(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 388 793 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
23.11.2011 Bulletin 2011/47

(51) Int Cl.:
H01H 51/01 *(2006.01)* ***H01H 71/32*** *(2006.01)*

(21) Application number: **10005318.0**

(22) Date of filing: **21.05.2010**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR
Designated Extension States:
BA ME RS

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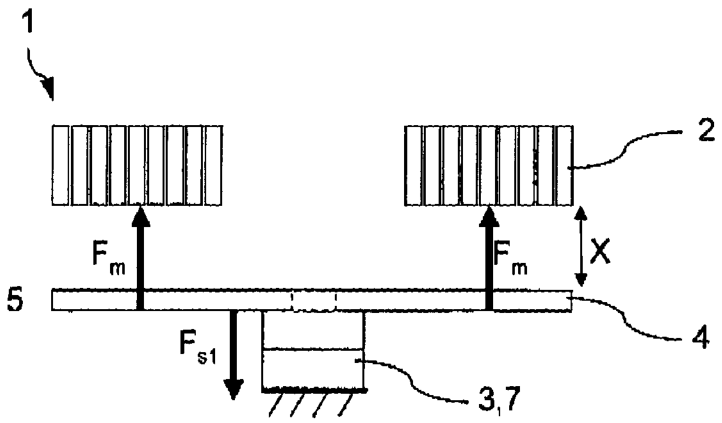
(54) **Actuator, tripping device and switch**

(57) The invention relates to an actuator for use in a tripping device or a switch, comprising a flat coil (2), a fixed power source (3) and a movable magnetic armature (4), whereby the fixed power source is constructed in such a way that the force exerted by the fixed power source (F_{s1}) keeps the movable magnetic armature in a first position (5) spaced apart from the flat coil, whereby the flat coil is constructed in such a way that during current having at least a certain strength is flowing through the flat coil the attractive magnetic force (F_m) exerted by the flat coil is larger than the force of the fixed power source to transfer the movable magnetic armature from the first position to a second position at or near the flat coil, whereby the movable magnetic armature is in the second position closer to the flat coil than in the first position. The invention further relates to a tripping device and a switch comprising a least one such actuator.

Fig. 2



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Description

[0001] The invention relates to an actuator comprising a flat coil and an armature being movable by an electromagnetic force being exerted by the flat coil. The invention further relates to a tripping device and to a switch.

[0002] The range of applications for actuators covers all technical areas so that actuators can be found as system components in nearly every controlled system. A special form of an actuator is an electromagnetic actuator. The ongoing trend towards the miniaturization of systems and the trend of system integration force the development engineers to construct smaller and smaller devices. Therefore, actuators working on the electromagnetic principle can be found in outer dimensions in the range of some millimeters. Today, applications of small electromagnetic actuators can be found in various fields. Small electromagnetic actuators are usually implemented in systems out of the innovative industries, like the automotive industry, the medical instrumentation industry, the computer industry or the like.

[0003] Known actuators consist of a coil and a movable iron core called the armature. When current flows through the windings of the coil, a magnetic field is set up around the windings. When the coil of the actuator is energized with current, the core moves to increase the flux linkage by closing the air gap between the cores, The movable core is spring-loaded to allow the core to retract when the current is switched off. The force generated is approximately proportional to the square of the current and inversely proportional to the square of the length of the air gap. Such actuators need permanent magnets in the armature. The magnetic force over the armature is not very high.

[0004] One object of the invention is to provide an actuator, particularly for the use in a tripping device or in a switch, a tripping device and a switch, both having an actuator, which are constructively very simple. A further object of the invention is to provide an actuator, particularly for the use in a tripping device or in a switch, a tripping device and a switch, both having an actuator, exercising a large magnetic force and a bistable movement of the movable armature of the actuator.

[0005] The problems of the invention are solved by an actuator with the features according to claim 1, by a tripping device with the features according to claim 14 and by a switch with the features according to claim 15. Advantages, features, details, aspects and effects of the invention arise from the dependent claims, the description and the figures. Features and details which are described in connection with the actuator count as well for the tripping device and the switch, and vice versa.

[0006] According to a first aspect of the present invention the problems are solved by an actuator for use in a tripping device or a switch, comprising a flat coil, a fixed power source and a movable magnetic armature, whereby the fixed power source is constructed in such a way that the force exerted by the fixed power source keeps the movable magnetic armature in a first position spaced apart from the flat coil, whereby the flat coil is constructed in such a way that during current having at least a certain strength is flowing through the flat coil the attractive magnetic force exerted by the flat coil is larger than the force of the fixed power source to transfer the movable magnetic armature from the first position to a second position at or near the flat coil, whereby the movable magnetic armature is in the second position closer to the flat coil than in the first position

[0007] Such an actuator for the use in a tripping device or a switch is constructive very simple and enables relative large magnetic forces being used for moving the movable magnetic armature to change a switching state of a switch, for example. Advantageously the actuator does not require a magnetic core around the coil as in an electromagnet. The magnetic force exerted by the flat coil is an attractive magnetic force. That means the magnetic force exerted by the flat coil is used to attract the movable magnetic armature in direction to the flat coil, if a strong enough current is flowing through the flat coil. Thereby the magnetic force overcomes the exerted force of the fixed power source.

[0008] That means, the movable magnetic armature is movable between a first and a second position. In the first position, also known as the initial position, the actuator enables a certain current flow to a load or a plant. If no current or a current below a certain strength is flowing through the flat coil the movable magnetic armature is hold back in the first position by the force exerted by the fixed power source. The force exerted by the fixed power source keeps the movable magnetic armature as long in the first position spaced apart from the flat coil, as no current having at least a certain strength is flowing through the flat coil. During current is flowing through the flat coil, whereby the current exceeds a certain strength, the attractive magnetic force exerted by the flat coil transfers the movable magnetic armature from the first position to a second position against the force exerted by the fixed power source. In the second position the movable magnetic armature is closer to the flat coil than in the first position.

[0009] This actuator interrupts a current flow to a load, for example a machine, if the current to the load exceeds a certain strength. In this case a current flow is guided to the flat coil which exerts an electromagnetic force to the movable magnetic armature to separate the movable magnetic armature from a stationary contact.

[0010] Advantageously no eddy currents are exerted by the flat coil pushing the movable magnetic armature away, but the magnetic force exerted by the flat coil is used to attract the movable magnetic armature to the flat coil to cause a change of state of a tripping device or a switch. The actuator can be used for a low-voltage or medium-voltage switch, for example.

[0011] The actuator is preferably constructed for use in tripping devices where high speed and small displacements are required. The displacement is reached by the electromagnetic attraction forces produced by the flat coil over the movable magnetic armature. Contrary to standard electromagnets, a magnetic core around the coil is not required.

[0012] The movable magnetic armature and the flat coil have the same axes and are spaced apart from each other. The movable magnetic armature is attracted towards the flat coil with magnetic force which increases as the movable magnetic armature moves. The attraction force is produced by the magnetic field generated by a current flowing through the flat coil. The force of the power source is used to keep the movable magnetic armature in the first, the initial, position. The permanent attraction force of the power source keeps the movable magnetic armature at the initial position under normal operation. Only when the magnetic force produced by the current flowing through the flat coil is larger than the counterforce of the power source, the movable magnetic armature starts to move towards the flat coil. Since the magnetic field of the flat coil is more intense closer to the flat coil, the attraction force exerted by the flat coil also increases as the movable magnetic armature approaches. This further increases the acceleration and velocity of the movable magnetic armature during its displacement and hence the time needed for the displacement from the first to the second position is decreased.

[0013] The movable magnetic armature can be a flat plate. In a preferred embodiment the flat plate comprises a hole in the middle.

[0014] According to a preferred development of the invention an actuator is provided, wherein the fixed power source is a fixed permanent magnet to exert a permanent magnetic force to the movable magnetic armature or the fixed power source comprises an elastic element to exert a spring force to the movable magnetic armature, whereby the movable magnetic armature is arranged at the elastic element. Both the fixed permanent magnet and the elastic element can exert a permanent force to the movable magnetic armature. A power source constructed as a fixed permanent magnet does not have to have a direct contact to the movable magnetic armature, whereby a power source constructed as an elastic element is fixed to the movable magnetic armature. The elastic element is advantageously a spring, in particular a helical spring. Alternatively, the elastic element is a rubber or an elastic material,

[0015] Since the movable magnetic armature is magnetic, the fixed permanent magnet attraction force keeps the movable magnetic armature at the initial position under normal operation. When the magnetic force produced by the current is larger than the counterforce of the fixed permanent magnet, the movable magnetic armature starts to move towards the coil.

[0016] The fixed power source can be arranged at either the first side of the movable magnetic armature or the second side of the movable magnetic armature. Preferred is an actuator, wherein the flat coil and the fixed power source being spaced apart from each other, said movable magnetic armature is arranged between the flat coil and the fixed power source. In this case the fixed power source, in particular the fixed permanent magnet, is arranged at the side of the movable magnetic armature facing away from the flat coil. This allows constructing the actuator in a very simple way.

[0017] Further an actuator is preferred, wherein the fixed power source and the movable magnetic armature are being arranged at a first side of the flat coil and a second fixed power source and a second movable magnetic armature are being arranged at the second opposite site of the flat coil, whereby the second fixed power source is constructed in such a way that the force exerted by the second fixed power source keeps the second movable magnetic armature in a first position spaced apart from the flat coil, whereby the flat coil is constructed in such a way that during current having at least a certain strength is flowing through the flat coil the attractive magnetic force exerted by the flat coil is larger than the force of the second fixed power source to transfer the second movable magnetic armature from its first position to a second position at or near the second side of the flat coil, whereby the second movable magnetic armature is in its second position closer to the flat coil than in its first position. Such an actuator enables to change the switching state of two separate switches, for example. The forces exerted by the two different power sources can be of the same size or can be of different sizes. Additionally or alternatively to that the distance between the power source and the flat coil at the first side of the flat coil can be equal or different to the distance between the second power source and the flat coil at the second side of the flat coil. This enables a different displacement of the movable magnetic armature and therefore a different change of switching state of a switch arranged at the first side of the flat coil and a switch arranged at the second side of the flat coil.

[0018] According to a further preferred development of the invention an actuator is provided, wherein the movable magnetic armature and/or the second movable magnetic armature have a low conductivity. This material feature reduces the possibility of the induction of eddy currents in the movable magnetic armature, whereby these induced eddy currents lead to magnetic fields which have the antipodal direction of the field produced by the flat coil and therefore reduce the resulting attractive force exerted by the flat coil onto the movable armature.

[0019] In a further preferred embodiment of the actuator the movable magnetic armatures each can be guided in linear guides during a movement between their first and their second position. This prevents the possibility of tilting of one of the movable armatures during the displacement from their respective first to their respective second position.

[0020] According to a further preferred development of the invention an actuator is provided, wherein each movable magnetic armature can be built up by several parts, whereby the parts are separated by isolating material. This construction feature reduces the strength of the induced eddy currents in the movable magnetic armature, whereby this induced eddy currents lead to magnetic fields which have the antipodal direction of the field produced by the flat coil and therefore reduce the resulting attractive force exerted by the flat coil onto the movable magnetic armature. The isolating material can be a plastic material, for example.

[0021] According to a further preferred development of the invention each movable magnetic armature can be made of a soft magnetic material. This allows a high saturation field of the flat coil and prevents each movable magnetic armature from being permanently magnetised.

[0022] Each movable magnetic armature can be made of a material which has a high magnetic permeability and/or a high saturation flux density. This leads to a saturation of the magnetic force at higher magnetic fields produced by the current flowing in the flat coil and thereby to a higher magnetic force acting on the movable magnetic armatures. This leads to a faster displacement of each movable magnetic armature from its first to its second position. Another preferable embodiment of the actuator in which each movable magnetic armature is made of a material with low mass density leads likewise to a faster displacement of each movable magnetic armature from its first to its second position. In embodiments of the actuator with two movable magnetic armatures, one or both of them can be constructed in this fashion.

[0023] In a further preferred embodiment of the actuator at least one further fixed permanent magnet is provided in the center of the flat coil. This at least one further fixed permanent magnet exerts a pull on each movable magnetic armature and fixes each movable magnetic armature at its second position after the current in the flat coil is switched of and therefore the magnetic force exerted by the flat coil is no longer present. By this a bistable operation of the actuator is reached. The at least one further fixed permanent magnet enables a bistable movement of each movable magnetic armature without bouncing back of the movable magnetic armature after reaching its second position.

[0024] According to a further preferred development of the invention each movable magnetic armature can be equipped with at least one switch contact for contacting at least one stationary contact of a tripping device or a switch. In their respective first position the switch contact of each movable magnetic armature is in touch with its respective stationary contact, closing an electric circuit for the tripping device or the switch. In the second position of each movable magnetic armature, the electric circuit is disconnected.

[0025] According to a further preferred development of the invention the actuator can have two or more fixed power sources at each side of the flat coil. The two or more fixed power sources at one side of the flat coil enable a uniform movement of the movable magnetic armature to the first position and a very strong hold of the movable magnetic armature in the first position. By this embodiment of the actuator, the force needed to fix a movable magnetic armature in its first position is distributed over the several fixed power sources. Therefore these fixed power sources and the actuator in total can be of a smaller size.

[0026] Further, as the actuator is using a magnetic force to displace at least one movable magnetic armature from its first to its second position in a motion perpendicular to the flat coil, the actuator can be used as an electromagnetic linear actuator. Therefore the actuator is preferred an electromagnetic linear actuator.

[0027] According to a second aspect of the invention the object is solved by a tripping device, wherein the tripping device comprises at least one actuator according to the first aspect of the invention. The tripping device can be used to disconnect an electric circuit if a certain current strength is exceeded. For this, the above mentioned contacts, at least one switch contact mounted on the movable magnetic armature and at least one stationary contact, and the flat coil of at least one actuator have to be connected to the same electric circuit. In addition the tripping current has to be matched to the current which is needed to build up the magnetic force to displace a movable magnetic armature from its first to its second position, in which the electric circuit is then disconnected. Therefore, during normal operation, a normal current is flowing through the flat coil, the switch contacts and the stationary contacts. The magnetic force of the magnetic field in the flat coil is not strong enough to overcome the force of the fixed power source. Therefore the movable magnetic armature stays in its first position. In case of a high current, for instance in a short circuit, the force of the magnetic field in the flat coil gets strong enough to overcome the force of the fixed power source. In this case, the movable magnetic armature is moved from its first to its second position at the flat coil and the electric circuit will be interrupted.

[0028] According to a third aspect of the invention the object is solved by a switch, wherein the switch comprises at least one actuator according to the first aspect of the invention. The switch can be used to disconnect an electric circuit if a certain current strength is exceeded, like described according to the second aspect of the invention. For this, the above mentioned contacts, the switch contacts mounted on the movable magnetic armature and the stationary contacts, and the flat coil of at least one actuator have to be connected to the same electric circuit. In addition the tripping current has to be matched to the current which is needed to build up the magnetic force to displace a movable magnetic armature from its first to its second position, in which the electric circuit is then disconnected.

[0029] The foregoing, and other features and advantages of the present invention, will become more apparent in the light of the above-mentioned description and the accompanying drawings, where:

Figure 1 shows schematic in a perspective view a first embodiment of the actuator which is constructed according to the inventive functional principle,

Figure 2	shows schematic in a cross-section a second embodiment of the actuator, whereby the movable magnetic armature is in its first position being retarded by a permanent magnet, so that a current circuit is closed,
Figure 3	shows schematic in a cross-section third embodiment of the actuator, whereby the movable magnetic armature is in its first position being retarded by a permanent magnet, so that a current circuit is closed, whereby in center of the flat coil a further permanent magnet is provided,
Figure 4	shows schematic in a cross-section the actuator according to fig. 3, whereby the movable magnetic armature is in its second position at the flat coil, in which a current circuit is interrupted,
Figure 5	shows schematic in a cross-section a fourth embodiment of the actuator, whereby the movable magnetic armature is in its first position being retarded by a spring, so that a current circuit is closed,
Figure 6	shows schematic in a cross-section a fifth embodiment of the actuator, whereby at each side of the flat coil a movable magnetic armature is arranged between the flat coil and corresponding power sources,
Figure 7	shows schematic in a cross-section a sixth embodiment of the actuator, whereby the movable magnetic armature is divided into several parts, whereby the parts are separated by isolating material,
Figure 8	shows schematic in a cross-section a seventh embodiment of the actuator, whereby the movable magnetic armature comprises three switch contacts in contact with four stationary contacts and three permanent magnets are provided, whereby a normal current is flowing,
Figure 9	shows schematic in a cross-section the actuator according to fig. 8, whereby a fault current is flowing,
Figure 10	shows schematic in a cross-section the actuator according to fig. 8, whereby the movable magnetic armature is in a position between the first and the second position,
Figure 11	shows schematic in a cross-section the actuator according to fig. 8, whereby the movable magnetic armature is in the second position and the current flow is interrupted.

[0030] Elements with the same function and mode of operation are provided in the fig. 1 to 11 with the same references.

[0031] Fig. 1 shows schematic in a perspective view a first embodiment of the actuator 1 which is constructed according to the inventive functional principle. The actuator 1 is using a movable magnetic armature 4 positioned over a flat coil 2.

[0032] Fig. 2 shows schematic in a cross-section a second embodiment of the actuator 1, whereby the movable magnetic armature 4 is in its first position 5 being retarded by a power source 3. In this first position the actuator closes a current circuit to a load. The movable magnetic armature 4 is movably arranged between the power source 3 and the flat coil 2. The movable magnetic armature 4 in its first position 5 is arranged in a distance X to the flat coil 2. The fixed power source 3 is realised as a fixed permanent magnet 7. Arrows illustrate the force F_{s1} of the fixed power source 3, 7 and the force F_m of the magnetic field in the flat coil 2.

[0033] In fig. 3 a third embodiment of the actuator 1 is shown in a cross-section view schematically, whereby the movable magnetic armature 4 is in its first position 5 being retarded by a permanent magnet 7, so that a current circuit is closed. In the center of the flat coil 2 a further permanent magnet 13 is arranged. The movable magnetic armature 4 in its first position 5 is positioned in a distance X to the flat coil 2 and the further fixed permanent magnet 13. Arrows illustrate the force F_{s1} of the fixed permanent magnet 7, the force F_{s3} of the further fixed permanent magnet 13 and the force F_m of the magnetic field of the flat coil 2.

[0034] Fig. 4 shows schematic in a cross-section the actuator 1 according to fig. 3, whereby the movable magnetic armature 4 is in its second position 6 next to the flat coil 2, in which a current circuit is interrupted. The movable magnetic armature 4 is attracted by the forces F_m and F_{s3} of the magnetic field of the flat coil 2 and the further fixed permanent magnet 13. Arrows illustrate the forces F_{s1}, F_{s3} of the fixed permanent magnets 7, 13 and the force F_m of the magnetic field in the flat coil 2.

[0035] Fig. 5 shows schematic in a cross-section a fourth embodiment of the actuator 1, whereby the movable magnetic armature 4 is in its first position 5 being retarded by a power source 3 in form of a spiral spring 8, so that a current circuit is closed. The movable magnetic armature 4 is arranged in a distance X to the flat coil 2.

[0036] Fig. 6 shows schematic in a cross-section a fifth embodiment of the actuator 1 having two movable magnetic armatures 4, 10 in their respective first position 5, 11 on opposite sides of the flat coil 2. A further fixed permanent magnet 13 is arranged in the center of the flat coil 2. The fixed power sources 3, 9 are each realised as fixed permanent magnets 7. Arrows illustrate the forces F_{S1}, F_{S2} of the fixed power sources 3, 9 and the force F_m of the magnetic field of the flat coil 2.

[0037] Fig. 7 shows schematic in a cross-section a sixth embodiment of the actuator 1, the movable magnetic armature 4 is in its first position 5 arranged in a distance to the flat coil 2. The fixed power source 3 is realised as a fixed permanent magnet 7. The movable magnetic armature 4 is segmented in several parts. The parts are separated from each other by insulating material 12. Arrows illustrate the force F_{s1} of the fixed permanent magnet 7 and the force F_m of the magnetic field in the flat coil 2.

[0038] Fig. 8 shows schematic in a cross-section a seventh embodiment of the actuator 1, whereby the movable magnetic armature 4 comprises three switch contacts 14 contacting four stationary contacts 15. The actuator 1 comprises three power sources 3 in the form of permanent magnets 7. The movable magnetic armature 4 in its first position 5 is positioned in a distance to the flat coil 2 and the further fixed permanent magnet 13 in the center of the flat coil 2. The three fixed power sources 3 are used to fix the movable magnetic armature 4 in its first position 5. The switch contacts 14 at the movable magnetic armature 4 contact the stationary contacts 15 closing an electric circuit 16 including the flat coil 2. In this electric circuit 16 a normal current I_N is flowing. Therefore the force F_m of the magnetic field of the flat coil 2 is not large enough to overcome the force F_{s1} of the three fixed power sources 3, 7, so that the movable magnetic armature 4 stays in its first position 5.

[0039] Fig. 9 shows schematic in a cross-section the actuator 1 according to fig. 8, whereby the movable magnetic armature 4 is starting to move towards the flat coil 2 and the further fixed permanent magnet 13 in the center of the flat coil 2. The switch contacts 14 at the movable magnetic armature 4 and the stationary contacts 15 are still closed. In contrast to fig. 8 in this electric circuit 16 a fault current I_F is flowing. The force F_m of the magnetic field of the flat coil 2 is now large enough to overcome the forces F_{s1} of the three fixed power sources 3, 7.

[0040] Fig. 10 shows schematic in a cross-section the actuator 1 according to fig. 8, whereby the movable magnetic armature 4 is positioned between the first and the second position. The movable magnetic armature 4 is moving towards the flat coil 2 and the further fixed permanent magnet 13 in the center of the flat coil 2. The switch contacts 14 at the movable magnetic armature 4 and the stationary contacts 15 are open now. Arc discharges 17 still keep the electric circuit 16 closed. In this electric circuit 16 a fault current I_F is flowing. The force F_m of the magnetic field of the flat coil 2 is large enough to overcome the forces F_{s1} (not shown) of the three fixed power sources 3, 7.

[0041] In fig. 11 is in a schematic view a cross-section of the actuator 1 according to fig. 8 shown, whereby the movable magnetic armature 4 is in the second position 6 and the current flow is interrupted. The movable magnetic armature 4 in its second position 6 at the flat coil 2 and fixed by the further fixed permanent magnet 13 mounted in the center of the flat coil 2. The switch contacts 14 at the movable magnetic armature 4 and stationary contacts 15 are opened, the electric circuit is not closed, so that no current $I_ø$ is flowing. The force F_{s3} of the further fixed permanent magnet 13 is large enough to overcome the forces F_{s1} of the three fixed power sources 3, 7.

Figure legend:

1	Actuator
2	Flat coil
3	fixed power source
4	movable magnetic armature
5	First position of movable magnetic armature
6	Second position of movable magnetic armature
7	Fixed permanent magnet
8	Fixed elastic element
9	Second fixed power source
10	Second movable magnetic armature
11	First position of second movable magnetic armature
12	isolating material between the segments
13 .	Further fixed permanent magnet
14	Switch contact
15	Stationary contact
16	Electric circuit
17	Arc discharge

(continued)

F_{s1}	Force of the first fixed power source
F_{s2}	Force of the second fixed power source
F_{s3}	Force of the further fixed permanent magnet
F_m	Magnetic force of the flat coil
I_N	Normal current
I_F	Fault current
$I_ø$	No current

Claims

1. Actuator (1) for use in a tripping device or a switch, comprising a flat coil (2), a fixed power source (3) and a movable magnetic armature (4), whereby the fixed power source (3) is constructed in such a way that the force (F_{s1}) exerted by the fixed power source (3) keeps the movable magnetic armature (4) in a first position (5) spaced apart from the flat coil (2), whereby the flat coil (2) is constructed in such a way that during current (IF) having at least a certain strength is flowing through the flat coil (2) the attractive magnetic force (F_M) exerted by the flat coil (2) is larger than the force (F_{s1}) of the fixed power source (3) to transfer the movable magnetic armature (4) from the first position (5) to a second position (6) at or near the flat coil (2), whereby the movable magnetic armature (4) is in the second position (6) closer to the flat coil (2) than in the first position (5).

2. Actuator (1) according to claim 1, wherein the fixed power source (3) is a fixed permanent magnet (7) to exert a permanent magnetic force (F_{s1}) to the movable magnetic armature (4) or the fixed power source (3) comprises an elastic element (8) to exert a spring force (F_{s1}) to the movable magnetic armature (4), whereby the movable magnetic armature (4) is arranged at the elastic element (8).

3. Actuator (1) according to at least one of the preceding claims 1 or 2, wherein the flat coil (2) and the fixed power source (3) being spaced apart from each other, said movable magnetic armature (4) is arranged between the flat coil (2) and the fixed power source (3).

4. Actuator (1) according to at least one of the preceding claims 1 to 3, wherein the fixed power source (3) and the movable magnetic armature (4) are being arranged at a first side of the flat coil (2) and a second fixed power source (9) and a second movable magnetic armature (10) are being arranged at the second opposite site of the flat coil (2), whereby the second fixed power source (9) is constructed in such a way that the force (F_{s2}) exerted by the second fixed power source (9) keeps the second movable magnetic armature (10) in a first position (11) spaced apart from the flat coil (2), whereby the flat coil (2) is constructed in such a way that during current (I_F) 1 having at least a certain strength is flowing through the flat coil (2) the attractive magnetic force (F_M) exerted by the flat coil (2) is larger than the force (F_{s2})of the second fixed power source (9) to transfer the second movable magnetic armature (10) from its first position (11) to a second position at or near the second side of the flat coil (2), whereby the second movable magnetic armature (10) is in its second position closer to the flat coil (2) than in its first position (11).

5. Actuator (1) according to at least one of the preceding claim 1 to 4, wherein the movable magnetic armature (4) and/or the second movable magnetic armature (10) have a low conductivity.

6. Actuator (1) according to at least one of the preceding claims 1 to 5, wherein the movable magnetic armature (4) and/or the second movable magnetic armature (10) are guided in linear guides during a movement between their first (5, 11) and their second positions (6) respectively.

7. Actuator (1) according to at least one of the preceding claims 1 to 6, wherein each movable magnetic armature (4) is divided into several parts, whereby the parts are separated by isolating material (12).

8. Actuator (1) according to at least one of the preceding claims 1 to 7, wherein each movable magnetic armature (4) exhibits a soft magnetic material.

9. Actuator (1) according to at least one of the preceding claims 1 to 8, wherein each movable magnetic armature (4) has a high magnetic permeability and/or a low mass density and/or a high saturation flux density.

10. Actuator (1) according to at least one of the preceding claims 1 to 9, wherein at least one further fixed permanent magnet (13) is provided in the center of the flat coil (2).

11. Actuator (1) according to at least one of the preceding claims 1 to 10, wherein each movable magnetic armature (4) comprises at least one switch contact (14) for contacting at least one stationary contact (15) of the tripping device or the switch in the first position (5) of each movable magnetic armature (4).

12. Actuator (1) according to at least one of the preceding claims 1 to 11, wherein two or more fixed power sources (3) are arranged at at least one side of the flat coil (2).

13. Actuator (1) according to at least one of the preceding claims 1 to 12, wherein the actuator (1) is an electromagnetic linear actuator.

14. Tripping device, wherein the tripping device comprises at least one actuator (1) according to at least one of the preceding claims 1 to 13.

15. Switch, wherein the switch comprises at least one actuator (1) according to at least one of the preceding claims 1 to 13.

Fig. 1

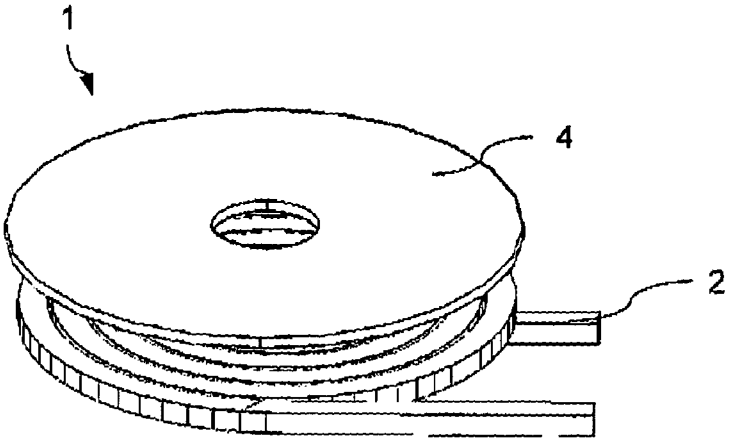

Fig. 2

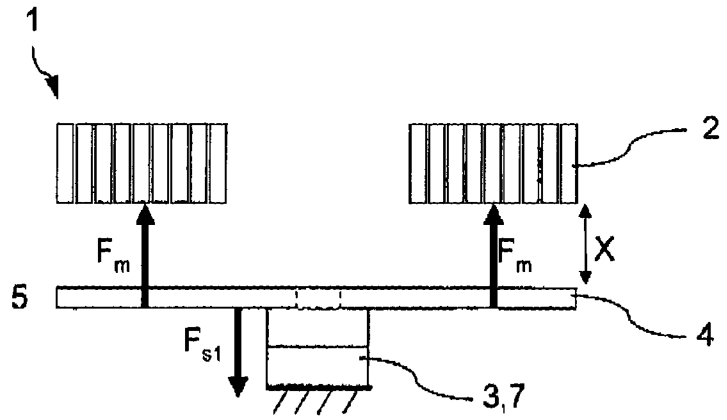

Fig. 3

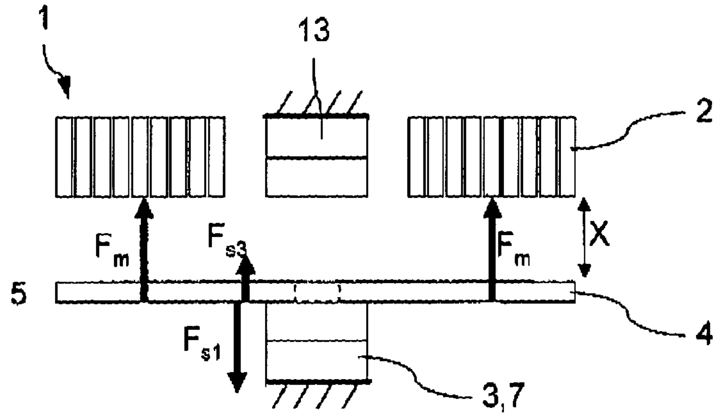

Fig. 4

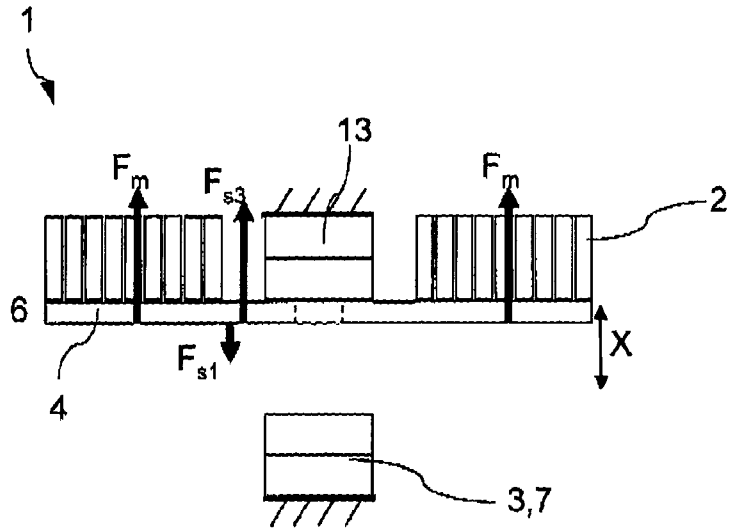

Fig. 5

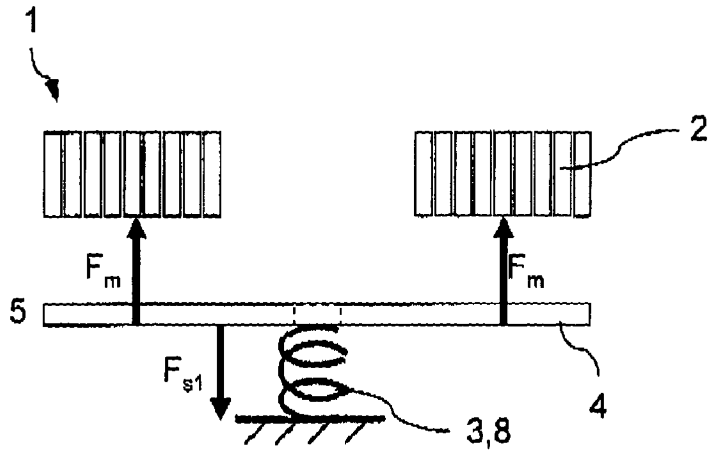

Fig. 6

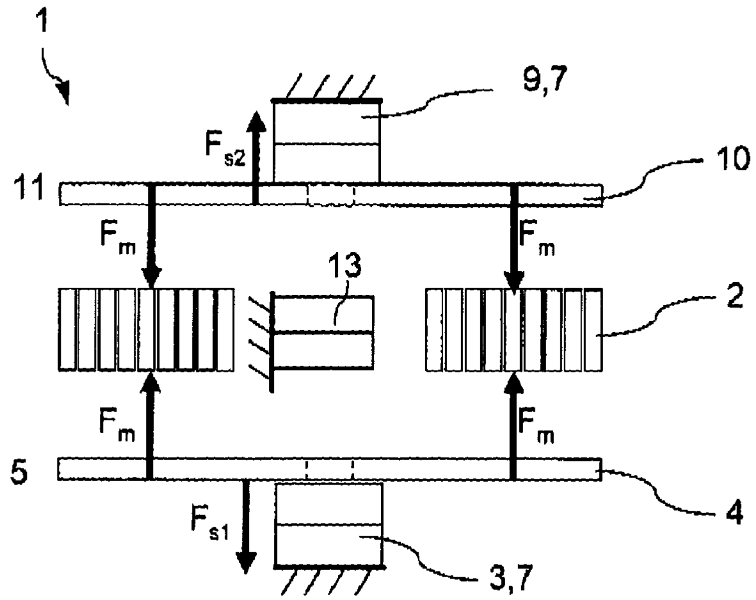

Fig. 7

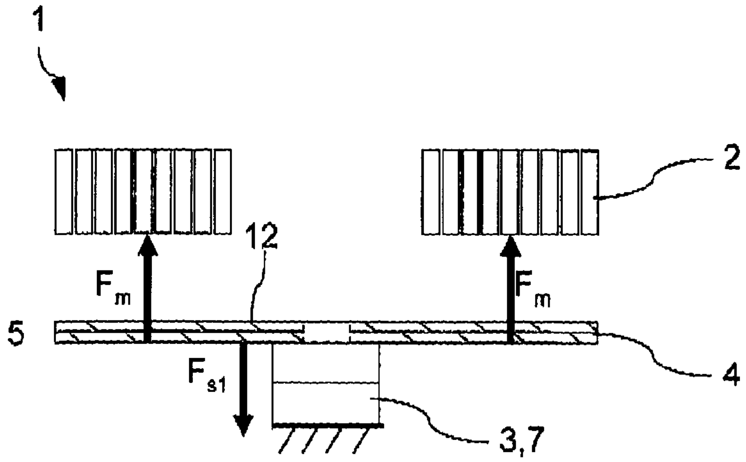

Fig. 8

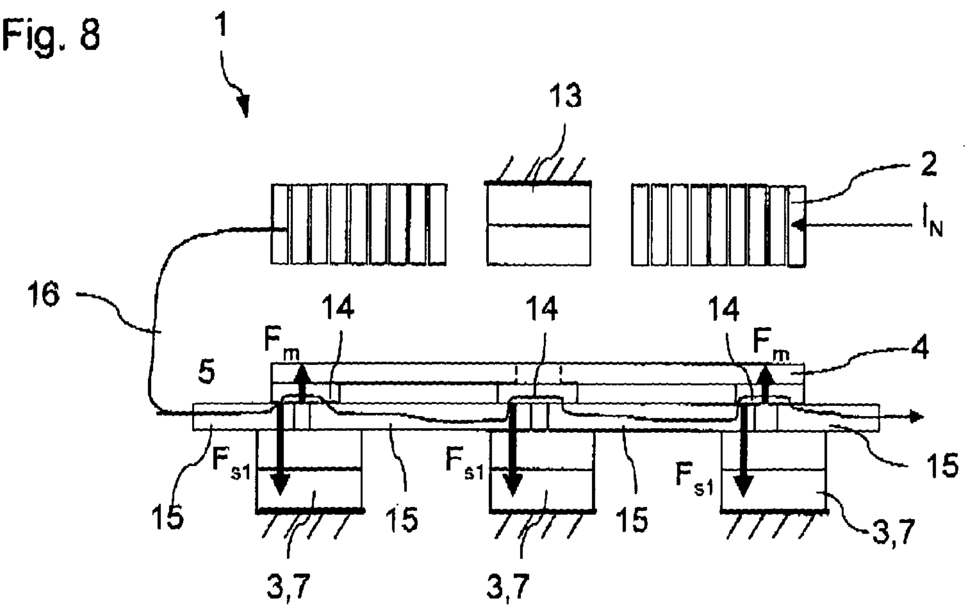
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Fig. 9

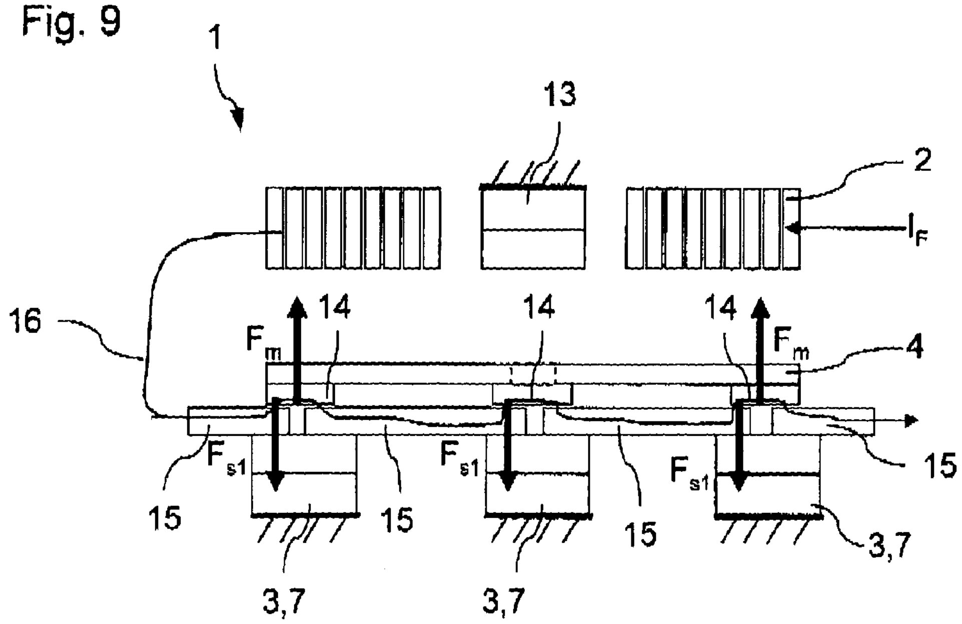
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Fig. 10

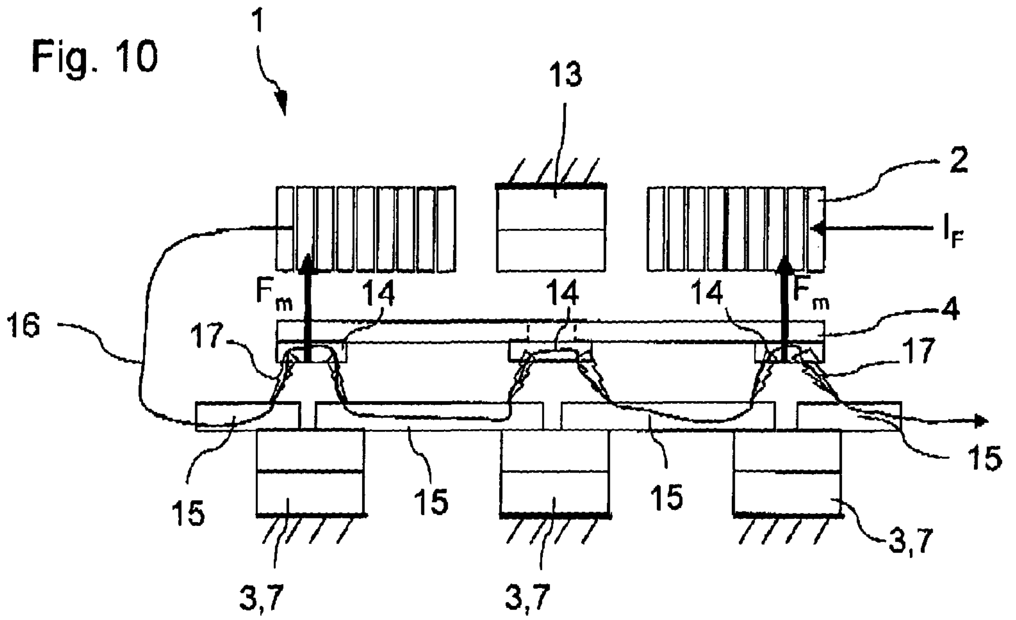
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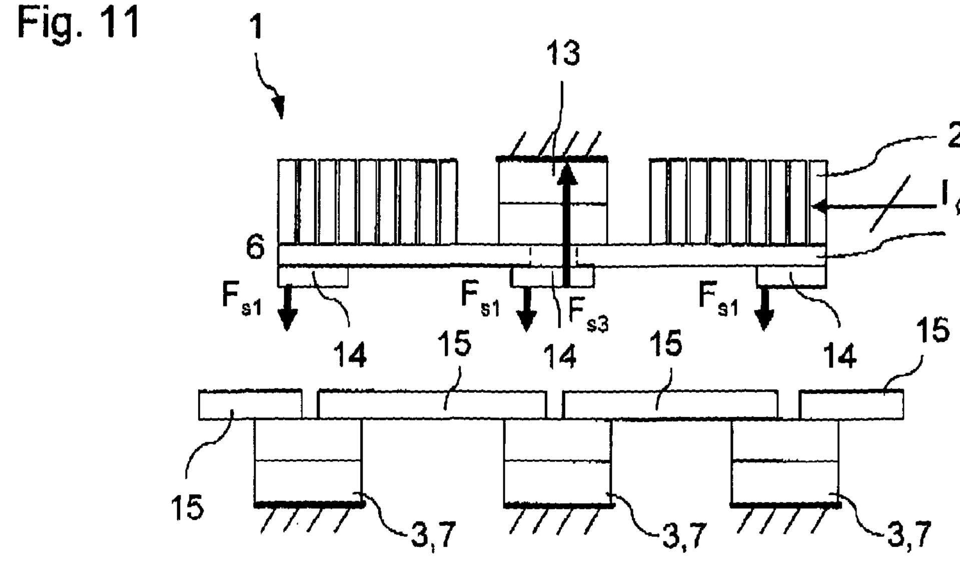
Fig. 11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EUROPEAN SEARCH REPORT

Application Number
EP 10 00 5318

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The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
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