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(54) **MAGNETIC LATCHING TRIP ACTUATOR AND SWITCHING APPLIANCE**

(57) The present disclosure provides a magnetic latching trip actuator and a switching appliance. The magnetic latching trip actuator includes a yoke, an armature (3), a coil (5) and a permanent magnet (4), the yoke includes a U-shaped yoke (10) with an opening toward the armature (3). The permanent magnet (4) is magnetically coupled to the yoke, and magnetic flux of the permanent magnet (4) is transmitted through a working magnetic loop of the permanent magnet (φ1) in the yoke and the armature (3). The coil (5) is wound on the yoke, magnetic flux of the coil (5) is transmitted through a magnetic loop for tripping drive (φ2) in the yoke and the armature (3) that reduces the magnetic flux of the permanent magnet (4). Wherein two short-circuit magnetic loops (φ3, φ4) are provided outside the permanent magnet (4) to short-circuit the permanent magnet (4).

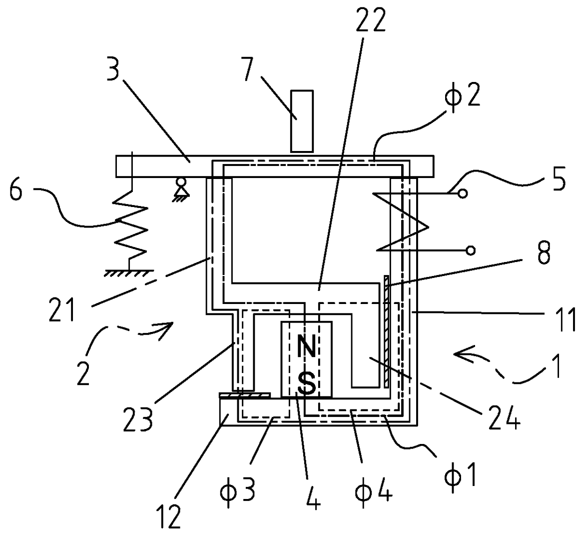

FIG. 4

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Description

TECHNICAL FIELD

[0001] The present disclosure relates to the field of switching appliances, in particular to a magnetic latching trip actuator.

BACKGROUND

[0002] With the popularization of electrical equipment, people have more access to related equipment, and electrical safety is getting more and more attention. In order to effectively prevent damage of residual current to humans and equipment, residual current devices (RCDs) are widely used in important occasions, and the RCDs have residual current protection action characteristics and are independent of power supply voltage. There is a type of residual current devices called electromagnetic RCD, which can be tripped to disconnect a circuit when the residual current does not exceed 100 mA, and does not require any auxiliary power supply. The electromagnetic RCD converts the residual current to a secondary side by using a transformer; an electromagnetic tripping actuator is driven by an output of the secondary side; and in turn the tripping actuator pushes the RCD to trip so as to disconnect the circuit. In the absence of the auxiliary power supply, the residual current input by the transformer is very small, so the current on the secondary side is very small, giving a very low driving power to the electromagnetic tripping actuator. Consequently, the electromagnetic tripping actuator is required to be very sensitive.

[0003] An existing magnetic latching trip actuator, as shown in FIGS. 1 and 2, includes 1, a second yoke 2, an armature 3, a permanent magnet 4, a coil 5, a tension spring 6 and a push rod 7. The first yoke 1 has an L-shaped structure. The second yoke 2 has a Z-shaped structure. The first yoke 1 and the second yoke 2 are combined to form a U-shaped yoke 10 with an opening facing the armature 3. The permanent magnet 4 is sandwiched between the first yoke 1 and the second yoke 2. The U-shaped yoke 10 includes a first pole surface 101 on the first yoke 1 and a second pole surface 102 on the second yoke 2. a working air gap magnetic field is formed between the first pole surface 101 and the second pole surface 102 under the action of the permanent magnet. The armature 3 is a swingable lever mechanism. One end of the tension spring 6 acts on the armature 3.

[0004] As shown in FIG. 1, in a closed state, the armature 3 is magnetically attracted to the U-shaped yoke 10, and the magnetic flux of the permanent magnet 4 passes through the working magnetic loop of the permanent magnet φ1 holds the armature 3 on the first pole surface 101 and the second pole surface 102 of the U-shaped yoke 10, and the tension spring 6 is stretched by the armature 3 to store energy. The coil 5 is wound on the first yoke 1. When the coil 5 is energized, the magnetic flux generated by the coil 5 passes through the magnetic loop for tripping drive φ2 to reduce the magnetic flux of the permanent magnet 4, so that the adsorption force of the U-shaped yoke 10 on the armature 3 is weakened. Under the elastic force of the tension spring 6, the armature 3 is separated from the U-shaped yoke 10 (as shown in FIG. 2). The push rod 7 is slidably arranged on a swing path of the armature 3. Once the armature 3 is disengaged, the push rod 7 can be pushed out of the trip actuator to trigger the tripping mechanism.

[0005] In addition, one arm 210 of the second yoke 2 is arranged to be parallel to and close to the winding segment 11 of the first yoke 1 on which the coil 5 is wound, so that the short-circuit magnetic loop φ3 of the permanent magnet 4 is formed on the side of the permanent magnet 4 close to the winding segment 11. When a magnetic gap is generated between the armature 3 and the U-shaped yoke 10, more magnetic flux will pass through the short-circuit magnetic loop φ3 (that is, the short-circuit magnetic loop φ3 shuts part of the magnetic flux of the permanent magnet), so that the magnetic flux at the first pole surface 101 and the second pole surface 102 decreases rapidly. Therefore, the coil 5 only needs a smaller current to achieve the disengagement of the armature 3.

[0006] The existing magnetic latching trip actuator is used in some occasions that require extremely high sensitivity; its sensitivity is not enough. At present, the conventional means to improve the sensitivity of the trip actuator is to increase the tension spring force of the tension spring 6 (such as replacing the tension spring with a larger elastic coefficient) so that the armature 3 is subjected to a larger pulling force of the tension spring 6 in the closed state, thus the tension spring 6 can pull the armature 3 faster when the armature 3 is disengaged. However, if the tension spring force of the tension spring 6 is increased, the magnetic holding force of the U-shaped yoke 10 on the armature 3 must also be increased accordingly to keep the armature 3 in the closed position, so that the total magnetic flux of the permanent magnet 4 needs to be increased. The magnetic flux in the working magnetic loop of the permanent magnet φ1 also increases, so it is necessary to make the trip actuator move and provide more power to the coil 5. Obviously, in the case of small currents that require extremely high sensitivity, this solution of increasing the tension spring is contradictory and not applicable.

SUMMARY

[0007] Accordingly, directed at the above problems, the present disclosure provides a magnetic latching trip actuator with optimized structure, which can maintain high sensitivity in applications with small input current, or make the driving current required for the coil smaller under the condition of equal magnetic holding force. The present disclosure also provides a switching appliance having the magnetic latching trip actuator.

[0008] The present disclosure is implemented by the following technical solutions.

[0009] In one aspect, a magnetic latching trip actuator includes a yoke, an armature, a coil and a permanent magnet, the yoke includes a U-shaped yoke with an opening toward the armature, the permanent magnet is magnetically coupled to the yoke, and magnetic flux of the permanent magnet is transmitted through a working magnetic loop of the permanent magnet in the yoke and the armature, the coil is wound on the yoke, magnetic flux of the coil is transmitted through a magnetic loop for tripping drive in the yoke and the armature that reduces the magnetic flux of the permanent magnet. Wherein two short-circuit magnetic loops are provided outside the permanent magnet to short-circuit the permanent magnet.

[0010] In some embodiment, a path of one of the short-circuit magnetic loops does not overlap with a path of the magnetic loop for tripping drive.

[0011] In some embodiment, the yoke comprises a first yoke and a second yoke, the first yoke and the second yoke are combined to form the U-shaped yoke, the first yoke and the second yoke clamp the permanent magnet, the first yoke and the second yoke are combined to form a frame structure that substantially surrounds the permanent magnet, thereby forming the two short-circuit magnetic loops on the frame structure.

[0012] In some embodiment, the first yoke comprises a first yoke arm, a first pole surface is formed on the first yoke arm, and the first yoke arm has a winding section for winding the coil; the second yoke comprises a second yoke arm, a second pole surface is formed on the second yoke arm, the armature is defined to be located at an upper side of the yoke, the first yoke arm and the second yoke arm are spaced apart and extend vertically up and down.

[0013] In some embodiment, the frame structure and the first yoke arm are spaced apart so that the winding space for winding the coil is provided on an entire first yoke arm.

[0014] In some embodiment, the first yoke is an L-shaped structure, and further comprises a first transverse straight arm, the second yoke is an h-shaped structure, and further comprises a second transverse straight arm connected to a lower end of the second yoke arm, and a first vertical straight arm and a second vertical straight arm spaced apart and connected to an lower end of the second transverse straight arm and extend downwards, the first transverse straight arm, the second transverse straight arm, the first vertical straight arm and the first yoke arm are combined to form the frame structure that substantially surrounds the permanent magnet; or,

the first yoke is a U-shaped structure, further comprising a first transverse straight arm connected to a lower end of the first yoke arm and a third vertical straight arm connected to an end of the first transverse straight arm away from the first yoke arm and extending upward, the second yoke is a Z-shaped structure, and further comprises a second transverse straight arm connected to a lower end of the second yoke arm and a fourth vertical straight arm connected to an end of the second transverse straight arm away from the second yoke arm and extending downward, the first transverse straight arm, the second transverse straight arm, the third vertical straight arm and the fourth vertical straight arm are combined to form the frame structure that substantially surrounds the permanent magnet.

[0015] In some embodiment, two magnetic poles of the permanent magnet are arranged in a vertical direction, or in a lateral direction perpendicular to the vertical direction.

[0016] In some embodiment, a path of one of the short-circuit magnetic loops does not overlap with a path of the magnetic loop for tripping drive.

[0017] In some embodiment, the first yoke comprises a first yoke arm, a first pole surface is formed on the first yoke arm, and the first yoke arm has a winding section for the coil winding thereon; the second yoke comprises a second yoke arm, a second pole surface is formed on the second yoke arm, the first yoke arm and the second yoke arm are spaced apart and extend in a same direction, the magnetic loop for tripping drive is arranged within a span range of the first yoke arm and the second yoke arm, and the permanent magnet is arranged outside the span range of the first yoke arm and the second yoke arm so that the path of one of the short-circuit magnetic loops does not overlap with the path of the magnetic loop for tripping drive.

[0018] In some embodiment, the armature is defined to be located at an upper side of the yoke, the first yoke arm and the second yoke arm are spaced apart and vertically extend, and the first yoke further comprises a first transverse straight arm connected to a lower end of the first yoke arm and a fifth vertical straight arm connected to the first transverse straight arm and extending upward, the fifth vertical straight arm is close to the second yoke arm, the second yoke further comprises a second transverse straight arm connected to a lower end of the second yoke arm and a sixth vertical straight arm connected to an end of the second transverse straight arm away from the second yoke arm and extending downward, the permanent magnet is arranged on a side of the fifth vertical straight arm away from the first yoke arm, the first yoke arm, the second yoke arm, the first transverse straight arm, the fifth vertical straight arm and the armature constitute the magnetic loop for tripping drive, the first transverse straight arm, the second transverse straight arm, the fifth vertical straight arm and the sixth vertical straight arm are combined to form the frame structure which substantially surrounds the permanent magnet.

[0019] In some embodiment, the armature is located at an upper side of the yoke, the first yoke arm and the second yoke arm are spaced apart and vertically extend, the first yoke is a U-shaped structure, and further comprises a first transverse straight arm connected to a lower end of the first yoke arm and a seventh vertical straight arm connected to an end of the first transverse straight arm away from the first yoke arm and extending upward, the second yoke further comprises a second transverse straight arm, wherein the second yoke arm extends downward to be close to the first transverse straight arm, the second transverse straight arm and the second yoke arm are crossed in a T-shaped, the permanent magnet is arranged on a side of the second yoke arm away from the first yoke arm, the first yoke arm, the second yoke arm, the first transverse straight arm and the armature constitute the magnetic loop for tripping drive, the first transverse straight arm, the second transverse straight arm, the second yoke arm and the seventh vertical straight arm are combined to form the frame structure which substantially surrounds the permanent magnet.

[0020] In some embodiment, an eighth vertical straight arm extending upward is further connected to an end of the second transverse straight arm away from the second yoke arm, the eighth vertical straight arm and the seventh vertical straight arm are close to each other.

[0021] In some embodiment, the yoke is single, the permanent magnet is in a strip-shaped structure, the permanent magnet is fixedly arranged outside a U-shaped enclosed area of the yoke, a non-magnetic end of the permanent magnet is arranged close to the yoke, thereby forming a short-circuit magnetic loop on the yoke that short-circuits the permanent magnet, the magnetic latching trip actuator further comprises a magnetizer, the magnetizer is fixedly arranged outside the permanent magnet, thereby forming another short-circuit magnetic loop that short-circuits the permanent magnet.

[0022] In some embodiment, the magnetizer is fixedly disposed at a side of the permanent magnet facing away from the yoke; or

a magnet spacer is provided between the magnetizer and the permanent magnet ; or
the magnetizer is a planar sheet structure or a U-shaped sheet structure that semi-encloses the permanent magnet; or
an end of the yoke away from the opening thereof comprises two right angle connecting portions, and the permanent magnet is disposed close to one side of the two right angle connecting portions; or
an end of the yoke away from the opening thereof comprises a right-angle connecting portion and an oblique angle connecting portion, and the permanent magnet is disposed close to the oblique angle connecting portion.

[0023] In another aspect, a switching appliance includes a tripping mechanism and a trip actuator, wherein the trip actuator is the magnetic latching trip actuator of present disclosure.

[0024] The present disclosure has the following beneficial effects:

[0025] The magnetic latching trip actuator of the present disclosure is provided with two short-circuit magnetic loops for short-circuiting the permanent magnet on the outer side of the permanent magnet, and the magnetic flux generated by the permanent magnet is shunted into three parts. When a magnetic gap is generated between the armature and the U-shaped yoke, more magnetic flux will be shunted by the short-circuit magnetic loops, so that the magnetic flux at the pole surface of the U-shaped yoke decreases faster, and the adsorption force of the permanent magnet on the armature decreases faster. Therefore, the coil only needs a smaller current (or a lower coil power) to achieve the disengagement of the armature, so that the magnetic flux in the permanent magnet working loop is more sensitive to the pole surface gap, thereby improving the sensitivity of the trip actuator; on the other hand, if the present disclosure increases the tension spring force of the tension spring to improve the sensitivity of the trip actuator, the energy required to increase the magnetic flux of the permanent magnet to increase the magnetic holding force is also less than that of the prior art.

[0026] The magnetic latching trip actuator disclosed in the present disclosure can surround the permanent magnet through the magnetizer, thereby better shielding the influence of the external magnetic field on the permanent magnet.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027]

FIG. 1 is a schematic diagram of the magnetic latching trip actuator in the prior art, wherein the armature is in a closed state.
FIG. 2 is a schematic diagram of the magnetic latching trip actuator in the prior art, wherein the armature is in a disengaged state.
FIG. 3 is a schematic diagram of the switching appliance in the first embodiment of the present disclosure.
FIG. 4 is a schematic diagram of the magnetic latching trip actuator in the first embodiment, wherein the armature is in a closed state.
FIG. 5 is a schematic diagram of the magnetic latching trip actuator in the first embodiment, wherein the armature is in a disengaged state.
FIG. 6 is a curve diagram showing the adsorption force of the permanent magnet at the pole surface of the permanent magnet of the magnetic latching trip actuator in the first embodiment compared to the magnetic latching trip actuator of the prior art.
FIG. 7 is a schematic diagram of the magnetic latching trip actuator in the second embodiment of the present disclosure.
FIG. 8 is a schematic diagram of the magnetic latching trip actuator in the third embodiment of the present disclosure.
FIG. 9 is a schematic diagram of the magnetic latching trip actuator in the fourth embodiment of the

present disclosure.

FIG. 10 is a schematic diagram of the magnetic latching trip actuator in the fifth embodiment of the present disclosure.

FIG. 11 is a schematic diagram of a variation of the fifth embodiment.

FIG. 12 is a schematic diagram of the magnetic latching trip actuator in the sixth embodiment of the present disclosure.

FIG. 13 is a schematic diagram of a variation of the sixth embodiment.

FIG. 14 is a schematic diagram of the magnetic latching trip actuator in the seventh embodiment of the present disclosure.

FIG. 15 is a schematic diagram of a switching appliance in an embodiment of the present disclosure.

FIG. 16 is a schematic diagram of the magnetic latching trip actuator in the eighth embodiment of the present disclosure, in which shows the outer shell and the armature in a disengaged state.

FIG. 17 is a schematic diagram of the magnetic latching trip actuator in the eighth embodiment, in which the outer shell is hidden and the armature is in a closed state.

FIG. 18 is a schematic diagram of the magnetic latching trip actuator in the ninth embodiment of the present disclosure.

FIG. 19 is a schematic diagram of the magnetic latching trip actuator in the tenth embodiment of the present disclosure.

DETAILED DESCRIPTION

[0028] To further illustrate each embodiment, the present disclosure provides drawings. These drawings are part of the disclosure of the present disclosure, and are mainly used to illustrate the embodiments, and can be used in conjunction with the relevant descriptions in the specification to explain the operating principles of the embodiments. With reference to these contents, a person of ordinary skill in the art should be able to understand other possible implementations and advantages of the present disclosure. The components in the drawings are not drawn to scale, and similar component symbols are generally used to represent similar components.

[0029] The present disclosure is now further described in conjunction with the accompanying drawings and specific embodiments.

the First Embodiment

[0030] Referring to FIG. 3, as a preferred embodiment of the present disclosure, a switching appliance, more specifically a circuit breaker, is provided, which includes a tripping mechanism 200 and a trip actuator 100 for triggering the tripping mechanism 200. The trip actuator 100 is a magnetic latching trip actuator, and its structure is shown in FIGS. 4 and 5, including a yoke, an armature 3, a permanent magnet 4, a coil 5, a tension spring 6 and a push rod 7. The yoke is a double yoke structure, including a first yoke 1 and a second yoke 2. The first yoke 1 and the second yoke 2 are combined to form a U-shaped yoke 10 with an opening toward the armature 3. The permanent magnet 4 is clamped between the first yoke 1 and the second yoke 2. The U-shaped yoke 10 includes a first yoke arm 11 and a second yoke arm 21 forming a first pole surface 101 and a second pole surface 102, respectively. The first yoke arm 11 is provided on the first yoke 1 and serves as a winding section for winding the coil 5. The second yoke arm 21 is provided on the second yoke 2. For convenience of description, it is defined that the armature 3 is located on the upper side of the yoke, and the first yoke arm 11 and the second yoke arm 21 are spaced from each other and extend vertically up and down.

[0031] Under the action of the permanent magnet 4, a working air gap magnetic field is formed between the first pole surface 101 and the second pole surface 102. The armature 3 is a lever mechanism that can swing. One end of the tension spring 6 is connected to the armature 3. As shown in FIG. 4, in the closed state, the armature 3 is magnetically attracted to the U-shaped yoke 10, and the magnetic flux of the permanent magnet 4 passes through the working magnetic loop of the permanent magnet $\varphi 1$ and holds the armature 3 on the first pole surface 101 and the second pole surface 102 of the U-shaped yoke 10. The tension spring 6 is stretched by the armature 3 to store energy. When the coil 5 is energized, the magnetic flux generated by the coil 5 passes through the magnetic loop for tripping drive $\varphi 2$ to reduce the magnetic flux of the permanent magnet 4, so that the adsorption force of the U-shaped yoke 10 on the armature 3 is weakened. Under the elastic force of the tension spring 6, the armature 3 is separated from the U-shaped yoke 10 (as shown in FIG. 5). The push rod 7 is slidably arranged on the swing path of the armature 3. Once the armature 3 is disengaged, the push rod 7 can be pushed out of the trip actuator to trigger the tripping mechanism.

[0032] It should be noted that "the U-shaped yoke 10" means that the structure formed by the combination of the first yoke 1 and the second yoke 2 is generally a yoke with a U-shaped opening, and the open end of the U-shaped yoke 10 is a U-shaped opening structure, the structure of the closed end of the U-shaped yoke 10 away from the open end may vary according to actual applications, and does not necessarily have to form a standard U shape.

[0033] As shown in FIG. 5, in particular, in this embodiment, the first yoke 1 and the second yoke 2 are enclosed to form a frame structure S that substantially surrounds the permanent magnet 4, thereby forming two short-circuit magnetic loops $\varphi 3$, $\varphi 4$ (see FIG. 4) on the frame structure S, which short-circuit the permanent magnet 4. Specifically, in this embodiment, the first yoke 1 is an L-shaped structure, including a first yoke arm 11 and a first transverse straight arm 12, and the second yoke 2 is an h-shaped structure, including a second yoke arm 21, a second transverse straight arm 22 connected to the lower end of the second yoke arm 21, and a first vertical straight arm 23 and a second vertical straight arm 24 connected to the lower end of the second transverse straight arm 22 spaced apart and extending downward. The first transverse straight arm 12, the second transverse straight arm 22, the first vertical straight arm 23 and the first yoke arm 11 surround the frame structure S, and the second vertical straight arm 24 can increase the magnetic transmission area and efficiency of the frame structure S and the first yoke 1.

[0034] The frame structure S of this embodiment is composed of several straight arm structures to form a roughly rectangular shape. In other embodiments, the frame structure may also be composed of bent arms or special-shaped arms, that is, as long as the frame structure can be formed to surround the permanent magnet 4. Since a slight gap between the first yoke 1 and the second yoke 2 can also achieve magnetic conduction, there may be a gap between the first yoke 1 and the second yoke 2. In other words, the frame structure S only needs to substantially surround the permanent magnet 4, and does not have to completely surround the permanent magnet 4.

[0035] The frame structure S of this embodiment can surround the permanent magnet 4 and better shield the influence of the external magnetic field on the permanent magnet 4. More importantly, in this embodiment, two short-circuit magnetic loops φ3, φ4 are provided on the outer side of the permanent magnet 4 to short-circuit the permanent magnet 4, so that the magnetic flux generated by the permanent magnet 4 is divided into three parts. When there is a magnetic gap between the armature 3 and the U-shaped yoke 10, more magnetic flux will pass through the short-circuit magnetic loop φ3, φ4, so that the magnetic flux at the first pole surface 101 and the second pole surface 102 decreases faster, so that the adsorption force of the permanent magnet 4 on the armature 3 decreases faster. Therefore, the coil 5 only needs a smaller current (or a lower coil power) to achieve the disengagement of the armature 3, so that the magnetic flux in the permanent magnet working loop is more sensitive to the pole surface gap (the gap between the pole surface of the U-shaped yoke 10 and the armature 3), thereby improving the sensitivity of the trip actuator.

[0036] FIG. 6 shows a curve diagram of the permanent magnet adsorption force at the pole face of the magnetic latching trip actuator of the present embodiment compared with the magnetic latching trip actuator of the prior art. Wherein, a1 is the tension spring force at the pole face position, a2 is the increased tension spring force at the pole face position; b1 is the magnetic adsorption force of the permanent magnet at the pole face position after the coil generates magnetic flux in the prior art, b2 is the magnetic adsorption force of the permanent magnet at the pole face position after the coil generates magnetic flux in the present disclosure; c1 is the magnetic adsorption force of the permanent magnet at the pole face position after the magnetic flux of the permanent magnet is increased in the prior art, c2 is the magnetic adsorption force of the permanent magnet at the pole face position after the magnetic flux of the permanent magnet is increased in the present disclosure; d is the magnetic adsorption force of the permanent magnet at the pole face position in the prior art; E is the area between c1 and c2, indicating the energy required to disengage the armature after the magnetic flux of the permanent magnet is increased in the present disclosure, which is a reduced energy compared with the prior art. It can be seen that the present embodiment is provided with two short-circuit magnetic loops, since more magnetic flux of the permanent magnet is divided by the short-circuit magnetic loops, the magnetic flux at the first pole surface 101 and the second pole surface 102 decreases faster, so that the adsorption force of the permanent magnet 4 on the armature 3 decreases faster. On the other hand, if the present embodiment increases the tension spring force of the tension spring 6 to improve the sensitivity of the trip actuator, the energy required to increase the magnetic flux of the permanent magnet to increase the magnetic holding force is also less than that of the prior art.

[0037] In this embodiment, the first yoke 1 and the second yoke 2 of the frame structure S have permanent magnet short-circuit surfaces arranged oppositely between their adjacent portions, and the gap between the two permanent magnet short-circuit surfaces is not greater than 0.2 mm. Furthermore, a magnet spacer can be provided between the first yoke 1 and the second yoke 2, for example, a magnet spacer 8 is provided between the second vertical straight arm 24 and the first yoke arm 11, and the magnet spacer 8 makes the gap between two permanent magnet short-circuit surfaces of the first yoke 1 and the second yoke 2 not greater than 0.2 mm. By controlling the thickness of the magnet spacer, the matching effect between the short-circuit magnetic loop φ3, φ4 and the working magnetic loop of the permanent magnet φ1 can be better.

[0038] The magnetic latching trip actuator of this embodiment has extremely high sensitivity and can be used in small current applications that require extremely high sensitivity.

the Second Embodiment

[0039] As shown in FIG. 7, this embodiment provides a magnetic latching trip actuator, which has a structure similar to that in the first embodiment and has the same technical effect of the same structure. The difference between the magnetic latching trip actuator in this embodiment and the magnetic latching trip actuator in the first embodiment is that the structures of the first yoke and the second yoke are different. In this embodiment, the first yoke 1A is a U-shaped structure, including a first yoke arm 11A, a first transverse straight arm 12A connected to the lower end of the first yoke arm 11A, and a third vertical straight arm 13A connected to the first transverse straight arm 12A away from the end of the first yoke arm 11A and extending upward. The second yoke 2A is a Z-shaped structure, including a second yoke arm 21A, a second transverse straight arm 22A connected to the lower end of the second yoke arm 21A, and a fourth vertical straight arm 23A connected to the second transverse straight arm 22A away from the end of the second yoke arm 21A and extending downward. The first transverse straight arm 12A, the second transverse straight arm 22A, the third vertical straight arm 13A and the fourth vertical straight arm 23A are enclosed to form a frame structure that basically surrounds the permanent magnet 4A, thereby forming two short-circuit magnetic loops φ3A and cp4A that short-circuit the permanent magnet 4A. The working magnetic loop of the permanent magnet φ1A and the magnetic loop for tripping drive φ2A are shown in the drawings for understanding.

[0040] In addition, in this embodiment, the frame structure formed by the first transverse straight arm 12A, the second transverse straight arm 22A, the third vertical straight arm 13A and the fourth vertical straight arm 23A is spaced from the first yoke arm 11A, so that the winding space for winding the coil 5A is provided in the circumferential direction of the entire first yoke arm 11A. By utilizing the winding space, the axial length of the coil 5A in this embodiment is substantially equal to the length of the first yoke arm 11A, thereby increasing the number of winding turns of the coil 5A, reducing the inductance of the coil 5A, and improving the coil efficiency of the coil 5A.

the Third Embodiment

[0041] As shown in FIG. 8, this embodiment provides a magnetic latching trip actuator, which has a structure similar to that of the second embodiment, except that the magnetic poles of the permanent magnet are oriented in different directions. The two magnetic poles of the permanent magnet 4Ain the second embodiment are in a vertical direction, while the two magnetic poles of the permanent magnet 4B in this embodiment are in a horizontal direction perpendicular to the vertical direction. The working magnetic loop of the permanent magnet φ1B, the magnetic loop for tripping drive φ2B and two short-circuit magnetic loops φ3B and φ4B are provided for understanding. Of course, in other embodiments, the orientation of the permanent magnet does not have to be vertical or horizontal, and even an orientation with some tilt angles is feasible.

the Fourth Embodiment

[0042] As shown in FIG. 9, the present embodiment provides a magnetic latching trip actuator, which has a structure that is basically similar to that of the magnetic latching trip actuator in the first embodiment and has the same technical effect as that of the magnetic latching trip actuator in the first embodiment. The present embodiment is different from the magnetic latching trip actuator in the first embodiment in that the structures of the first yoke and the second yoke are different. In the present embodiment, the first yoke 1C includes a first yoke arm 11C, a first transverse straight arm 12C connected to the lower end of the first yoke arm 11C, and a fifth vertical straight arm 13C connected to the first transverse straight arm 12C and extending upward. The fifth vertical straight arm 13C is close to the second yoke arm 21C. The second yoke 2C includes a second yoke arm 21C, a second transverse straight arm 22C connected to the lower end of the second yoke arm 21C, and a sixth vertical straight arm connected to one end of the second transverse straight arm 22C away from the second yoke arm 21C and extending downward. 23C. The permanent magnet 4C is arranged on the side of the fifth vertical straight arm 13C away from the first yoke arm 11C. The first yoke arm 11C is still used as the winding segment of the coil 5C. The first yoke arm 11C, the second yoke arm 21C, the first transverse straight arm 12C, the fifth vertical straight arm 13C and the armature 3C constitute the magnetic loop for tripping drive cp2C. The first transverse straight arm 12C, the second transverse straight arm 22C, the fifth vertical straight arm 13C and the sixth vertical straight arm 23C are combined to form a frame structure which basically surrounds the permanent magnet 4C, thereby forming two short-circuit magnetic loops φ3C and φ4C, which short-circuit the permanent magnet 4C. The working magnetic loop of the permanent magnet φ1C is shown in the drawings for understanding.

[0043] Most importantly, the magnetic loop for tripping drive cp2C is disposed within the span of the first yoke arm 11C and the second yoke arm 21C, while the permanent magnet 4C is disposed outside the span of the first yoke arm 11C and the second yoke arm 21C, so that the path of the short-circuit magnetic loop φ3C does not overlap with the path of the magnetic loop for tripping drive cp2C. Through this arrangement, when the coil 5C is energized, the short-circuit magnetic loop φ3C can more effectively short-circuit the magnetic flux generated by the permanent magnet 4C, and the magnetic flux generated by the coil 5C is also more efficient due to the reduction of the obstruction caused by the magnetic flux of the permanent magnet. Therefore, the coil power required for the trip actuator to operate becomes smaller, thereby improving the sensitivity of the trip actuator.

the Fifth Embodiment

[0044] As shown in FIG. 10, the present embodiment provides a magnetic latching trip actuator, which has a structure similar to that of the magnetic latching trip actuator in the first embodiment and has the same technical effect as that of the magnetic latching trip actuator in the first embodiment. The difference between the present embodiment and the magnetic latching trip actuator in the first embodiment is that the structures of the first yoke and the second yoke are different. In the present embodiment, the first yoke 1D is a U-shaped structure, including a first yoke arm 11D, a first transverse straight arm 12D connected to the lower end of the first yoke arm 11D, and a seventh vertical straight arm 13D connected to one end of the first transverse straight arm 12D away from the first yoke arm 11D and extending upward. The second yoke 2D includes a second yoke arm 21D and a second transverse straight arm 22D. Wherein the second yoke arm 21D extends downward to be close to the first transverse straight arm 12D. The second transverse straight arm 22D and the second yoke arm 21D are crossed in a T-shaped. The permanent magnet 4D is arranged on the side of the second yoke arm 21D away from the first yoke arm 11D, and the first yoke arm 11D is still used as a winding segment for winding the coil 5D. The first yoke arm 11D, the second yoke arm 21D, the first transverse straight arm 12D and the armature 3D form the magnetic loop for tripping drive cp2D. The first transverse straight arm 12D, the second transverse straight arm 22D, the second yoke arm 21D and the seventh vertical straight arm 13D are combined to form a frame structure that basically surrounds the permanent magnet 4D, thereby forming two short-circuit magnetic loops φ3D and φ4D that short-circuit the permanent magnet 4D. The drawings also indicate the working magnetic loop of the permanent magnet φ1D for understanding.

[0045] Most importantly, the magnetic loop for tripping drive cp2D is disposed within the span of the first yoke arm 11D and the second yoke arm 21D, while the permanent magnet 4D is disposed outside the span of the first yoke arm 11D and the second yoke arm 21D, so that the path of the short-circuit magnetic loop φ3D does not overlap with the path of the magnetic loop for tripping drive cp2D. Through this arrangement, when the coil 5D is energized, the short-circuit magnetic loop φ3D can more effectively short-circuit the magnetic flux generated by the permanent magnet 4D, and the magnetic flux generated by the coil 5D becomes more efficient due to the reduced obstruction caused by the magnetic flux of the permanent magnet, so the coil power required for the trip actuator to operate becomes smaller, thereby improving the sensitivity of the trip actuator.

[0046] FIG. 11 shows a variation of the present embodiment, in which the end of the second transverse straight arm 22D away from the second yoke arm 21D is further connected to an eighth vertical straight arm 23D extending upward. The eighth vertical straight arm 23D and the seventh vertical straight arm 13D are close to each other to improve the magnetic conductivity. A magnet spacer is further provided between the eighth vertical straight arm 23D and the seventh vertical straight arm 13D. By controlling the thickness of the magnet spacer, the matching effect of the working magnetic loop of the permanent magnet φ1D can be better.

the Sixth Embodiment

[0047] In addition, the present embodiment provides a magnetic latching trip actuator which is similar to the magnetic latching trip actuator in the first embodiment and has structures such as an armature 63, a tension spring, a push rod, etc. In the present embodiment, the yoke 60 is a single yoke with a U-shaped structure, and its U-shaped opening faces the armature 63. The permanent magnet 64 is a strip-shaped structure. The permanent magnet 64 is fixedly arranged outside the U-shaped enclosed area of the yoke 60. A non-magnetic end of the permanent magnet 64 is arranged close to the yoke 60, so as to form a short-circuit magnetic loop cp3E on the yoke 60 that short-circuits the permanent magnet 64. In the closed state, the armature 63 is magnetically attracted to the yoke 60, the magnetic flux of the permanent magnet 64 passes through the working magnetic loop of the permanent magnet φ1E and holds the armature 63 at the open end of the yoke 60, and the tension spring is stretched by the armature 63 to store energy. The coil 61 is wound on the yoke 60. When the coil 61 is energized, the magnetic flux generated by the coil 61 passes through the magnetic loop for tripping drive cp2E to reduce the magnetic flux of the permanent magnet 64, so that the attraction force of the yoke 60 to the armature 63 is weakened, and under the elastic force of the tension spring, the armature 63 is disengaged.

[0048] This embodiment also has a magnetizer 65, the magnetizer 65 is fixedly arranged outside the permanent magnet 64, thereby forming another short-circuit magnetic loop cp4E that short-circuits the permanent magnet.

[0049] This embodiment adopts a single yoke structure, which is simpler to manufacture. By adding the magnetizer 65, the permanent magnet 64 forms a double short-circuit loop design, thereby improving the sensitivity of the trip actuator. On the other hand, the magnetizer 65 and the yoke 60 clamp the permanent magnet 64 therebetween, which can better shield the influence of the external magnetic field on the permanent magnet 64.

[0050] The magnetizer 65 and the yoke 60 may be arranged opposite to each other, and the gap between two magnet short-circuit surfaces is preferably no greater than 0.2 mm. In this embodiment, a magnet spacer 66 is arranged between the magnetizer 65 and the yoke 60, and the gap between the magnet spacer 66 and permanent magnet short-circuit surface is preferably no greater than 0.2 mm. By controlling the thickness of the magnet spacer, the matching effect of the short-circuit magnetic loops φ3E, φ4E and the working magnetic loop of the permanent magnet φ1E can be better.

[0051] In this embodiment, the magnetizer 65 is a planar sheet structure, and the magnetizer 65 is fixedly arranged on the side of the permanent magnet 64 away from the yoke 60 to avoid interference between magnetic circuits as much as possible. FIG. 13 shows a variation of this embodiment, in which the magnetizer 65A is a U-shaped sheet structure that half surrounds the permanent magnet 64A, so that the magnetizer 65A and the yoke 60A can basically surround the permanent magnet 64A, and better shield the influence of the external magnetic field on the permanent magnet 64A.

[0052] Referring to FIG. 12, in this embodiment, the yoke 60 includes two right-angle connecting portions 67, 68 at one end away from the opening thereof, and the permanent magnet 64 is disposed close to one side of the two right-angle connecting portions 67, 68 connected thereto. The yoke 60 of this structure is simple in structure and easy to manufacture.

the Seventh Embodiment

[0053] Referring to FIG. 14, this embodiment provides a magnetic latching trip actuator, which is basically similar to the sixth embodiment. In this embodiment, a magnetizer is also provided on the outer side of the permanent magnet 64B to form two short-circuit loops, and its structure and function are the same as those of the sixth embodiment, and will not be described in detail. The difference between this embodiment and the sixth embodiment is that the end of the yoke 60B away from its opening includes one right-angle connecting portion 70 and one oblique angle connecting portion 69. The permanent magnet 64B is arranged close to the oblique angle connecting portion 69. This structure can arrange the permanent magnet 64B at an oblique angle position of the frame-shaped yoke 60B, thereby reducing the volume of the entire magnetic latching trip actuator.

[0054] In addition, the trip actuator is often used in the switching appliance such as a circuit breaker to trigger the tripping action of the tripping mechanism of the switching appliance. An existing trip actuator is a magnetic latching type, and its structure is shown in FIGS. 1 and 2, including includes 1, a second yoke 2, an armature 3, a permanent magnet 4, a coil 5, a tension spring 6 and a push rod 7. The first yoke 1 has an L-shaped structure. The second yoke 2 has a Z-shaped structure. The first yoke 1 and the second yoke 2 are combined to form a U-shaped yoke 10 with an opening facing the armature 3. The permanent magnet 4 is sandwiched between the first yoke 1 and the second yoke 2. The U-shaped yoke 10 includes a first pole surface 101 on the first yoke 1 and a second pole surface 102 on the second yoke 2. a working air gap magnetic field is formed between the first pole surface 101 and the second pole surface 102 under the action of the permanent magnet. The armature 3 is a swingable lever mechanism. One end of the tension spring 6 acts on the armature 3. As shown in FIG. 1, in a closed state, the armature 3 is magnetically attracted to the U-shaped yoke 10, and the magnetic flux of the permanent magnet 4 passes through the working magnetic loop of the permanent magnet $\varphi 1$ holds the armature 3 on the first pole surface 101 and the second pole surface 102 of the U-shaped yoke 10, and the tension spring 6 is stretched by the armature 3 to store energy. The coil 5 is wound on the first yoke 1. When the coil 5 is energized, the magnetic flux generated by the coil 5 passes through the magnetic loop for tripping drive $\varphi 2$. Under the elastic force of the tension spring 6, the armature 3 is separated from the U-shaped yoke 10 (as shown in FIG. 2). The push rod 7 is slidably arranged on a swing path of the armature 3. Once the armature 3 is disengaged, the push rod 7 can be pushed out of the trip actuator to trigger the tripping mechanism.

[0055] The magnetic circuit structure described above can not only realize the state maintenance (i.e., magnetic holding) of the armature 3 in the closed state, but also can quickly and automatically release the armature 3 by energizing the coil 5, thereby completing the tripping and triggering actions of the trip actuator. On this basis, in order to reduce the power consumption of the coil 5 and improve the sensitivity of the tripping response, one of the arms 210 of the second yoke 2 is arranged to be parallel and close to the first yoke arm 11 of the first yoke 1 on which the coil 5 is wound. After such arrangement, the short-circuit magnetic loop $\varphi 3$ of the permanent magnet 4 is formed on a side of the permanent magnet 4 close to the first yoke arm 11. The magnetic flux of the permanent magnet in the working magnetic loop of the permanent magnet $\varphi 1$ can reduce through the short-circuit magnetic loop cp3, so that the coil 5 only needs a smaller current to achieve the disengagement of the armature 3. However, this design also causes another problem, that is, since part of the circumferential space of the first yoke arm 11 is occupied by the arm 210, the coil 5 cannot be wound on the entire first yoke arm 11, and the coil 5 can only be compressed between the arm 210 and the open end of the U-shaped yoke 10, resulting in the coil 5 being short and fat, with a small axial length, a small number of winding turns, an excessively high inductance, and a relatively low coil efficiency.

[0056] Accordingly, directed at the above problems, the present disclosure provides a magnetic latching trip actuator with optimized structure, and a switching appliance having the magnetic latching trip actuator.

[0057] The present disclosure is implemented by the following technical solutions:

[0058] The present disclosure provides a magnetic latching trip actuator for triggering the tripping mechanism in the switching appliance, including a yoke, an armature, a coil and a permanent magnet. Wherein the permanent magnet is magnetically coupled to the yoke, the yoke includes a U-shaped yoke with an opening facing the armature, the U-shaped yoke includes a first yoke arm and a second yoke arm for forming a first pole surface and a second pole surface respectively. The first yoke arm has a winding segment for winding the coil, and a yielding structure is arranged on the outer circumference side of the first yoke arm so that a winding space for winding the coil is provided in the circumferential direction of the entire first yoke arm.

[0059] In one embodiment, the yoke includes a first yoke and a second yoke, the first yoke and the second yoke are combined to form the U-shaped yoke. The permanent magnet is clamped between the first yoke and the second yoke. The first yoke includes a first yoke arm and A connecting segment integrally bent and connected to the first yoke arm, one end of the connecting segment away from the first yoke arm is close to the second yoke to achieve magnetic flux transmission between the first yoke and the second yoke. The second yoke and the first yoke arm are spaced apart to form a yield structure.

[0060] In one embodiment, the connecting segment and the second yoke are arranged outside the permanent magnet to form a short-circuit magnetic loop that short-circuits the permanent magnet.

[0061] In one embodiment, the short-circuit magnetic loop is disposed on a side of the permanent magnet facing away from the first yoke arm.

[0062] In one embodiment, the first yoke arm and the second yoke arm extend vertically, and the connecting segment includes a first transverse straight arm and a first vertical straight arm. The second yoke includes a second transverse straight arm and a second yoke arm. The first transverse straight arm and the first yoke arm are connected. The second yoke arm is close to the side of the first vertical straight arm facing the first yoke arm. The permanent magnet is arranged between the first transverse straight arm and the second transverse straight arm. The first transverse straight arm, the second transverse straight arm and the first vertical straight arm form the short-circuit magnetic loop.

[0063] In one embodiment, the connecting segment includes a first transverse straight arm and a first vertical straight arm, and the second yoke is a rectangular block structure. The first yoke arm extends vertically. The first transverse straight arm and the first yoke arm are connected. The second yoke is close to the side of the first vertical straight arm facing the first yoke arm. The permanent magnet is arranged between the second yoke and the first transverse straight arm, and the first transverse straight arm, the first vertical straight arm and the end of the second yoke close to the permanent magnet form the short-circuit magnetic loop.

[0064] In one embodiment, the first yoke arm extends vertically, the connecting segment extends horizontally. The second yoke has a Z-shaped bending structure, including a second yoke arm, a third transverse straight arm and a second vertical straight arm connected in sequence, the end of the second yoke arm faces the armature, the end of the second vertical straight arm faces the connecting segment, the permanent magnet is arranged between the third transverse straight arm and the connecting segment, the second vertical straight arm is arranged on a side of the permanent magnet facing the first yoke arm, and the second vertical straight arm and the first yoke arm are spaced to form the winding space. The third transverse straight arm, the second vertical straight arm and the connecting segment surround the short-circuit magnetic loop.

[0065] In one embodiment, a magnet spacer is provided between the connecting segment and the second yoke, and the magnet spacer is made of a material with low magnetic permeability.

[0066] Based on the above-mentioned magnetic latching trip actuator, the present disclosure further proposes a switching appliance, including a tripping mechanism and a magnetic latching trip actuator for triggering the tripping mechanism.

[0067] The present disclosure has the following beneficial effects: in the present invention, the winding space for winding the coil is provided in the circumferential direction of the entire first yoke arm, and by utilizing the winding space, the axial length of the coil of the present disclosure is substantially equal to the length of the first yoke arm, thereby increasing the number of winding turns of the coil, reducing the inductance of the coil, and improving the coil efficiency of the coil.

[0068] The present disclosure is now further described in conjunction with the accompanying drawings and specific embodiments.

the Eighth Embodiment

[0069] Referring to FIG. 15, as a preferred embodiment of the present disclosure, a switching appliance, more specifically a low voltage circuit breaker, is provided, including a tripping mechanism 200 and a trip actuator 100 for triggering the tripping mechanism 200. The trip actuator 100 is A magnetic latching trip actuator, and its structure is shown in FIGS. 16 and 17. The trip actuator 100 includes an outer shell 8, and a yoke and a permanent magnet 4 fixedly mounted in the outer shell 8. The yoke includes a first yoke 1 and a second yoke 2, and the first yoke 1 and the second yoke 2 are combined to form a U-shaped yoke 10. The permanent magnet 4 is clamped between the first yoke 1 and the second yoke 2. The armature 3 is a lever mechanism with a movable fulcrum, and in this embodiment, the movable fulcrum of the armature 3 is spaced apart from the U-shaped yoke 10. The opening of the U-shaped yoke 10 faces the armature 3. The U-shaped yoke 10 includes a first yoke arm 11 and a second yoke arm 21 for forming a first pole surface and ae second pole surface, respectively, and one end of the tension spring 6 is connected to the armature 3 and the other end is fixed to a certain point on the outer shell 8.

[0070] The first yoke 1 is of a U-shaped structure as a whole, and includes the first yoke arm 11 and a connecting segment 12P which are integrally bent and connected. The first yoke arm 11 is a vertically extending structure, the connecting segment 12P is an L-shaped bent structure. The coil 5 is wound on the first yoke arm 11, One end of the connecting segment 12P away from the first yoke arm 11 is close to the second yoke 2 to realize the magnetic flux transmission between the first yoke 1 and the second yoke 2. The second yoke 2 and the first yoke arm 11 are spaced apart to form a yield structure, so that the winding space for winding the coil 5 is provided in the circumferential direction of the entire first yoke arm 11. By utilizing the winding space, the axial length of the coil 5 in this embodiment is substantially equal to the length of the first yoke arm 11, thereby increasing the number of winding turns of the coil 5, reducing the inductance of the coil 5, and improving the Coil efficiency.

[0071] The connecting segment 12P specifically includes a first transverse straight arm 122 and a first vertical straight arm 121. The second yoke 2 is an L-shaped bending structure, including a second transverse straight arm 22 and a second yoke arm 21. The first transverse straight arm 122 and the first yoke arm 11 are connected. The second yoke arm 21 is close to the side of the first vertical straight arm 121 facing the first yoke arm 11. The permanent magnet 4 is arranged between the first transverse straight arm 122 and the second transverse straight arm 22, and the second transverse straight arm 22 is spaced from the first yoke arm 11 to form a giving way structure of the coil 5. As shown in FIG. 17, when the armature 3 is in a closed state, the magnetic flux of the permanent magnet 4 passes through the working magnetic loop of the permanent magnet φ1 and holds the armature 3 on the U-shaped yoke 10. The tension spring 6 is stretched by the armature 3 to store energy. When the coil 5 is energized, the magnetic flux generated by the coil 5 passes through the magnetic loop for tripping drive φ2, making the magnetic flux of the permanent magnet in the working magnetic loop of the permanent magnet φ1 reduced at the pole surface of the U-shaped yoke 10, and the adsorption force of the U-shaped yoke 10 on the armature 3 is weakened. Under the elastic force of the tension spring 6, the armature 3 is disengaged (as shown in FIG. 16). The push rod 7 can be slidably arranged on the swing path of the armature 3 after the disengagement. Once the armature 3 is disengaged, the push rod 7 can be pushed out of the trip actuator to trigger the tripping action of the tripping mechanism. On the other hand, through the special structure and relative arrangement of the first yoke 1 and the second yoke 2 of this embodiment, the first transverse straight arm 122, the second transverse straight arm 22 and the first vertical straight arm 121 form a short-circuit magnetic loop cp3 on the side of the permanent magnet 4 away from the first yoke arm 11. The short-circuit magnetic loop cp3 can shunt the magnetic flux of the permanent magnet 4 and the first vertical straight arm 121. The working magnetic loop of the permanent magnet φ1 reduces the magnetic flux of the permanent magnet, so that the coil 5 only needs a smaller current to achieve the disengagement of the armature 3, thereby reducing the power consumption of the coil 5 and improving the sensitivity of the trip actuator.

[0072] It should be pointed out that the "U-shaped yoke 10" in this embodiment refers to a structure formed by combining the first yoke 1 and the second yoke 2, which is generally a yoke with a U-shaped opening. The open end of the U-shaped yoke 10 is a U-shaped opening structure, the structure of the closed end of the U-shaped yoke 10 away from the open end may vary according to actual applications, and does not necessarily have to form a standard U-shaped shape.

[0073] In this embodiment, the short-circuit magnetic loop φ3 is arranged on the side of the permanent magnet 4 away from the first yoke arm 11, so it does not occupy the winding space in the circumferential direction of the first yoke arm 11, so this embodiment can increase the number of turns of the coil 5 on the basis of retaining the short-circuit magnetic loop. At the same time, in this embodiment, the U-shaped yoke 10 composed of the first yoke 1 and the second yoke 2 is a roughly frame-shaped one with a closed end width greater than an open end width, and the grinding is relatively stable, and no special fixing process is required.

[0074] In this embodiment, a magnet spacer 9 is provided between the connecting segment 12P and the second yoke 2. The thickness of the magnet spacer 9 can control the magnetic flux of the permanent magnet shunted from the short-circuit magnetic loop φ3. Usually, the thickness of the magnet spacer 9 is not more than 0.2 mm. The magnet spacer 9 is made of materials with low magnetic permeability such as copper, glue, etc. In other embodiments, the magnet spacer 9 may not be provided, and the magnetic isolation effect is achieved by the air in the gap between the connecting segment 12P and the second yoke 2. The tension spring 6 may also be replaced by other elastic members, such as compression springs, in other embodiments, and the installation position needs to be changed accordingly, as long as the elastic member acts on the armature, it can store energy when the armature 3 is closed relative to the U-shaped yoke 10, and provide an elastic driving force to drive the armature 3 to disengage relative to the U-shaped yoke 10.

the Ninth Embodiment

[0075] As shown in FIG. 18, the present embodiment provides a magnetic latching trip actuator, which is basically similar to the magnetic latching trip actuator in the eighth embodiment and has the same technical effect. The difference therebetween is that the second yoke 2A in the present embodiment adopts another structure. In the present embodiment, the second yoke 2A is a rectangular block structure. The first yoke 1 includes a first yoke arm 11 extending vertically and a connecting segment 12P with an L-shaped structure in the eighth embodiment. The connecting segment 12P includes a first transverse straight arm and a first vertical straight arm (not shown in the drawings, refer to the description of the eighth embodiment). The first transverse straight arm is connected to the first yoke arm 11. The second yoke 2A is close to the side of the first vertical straight arm facing the first yoke arm 11. The second yoke 2A and the first yoke arm 11 are spaced to form the winding space of the coil 5. The permanent magnet 4 is arranged between the second yoke 2A and the first transverse straight arm. The first transverse arm, the first vertical straight arm and one end of the second yoke 2A near the permanent magnet 4 forms the short-circuit magnetic loop φ3 on the side of the permanent magnet 4 facing away from the first yoke arm 11. The embodiment also shows the working magnetic loop of the permanent magnet φ1 through which the magnetic flux of the permanent magnet 4 passes and the magnetic loop for tripping drive φ2 through which the magnetic flux of the coil 5 passes for reference.

[0076] Compared to the L-shaped second yoke 2 structure in the eighth embodiment, the rectangular block-shaped second yoke 2A in this embodiment is easier to manufacture and install, and its polar surface area is expanded.

the Tenth Embodiment

[0077] As shown in FIG. 19, the present embodiment provides a magnetic latching trip actuator, which is basically similar to the magnetic latching trip actuator in the eighth embodiment, except that the first yoke 1B and the second yoke 2B of the present embodiment both adopt another structure. The first yoke 1B of the present embodiment is an L-shaped bending structure, including a first yoke arm 1B-1 extending vertically and a connecting segment 1B-2 extending horizontally. The second yoke 2B is a Z-shaped bending structure, including a second yoke arm 2B-1, a third transverse straight arm 2B-2 and a second vertical straight arm 2B-3 connected in sequence. The end of the second yoke arm 2B-1 faces the armature 3, and the end of the second vertical straight arm 2B-3 faces the connecting segment 1B-2. The permanent magnet 4 is arranged between the third transverse straight arm 2B-2 and the connecting segment 1B-2. The second vertical straight arm 2B-3 is arranged at the side of the permanent magnet 4 facing the first yoke arm 2B-1. The second vertical straight arm 2B-3 and the first yoke arm 1B-1 are spaced apart to form the winding space of the coil 5. The third transverse straight arm 2B-2, the second vertical straight arm 2B-3 and the connecting segment 1B-2 combined to form the short-circuit magnetic loop φ3. The embodiment also shows the working magnetic loop of the permanent magnet φ1 through which the magnetic flux of the permanent magnet 4 passes and the magnetic loop for tripping drive φ2 through which the magnetic flux of the coil 5 passes for reference.

[0078] Compared to the eighth embodiment, this embodiment can simplify the structure of the first yoke 1B, and similarly, the U-shaped yoke composed of the first yoke 1B and the second yoke 2B is a roughly frame-shaped yoke with a closed end width greater than an open end width, and the grinding is relatively stable, and no special fixing process is required.

[0079] In addition, as shown in FIG. 1 and FIG. 2, The existing magnetic latching trip actuator is used in some occasions that require extremely high sensitivity, its sensitivity is not enough. At present, the conventional means to improve the sensitivity of the trip actuator is to increase the tension spring force of the tension spring 6 (such as replacing the tension spring with a larger elastic coefficient) so that the armature 3 is subjected to a larger pulling force of the tension spring 6 in the closed state, thus the tension spring 6 can pull the armature 3 faster when the armature 3 is disengaged. However, if the tension spring force of the tension spring 6 is increased, the magnetic holding force of the U-shaped yoke 10 on the armature 3 must also be increased accordingly to keep the armature 3 in the closed position, so that the total magnetic flux of the permanent magnet 4 needs to be increased. The magnetic flux in the working magnetic loop of the permanent magnet φ1 also increases, so it is necessary to make the trip actuator move and provide more power to the coil 5. Obviously, in the case of small currents that require extremely high sensitivity, this solution of increasing the tension spring is contradictory and not applicable.

[0080] Accordingly, directed at the above problems, the present disclosure provides a magnetic latching trip actuator with optimized structure, which can maintain high sensitivity in applications with small input current, or make the driving current required for the coil smaller under the condition of equal magnetic holding force. The present disclosure also provides a switching appliance having the magnetic latching trip actuator.

[0081] The present disclosure is implemented by the following technical solutions:

[0082] The present disclosure provides a magnetic latching trip actuator for triggering the tripping mechanism in the switching appliance, including a yoke, an armature, a coil and a permanent magnet. Wherein the yoke includes a first yoke and a second yoke, and the first yoke and the second yoke are combined to form a U-shaped yoke with an opening facing the armature. The first yoke and the second yoke clamp the permanent magnet. The magnetic flux of the permanent magnet is transmitted through a working magnetic loop of the permanent magnet in the yoke and the armature. The coil is wound on the yoke. The magnetic flux of the coil is transmitted through a magnetic loop for tripping drive in the yoke and the armature that reduces the magnetic flux of the permanent magnet. The first yoke and the second yoke are combined to form a frame structure that substantially surrounds the permanent magnet, thereby forming two short-circuit magnetic loops on the frame structure that short-circuit the permanent magnet.

[0083] In one embodiment, the U-shaped yoke includes the first yoke arm and the second yoke arm forming a first pole surface and a second pole surface respectively. The first yoke arm is provided on the first yoke aw a winding section for winding the coil thereon, the second yoke arm is provided on the second yoke, the armature is defined to be located on the upper side of the yoke, and the first yoke arm and the second yoke arm are spaced apart and extend vertically up and down.

[0084] In one embodiment, the frame structure and the first yoke arm are spaced apart so that the winding space for winding the coil is provided throughout a circumference of the first yoke arm.

[0085] In one embodiment, the first yoke is an L-shaped structure, and further comprises a first transverse straight arm, the second yoke is an h-shaped structure, and further comprises a second transverse straight arm connected to a lower end of the second yoke arm, and a first vertical straight arm and a second vertical straight arm spaced apart and connected to an lower end of the second transverse straight arm and extend downwards, the first transverse straight arm, the second transverse straight arm, the first vertical straight arm and the first yoke arm are combined to form the frame structure that substantially surrounds the permanent magnet; or, the first yoke is a U-shaped structure, further comprising a first transverse straight arm connected to a lower end of the first yoke arm and a third vertical straight arm connected to an end of the first transverse straight arm away from the first yoke arm and extending upward, the second yoke is a Z-shaped structure, and further comprises a second transverse straight arm connected to a lower end of the second yoke arm and a fourth vertical straight arm connected to an end of the second transverse straight arm away from the second yoke arm and extending downward, the first transverse straight arm, the second transverse straight arm, the third vertical straight arm and the fourth vertical straight arm are combined to form the frame structure that substantially surrounds the permanent magnet.

[0086] In one embodiment, the directions of the two poles of the permanent magnet are in the vertical direction, or in the lateral direction perpendicular to the vertical direction.

[0087] In one embodiment, the U-shaped yoke includes the first yoke arm and the second yoke arm forming a first pole surface and a second pole surface respectively. The first yoke arm has a winding section for the coil winding thereon; the second yoke comprises a second yoke arm, a second pole surface is formed on the second yoke arm, the first yoke arm and the second yoke arm are spaced apart and extend in a same direction, the magnetic loop for tripping drive is arranged within a span range of the first yoke arm and the second yoke arm, and the permanent magnet is arranged outside the span range of the first yoke arm and the second yoke arm so that the path of one of the short-circuit magnetic loops does not overlap with the path of the magnetic loop for tripping drive.

[0088] In one embodiment, In some embodiment, the armature is defined to be located at an upper side of the yoke, the first yoke arm and the second yoke arm are spaced apart and vertically extend, and the first yoke further comprises a first transverse straight arm connected to a lower end of the first yoke arm and a fifth vertical straight arm connected to the first transverse straight arm and extending upward, the fifth vertical straight arm is close to the second yoke arm, the second yoke further comprises a second transverse straight arm connected to a lower end of the second yoke arm and a sixth vertical straight arm connected to an end of the second transverse straight arm away from the second yoke arm and extending downward, the permanent magnet is arranged on a side of the fifth vertical straight arm away from the first yoke arm, the first yoke arm, the second yoke arm, the first transverse straight arm, the fifth vertical straight arm and the armature constitute the magnetic loop for tripping drive, the first transverse straight arm, the second transverse straight arm, the fifth vertical straight arm and the sixth vertical straight arm are combined to form the frame structure which substantially surrounds the permanent magnet.

[0089] In one embodiment, the armature is located at an upper side of the yoke, the first yoke arm and the second yoke arm are spaced apart and vertically extend, the first yoke is a U-shaped structure, and further comprises a first transverse straight arm connected to a lower end of the first yoke arm and a seventh vertical straight arm connected to an end of the first transverse straight arm away from the first yoke arm and extending upward, the second yoke further comprises a second transverse straight arm, wherein the second yoke arm extends downward to be close to the first transverse straight arm, the second transverse straight arm and the second yoke arm are crossed in a T-shaped, the permanent magnet is arranged on a side of the second yoke arm away from the first yoke arm, the first yoke arm, the second yoke arm, the first transverse straight arm and the armature constitute the magnetic loop for tripping drive, the first transverse straight arm, the second transverse straight arm, the second yoke arm and the seventh vertical straight arm are combined to form the frame structure which substantially surrounds the permanent magnet.

[0090] In one embodiment, an eighth vertical straight arm extending upward is further connected to an end of the second transverse straight arm away from the second yoke arm, the eighth vertical straight arm and the seventh vertical straight arm are close to each other.

[0091] Based on the magnetic latching trip actuator, the present disclosure further provides a switching appliance, including a tripping mechanism and a magnetic latching trip actuator for triggering the tripping mechanism of present disclosure.

[0092] The present disclosure has the following beneficial effects:

[0093] The magnetic latching trip actuator of the present disclosure is provided with two short-circuit magnetic loops for short-circuiting the permanent magnet on the outer side of the permanent magnet, and the magnetic flux generated by the permanent magnet is shunted into three parts. When a magnetic gap is generated between the armature and the U-shaped yoke, more magnetic flux will be shunted by the short-circuit magnetic loops, so that the magnetic flux at the pole surface of the U-shaped yoke decreases faster, and the adsorption force of the permanent magnet on the armature decreases faster. Therefore, the coil only needs a smaller current (or a lower coil power) to achieve the disengagement of the armature, so that the magnetic flux in the permanent magnet working loop is more sensitive to the pole surface gap, thereby improving the sensitivity of the trip actuator; on the other hand, if the present disclosure increases the tension spring force of the tension spring to improve the sensitivity of the trip actuator, the energy required to increase the magnetic flux of the permanent magnet to increase the magnetic holding force is also less than that of the prior art.

[0094] The magnetic latching trip actuator disclosed in the present disclosure can surround the permanent magnet through the magnetizer, thereby better shielding the influence of the external magnetic field on the permanent magnet.

[0095] The present disclosure is now further described in conjunction with the accompanying drawings and specific embodiments.

the Eleventh Embodiment

[0096] Referring to FIG. 3, as a preferred embodiment of the present disclosure, a switching appliance, more specifically a circuit breaker, is provided, which includes a tripping mechanism 200 and a trip actuator 100 for triggering the tripping mechanism 200. The trip actuator 100 is a magnetic latching trip actuator, and its structure is shown in FIGS. 4 and 5, including a yoke, an armature 3, a permanent magnet 4, a coil 5, a tension spring 6 and a push rod 7. The yoke is a double yoke structure, including a first yoke 1 and a second yoke 2. The first yoke 1 and the second yoke 2 are combined to form a U-shaped yoke 10 with an opening toward the armature 3. The permanent magnet 4 is clamped between the first yoke 1 and the second yoke 2. The U-shaped yoke 10 includes a first yoke arm 11 and a second yoke arm 21 forming a first pole surface 101 and a second pole surface 102, respectively. The first yoke arm 11 is provided on the first yoke 1 and serves as a winding section for winding the coil 5. The second yoke arm 21 is provided on the second yoke 2. For convenience of description, it is defined that the armature 3 is located on the upper side of the yoke, and the first yoke arm 11 and the second yoke arm 21 are spaced from each other and extend vertically up and down.

[0097] Under the action of the permanent magnet 4, a working air gap magnetic field is formed between the first pole surface 101 and the second pole surface 102. The armature 3 is a lever mechanism that can swing. One end of the tension spring 6 is connected to the armature 3. As shown in FIG. 4, in the closed state, the armature 3 is magnetically attracted to the U-shaped yoke 10, and the magnetic flux of the permanent magnet 4 passes through the working magnetic loop of the permanent magnet φ1 and holds the armature 3 on the first pole surface 101 and the second pole surface 102 of the U-shaped yoke 10. The tension spring 6 is stretched by the armature 3 to store energy. When the coil 5 is energized, the magnetic flux generated by the coil 5 passes through the magnetic loop for tripping drive φ2 to reduce the magnetic flux of the permanent magnet 4, so that the adsorption force of the U-shaped yoke 10 on the armature 3 is weakened. Under the elastic force of the tension spring 6, the armature 3 is separated from the U-shaped yoke 10 (as shown in FIG. 5). The push rod 7 is slidably arranged on the swing path of the armature 3. Once the armature 3 is disengaged, the push rod 7 can be pushed out of the trip actuator to trigger the tripping mechanism.

[0098] It should be noted that "the U-shaped yoke 10" means that the structure formed by the combination of the first yoke 1 and the second yoke 2 is generally a yoke with a U-shaped opening, and the open end of the U-shaped yoke 10 is a U-shaped opening structure, the structure of the closed end of the U-shaped yoke 10 away from the open end may vary according to actual applications, and does not necessarily have to form a standard U shape.

[0099] As shown in FIG. 5, in particular, in this embodiment, the first yoke 1 and the second yoke 2 are enclosed to form a frame structure S that substantially surrounds the permanent magnet 4, thereby forming two short-circuit magnetic loops φ3, φ4 (see FIG. 4) on the frame structure S, which short-circuit the permanent magnet 4. Specifically, in this embodiment, the first yoke 1 is an L-shaped structure, including a first yoke arm 11 and a first transverse straight arm 12, and the second yoke 2 is an h-shaped structure, including a second yoke arm 21, a second transverse straight arm 22 connected to the lower end of the second yoke arm 21, and a first vertical straight arm 23 and a second vertical straight arm 24 connected to the lower end of the second transverse straight arm 22 spaced apart and extending downward. The first transverse straight arm 12, the second transverse straight arm 22, the first vertical straight arm 23 and the first yoke arm 11 surround the frame structure S, and the second vertical straight arm 24 can increase the magnetic transmission area and efficiency of the frame structure S and the first yoke 1.

[0100] The frame structure S of this embodiment is composed of several straight arm structures to form a roughly rectangular shape. In other embodiments, the frame structure may also be composed of bent arms or special-shaped arms, that is, as long as the frame structure can be formed to surround the permanent magnet 4. Since a slight gap between the first yoke 1 and the second yoke 2 can also achieve magnetic conduction, there may be a gap between the first yoke 1 and the second yoke 2. In other words, the frame structure S only needs to substantially surround the permanent magnet 4, and does not have to completely surround the permanent magnet 4.

[0101] The frame structure S of this embodiment can surround the permanent magnet 4 and better shield the influence of the external magnetic field on the permanent magnet 4. More importantly, in this embodiment, two short-circuit magnetic loops φ3, φ4 are provided on the outer side of the permanent magnet 4 to short-circuit the permanent magnet 4, so that the magnetic flux generated by the permanent magnet 4 is divided into three parts. When there is a magnetic gap between the armature 3 and the U-shaped yoke 10, more magnetic flux will pass through the short-circuit magnetic loop φ3, φ4, so that the magnetic flux at the first pole surface 101 and the second pole surface 102 decreases faster, so that the adsorption force of the permanent magnet 4 on the armature 3 decreases faster. Therefore, the coil 5 only needs a smaller current (or a lower coil power) to achieve the disengagement of the armature 3, so that the magnetic flux in the permanent magnet working loop is more sensitive to the pole surface gap (the gap between the pole surface of the U-shaped yoke 10 and the armature 3), thereby improving the sensitivity of the trip actuator.

[0102] FIG. 6 shows a curve diagram of the permanent magnet adsorption force at the pole face of the magnetic latching trip actuator of the present embodiment compared with the magnetic latching trip actuator of the prior art. Wherein, a1 is the tension spring force at the pole face position, a2 is the increased tension spring force at the pole face position; b1 is the magnetic adsorption force of the permanent magnet at the pole face position after the coil generates magnetic flux in the prior art, b2 is the magnetic adsorption force of the permanent magnet at the pole face position after the coil generates magnetic flux in the present disclosure; c1 is the magnetic adsorption force of the permanent magnet at the pole face position after the magnetic flux of the permanent magnet is increased in the prior art, c2 is the magnetic adsorption force of the permanent magnet at the pole face position after the magnetic flux of the permanent magnet is increased in the present disclosure; d is the magnetic adsorption force of the permanent magnet at the pole face position in the prior art; E is the area between c1 and c2, indicating the energy required to disengage the armature after the magnetic flux of the permanent magnet is increased in the present disclosure, which is a reduced energy compared with the prior art. It can be seen that the present embodiment is provided with two short-circuit magnetic loops, since more magnetic flux of the permanent magnet is divided by the short-circuit magnetic loops, the magnetic flux at the first pole surface 101 and the second pole surface 102 decreases faster, so that the adsorption force of the permanent magnet 4 on the armature 3 decreases faster. On the other hand, if the present embodiment increases the tension spring force of the tension spring 6 to improve the sensitivity of the trip actuator, the energy required to increase the magnetic flux of the permanent magnet to increase the magnetic holding force is also less than that of the prior art.

[0103] In this embodiment, the first yoke 1 and the second yoke 2 of the frame structure S have permanent magnet short-circuit surfaces arranged oppositely between their adjacent portions, and the gap between the two permanent magnet short-circuit surfaces is not greater than 0.2 mm. Furthermore, a magnet spacer can be provided between the first yoke 1 and the second yoke 2, for example, a magnet spacer 8 is provided between the second vertical straight arm 24 and the first yoke arm 11, and the magnet spacer 8 makes the gap between two permanent magnet short-circuit surfaces of the first yoke 1 and the second yoke 2 not greater than 0.2 mm. By controlling the thickness of the magnet spacer, the matching effect between the short-circuit magnetic loop φ3, φ4 and the working magnetic loop of the permanent magnet φ1 can be better.

[0104] The magnetic latching trip actuator of this embodiment has extremely high sensitivity and can be used in small current applications that require extremely high sensitivity.

the Twelfth Embodiment

[0105] As shown in FIG. 7, this embodiment provides a magnetic latching trip actuator, which has a structure similar to that in the first embodiment and has the same technical effect of the same structure. The difference between the magnetic latching trip actuator in this embodiment and the magnetic latching trip actuator in the first embodiment is that the structures of the first yoke and the second yoke are different. In this embodiment, the first yoke 1A is a U-shaped structure, including a first yoke arm 11A, a first transverse straight arm 12A connected to the lower end of the first yoke arm 11A, and a third vertical straight arm 13A connected to the first transverse straight arm 12A away from the end of the first yoke arm 11A and extending upward. The second yoke 2A is a Z-shaped structure, including a second yoke arm 21A, a second transverse straight arm 22A connected to the lower end of the second yoke arm 21A, and a fourth vertical straight arm 23A connected to the second transverse straight arm 22A away from the end of the second yoke arm 21A and extending downward. The first transverse straight arm 12A, the second transverse straight arm 22A, the third vertical straight arm 13A and the fourth vertical straight arm 23A are enclosed to form a frame structure that basically surrounds the permanent magnet 4A, thereby forming two short-circuit magnetic loops φ3A and φ4A that short-circuit the permanent magnet 4A. The working magnetic loop of the permanent magnet φ1A and the magnetic loop for tripping drive φ2A are shown in the drawings for understanding.

[0106] In addition, in this embodiment, the frame structure formed by the first transverse straight arm 12A, the second transverse straight arm 22A, the third vertical straight arm 13A and the fourth vertical straight arm 23A is spaced from the first yoke arm 11A, so that the winding space for winding the coil 5A is provided in the circumferential direction of the entire first yoke arm 11A. By utilizing the winding space, the axial length of the coil 5A in this embodiment is substantially equal to the length of the first yoke arm 11A, thereby increasing the number of winding turns of the coil 5A, reducing the inductance of the coil 5A, and improving the coil efficiency of the coil 5A.

the Thirteenth Embodiment

[0107] As shown in FIG. 8, this embodiment provides a magnetic latching trip actuator, which has a structure similar to that of the second embodiment, except that the magnetic poles of the permanent magnet are oriented in different directions. The two magnetic poles of the permanent magnet 4Ain the second embodiment are in a vertical direction, while the two magnetic poles of the permanent magnet 4B in this embodiment are in a horizontal direction perpendicular to the vertical direction. The working magnetic loop of the permanent magnet φ1B, the magnetic loop for tripping drive φ2B and two short-circuit magnetic loops φ3B and φ4B are provided for understanding. Of course, in other embodiments, the orientation of the permanent magnet does not have to be vertical or horizontal, and even an orientation with some tilt angles is feasible.

the Fourth Embodiment

[0108] As shown in FIG. 9, the present embodiment provides a magnetic latching trip actuator, which has a structure that is basically similar to that of the magnetic latching trip actuator in the first embodiment and has the same technical effect as that of the magnetic latching trip actuator in the first embodiment. The present embodiment is different from the magnetic latching trip actuator in the first embodiment in that the structures of the first yoke and the second yoke are different. In the present embodiment, the first yoke 1C includes a first yoke arm 11C, a first transverse straight arm 12C connected to the lower end of the first yoke arm 11C, and a fifth vertical straight arm 13C connected to the first transverse straight arm 12C and extending upward. The fifth vertical straight arm 13C is close to the second yoke arm 21C. The second yoke 2C includes a second yoke arm 21C, a second transverse straight arm 22C connected to the lower end of the second yoke arm 21C, and a sixth vertical straight arm connected to one end of the second transverse straight arm 22C away from the second yoke arm 21C and extending downward. 23C. The permanent magnet 4C is arranged on the side of the fifth vertical straight arm 13C away from the first yoke arm 11C. The first yoke arm 11C is still used as the winding segment of the coil 5C. The first yoke arm 11C, the second yoke arm 21C, the first transverse straight arm 12C, the fifth vertical straight arm 13C and the armature 3C constitute the magnetic loop for tripping drive cp2C. The first transverse straight arm 12C, the second transverse straight arm 22C, the fifth vertical straight arm 13C and the sixth vertical straight arm 23C are combined to form a frame structure which basically surrounds the permanent magnet 4C, thereby forming two short-circuit magnetic loops φ3C and cp4C, which short-circuit the permanent magnet 4C. The working magnetic loop of the permanent magnet φ1C is shown in the drawings for understanding.

[0109] Most importantly, the magnetic loop for tripping drive cp2C is disposed within the span of the first yoke arm 11C and the second yoke arm 21C, while the permanent magnet 4C is disposed outside the span of the first yoke arm 11C and the second yoke arm 21C, so that the path of the short-circuit magnetic loop φ3C does not overlap with the path of the magnetic loop for tripping drive cp2C. Through this arrangement, when the coil 5C is energized, the short-circuit magnetic loop φ3C can more effectively short-circuit the magnetic flux generated by the permanent magnet 4C, and the magnetic flux generated by the coil 5C is also more efficient due to the reduction of the obstruction caused by the magnetic flux of the permanent magnet. Therefore, the coil power required for the trip actuator to operate becomes smaller, thereby improving the sensitivity of the trip actuator.

the Fifth Embodiment

[0110] As shown in FIG. 10, the present embodiment provides a magnetic latching trip actuator, which has a structure similar to that of the magnetic latching trip actuator in the first embodiment and has the same technical effect as that of the magnetic latching trip actuator in the first embodiment. The difference between the present embodiment and the magnetic latching trip actuator in the first embodiment is that the structures of the first yoke and the second yoke are different. In the present embodiment, the first yoke 1D is a U-shaped structure, including a first yoke arm 11D, a first transverse straight arm 12D connected to the lower end of the first yoke arm 11D, and a seventh vertical straight arm 13D connected to one end of the first transverse straight arm 12D away from the first yoke arm 11D and extending upward. The second yoke 2D includes a second yoke arm 21D and a second transverse straight arm 22D. Wherein the second yoke arm 21D extends downward to be close to the first transverse straight arm 12D. The second transverse straight arm 22D and the second yoke arm 21D are crossed in a T-shaped. The permanent magnet 4D is arranged on the side of the second yoke arm 21D away from the first yoke arm 11D, and the first yoke arm 11D is still used as a winding segment for winding the coil 5D. The first yoke arm 11D, the second yoke arm 21D, the first transverse straight arm 12D and the armature 3D form the magnetic loop for tripping drive cp2D. The first transverse straight arm 12D, the second transverse straight arm 22D, the second yoke arm 21D and the seventh vertical straight arm 13D are combined to form a frame structure that basically surrounds the permanent magnet 4D, thereby forming two short-circuit magnetic loops φ3D and φ4D that short-circuit the permanent magnet 4D. The drawings also indicate the working magnetic loop of the permanent magnet φ1D for understanding.

[0111] Most importantly, the magnetic loop for tripping drive cp2D is disposed within the span of the first yoke arm 11D and the second yoke arm 21D, while the permanent magnet 4D is disposed outside the span of the first yoke arm 11D and the second yoke arm 21D, so that the path of the short-circuit magnetic loop φ3D does not overlap with the path of the magnetic loop for tripping drive cp2D. Through this arrangement, when the coil 5D is energized, the short-circuit magnetic loop φ3D can more effectively short-circuit the magnetic flux generated by the permanent magnet 4D, and the magnetic flux generated by the coil 5D becomes more efficient due to the reduced obstruction caused by the magnetic flux of the permanent magnet, so the coil power required for the trip actuator to operate becomes smaller, thereby improving the sensitivity of the trip actuator.

[0112] FIG. 11 shows a variation of the present embodiment, in which the end of the second transverse straight arm 22D away from the second yoke arm 21D is further connected to an eighth vertical straight arm 23D extending upward. The eighth vertical straight arm 23D and the seventh vertical straight arm 13D are close to each other to improve the magnetic conductivity. A magnet spacer is further provided between the eighth vertical straight arm 23D and the seventh vertical straight arm 13D. By controlling the thickness of the magnet spacer, the matching effect of the working magnetic loop of the permanent magnet φ1D can be better.

[0113] In addition, when the existing magnetic latching trip actuator is used in some occasions that require extremely high sensitivity, its sensitivity is not enough. At present, the conventional means to improve the sensitivity of the trip actuator is to increase the tension spring force of the tension spring 6 (such as replacing the tension spring with a larger elastic coefficient) so that the armature 3 is subjected to a larger pulling force of the tension spring 6 in the closed state, thus the tension spring 6 can pull the armature 3 faster when the armature 3 is disengaged. However, if the tension spring force of the tension spring 6 is increased, the magnetic holding force of the U-shaped yoke 10 on the armature 3 must also be increased accordingly to keep the armature 3 in the closed position, so that the total magnetic flux of the permanent magnet 4 needs to be increased. The magnetic flux in the working magnetic loop of the permanent magnet φ1 also increases, so it is necessary to make the trip actuator move and provide more power to the coil 5. Obviously, in the case of small currents that require extremely high sensitivity, this solution of increasing the tension spring is contradictory and not applicable.

[0114] Therefore, in view of the above problems, the present disclosure provides a magnetic latching trip actuator with optimized structure, which can maintain high sensitivity in applications with small input current, or make the driving current required for the coil smaller under the condition of equal magnetic holding force. The present disclosure also provides a switching appliance having the magnetic latching trip actuator.

[0115] The present disclosure is implemented by the following technical solutions:

[0116] The present disclosure provides a magnetic latching trip actuator for triggering the tripping mechanism of the switching appliance, including a yoke, an armature, a coil and a permanent magnet. The yoke is a single yoke with a U-shaped structure, an opening of the yoke faces the armature. The permanent magnet is fixedly arranged outside a U-shaped enclosed area of the yoke, a non-magnetic end of the permanent magnet is arranged close to the yoke, thereby forming a short-circuit magnetic loop on the yoke that short-circuits the permanent magnet. The coil is wound on the yoke. The magnetic latching trip actuator further comprises a magnetizer, the magnetizer is fixedly arranged outside the permanent magnet, thereby forming another short-circuit magnetic loop that short-circuits the permanent magnet.

[0117] In one embodiment, the magnetizer is fixedly disposed on a side of the permanent magnet facing away from the yoke.

[0118] In one embodiment, a magnet spacer is provided between the magnetizer and the permanent magnet.

[0119] In one embodiment, the magnetizer has a planar sheet structure or a U-shaped sheet structure that semi-encloses the permanent magnet.

[0120] In one embodiment, the yoke includes two right-angle connecting portions at one end away from the opening thereof, and the permanent magnet is disposed close to one side edge where the two right-angle connecting portions are connected.

[0121] In one embodiment, the end of the yoke away from the opening thereof includes a right-angle connecting portion and an oblique angle connecting portion, and the permanent magnet is disposed close to the oblique angle connecting portion.

[0122] Based on the above-mentioned magnetic latching trip actuator, the present disclosure further proposes a switching appliance, including a tripping mechanism and a magnetic latching trip actuator for triggering the tripping mechanism.

[0123] The present disclosure has the following beneficial effects:

[0124] The magnetic latching trip actuator of the present disclosure is provided with two short-circuit magnetic loops for short-circuiting the permanent magnet on the outer side of the permanent magnet. The magnetic flux generated by the permanent magnet is shunted into three parts. When a magnetic gap is generated between the armature and the U-shaped yoke, more magnetic flux will be shunted by the short-circuit magnetic loops, so that the magnetic flux at the pole surface of the U-shaped yoke decreases faster, and the adsorption force of the permanent magnet on the armature decreases faster. Therefore, the coil only needs a smaller current (or a lower coil power) to achieve the disengagement of the armature, so that the magnetic flux in the permanent magnet working loop is more sensitive to the pole surface gap, thereby improving the sensitivity of the trip actuator; on the other hand, if the present disclosure increases the tension spring force of the tension spring to improve the sensitivity of the trip actuator, the energy required to increase the magnetic flux of the permanent magnet to increase the magnetic holding force is also less than that of the prior art.

[0125] The magnetic latching trip actuator disclosed in the present disclosure can surround the permanent magnet through the magnetizer, thereby better shielding the influence of the external magnetic field on the permanent magnet.

[0126] The present disclosure is now further described in conjunction with the accompanying drawings and specific embodiments.

the Sixteenth Embodiment

[0127] Referring to FIG. 3, as a preferred embodiment of the present disclosure, a switching appliance, more specifically a circuit breaker, is provided, including a tripping mechanism 200 and a trip actuator 100 for triggering the tripping mechanism 200. The trip actuator 100 is the magnetic latching trip actuator. Specifically, as shown in FIG. 12, the magnetic latching trip actuator of the present embodiment and the magnetic latching trip actuator in the background have the same structures as the armature 63, the tension spring, the push rod, etc. In the present embodiment, the yoke 60 is a single yoke with a U-shaped structure, and its U-shaped opening faces the armature 63. The permanent magnet 64 is a bar magnet in the present embodiment, it can also be a disc magnet in other embodiments. As long as the directions of the south and north poles of the permanent magnet are basically consistent with the magnetic flux direction in the yoke, and the direction can be the same as or opposite to that shown in the drawings. The permanent magnet 64 is fixedly arranged outside the U-shaped enclosed area of the yoke 60, and a non-magnetic end of the permanent magnet 64 is arranged close to the yoke 60, thereby forming a short-circuit magnetic loop φ3E on the yoke 60 that short-circuits the permanent magnet 64. In the closed state, the armature 63 is magnetically attracted to the yoke 60, and the magnetic flux of the permanent magnet 64 passes through the working magnetic loop of the permanent magnet φ1E and holds the armature 63 at the open end of the yoke 60, and the tension spring is stretched by the armature 63 to store energy. The coil 61 is wound on the yoke 60. When the coil 61 is energized, the magnetic flux generated by the coil 61 passes through the magnetic loop for tripping drive φ2E to reduce the magnetic flux of the permanent magnet 64, so that the attraction force of the yoke 60 to the armature 63 is weakened, and under the elastic force of the tension spring, the armature 63 is disengaged.

[0128] This embodiment also has a magnetizer 65, the magnetizer 65 is fixedly arranged outside the permanent magnet 64, thereby forming another short-circuit magnetic loop φ4E that short-circuits the permanent magnet.

[0129] This embodiment adopts a single yoke structure, which is simpler to manufacture. By adding the magnetizer 65, a double short-circuit loop of the permanent magnet 64 is formed. The magnetic flux generated by the permanent magnet 64 is divided into three parts. When a magnetic gap is generated between the armature 63 and the yoke 60, more magnetic flux will be shunted by the short-circuit magnetic loops φ3E, φ4E, so that the magnetic flux at the pole surface of the yoke 60 decreases faster, and the adsorption force of the permanent magnet 64 on the armature 63 decreases faster. Therefore, the coil 61 only needs a smaller current (or a lower coil power) to achieve the disengagement of the armature 63, making the magnetic flux in the permanent magnet working loop more sensitive to the pole surface gap, thereby improving the sensitivity of the trip actuator. At the same time, the magnetizer 65 and the yoke 60 clamp the permanent magnet 64 therebetween, which can better shield the influence of the external magnetic field on the permanent magnet 64.

[0130] In this embodiment, the magnetizer 65 is a planar sheet structure, and the magnetizer 65 is fixedly arranged on the side of the permanent magnet 64 away from the yoke 60 to avoid interference between magnetic circuits as much as possible. FIG. 13 shows a variation of this embodiment, in which the magnetizer 65A is a U-shaped sheet structure that half surrounds the permanent magnet 64A, so that the magnetizer 65A and the yoke 60A can basically surround the permanent magnet 64A, and better shield the influence of the external magnetic field on the permanent magnet 64A.

[0131] FIG. 6 shows a curve diagram of the permanent magnet adsorption force at the pole face of the magnetic latching trip actuator of the present embodiment compared with the magnetic latching trip actuator of the prior art. Wherein, a1 is the tension spring force at the pole face position, a2 is the increased tension spring force at the pole face position; b1 is the magnetic adsorption force of the permanent magnet at the pole face position after the coil generates magnetic flux in the prior art, b2 is the magnetic adsorption force of the permanent magnet at the pole face position after the coil generates magnetic flux in the present disclosure; c1 is the magnetic adsorption force of the permanent magnet at the pole face position after the magnetic flux of the permanent magnet is increased in the prior art, c2 is the magnetic adsorption force of the permanent magnet at the pole face position after the magnetic flux of the permanent magnet is increased in the present disclosure; d is the magnetic adsorption force of the permanent magnet at the pole face position in the prior art; E is the area between c1 and c2, indicating the energy required to disengage the armature after the magnetic flux of the permanent magnet is increased in the present disclosure, which is a reduced energy compared with the prior art. It can be seen that the present embodiment is provided with two short-circuit magnetic loops, since more magnetic flux of the permanent magnet is divided by the short-circuit magnetic loops, the magnetic flux at the pole surface of the yoke 60 decreases faster, so that the adsorption force of the permanent magnet 64 on the armature 63 decreases faster. On the other hand, if the present embodiment increases the tension spring force of the tension spring to improve the sensitivity of the trip actuator, the energy required to increase the magnetic flux of the permanent magnet to increase the magnetic holding force is also less than that of the prior art.

[0132] The magnetizer 65 and the yoke 60 may be spaced apart from each other, and the gap between the short-circuit magnetic loops is preferably no greater than 0.2 mm. In this embodiment, a magnet spacer 66 is provided between the magnetizer 65 and the yoke 60. The magnet spacer 66 makes the gap between two permanent magnet short-circuit surfaces of the first yoke 1 and the second yoke 2 no greater than 0.2 mm. By controlling the thickness of the magnet spacer, the short-circuit magnetic loops φ3E, φ4E and φ7E can be made thinner. The matching effect of the working magnetic loop of the permanent magnet φ1E can be better.

[0133] In this embodiment, the yoke 60 includes two right-angle connecting portions 67, 68 at one end away from the opening, and the permanent magnet 64 is disposed close to one side of the two right-angle connecting portions 67, 68. The yoke 60 of this structure is simple in structure and easy to manufacture.

[0134] The magnetic latching trip actuator of this embodiment has high sensitivity and can be used in small current applications that require high sensitivity.

the Seventeenth Embodiment

[0135] The present embodiment provides a magnetic latching trip actuator, which is basically similar to the magnetic latching trip actuator in the sixteenth embodiment. In this embodiment, a magnetizer is also provided on the outer side of the permanent magnet 64B to form two short-circuit loops, and its structure and function are the same as those of the sixteenth embodiment, and will not be described in detail. The difference between this embodiment and the sixteenth embodiment is that the end of the yoke 60B away from its opening includes one right-angle connecting portion 70 and one oblique angle connecting portion 69. The permanent magnet 64B is arranged close to the oblique angle connecting portion 69. This structure can arrange the permanent magnet 64B at an oblique angle position of the frame-shaped yoke 60B, thereby reducing the volume of the entire magnetic latching trip actuator.

[0136] Although the present disclosure is specifically shown and described in conjunction with the preferred embodiments, it should be understood by those skilled in the art that various changes made to the present disclosure in form and detail without departing from the spirit and scope of the present disclosure as defined in the appended claims fall within the scope of protection of the present disclosure.

Claims

1. A magnetic latching trip actuator comprises a yoke, an armature (3), a coil (5) and a permanent magnet (4), the yoke comprises a U-shaped yoke (10) with an opening toward the armature (3), the permanent magnet (4) is magnetically coupled to the yoke, and magnetic flux of the permanent magnet (4) is transmitted through a working magnetic loop of the permanent magnet (φ1) in the yoke and the armature (3), the coil (5) is wound on the yoke, magnetic flux of the coil (5) is transmitted through a magnetic loop for tripping drive (φ2) in the yoke and the armature (3) that reduces the magnetic flux of the permanent magnet (4), wherein two short-circuit magnetic loops (φ3, φ4) are provided outside the permanent magnet (4) to short-circuit the permanent magnet (4).

2. The magnetic latching trip actuator according to claim 1, wherein a path of one of the short-circuit magnetic loops (φ3, φ4) does not overlap with a path of the magnetic loop for tripping drive (φ2).

3. The magnetic latching trip actuator according to claim 1, wherein the yoke comprises a first yoke (1) and a second yoke (2), the first yoke (1) and the second yoke (2) are combined to form the U-shaped yoke (10), the first yoke (1) and the second yoke (2) clamp the permanent magnet (4), the first yoke (1) and the second yoke (2) are combined to form a frame structure that substantially surrounds the permanent magnet (4), thereby forming the two short-circuit magnetic loops (φ3, φ4) on the frame structure.

4. The magnetic latching trip actuator according to claim 3, wherein the first yoke (1) comprises a first yoke arm (11), a first pole surface (101) is formed on the first yoke arm (11), and the first yoke arm (11) has a winding section for winding the coil (5) ; the second yoke (2) comprises a second yoke arm (21), a second pole surface (102) is formed on the second yoke arm (21), the armature (3) is defined to be located at an upper side of the yoke, the first yoke arm (11) and the second yoke arm (21) are spaced apart and extend vertically up and down.

5. The magnetic latching trip actuator according to claim 4, wherein the frame structure and the first yoke arm (11) are spaced apart so that the winding space for winding the coil (5) is provided on an entire first yoke arm (11).

6. The magnetic latching trip actuator according to claim 4, wherein the first yoke (1) is an L-shaped structure, and further comprises a first transverse straight arm (12), the second yoke (2) is an h-shaped structure, and further comprises a second trans-

verse straight arm (22) connected to a lower end of the second yoke arm (21), and a first vertical straight arm (23) and a second vertical straight arm (24) spaced apart and connected to an lower end of the second transverse straight arm (22) and extend downwards, the first transverse straight arm (12), the second transverse straight arm (22), the first vertical straight arm (23) and the first yoke arm (11) are combined to form the frame structure that substantially surrounds the permanent magnet (4) ; or,

the first yoke (1) is a U-shaped structure, further comprising a first transverse straight arm (12) connected to a lower end of the first yoke arm (11) and a third vertical straight arm (13A) connected to an end of the first transverse straight arm (12) away from the first yoke arm (11) and extending upward, the second yoke (2) is a Z-shaped structure, and further comprises a second transverse straight arm (22) connected to a lower end of the second yoke arm (21) and a fourth vertical straight arm (23A) connected to an end of the second transverse straight arm (22) away from the second yoke arm (21) and extending downward, the first transverse straight arm (12), the second transverse straight arm (22), the third vertical straight arm (13A) and the fourth vertical straight arm (23A) are combined to form the frame structure that substantially surrounds the permanent magnet (4).

7. The magnetic latching trip actuator according to claim 6, wherein two magnetic poles of the permanent magnet (4) are arranged in a vertical direction, or in a lateral direction perpendicular to the vertical direction.

8. The magnetic latching trip actuator according to claim 3, wherein a path of one of the short-circuit magnetic loops (φ3, φ4) does not overlap with a path of the magnetic loop for tripping drive (φ2).

9. The magnetic latching trip actuator according to claim 8, wherein the first yoke (1) comprises a first yoke arm (11), a first pole surface (101) is formed on the first yoke arm (11), and the first yoke arm (11) has a winding section for the coil (5) winding thereon; the second yoke (2) comprises a second yoke arm (21), a second pole surface (102) is formed on the second yoke arm (21), the first yoke arm (11) and the second yoke arm (21) are spaced apart and extend in a same direction, the magnetic loop for tripping drive (φ2) is arranged within a span range of the first yoke arm (11) and the second yoke arm (21), and the permanent magnet (4) is arranged outside the span range of the first yoke arm (11) and the second yoke arm (21) so that the path of one of the short-circuit magnetic loops (φ3,φ4) does not overlap with the path of the magnetic loop for tripping drive (φ2).

10. The magnetic latching trip actuator according to claim 9, wherein the armature (3) is defined to be located at an upper side of the yoke, the first yoke arm (11) and the second yoke arm (21) are spaced apart and vertically extend, and the first yoke (1) further comprises a first transverse straight arm (12) connected to a lower end of the first yoke arm (11) and a fifth vertical straight arm (13C) connected to the first transverse straight arm (12) and extending upward, the fifth vertical straight arm (13C) is close to the second yoke arm (21), the second yoke (2) further comprises a second transverse straight arm (22) connected to a lower end of the second yoke arm (21) and a sixth vertical straight arm (23C) connected to an end of the second transverse straight arm (22) away from the second yoke arm (21) and extending downward, the permanent magnet (4) is arranged on a side of the fifth vertical straight arm (13C) away from the first yoke arm (11), the first yoke arm (11), the second yoke arm (21), the first transverse straight arm (12), the fifth vertical straight arm (13C) and the armature (3) constitute the magnetic loop for tripping drive (φ2), the first transverse straight arm (12), the second transverse straight arm (22), the fifth vertical straight arm (13C) and the sixth vertical straight arm (23C) are combined to form the frame structure which substantially surrounds the permanent magnet (4).

11. The magnetic latching trip actuator according to claim 9, wherein the armature (3) is located at an upper side of the yoke, the first yoke arm (11) and the second yoke arm (21) are spaced apart and vertically extend, the first yoke (1) is a U-shaped structure, and further comprises a first transverse straight arm (12) connected to a lower end of the first yoke arm (11) and a seventh vertical straight arm (13D) connected to an end of the first transverse straight arm (12) away from the first yoke arm (11) and extending upward, the second yoke (2) further comprises a second transverse straight arm (22), wherein the second yoke arm (21) extends downward to be close to the first transverse straight arm (12), the second transverse straight arm (22) and the second yoke arm (21) are crossed in a T-shaped, the permanent magnet (4) is arranged on a side of the second yoke arm (21) away from the first yoke arm (11), the first yoke arm (11), the second yoke arm (21), the first transverse straight arm (12) and the armature (3) constitute the magnetic loop for tripping drive (φ2), the first transverse straight arm (12), the second transverse straight arm (22), the second yoke arm (21) and the seventh vertical straight arm (13D) are combined to form the frame structure which substantially surrounds the permanent magnet (4).

12. The magnetic latching trip actuator according to claim 11, wherein an eighth vertical straight arm extending upward is further connected to an end

of the second transverse straight arm (22) away from the second yoke arm (21), the eighth vertical straight arm and the seventh vertical straight arm (13D) are close to each other.

13. The magnetic latching trip actuator according to claim 1, wherein the yoke is single, the permanent magnet (4) is in a strip-shaped structure, the permanent magnet (4) is fixedly arranged outside a U-shaped enclosed area of the yoke, a non-magnetic end of the permanent magnet (4) is arranged close to the yoke, thereby forming a short-circuit magnetic loop (φ3) on the yoke that short-circuits the permanent magnet (4), the magnetic latching trip actuator further comprises a magnetizer (65), the magnetizer (65) is fixedly arranged outside the permanent magnet (4), thereby forming another short-circuit magnetic loop (φ4) that short-circuits the permanent magnet (4).

14. The magnetic latching trip actuator according to claim 13, wherein the magnetizer (65) is fixedly disposed at a side of the permanent magnet (4) facing away from the yoke; or

a magnet spacer is provided between the magnetizer (65) and the permanent magnet (4); or
the magnetizer (65) is a planar sheet structure or a U-shaped sheet structure that semi-encloses the permanent magnet (4); or
an end of the yoke away from the opening thereof comprises two right-angle connecting portions, and the permanent magnet (4) is disposed close to one side of the two right-angle connecting portions; or
an end of the yoke away from the opening thereof comprises a right-angle connecting portion and an oblique angle connecting portion, and the permanent magnet (4) is disposed close to the oblique angle connecting portion.

15. A switching appliance, comprising a tripping mechanism and a trip actuator, wherein the trip actuator is the magnetic latching trip actuator of any one of claims 1-14.

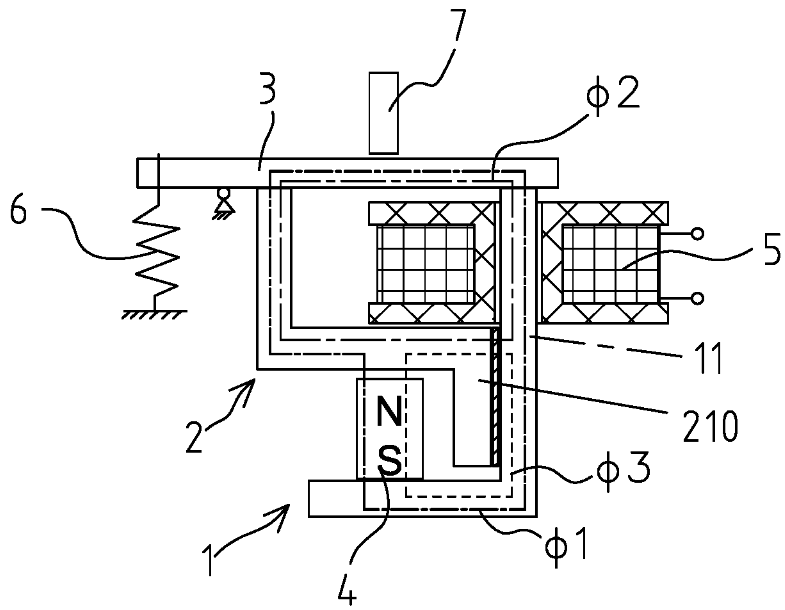

FIG. 1

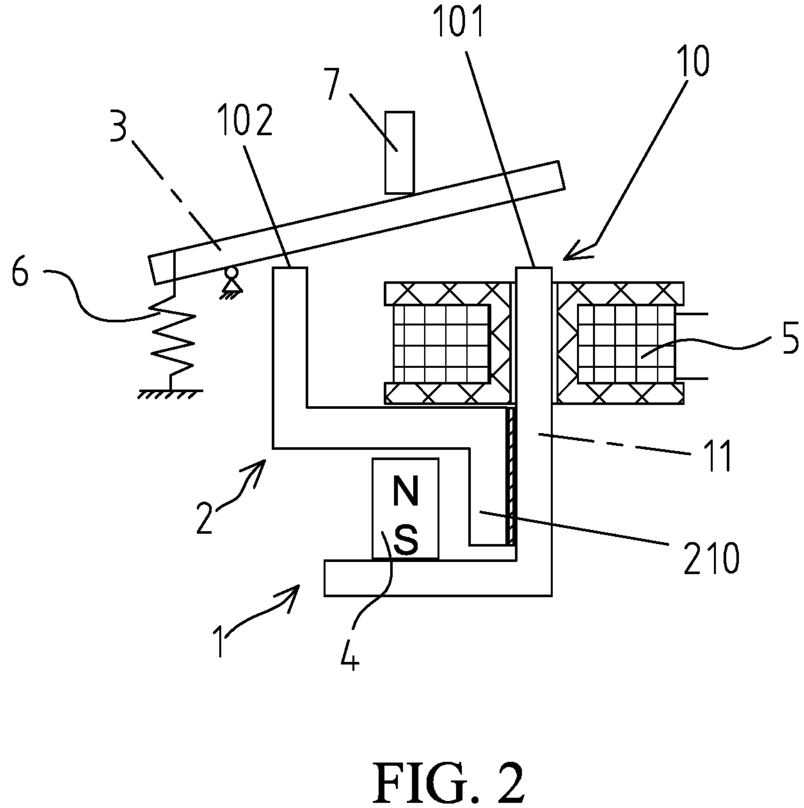

FIG. 2

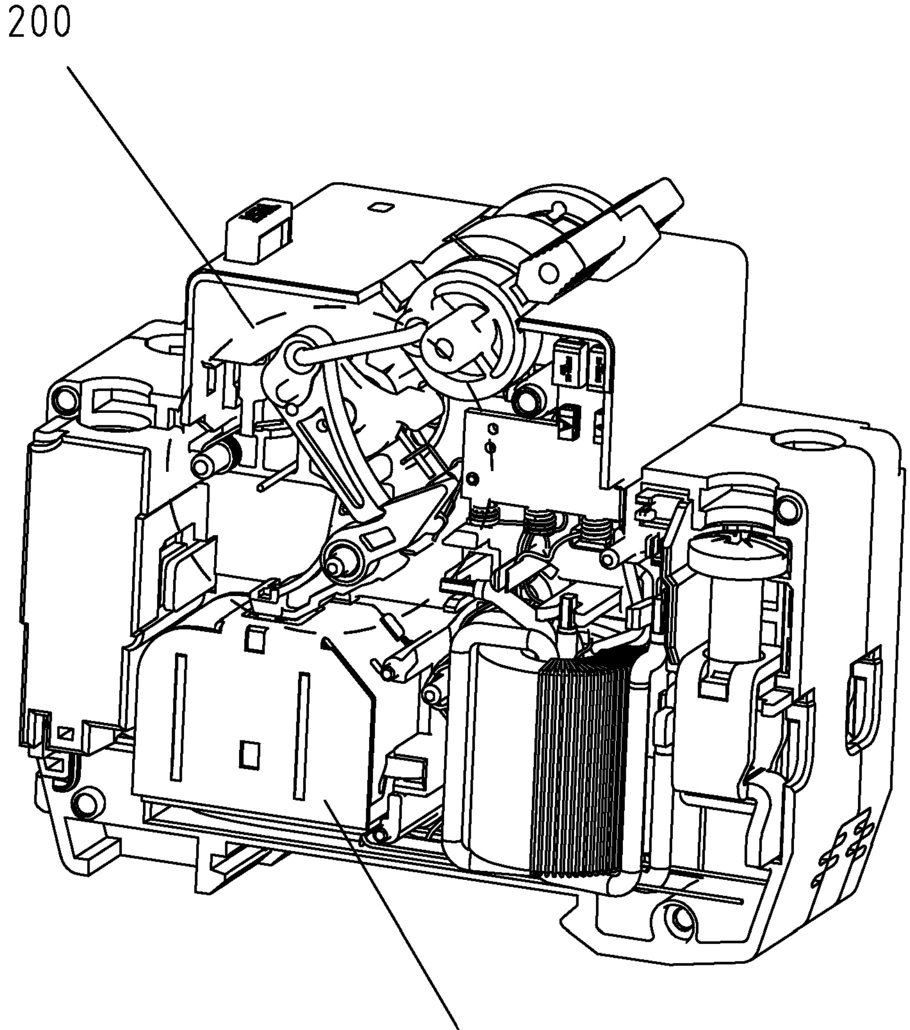

FIG. 3

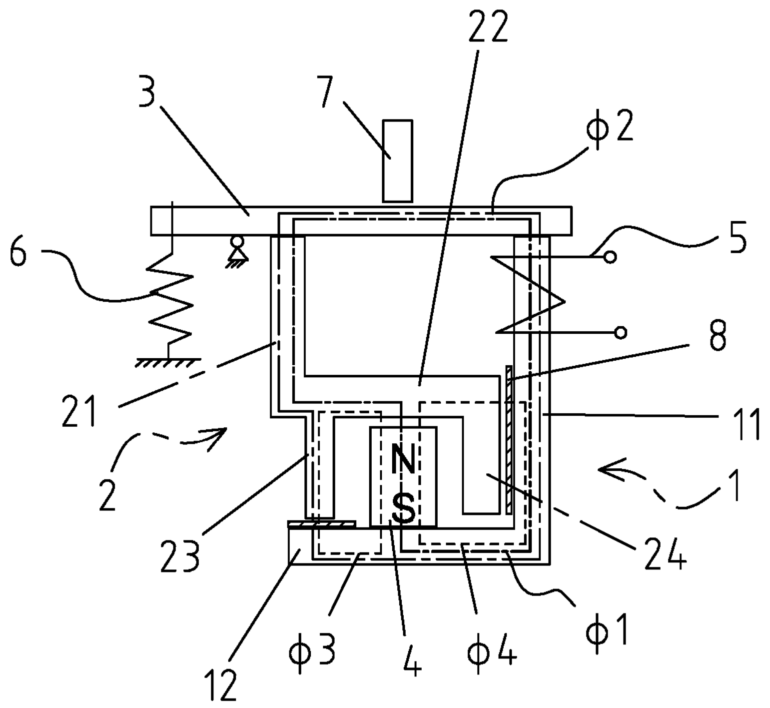
22
3
7
ϕ2
6
5
8
21
11
2
1
23
24
12
ϕ3
4
ϕ4
ϕ1
N
S

FIG. 4

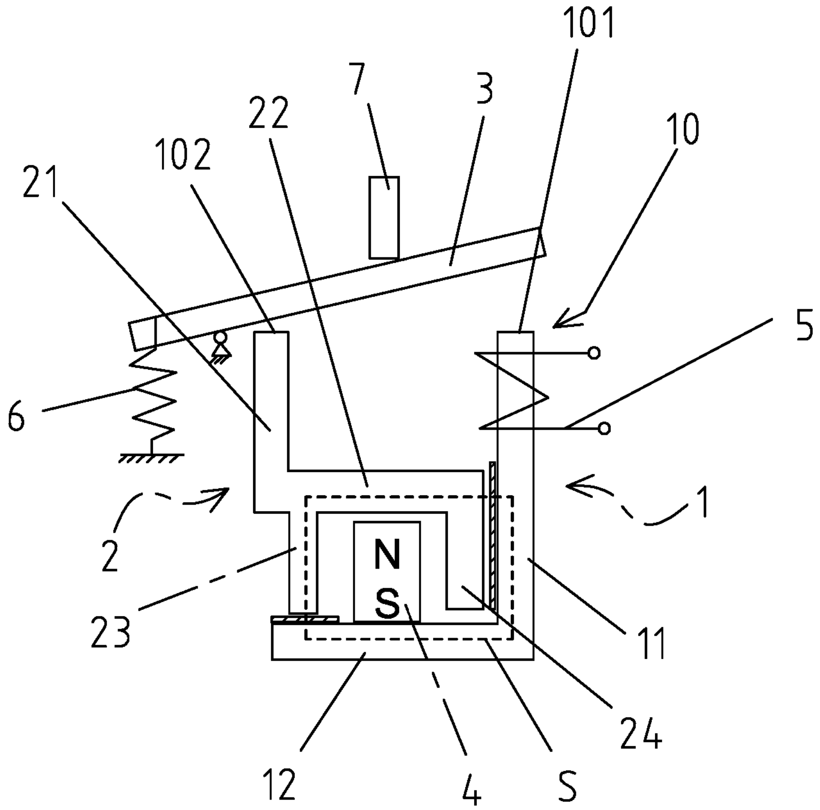
101
7
3
22
10
102
21
5
6
1
2
23
11
24
12
4
S
N
S

FIG. 5

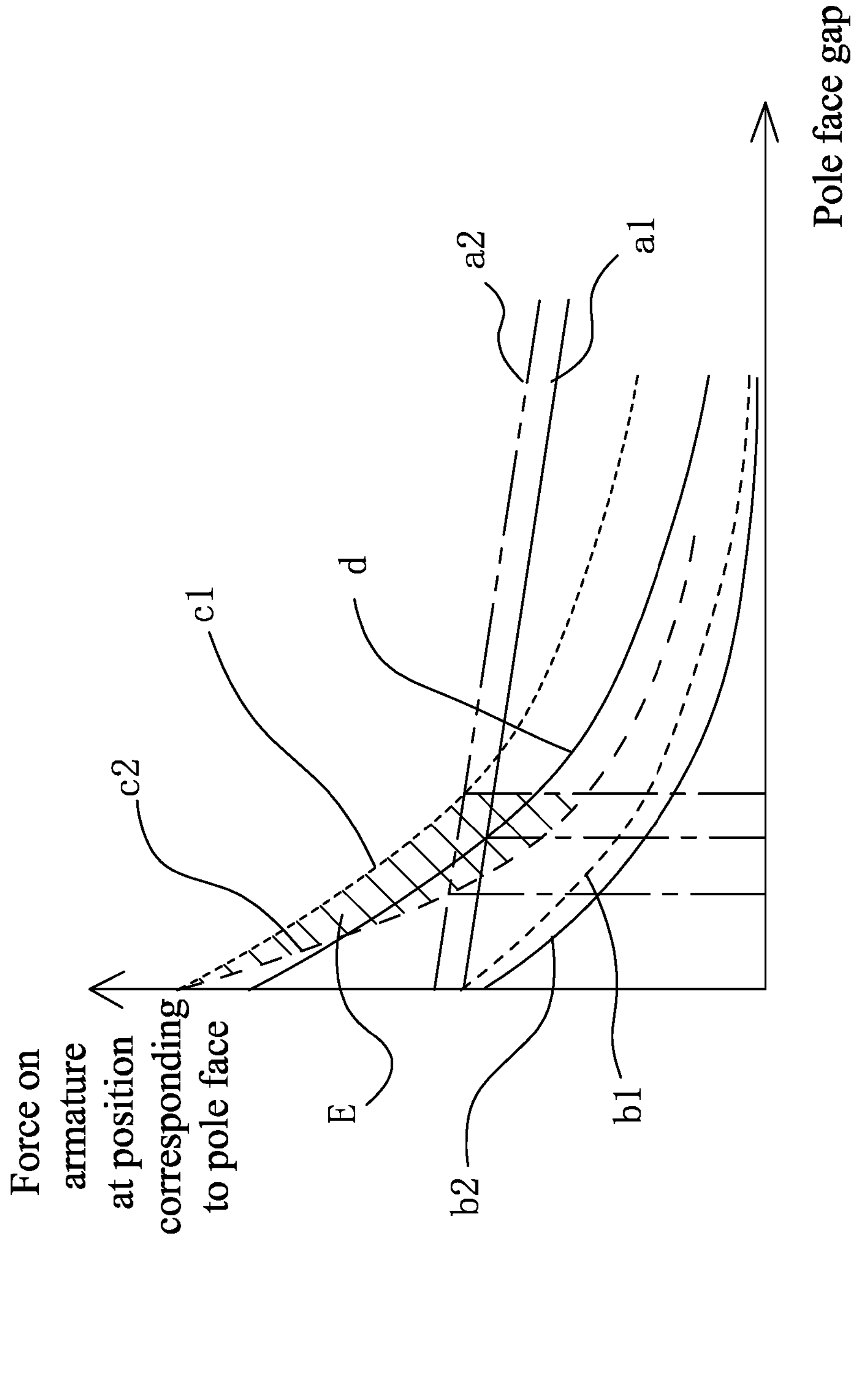
Force on armature at position corresponding to pole face
Pole face gap
a1
a2
b1
b2
c1
c2
d
E

FIG. 6

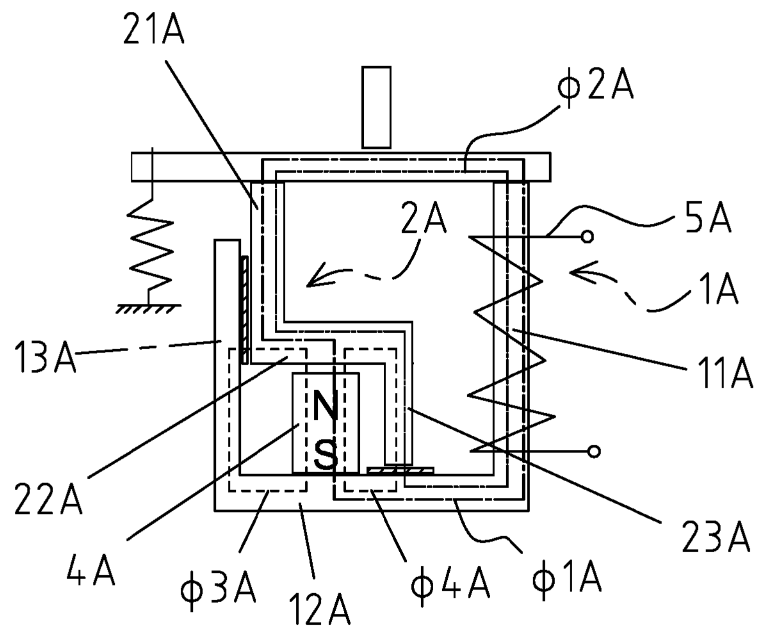
21A
ϕ2A
2A
5A
1A
13A
11A
N
S
22A
23A
4A
ϕ3A
12A
ϕ4A
ϕ1A

FIG.7

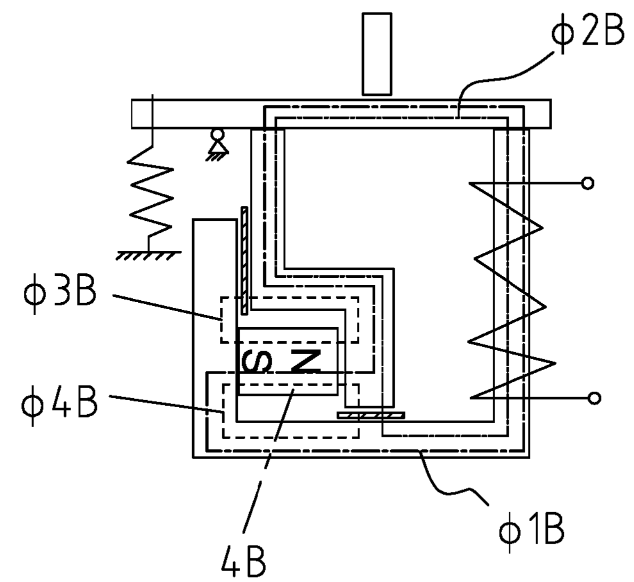
ϕ2B
ϕ3B
S N
ϕ4B
4B
ϕ1B

FIG.8

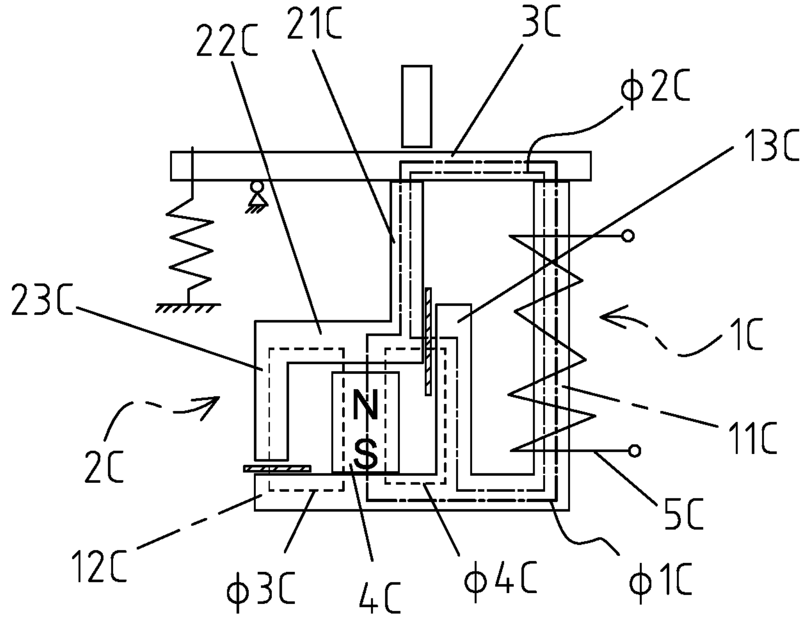
22C
21C
3C
ϕ2C
13C
23C
1C
N
S
11C
2C
5C
12C
ϕ3C
4C
ϕ4C
ϕ1C

FIG. 9

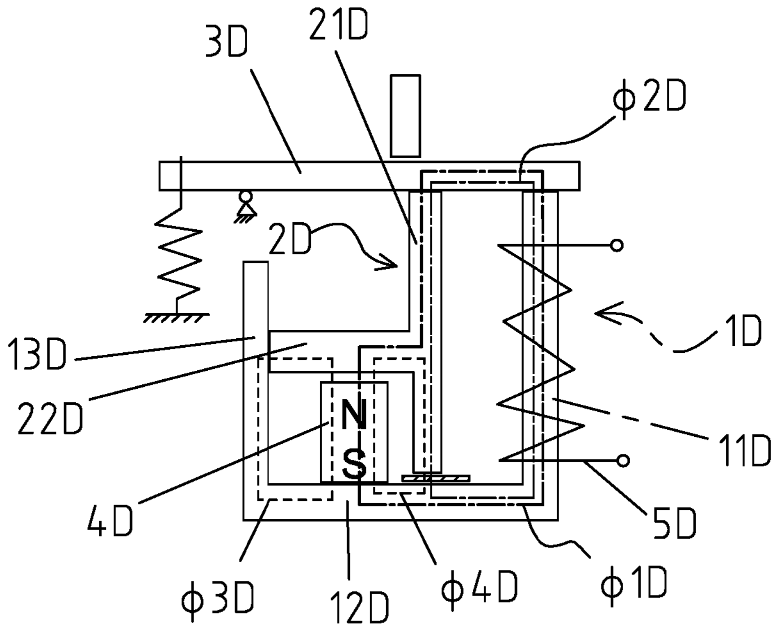
3D
21D
ϕ2D
2D
1D
13D
22D
N
S
11D
4D
5D
ϕ3D
12D
ϕ4D
ϕ1D

FIG. 10

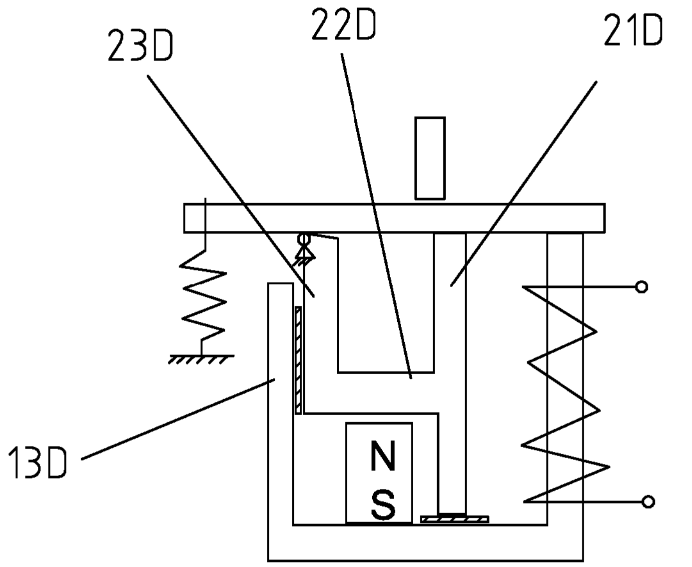

FIG. 11

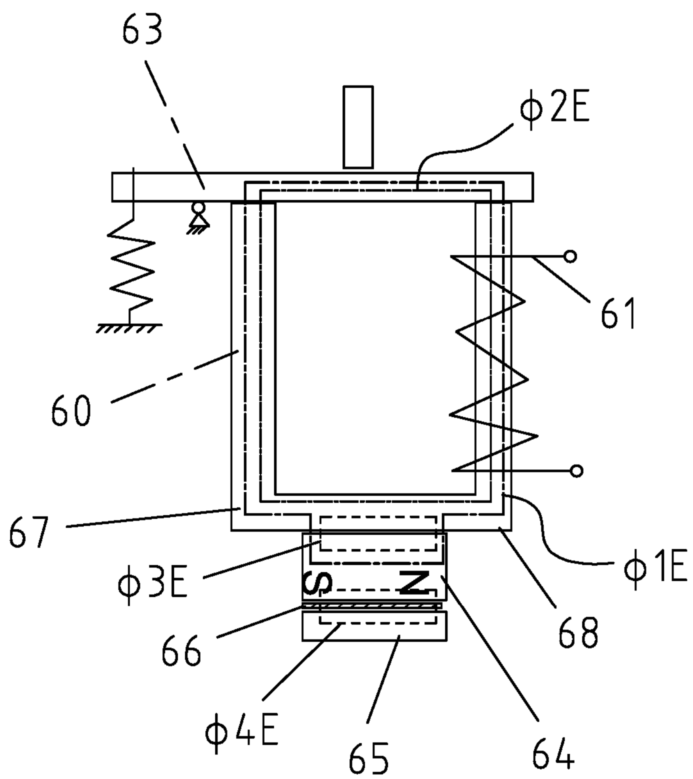

FIG. 12

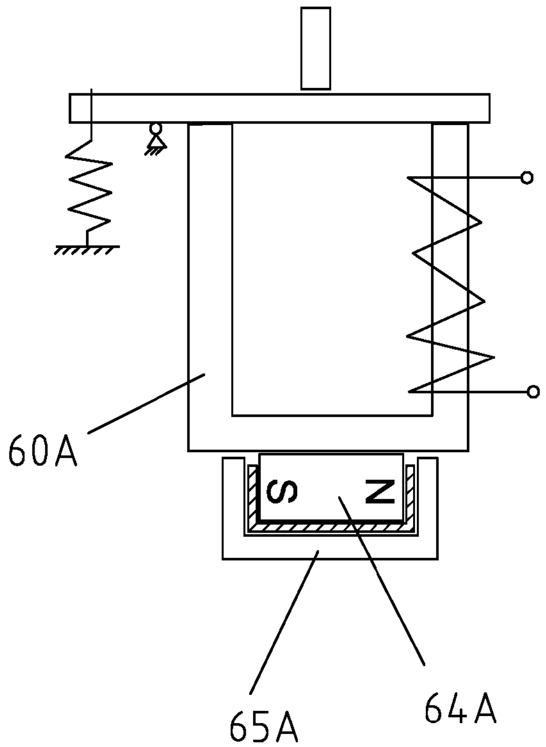

FIG. 13

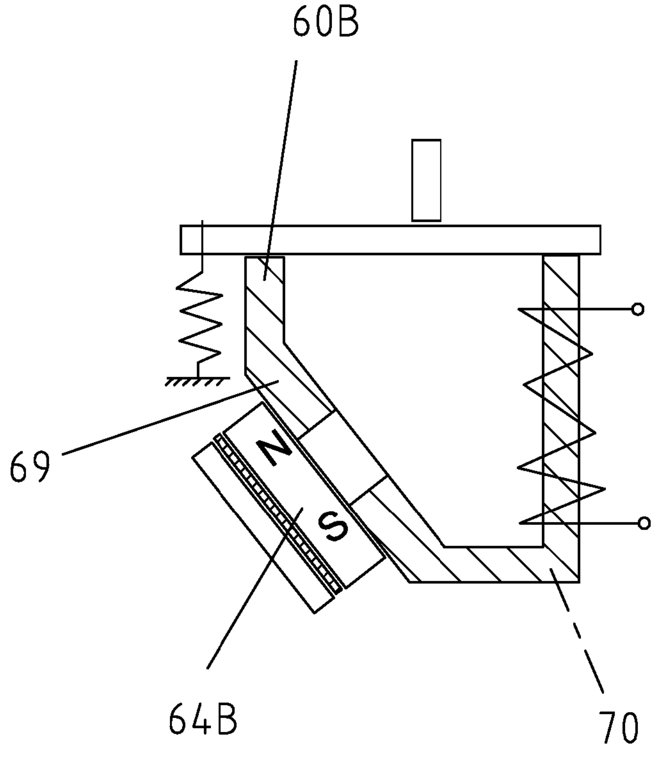

FIG. 14

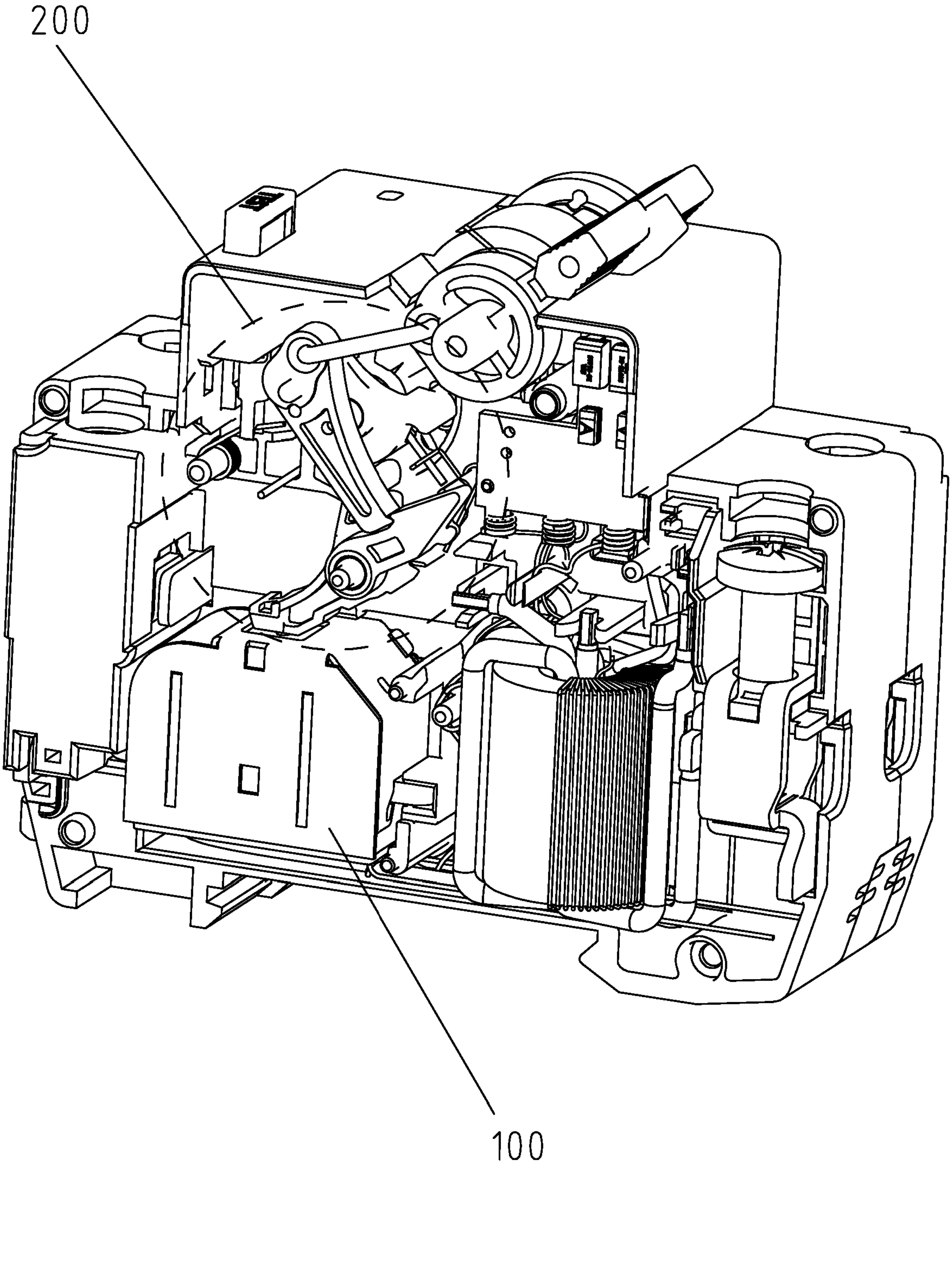

FIG. 15

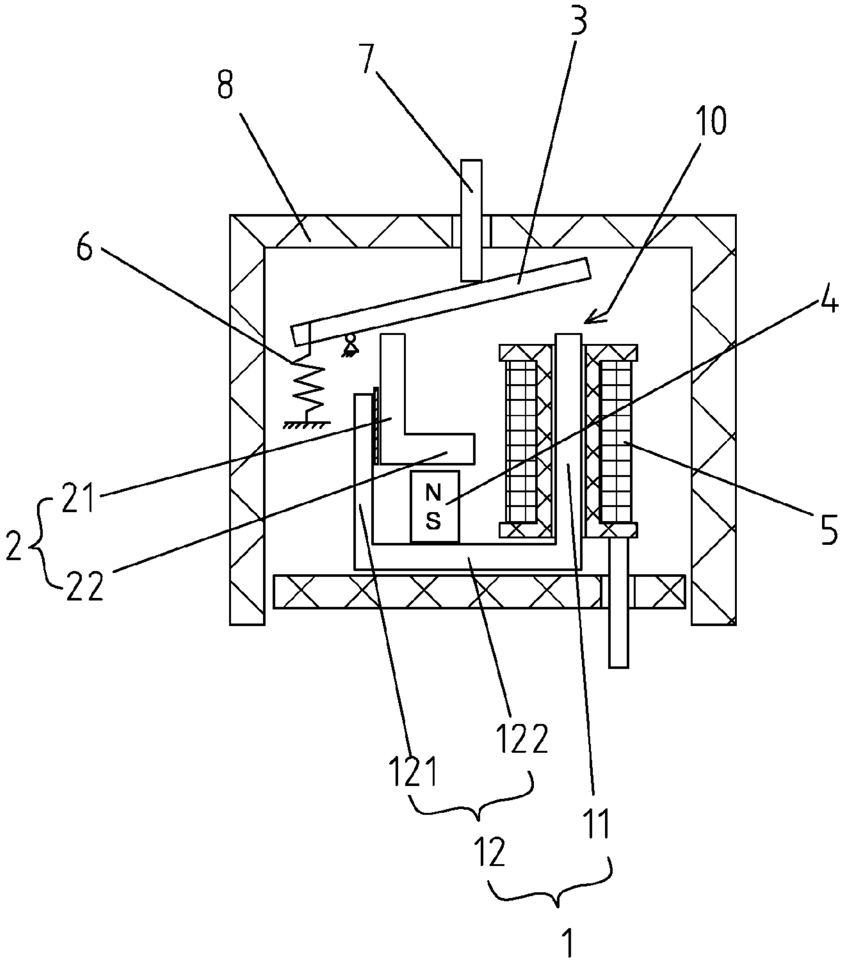

FIG. 16

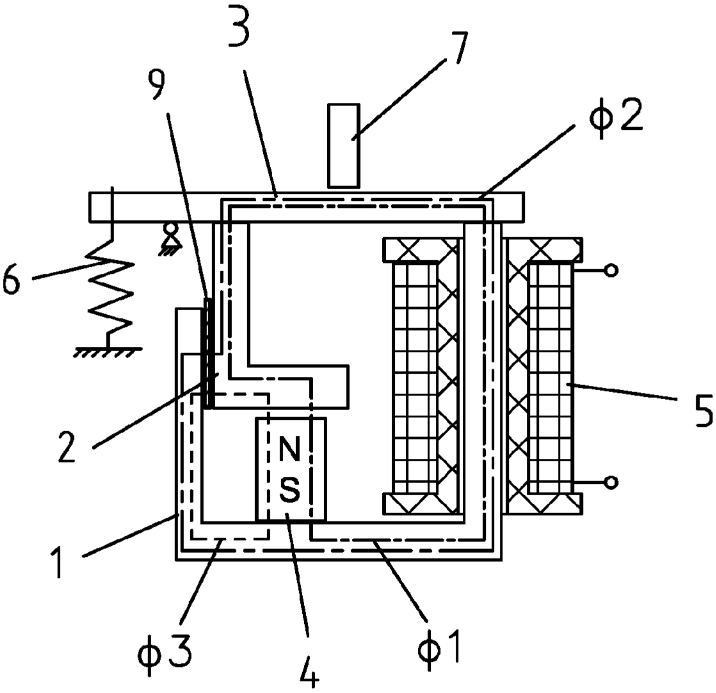

FIG. 17

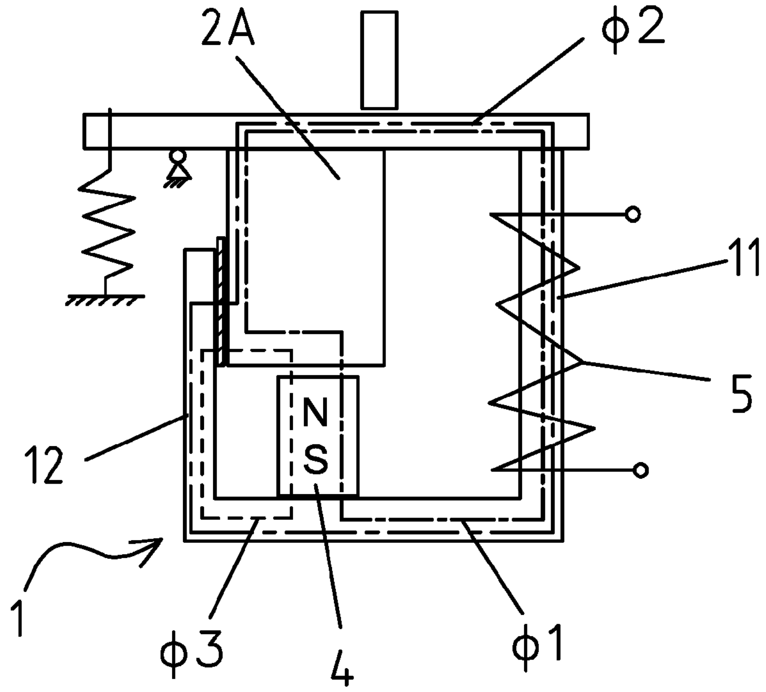

FIG. 18

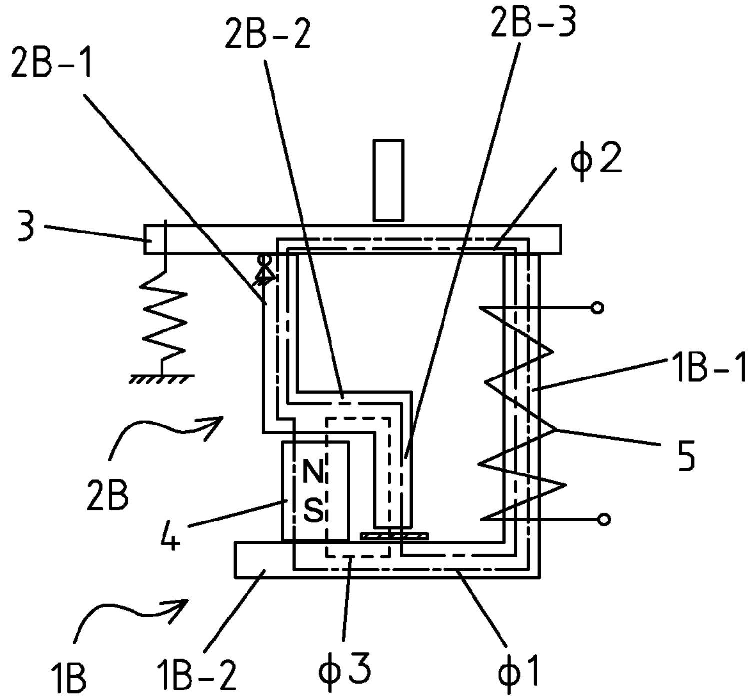

FIG. 19

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EUROPEAN SEARCH REPORT

Application Number
EP 24 22 2381

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	DE 41 11 092 A1 (SCHIELE GMBH & CO KG [DE]) 8 October 1992 (1992-10-08) * column 2, line 25 - column 3, line 64; figure 1 *	1-15	INV. H01H71/24 H01H71/32
A	CN 115 331 985 A (SANYOU LIANZHONG GROUP CO LTD) 11 November 2022 (2022-11-11) * page 6, paragraph 0041 - page 9, paragraph 0076; figures 3-6 *	1-15	
A	WO 2012/169975 A1 (ETI ELEKTROELEMENT DD [SI]; KOPRIVSEK MITJA [SI] ET AL.) 13 December 2012 (2012-12-13) * page 20, paragraph 3 - page 25, paragraph 3; figures 2-4 *	1-15	

TECHNICAL FIELDS SEARCHED (IPC)

H01H

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	24 April 2025	Pavlov, Valeri

CATEGORY OF CITED DOCUMENTS

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& : member of the same patent family, corresponding document

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24-04-2025

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82