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(54) CORE FOR CIRCUIT BREAKER MECHANISM AND CIRCUIT BREAKER MECHANISM

(57) The invention relates to a core for a circuit breaker mechanism and a circuit breaker mechanism designed for a high current bus bars.

A core for a circuit breaker mechanism comprising: a first limb (2), a second limb (3), a first yoke (4), a second yoke (5), a third yoke (6); wherein between the first limb (2) and the second limb (3) there are the first yoke (4), the second yoke (5) and the third yoke (6), wherein the third yoke (6) has a smaller cross-section area then the second yoke (5), wherein the second yoke (5) comprises a first air gap (7) and at least one opening (9), where edges (10) of the first air gap (7) are tilted such that the first air gap (7) forms a trapezoid, and wherein the third yoke (6) comprises a second air gap (8).

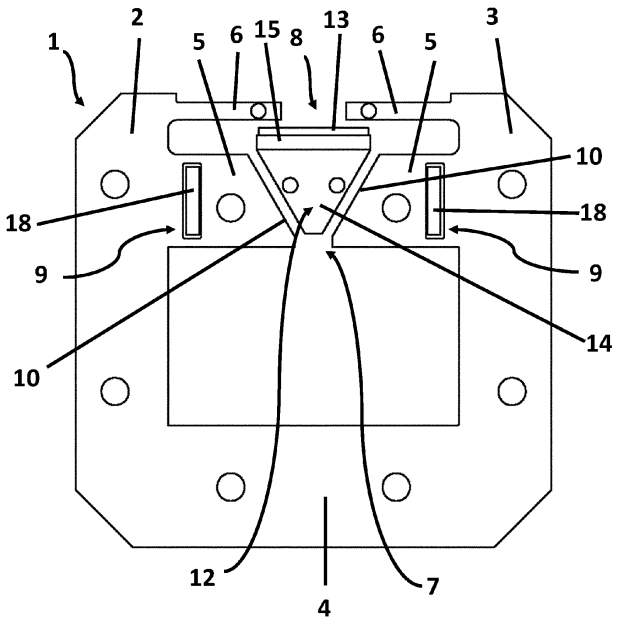

Fig. 1

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Description

[0001] The invention relates to a core for a circuit breaker mechanism and a circuit breaker mechanism designed for a high current bus bars.

Document EP2431991A1 discloses an electromechanical release mechanism to be used in a circuit interrupting device such as a circuit breaker mechanism and in particular in a DC (direct current) circuit interrupting device. The object of the invention shown in this document is a release mechanism for a circuit interrupting device comprising a ferromagnetic main frame through which can flow a current and a ferromagnetic movable core designed to be translated in an opening of the main frame between a first position in which the circuit interrupting device remains closed and a second position in which the circuit interrupting device is opened. The said release mechanism is designed to use the flux generated inside the main frame by the current flowing through it to displace the movable core between its first and second positions. The release mechanism further comprises at least two permanent magnets mounted on the main frame on each side of the opening and relatively oriented so as to generate a unidirectional unique magnetic flux inside the main frame and the movable core, the said magnetic flux creating a first force on the movable core that tends to maintain it in its first position. The permanent magnets, the movable core and the main frame are further conformed so that the movable core is displaced from its first position into its second position when a first current flowing through the main frame and generating a first flux inside the main frame and the movable core in the same direction as the magnetic flux exceeds a first limit value or when a second current flowing through the main frame and generating a second flux inside the main frame and the movable core in the direction opposite to the magnetic flux exceeds a second limit value, the said second limit value being different than the first limit value.

[0002] A first embodiment of the present invention is a core for a circuit breaker mechanism. The core comprising a first limb, a second limb, a first yoke, a second yoke, a third yoke. Between the first limb and the second limb there are the first yoke, the second yoke and the third yoke. The third yoke has a smaller cross-section area then the second yoke. The second yoke comprises a first air gap and at least one opening. Edges of the first air gap are tilted such that the first air gap forms a trapezoid. The third yoke comprises a second air gap.

[0003] Preferably the at least one opening is located near the first limb and/or the second limb.

[0004] Preferably there are two openings, wherein preferably one of the openings is located near the first limb, and where the other openings is located near the second limb.

[0005] Preferably the at least one opening has a rectangular shape.

[0006] Preferably the at least one opening axis is perpendicular to a plane formed by the first limb and the second limb.

[0007] A second embodiment of the present invention is a circuit breaker mechanism. The circuit breaker mechanism comprising a core, a movable armature and a bus bar. The core comprising a first limb, a second limb, a first yoke, a second yoke, a third yoke. Between the first limb and the second limb there are the first yoke, the second yoke and the third yoke. The third yoke has a smaller cross-section area then the second yoke. The second yoke comprises a first air gap. Edges of the first air gap are tilted such that the first air gap forms a trapezoid. The third yoke comprises a second air gap. The movable armature comprising a first magnetic part, a second magnetic part, a magnetic separator made of a paramagnetic material, a sliding mechanism configured for providing a sliding movement of the movable armature. The first magnetic part has such a shape that it may adjoin to the third yoke over the second air gap. The second magnetic part has such a shape that it may be placed in the first air gap. The first magnetic part is separated from the second magnetic part with the magnetic separator. The bus bar is placed in a window formed by the first limb, the second limb, the first yoke, and the second yoke. The moveable armature is configured such that it may move between a first position and a second position, where in the first position the first magnetic part adjoins the third yoke and there is a first gap between the second magnetic part and the second yoke, and in the second position there is a second gap between the first magnetic part and the third yoke and the second magnetic part adjoins the second yoke. When the current flowing through the bus bar is lower than a threshold current, the movable armature is configured such that it is in the first position. In the second yoke and/or the second magnetic part there is at least one permanent magnet, wherein each of the at least one permanent magnet are placed such, that a magnetic flux in one direction is amplified and in other direction is attenuate.

[0008] Preferably the core is as described in claims 1-5, wherein the at least one permanent magnet is located in an opening in the second yoke, preferably there are two permanent magnets and two openings in the second yoke, in each opening there is one permanent magnet.

[0009] Preferably each of the at least one permanent magnet is placed such that a first magnetic pole point toward the first limb and a second magnetic pole points towards the second limb.

[0010] Preferably the first magnetic part is in a form of a bar.

[0011] Preferably the second magnetic part is in a form of a triangle or trapezoid block.

[0012] Preferably the second magnetic part comprises an additional opening in which the permanent magnet is placed.

[0013] Preferably the sliding mechanism comprises a spring configured such that the movable armature is being forced toward the first position.

[0014] Preferably the at least one ring made of a diamagnetic metal, preferably copper, is placed on the third yoke.

[0015] It is the purpose of the present invention to provide circuit breaker mechanism designed for a high current bus bars with an asymmetrical characteristics, which practically acts as a single current direction circuit breaker mechanism. A design according to the invention further allows to lower the activation current of the circuit breaker mechanism and it is suitable to use in a currently used circuit breaker mechanisms.

[0016] Preferred embodiments of the invention are described below by way of example with reference to the following drawings, where:

Fig. 1 shows a simplified view of a first embodiment where two permanent magnets are used,

Fig. 2 shows a simplified view of a first embodiment where one permanent magnet is used,

Fig. 3 shows two positions of a movable armature,

Fig. 4 shows a circuit breaker mechanism with all necessary elements,

Fig. 5 shows a diagram of forces in a prior art circuit breaker mechanism,

Fig. 6 shows a diagram of forces in a circuit breaker mechanism with two magnets,

Fig. 7 shows a diagram of forces in a circuit breaker mechanism with one magnet.

[0017] The general idea behind this invention is to provide at least one magnet such that the it will either reduce a magnetic flux in a second yoke 4 or the magnetic flux will be increased. It will depend on a current flow direction in a bus bar 11.

[0018] During tests it appears that two locations for magnets are suitable. A first place is located in the second yoke 4. Due to other mechanical limitations, such as mounting holes, edge 10 of a first air gap 7 etc. a final location has been determined where openings 9 are located, however, if redesigned, the openings 9 might be placed in other parts of the second yoke 4, as shown in fig. 1. Other suitable place is located in a second magnetic part 14 of a movable armature 14, as shown in fig. 2. It should be noted that both locations for permanent magnets may be used in the same circuit breaker mechanism.

[0019] For the first embodiment the core 1 has been designed such that it may be implemented in currently used circuit breaker mechanisms. A core 1 for a circuit breaker mechanism comprising a first limb 2, a second limb 3, a first yoke 4, a second yoke 5, a third yoke 6. Between the first limb 2 and the second limb 3 there are the first yoke 4, the second yoke 5 and the third yoke 6. The third yoke 6 has a smaller cross-section area then the second yoke 5. The second yoke 5 comprises a first air gap 7 and at least one opening 9, preferably at least one opening 9 is located near the first limb 2 and/or the second limb 3. Edges 10 of the first air gap 7 are tilted such that the first air gap 7 forms a trapezoid. The third yoke 6 comprises a second air gap 8.

[0020] In yet another example there are two openings 9, wherein preferably one of the openings 9 is located near the first limb 2, and where the other openings 9 is located near the second limb 3. In such core 1 two smaller permanent magnets 18 may be used.

[0021] In another example the at least one opening 9 has a rectangular shape. Such shape allows to use the permanent magnet 18 with a standard bar shape.

[0022] In yet another example the at least one opening 9 axis is perpendicular to a plane formed by the first limb 2 and the second limb 3. Such opening 9 enables an easier manufacturing process by providing easy access to the opening, even when the core 1 is placed in the circuit breaker mechanism.

[0023] In general a circuit breaker mechanism is proposed which comprises a core 1, a movable armature 12 and a bus bar 11. The core 1 comprising a first limb 2, a second limb 3, a first yoke 4, a second yoke 5, and a third yoke 6. Between the first limb 2 and the second limb 3 there are the first yoke 4, the second yoke 5 and the third yoke 6. The third yoke 6 has a smaller cross-section area then the second yoke 5. The second yoke 5 comprises a first air gap 7, where edges 10 of the first air gap 7 are tilted such that the first air gap 7 forms a trapezoid. The third yoke 6 comprises a second air gap 8. The movable armature 12 comprising a first magnetic part 13, a second magnetic part 14, a magnetic separator 15 made of a non-magnetic material, such as a paramagnetic material. A sliding mechanism 20 is configured for providing a sliding movement of the movable armature 12. The first magnetic part 13 has such a shape that it may adjoin to the third yoke 6 over the second air gap 8. The second magnetic part 14 has such a shape that it may be placed in the first air gap 7. The first magnetic part 13 is separated from the second magnetic part 14 with the magnetic separator 15. The bus bar 11 is placed in a window formed by the first limb 2, the second limb 3, the first yoke 4, and the second yoke 5. The moveable armature 12 is configured such that it may move between a first position 16 and a second position 17, where in the first position 16 the first magnetic part 13 adjoins the third yoke 6 and there is a first gap between the second magnetic part 14 and the second yoke 5, and in the second position 17 there is a second gap between the first magnetic part 13 and the third yoke 6 and the second magnetic part 14 adjoins the second yoke 5, as shown in fig. 3. In the second yoke 5 and/or the second magnetic part 14 there is at least one permanent magnet 18, wherein each of the at least one permanent magnet 18 are placed such, that a magnetic flux in one direction is

amplified and in other direction is attenuated. It should be noted that, when the current flowing through the bus bar 11 is lower than a threshold current, the movable armature 12 is configured such that it is in the first position 16. Such result may be achieved gravitationally or mechanically and the person skilled in the art will know how to achieve it.

[0024] In a fig. 4 all necessary parts of the circuit breaker mechanisms are shown, especially bus bars 11 and mechanical, such as sliding mechanism 20 and spring 21. Such parts are however typical in already used circuits breakers and, for a clarity of disclosure, are not shown in fig. 1-3.

[0025] The circuit breaker mechanism according to the invention works as follows. The current flows through the bus bar 11 (or more bus bars 11 as shown on fig. 4), which generates a magnetic flux in the core 1. For now, for a purpose of the explanation, it is assumed that there are no permanent magnets and basically a prior art circuit breaker mechanism is described. In such a case a magnetic flux runs through the first limb 2, the first yoke 3, the second limb 3 and it will split into the second yoke 5 and the third yoke 6. Since the movable armature 12 is in the first position 16, the first magnetic part 13 is closer to the third yoke 6, over the second air gap 8, than the second magnetic part 14 to the edges 10 of the first air gap 7 in the second yoke 5.

[0026] Due to the magnetic flux running through the second yoke 5 and the third yoke 6 both the first magnetic part 13 and the second magnetic part 14 acts as electromagnets being attracted to, respectively, the third yoke 6 and the second yoke 5.

[0027] In the case of an increasing current running through the bus bar 11 the magnetic flux also increases. Due to the fact that the third yoke 6 has a smaller cross section than the second yoke 5, the saturation of the third yoke 6 will happen faster and after that increase in the current running through the bus bar 11 will only increase the magnetic flux in the second yoke 5 which will increase the attraction force in the electromagnet made of the second magnetic part 14. In the high enough current the attraction force generated by the second magnetic part 14 will be greater than the attraction force generated by the first magnetic part 13 and the movable armature 12 will move to the second position 17 and further activate a switch - the switch and further mechanical and electrical circuits are not shown since those are known for the person skilled in the art. It should also be noted that due to the magnetic separator 15, made of a non-magnetic material such as a plastic, both magnetic fluxes running through the third yoke 6 and the second yoke 5 are separated between the first limb 2 and the second limb 3.

[0028] The prior art circuit breaker mechanism will have a characteristic as shown on fig. 5. It is apparent that the characteristic is symmetrical and the same values appears for the same current regardless of a direction of the current flowing through the bus bar 11. A first graph 23 shows a force acting on the movable armature 12 toward the first position 17. A second graph 24 shows a force acting on the movable armature 12 toward the second position 18. A third graph 25 shows a sum of the first graph 23 and the second graph 24. It may be seen that up to approx. 1500 A the sum has a positive value (more force toward the first position 17) and after that it quickly become more negative (more force towards the second position 18) which will cause the movable armature 12 to change position.

[0029] The top line is a force generated by the first electromagnet made of the first magnetic part 13 and the third yoke 4. The bottom line is the force generated by the second electromagnet made of the second magnetic part 14 and the second yoke 5. It should be noted that the bottom line shows a negative force since it is pointing toward the opposite direction. The middle line is a sum of forces acting on the movable armature 12. It should be noted that up to approx. 1400 A forces are balanced and after that the force generated by the second electromagnet is greater which will result in movement of the movable armature 12 to the second position 17. It should be noted that it is an example and other values may be archived. It should also be noted that the force generated by a spring 21 is not discussed here and the spring 21 will be elaborated more hereinafter.

[0030] In the disclosed invention the permanent magnet 18 is introduced in at least one place. On fig. 1 it is shown that the permanent magnets 18 are placed in the second yoke 5, however it should be noted that one permanent magnets 18, or more than two, may be used. In the other embodiment shown on fig. 2 the permanent magnet 18 is located in the second magnetic part 14. Regardless of the variant the result is the same - the magnetic flux running though the second yoke 5 is weekend, in one direction, and boosted in the other direction. In such a case the asymmetrical characteristics, as shown on fig. 6 and 7, are achieved - fig. 6 and 7 will be discussed more hereinafter.

[0031] The first consequence of the use of the permanent magnets 18 is that, in practical application, the circuit breaker mechanism according to the invention is a unidirectional circuit breaker mechanism. The other benefit is that an activation current may also be lowered. Additionally such solution may be used in the currently manufactured circuit breakers which is additionally beneficial.

[0032] In the preferred example the core 1 as described previously is used in the circuit breaker mechanism. The at least one permanent magnet 18 is located in an opening 9 in the second yoke 5. Preferably there are two permanent magnets 18 and two openings 9 in the second yoke 5, in each opening 9 there is one permanent magnet 18. As shown on fig. 1 one of the openings 9 is located near the first limb 2, and the other of the openings 9 is located near the second limb 3. It should be however noted that placing the permanent magnet 18 in the opening is solution directed to the assembling of the circuit breaker mechanism rather than toward the core idea.

Other solutions directed toward placing the permanent magnet 18 in designated place may be developed. The one solution proposed in this specification is directed toward the use of, in principle, the core 1 of the same general shape as previously and should not be treated as essential feature of this invention.

[0033] In yet another preferred example each of the at least one permanent magnet 18 is placed such that a first magnetic pole point toward the first limb 2 and a second magnetic pole points towards the second limb 3. In this case a result will be better than in the case in which the first magnetic pole and the second magnetic pole are tilted with respect to the magnetic flux in the second yoke 5. Some variations of the permanent magnets 18 orientation are allowable, however, as stated hereinbefore, the magnetic flux in one direction must be amplified and in other direction must be attenuate.

[0034] In another example the first magnetic part 13 is in a form of a bar.

[0035] In another example the second magnetic part 14 is in a form of a triangle or trapezoid block, however other shapes may be suitable. One may even consider the second magnetic part 14 in a bar shape, however proposed shape provides a greater cross section for the magnetic flux.

[0036] In another example the second magnetic part 14 comprises an additional opening 22 in which the permanent magnet 18 is placed. As previously mentioned other solutions directed toward placing the permanent magnet 18 in designated place may be developed. The one solution proposed in this specification is directed toward the use of, in principle, the second magnetic part 14 of the same general shape as previously and should not be treated as essential feature of this invention.

[0037] It should be understood that in the case of the opening 9 and the additional opening 22 both may have other shapes or may be a slit, as long as those structures enables the permanent magnet 18 to be placed in the designated place.

[0038] In another example the sliding mechanism 20 comprises a spring 21 configured such that the movable armature 12 is being forced toward the first position 16. The spring 21 is providing means for the movable armature 12 to be configured such that it is in the first position 16 when the current flowing through the bus bar 11 is lower than the threshold current. On the other hand the second electromagnet generates the force that must be grater than the force generated by the first electromagnet and the spring 21. The spring 21 may be used to fine tune the circuit breaker mechanism so that the threshold current is higher. Other parameters may also be used for tuning the circuit breaker mechanism. Those parameters are: strength of the permanent magnet 18, the permanent magnet 18 size (a width and an area - the best results are achieved when the area of the permanent magnet 18 is as big as possible in relation to the cross section of the second yoke 5), as well as other geometrical parameters of both the first air gap 7, the second air gap 8, opening 9 and additional opening 22.

[0039] In yet another example at least one ring 19 made of a diamagnetic metal, preferably copper, is placed on the third yoke 6. The purpose of such ring 19 is that, during a change of the magnetic flux in the third yoke 6, eddy currents are generated in the ring 19 which generate another magnetic flux, in the opposite direction. The ring 19 causes that a rapid current changes will activate the circuit breaker mechanism faster due to lower magnetic flux in the third yoke 6 and thus lower force generated by the first electromagnet.

[0040] Fig. 6 shows a diagram of forces in a circuit breaker mechanism with two magnets while fig. 7 shows a diagram of forces in a circuit breaker mechanism with one magnet, wherein in both fig. 6 and 7 X axis represents a current and the Y axis represents a force - if the force is greater than 0, then the movable armature 12 stays in the first position 16 and when the force is less than 0 then the movable armature 12 moves toward the second position 17. The person skilled in the art will know that when the movable armature 12 moves toward the second position 17 the force acting on the moveable armature also increases due to the fact the first air gap 7 decreases, which results in more "negative" force, while the second air gap 8 increases which results in less "positive" force. It should be noted that each graph on fig. 6 and 7 is a sum of forces in the same meaning as in the fig. 5 but in a modified circuit breaker.

[0041] Abovementioned diagrams should be compared to the prior art circuits as shown in fig. 5. It should be noted that the diagram shown in fig. 6 and 7 are not symmetrical. In fig. 6 diagram reaches 0, that is a point of imbalance, at aprox. 1500A and -7000A. In fig. 7 diagram reaches 0 at aprox. 1350A and -6000A. It should be noted that the value 1350A is lower than typical 1500A - the present invention may also be applied to lower a current needed to activate the circuit breaker.

[0042] In fig. 6 a fourth graph 26 shows a sum of forces acting on the movable armature 12 in the first position 17, a fifth graph 27 shows a sum of forces acting on the movable armature 12 when the movable armature 12 is moved 0,2 mm toward the second position 18 from the first position 17, a the sixth graph 28 shows a sum of forces acting on the movable armature 12 when the movable armature is in the second position 18.

[0043] In fig. 7 a seventh graph 29 shows a sum of forces acting on the movable armature 12 in the first position 17, a eighth graph 30 shows a sum of forces acting on the movable armature 12 when the movable armature 12 is moved 0,3 mm toward the second position 18 from the first position 17, and a ninth graph 31 shows a sum of forces acting on the movable armature 12 when the movable armature 12 is in the second position 18.

[0044] As it may be seen in both fig. 6 and 7 fourth graph 26 and seventh graph 29 shows a sum of forces acting on the movable armature 12 in the first position 17. After the current reaches a threshold value the movable

armature 12 is moving toward the second position 18 due to the negative sum of the forces. At the beginning the sum of forces may be represented as in fifth graph 27 and eighth graph 30 - after even the smallest movement toward the second position 18 the first air gap 7 is getting smaller and the second air gap 8 is getting larger and thus the sum of forces become even more negative. After the movable armature 12 is in the second position 18, as shown in sixth graph 28 and ninth graph 31 practically any positive current will generate enough flux to keep the movable armature 12 in the second position 18. The movable armature 12 will go back to the first position 17 after the current will reach 0A.

1	core
2	first limb
3	second limb
4	first yoke
5	second yoke
6	third yoke
7	first air gap
8	second air gap
9	opening
10	edge of the first air gap
11	bus bar
12	movable armature
13	first magnetic part
14	second magnetic part
15	magnetic separator
16	first position of the movable armature
17	second position of the movable armature
18	permanent magnet
19	ring
20	sliding mechanism
21	spring
22	additional opening

Claims

1. A core for a circuit breaker mechanism comprising:

a first limb (2),
a second limb (3),
a first yoke (4),
a second yoke (5),
a third yoke (6);
wherein between the first limb (2) and the second limb (3) there are the first yoke (4), the second yoke (5) and the third yoke (6), wherein the third yoke (6) has a smaller cross-section area then the second yoke (5),
wherein the second yoke (5) comprises a first air gap (7) and at least one opening (9), where edges (10) of the first air gap (7) are tilted such that the first air gap (7) forms a trapezoid, and
wherein the third yoke (6) comprises a second air gap (8).

2. The core according to claim 1, **characterized in that** the at least one opening (9) is located near the first limb (2) and/or the second limb (3).

3. The core according to claim 1 or 2, **characterized in that** there are two openings (9), wherein preferably one of the openings (9) is located near the first limb (2), and where the other openings (9) is located near the second limb (3).

4. The core according to anyone of the previous claims, **characterized in that** the at least one opening (9) has a rectangular shape.

5. The core according to anyone of the previous claims, **characterized in that** the at least one opening (9) axis is perpendicular to a plane formed by the first limb (2) and the second limb (3).

6. A circuit breaker mechanism comprising a core (1), a movable armature (12) and a bus bar (11), wherein the core (1) comprising:

a first limb (2),
a second limb (3),
a first yoke (4),
a second yoke (5),
a third yoke (6);
wherein between the first limb (2) and the second limb (3) there are the first yoke (4), the second yoke (5) and the third yoke (6), wherein the third yoke (6) has a smaller cross-section area then the second yoke (5),
wherein the second yoke (5) comprises a first air gap (7), where edges (10) of the first air gap (7) are tilted such that the first air gap (7) forms a trapezoid, and
wherein the third yoke (6) comprises a second air gap (8),
wherein the movable armature (12) comprising:

a first magnetic part (13),
a second magnetic part (14),
a magnetic separator (15) made of a paramagnetic material,
a sliding mechanism (20) configured for providing a sliding movement of the movable armature (12);

wherein the first magnetic part (13) has such a shape that it may adjoin to the third yoke (6) over the second air gap (8),
wherein the second magnetic part (14) has such a shape that it may be placed in the first air gap (7),
wherein the first magnetic part (13) is separated from the second magnetic part (14) with the magnetic separator (15),

the bus bar (11) is placed in a window formed by the first limb (2), the second limb (3), the first yoke (4), and the second yoke (5),
wherein the moveable armature (12) is configured such that it may move between a first position (16) and a second position (17), where in the first position (16) the first magnetic part (13) adjoins the third yoke (6) and there is a first gap between the second magnetic part (14) and the second yoke (5), and in the second position (17) there is a second gap between the first magnetic part (13) and the third yoke (6) and the second magnetic part (14) adjoins the second yoke (5),
wherein, when the current flowing through the bus bar (11) is lower than a threshold current, the movable armature (12) is configured such that it is in the first position (16),
wherein in the second yoke (5) and/or the second magnetic part (14) there is at least one permanent magnet (18), wherein each of the at least one permanent magnet (18) are placed such, that a magnetic flux in one direction is amplified and in other direction is attenuate.

7. The circuit breaker mechanism according to claim 6, **characterized in that** the core (1) is as described in claims 1-5, wherein the at least one permanent magnet (18) is located in an opening (9) in the second yoke (5), preferably there are two permanent magnets (18) and two openings (9) in the second yoke (5), in each opening (9) there is one permanent magnet (18).

8. The circuit breaker mechanism according to claim 6 or 7, **characterized in that** each of the at least one permanent magnet (18) is placed such that a first magnetic pole point toward the first limb (2) and a second magnetic pole points towards the second limb (3).

9. The circuit breaker mechanism according to anyone of claims 6-8, **characterized in that** the first magnetic part (13) is in a form of a bar.

10. The circuit breaker mechanism according to anyone of claims 6-9, **characterized in that** the second magnetic part (14) is in a form of a triangle or trapezoid block.

11. The circuit breaker mechanism according to anyone of claims 6-10, **characterized in that** the second magnetic part (14) comprises an additional opening (22) in which the permanent magnet (18) is placed.

12. The circuit breaker mechanism according to anyone of claims 6-11, **characterized in that** the sliding mechanism (20) comprises a spring (21) configured such that the movable armature (12) is being forced toward the first position (16).

13. The circuit breaker mechanism according to anyone of claims 6-12, **characterized in that** the at least one ring (19) made of a diamagnetic metal, preferably copper, is placed on the third yoke (6).

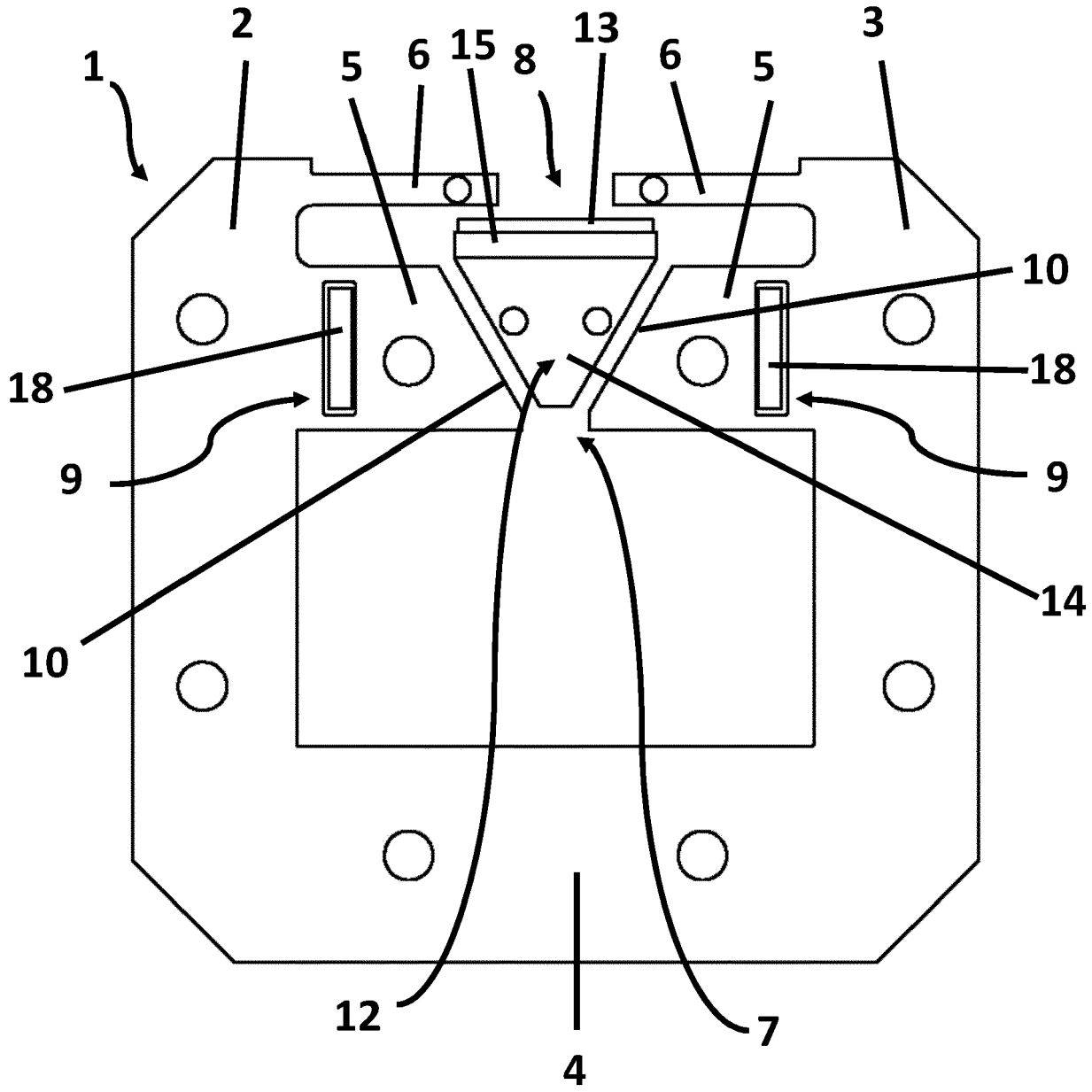

Fig. 1

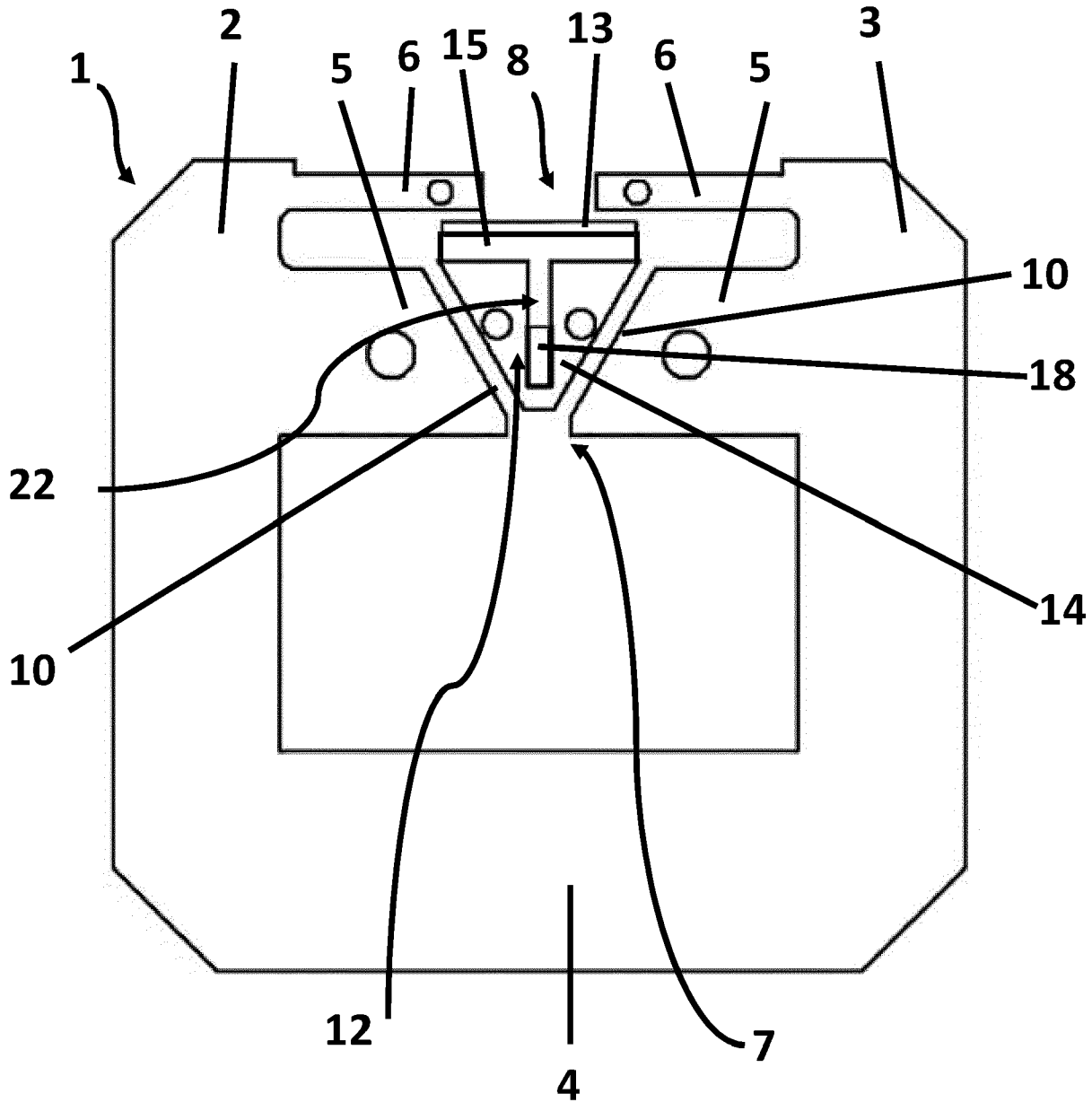

Fig. 2

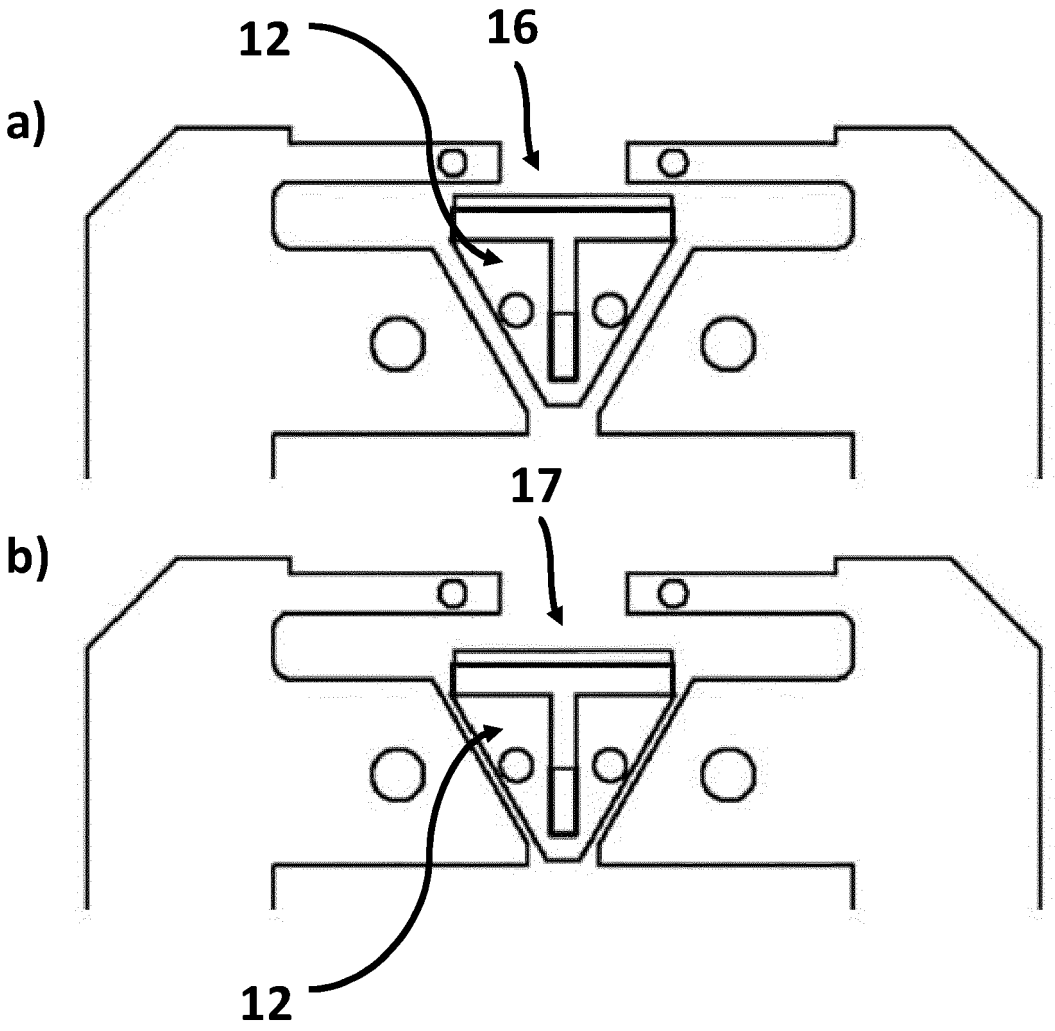

Fig. 3

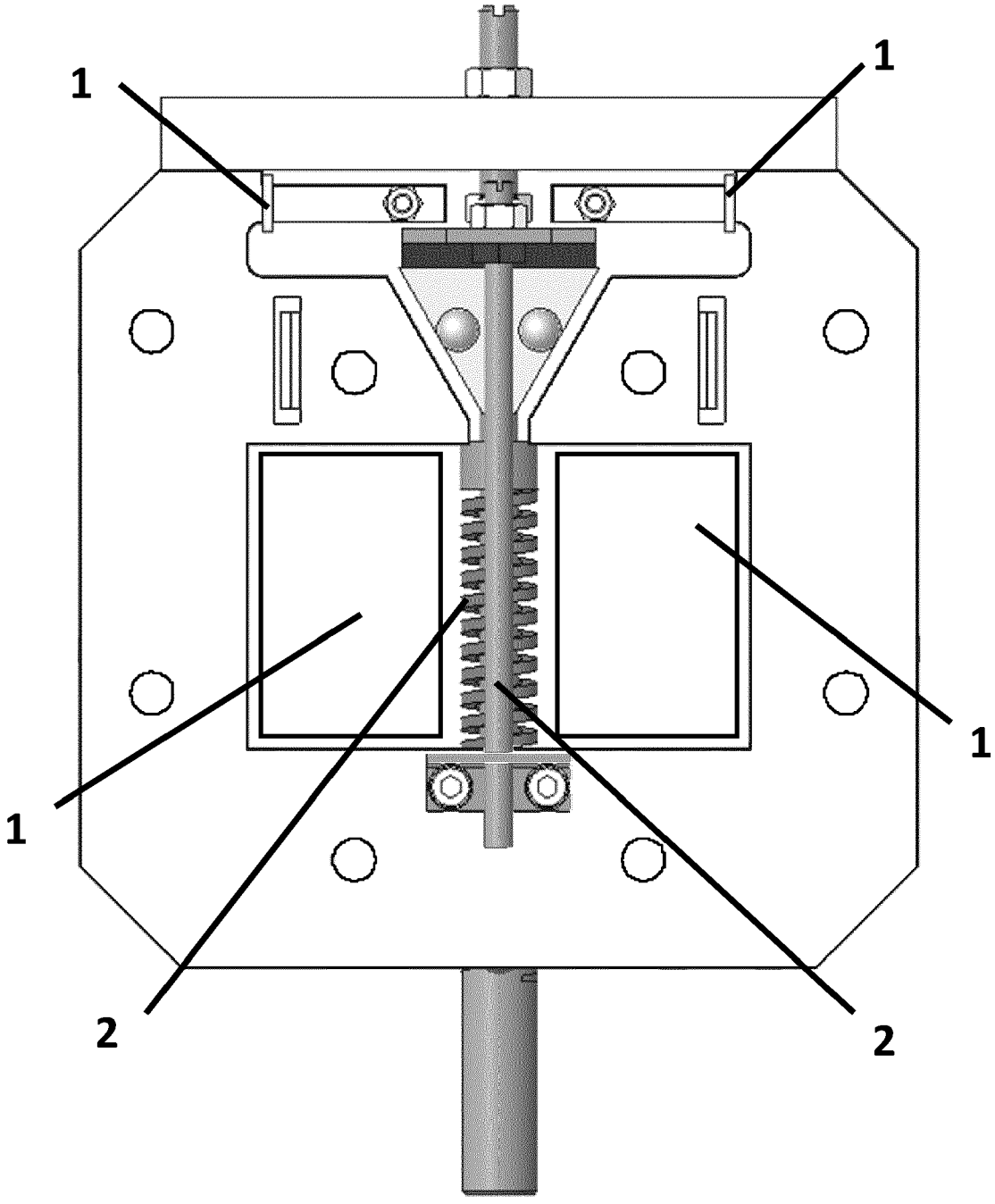

Fig. 4

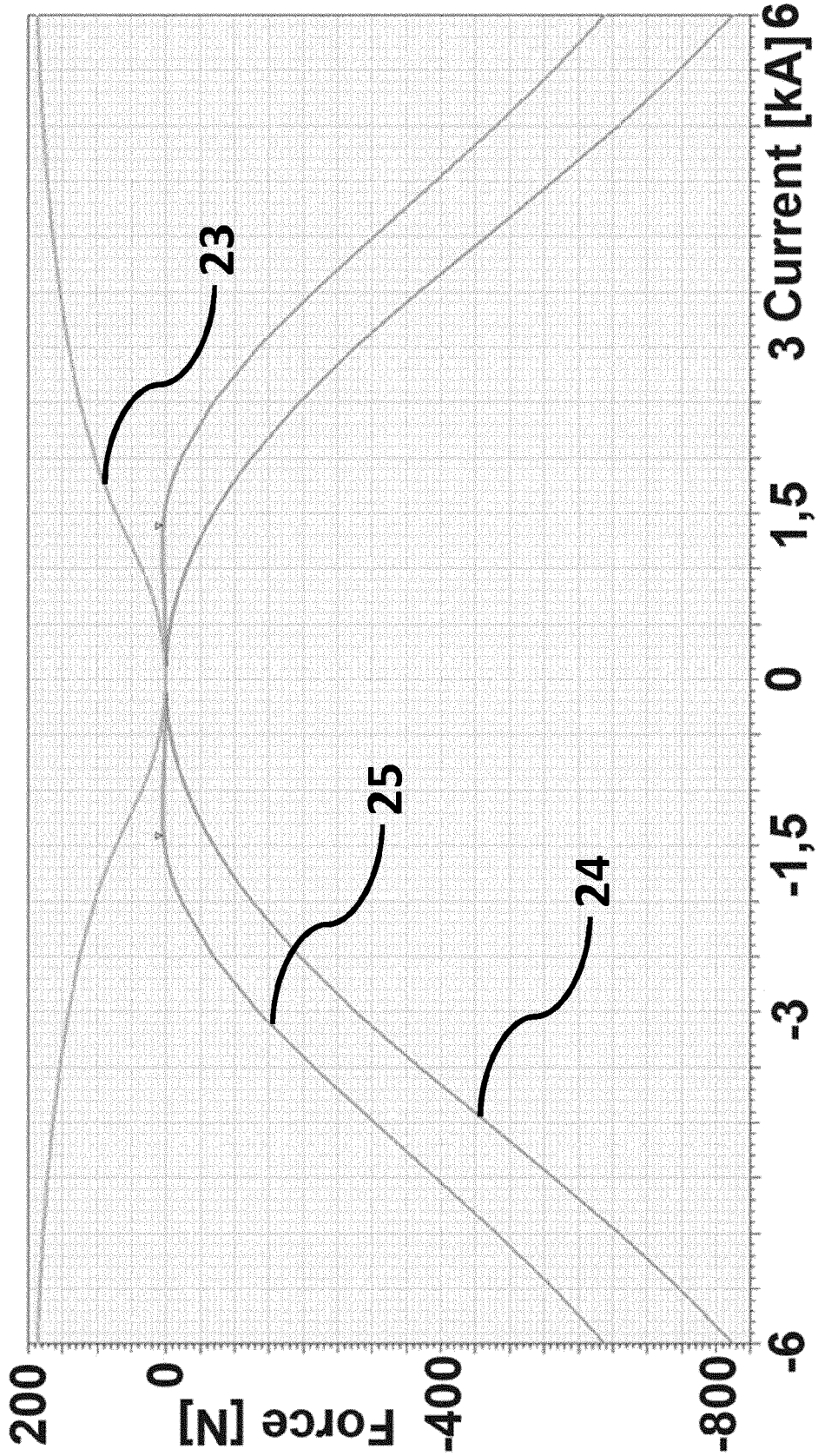

Fig. 5

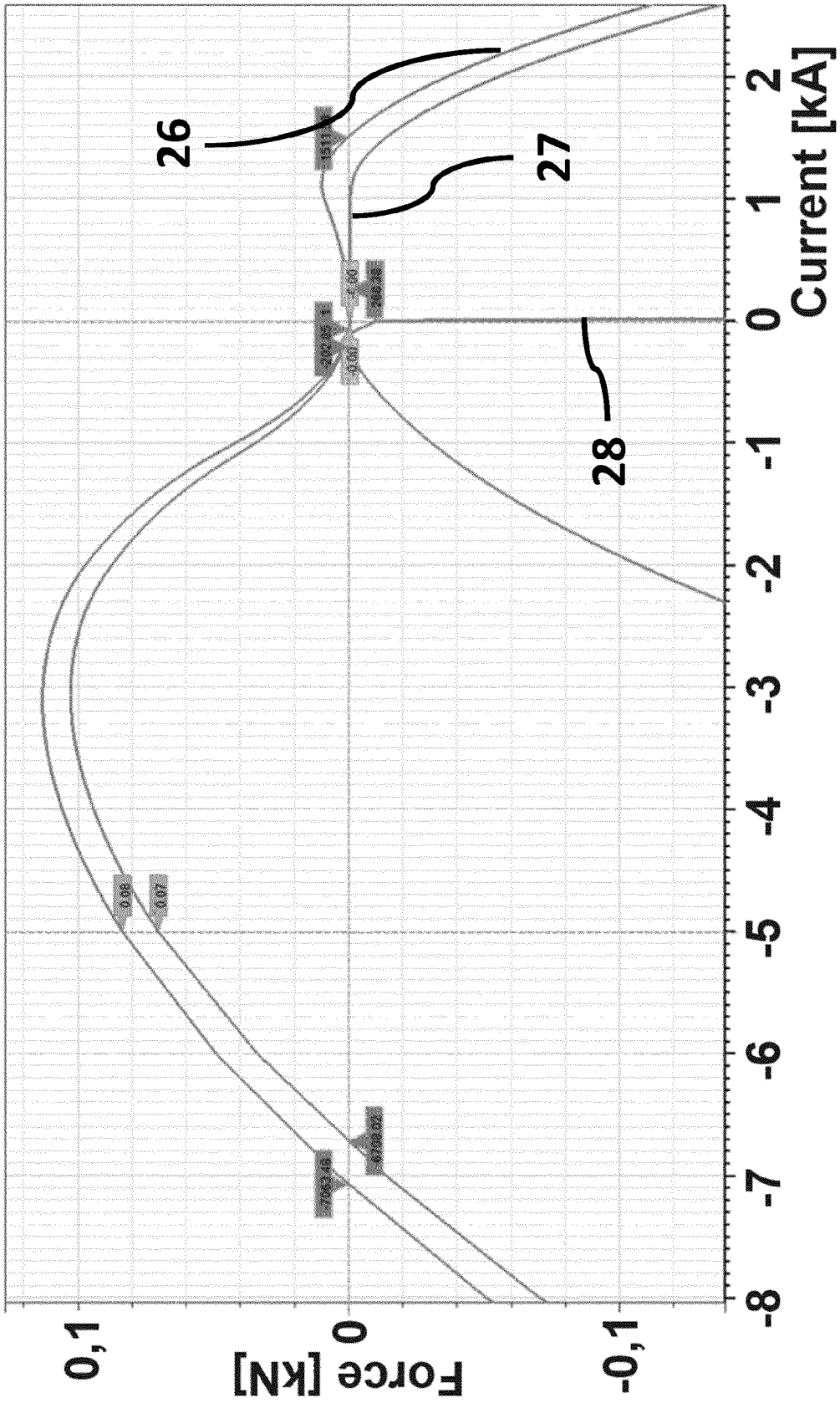

Fig. 6

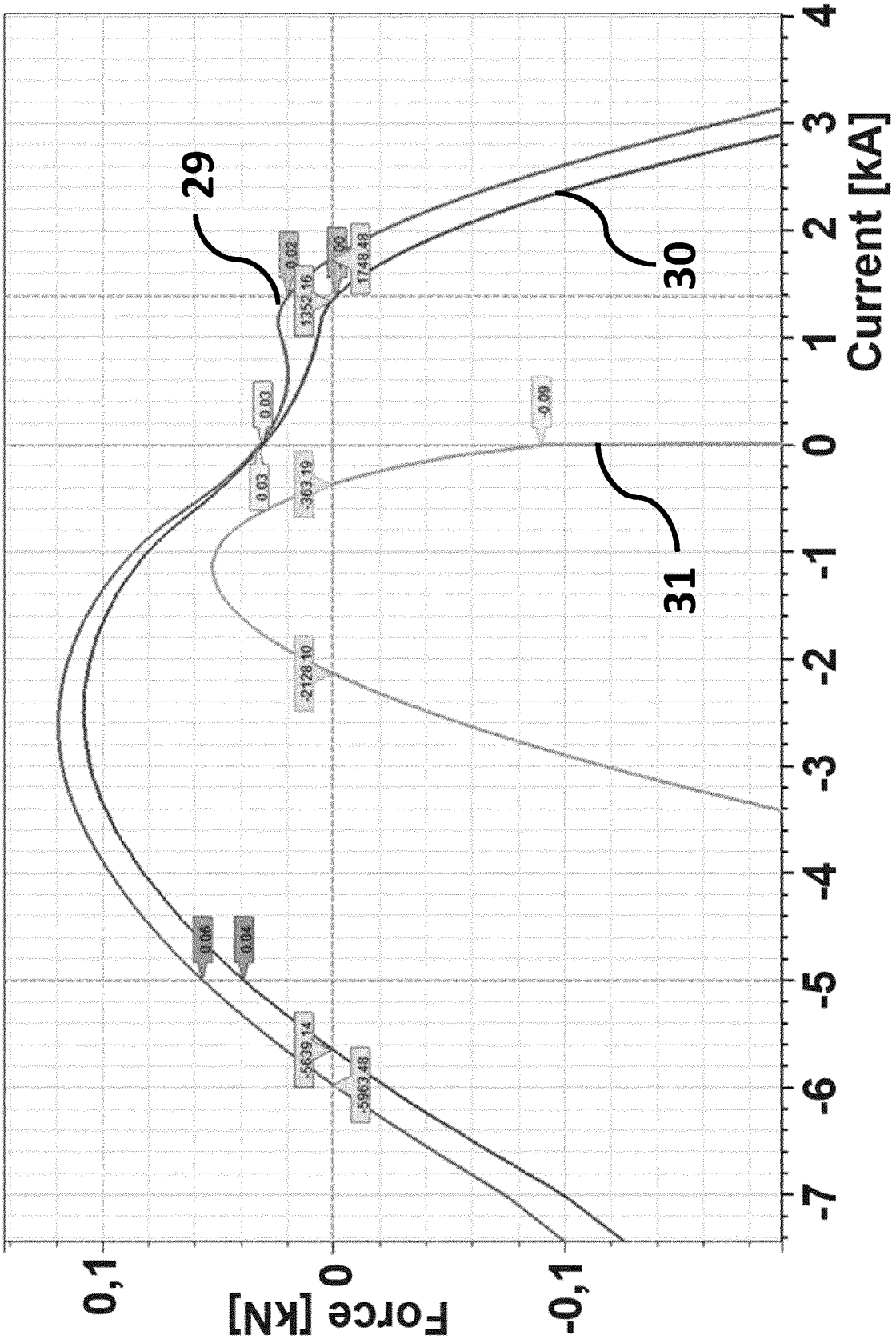
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Fig. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 23 21 3227

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	15 April 2024	Pavlov, Valeri

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