove of the plunger rod for fastening the lower plunger thereon. The gripper elements can consist of sheet metal mounted below the lower plunger with screws. Additionally, the fixing means can comprise a spring element for pressing the gripper elements against the groove of the plunger rod. The spring element serves to secure the form-fit mechanical connection.

In order to release the lever arm arrangement of the fixing means easily, a bowden cable could preferably be used operated by a low-energy electromagnetic actuator in accordance with an electrical control signal. As the lower plunger is no longer locked on the plunger rod, it now can be moved towards the core element as described above to initiate the opening operation.

The foregoing and other aspects of the invention will become apparent following the detailed description of the invention when considered in conjunction with the enclosed drawings.

Brief description of the drawings

Figure 1 is a schematic view of the medium-voltage circuit breaker operated by a magnetic actuator,

Figure 2a is a detailed schematic view of the magnetic actuator in the closed position,

Figure 2b is a detailed schematic view of the magnetic actuator in an intermediate position

Figure 2c is a detailed schematic view of the magnetic actuator in the open position, and

Figure 3 is a perspective schematic view of the view of magnetic actuator's fixing means on the lower plunger.

Detailed description of the drawings

The medium-voltage circuit breaker as shown in Figure 1 principally consists of a vacuum interruptor 1 having an inner fixed electrical contact 2 and a corresponding moveable electrical contact 3. Both electrical contacts 2 and 3 form a switch for electrical power interruption. The moveable electrical contact 3 is moveable between the closed and the open position via a jack shaft 4. This jack shaft 4 internally couples the mechanical energy of a bistable magnetic actuator 5 to the moving electrical contact 3 of the vacuum interruptor 1. The magnetic actuator 5 consists of a bistable magnetic system in which switching of an armature 6 to the relative positions are affected by magnetic fields generated by an electromagnet and permanent magnet arrangement.

According to Figure 2a the magnet actuator 5 comprises an electrical coil 7 to move the ferromagnetic armature 6 between two limit positions effected by a magnetic field. In the closed position (as shown) the magnetic actuator keeps the connected vacuum interruptor closed. Additionally, separate opening springs will be compressed by the static holding force of the magnetic actuator 5 that originates from the flux of a permanent magnet 8 which is arranged beside the electrical coil 7. No additional power or current in the electrical coil 7 is needed to maintain the shown closed position.

The armature 5 further comprises an upper plunger 9 resting on a ferromagnetic core element 10 of the one electrical coil 7 for static holding the armature 5 in the first limit position, i. e. the closed position. The upper plunger 9 is attached to a plunger rod 12. The plunger rod 12 extends moveable axially through the ferromagnetic core element 10 for coupling the actuator 5 mechanically to the circuit breaker arrangement as described above.

Since the upper plunger 9 rests on the core element 10, the magnetic flux that is generated by the permanent magnet 8 is lead upwards through the core element 10 into the upper plunger 9. Here, at the transition from the core element 10 to the upper plunger 9, about the half of the total static holding force is being generated. The flux splits up in the plunger 9 and flows back through a ferromagnetic yoke 11 surrounding the electrical coil 7 and the permanent magent 8. At the transition from the upper plunger 9 to the yoke 11, the other half of the total static holding force is being generated.

A lower plunger 13 is located on the plunger rod 12 at a position that is far from the core element 10 so that is does not affect the magnetic circuit.

Figure 2b shows how the opening operation is initiated. The lower plunger 13 is released from the plunger rod 12 and forwarded to the core element 10 by the help of a – not shown – small spring element. As a consequence, a fraction of the flux of the permanent magnet 8 will be drained into the lower plunger 13. The force that is generated by the remaining flux of the transitions form the core element 10 to the upper plunger 9 is no longer sufficient to latch the drive against the opening force of the connected circuit breaker.

In consequence, the plunger rod 12 moves into the open position as shown in Figure 2c. A stop element 14 attached to the plunger rod 12 is provided in order to define the second limit position of the armature 6. An intermediate plate 15, made of non-magnetic material, is provided in order to control the magnetic distance of the lower plunger 13 to the core element 10. This can be used to adjust the actuator's static force in the open position to the needs of the application. After having completed the opening operation, as shown in figure 3, the lower plunger 13 can now be latched to the plunger rod 12.

According to Figure 3 the lower plunger 13 comprises fixing means for fastening or releasing it to the plunger rod 12. The fixing means comprises two gripper elements 16a, 16b consisting of sheet metal and pivoting attached to the lower surface 17 of the lower plunger 13. Both gripper elements 16a, 16b correspond with a groove 18 of the plunger rod 12 for fastening the lower plunger 13 thereon. If the actuator is not operating, a spring element 19 presses the gripper elements 16a and 16b slidely against the groove 18 in the plunger rod 12, so that the lower plunger 13 is locked and cannot be moved along the plunger rod 12.

If the actuator is supposed to open, both gripper elements 16a, 16b can be pulled away from the plunger rod 12 using an actuatable lever arm arrangement 20. A bowden cable 21 is provided for releasing the lever arm arrangement 20 by a – not shown – electromagnet or the like. As the lower plunger 13 is no longer locked on the plunger rod 12, it can now be moved towards the core element 10, as described above, to initiate the opening operation.

When the opening operation is accomplished and the bowden cable 21 is no longer being pulled, the spring element 19 can press gripper elements 16a and 16b on the plunger rod 12 to re-lock the lower plunger 13. Subsequently, a normal closing operation can be performed.

The invention is not limited by the preferred embodiment as described above which is presented as an example only but can be modified in various ways within this scope of protection defined by the appended patent claims.

Reference list

1	vacuum interrupter
2	electrical contact (fix)
3	electrical contact (moveable)
4	jack shaft
5	magnetic actuator
6	armature
7	electrical coil
8	permanent magnet
9	upper plunger
10	core element
11	yoke
12	plunger rod
13	lower plunger
14	stop element
15	intermediate plate
16	gripper element
17	lower surface
18	groove
19	spring element
20	lever arm arrangement
21	bowden cable