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(54) **ELECTROMAGNETIC RELAY FOR THREE SWITCHING POSITIONS**

(57) The invention related to an electromagnetic relay, especially for motor reverse relays applications having a single magnetic system to achieve three switching positions, the magnetic system comprising two armatures, at least one magnet, one core/pole and a mechanical system consisting of two spring arrangements comprising each one central spring and two terminal springs characterized in that the relay has a non-conductive card used to bridge together the two central springs, and having the function to couple the two central spring motion and the two armature motion

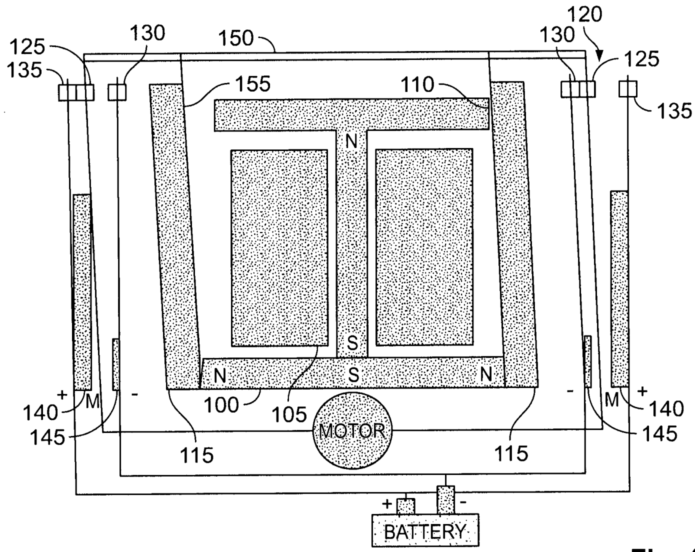

Fig. 4

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Description

[0001] The present invention relates to an electromagnetic relay for motor reverse applications which has one coil to control two armatures for switching two spring arrangements coupled by a slider in to three switching positions, i.e. a center position defined as neutral or resting position corresponding to a motor brake or motor blocked situation, a right position defined as the coil being energized in a certain polarity corresponding to the application motor rotating clockwise, and a left slider position for an inversely polarized coil corresponding to the motor application rotating counter clockwise.
Most of the currently available automotive relay designs for motor reverse involve a double relay solution in one housing with a standard armature rotation around a frame hinge, contact motion is circular and directly coupled to the armature through an electrical conducting metal spring element.
However, for motor reverse applications, translational systems, obtained through coupling together two armatures, offer a significant advantage since all rotating parts are coupled to one single translational slider element removing the need to use an individual coil winding per armature in two different locations, allowing to further miniaturizing the relay, using less parts and with reduced weight.
In a standard approach to control a motor with two changeovers relays, the positive polarity from the battery is connected to the Normally Open (NO) terminals of both switching systems and the negative polarity to the Normally Closed (NC) terminals; the changeover (CO) terminals of both systems are connected to the actual application (a motor). In the resting (neutral) position the CO terminals contact their corresponding NC terminals. Both relays are controlled by individual drivers, which transform a digital signal into a power signal that will activate the relay. When one of the relays is being activated, the motor will rotate in a certain direction. By reversing the polarity of the motor, its angular motion can be reversed. The event in which both relays are activated at the same time has no practical function (both motor terminals connected to the positive potential). Thus, for motor reverse applications theoretically only three states are necessary, whereas four states are available. If the system can be reduced down to the only required three states, it can be controlled by one magnetic system only. Additionally the total number of required components may be reduced, and consequently the size of the system and assembly costs decreased as requested by the increased complexity of transportation solutions.

[0002] One approach to achieve together a smaller system and three states relay is shown in the US5382934. The system, which is disclosed in this case, has one relay with two magnetic systems, which share a frame, an armature, and NO terminal. The relay has two coils each having a winding and a core, which can be driven separately. The two coils are displaced on a base body. The relay has a common negative terminal, a single yoke and a single armature.
This system, due to the use of two coils and a spring arrangement being placed in the center, still requires more volume (two coil windings) enclosing the armature, and an increased assembly complexity when achieving smaller form factors since the armature and spring are placed in-between motors.

[0003] Other approaches are known to miniaturize relays for motor reverse applications. One consists of two individual relays mounted in the same base and cover. Miniaturization was achieved through reduction of each independent relay.

[0004] The JPH06283088A discloses a small sized three states relay. Two electrical contacts, decoupled from each other, can be opened and closed with a single coil and two magnetic armatures. The two magnetic armatures anchored with the contacts are freely rotatable around supporting points and will move only in inwards direction from the resting position to the pole when the coil is energized. Only one armature is supposed to move to the pole when the coil is energized the other armature will stay in place. The disadvantage of this approach is the lack of an easy electrical decoupling solution between the two changeover systems that may require more volume, the difficulty in maintaining contact force on the armature, which is supposed to stay in place when the coil is energized since both armatures are attracted inwards although at different intensities.
These approaches hinder the possibility of miniaturization, requiring large volume, several parts and costs.

[0005] Is therefore an object of the invention to provide a relay for motor reverse applications having further decreased dimensions and compact dense construction. The relay can be built at low cost.

[0006] This object is solved by the subject matter of the independent claims. Advantageous embodiments of the present invention are subject matter of the dependent claims.

[0007] The object is achieved by an electromagnetic relay according to claim 1.

[0008] This electromagnetic relay has only three possible configurations instead of four, with a stable central neutral position and two additional positions controlled by one magnetic coil.

[0009] Such relay can be used for motor reverse relays applications, where the main advantage is to have a smaller printable circuit board profile size, reduced weigh, less connections and lower cost.

[0010] According to the present invention least one magnet of the magnetic system is a three poles system. The magnetic system of the relay is one coil winding around a core with a magnet on the base having three poles centered between two armatures. The advantage of using a single three poles magnet is the manufacturing simplicity since we use one bigger magnet instead of two small ones or two winded coils, coil bodies and cores. An additional advantage is that such system can be produced at low cost. Another advantage is that this approach will function with a relatively weak magnet.

[0011] According to another embodiment of the present invention, the magnetic system comprises two inversely polarized magnets having the core in the middle. The core is centered relatively to the magnet. This assures a symmetric polarization.

[0012] According to a further development the magnets have a North South North or South North South polarization; in this case the magnetic polarization intensity is not symmetric. Alternatively it is possible to have two magnets enclosing the core; in this case we have two possibilities, both working with inversely polarized magnets, a North South with South North combination which is the same as the single three poles magnet or a North South with North South configuration (or vice versa). This approach combined with the coupled mechanical system makes possible to use stronger magnets to reduce coil windings meanwhile maintaining contact forces and resilience to mechanical vibration something not possible in standard approaches like latching relays or other mono-stable non mechanically coupled systems.

[0013] The electromagnetic relay described in this invention has one motor only instead of two. It needs only one signal source (driver), uses fewer parts (no second coil winding), has less complex shaped parts for the performance required by the application and can be reduced in size and weight compared to today's state of the art.

[0014] The coil body and winding pay a relevant role in the final relay cost, due to copper consumption and size. As we need to place the windings offset from each other, the single location coil-winding relay covered by this invention can be built at a very low cost and size.

[0015] According to another embodiment of the present invention, the iron core can have a circular or rectangular section. Having a circular section provides better magnetic flux efficiency but may be harder to create T-Shape geometry (core/pole) in a single part. The rectangular shape main advantage is that it makes possible to stamp a relatively square profile in a single part. The core can have a T shape formed by joining two parts or by one single part. The bottom faces of the core are connected to a magnet if a three-pole magnet is used or if not, each magnet is placed adjacent to a center iron part. The coil can be single or double but winded in the same coil body; this will be dependent on the application.

[0016] Preferable, the motor is placed centered within two armatures on each side. The magnetic system purpose is to generate an attractive force on the rotating armature located in front of the pole. The magnetic force is obtained by the resultant of a magnetic field generated by a magnet and the energizing of a coil. The magnets purpose is to create a force imbalance on the two armatures defining in which direction the coupled system will move (left or right). Position and polarization of the magnets affect the behavior of the magnetic system. The magnets have to be placed in a way to affect the two branches of the magnetic system, i.e. either centered in regards to the core, but in this case a three pole magnet would be more favorable, or positioned anywhere on the magnetic flux path in one of the two branches. The three pole magnet is asymmetric in polarization and is placed centered to the core, generating different flux intensities in each flux path which in turn generates a flux differential when pulling the armatures to the center pole (one branch will have stronger pull forces). The flux differential associated to the energizing of the coil in normal or reversed polarity generates in each case a stronger magnetic pull on one of the sides; the use of a three-pole magnet reduces the number of components and respective cost of the final product. The use of two core enclosing magnets with reverse magnetization (North - South with North - South i.e.) provides the same function but with the advantage that stronger magnets can be used, which can help reducing the number of coil windings but adds part count.

[0017] The two armatures can only rotate towards the central pole due to magnetic influence. However since both armatures are coupled by the card and as the magnetic field attraction is higher with approximation to the pole for each activation they will rotate in respect to a rotation hinge at a certain angle in clockwise or counter clockwise direction so to reach the rotate right or rotate left states. Consequently, one armature will move towards the pole and the other will move away from it. The armatures rotate around the base or, a magnet edge or an iron edge.

[0018] The armatures can vary in dimensions, i.e. height and width and thickness.

[0019] According to a further development, the armatures are coupled to the non-conductive card each by a metal connection. Coupling will ensure having a stable system. The card, in particular the non-conductive card, will move left or right, giving rise to a hybrid rotational/translational motion system. The advantage of using a metal is that it is easier to process.

[0020] The connections may have different shapes, including for example L shape, or U shape. The L shaped connection between armature and card reduce the degrees of freedom of motion between parts. The U shape connection between two armatures and the card reduce degrees of freedom and number of parts used. Both U and L shape parts can be over molded into the card.

[0021] In an alternative embodiment, the armatures are in direct contact with the non-conductive card, which will improve the manufacturing process and reduce system complexity further. The function of the card is to connect mechanically the two springs and magnetic systems on both sides of the coil body. However the two systems have to be electrically isolated for the relay to function and prevent short-circuit. The armatures can be shaped in such way to be thinner at the top and at the bottom faces, and around at the rotation hinge.

[0022] According to a further embodiment, the non-conductive card can be rigid or flexible. The advantage of being flexible is that this helps to reduce the overall stiffness of the armature card connection especially when using an L shape metal connection. The advantage of being rigid is that it is easier to produce in the case of direct contact between armature and card.

[0023] According to a further development the central spring of each spring arrangement is in contact with one terminal spring on one side in a normally closed configuration and is simultaneously not in contact with the other terminal spring on the other side in a normally open configuration. The central spring of each spring arrangement is a spring which can contact two terminals, called change-over (CO) spring. When the relay is in a resting position, the CO spring of each springs arrangement is in contact with one terminal spring on one side in a normally closed (NC) configuration or NC terminal and is simultaneously not in contact with the other terminal spring on the other side in a normally open (NO) configuration or NO terminal, all terminals have a contact element attached to it. When one contact is closed the other side stays in contact and is in fact pressured further against increasing contact force. The CO spring in resting position is touching the NC terminals.

[0024] To further reduce the amount of parts, the four required NO and NC terminal springs can be reduced to one single copper strip part which is afterwards overmolded in plastic and bended in position afterwards.

[0025] According to a further development, the two central springs are connected to the non-conductive card.

[0026] The non-conductive card or slider or translational card bridging the two central springs has the function to couple together the motion of the CO springs and the motion of the armatures. The card is placed above the base part and the motor in between the CO springs.

[0027] When the card moves to the left it will bend each CO spring towards the motion direction and when it moves to the right the same will happen. The advantage of this approach is that it stabilizes the mechanical system towards the center position or resting position since when the CO springs bend towards the direction of the cards motion they will tend to move if released to their resting position. The motion is communicated to the card by means of the armatures.

[0028] According to a further development, the spring arrangements makes simultaneous movement in the left or right direction coupled to the armatures movement. Both armatures rotate simultaneously in the same direction but one armature will have a strong magnetic pull towards the pole face. The motion direction of the card is given by the armature which has the strongest magnetic attraction force. The advantage of this approach is to obtain three stable states out of one magnetic coil system.

[0029] When the system is energized, it gets out of the stable position due to the combination of the magnet effect on each branch of the magnetic circuit and the coil generated flux, this will generate different pull forces on each armature and thus the stronger one will be defined mostly by the coil polarization. This will generate a movement of the two coupled armatures simultaneously and progressively strengthening one side with proximity to the pole and weakening the other side with the added distance to the pole. When the armatures move, the conductive card moves in a translational movement a certain contact distance until coming in contact with the NO terminal springs, there after it will translate further as to over-travel, over-travel function is to prevent the armature from opening due to shock and vibration. The armatures will move either both to the left direction or both to the right direction according to the polarity of the armatures causing the movement of the translational card to the left or to the right.

[0030] In a further development, each spring arrangement includes one or more stopper element to keep the contact spring in a pre-tensioned rest position. The stopper elements or base stoppers can be of three different types. The first stopper element is located near the two NO spring terminals and the second stopper is located near the NC spring terminal. Both stoppers have the function to prevent the spring terminals from moving inwards towards the CO spring. The base stoppers are made from plastic or metal. Stoppers can either be a protrusion from the base part or independent elements built from other parts. The advantage of using plastic has to do with the easy processability, i.e. when the stopper is a protrusion of the base part, it is made out of a unitary injected part, without involvement of additional assembly process steps. Metal stoppers have increased strengths resistance.

[0031] The advantage of using independent parts is that not only the base but also the cover can be used as stoppers as well. The third type of base stopper in located near the two CO springs. This type of stopper has the effect of pre-tensioning the spring in one direction. This type of stopper is a protrusion from the base part that bends outwards gaining a pretension when the CO spring is stitched in the base part.

[0032] Over-travel is defined by the displacement of the NO contact after the CO contact reaches it. Is the additional travel done from the CO spring to bring the NO contact out of the centered position.

[0033] The two NC terminals can be set to be pre-tensioned against the CO spring to ensure vibration resistance. Pre-tension of CO contact to NC contact is obtained by their positioning and overall difference of stiffness between both CO springs versus both NC terminals. Terminals and spring have cuts on their surface in the bending area to help increase or decrease spring stiffness for adjusting relay performance and to improve fatigue resistance. Terminals can be flexible or stiff. In an alternative embodiment, pretension can also be reached with an S form element formed by a bending in the terminal itself.

[0034] In the present invention, preferably the left and right normally open terminals are connected together with a single output terminal and are stamped from a single metal strip and/or the left and right normally closed terminals are connected together with a different single output terminal, stamped from a single metal strip. This configuration allows having overtravel in a three state relay.

[0035] According to a further embodiment of the present invention all terminal springs, normally open and normally closed can be produced in and from one single copper strip. Working with a single copper strip, allows reducing the complexity of the process by producing four flexible terminals with a single stamping tool out of a single strip. With the approach used in the present invention, in a first step, a spring profile is stamped. Then the base is over-molded into the metal strip profile. As soon as the base is over-molded into the metal strip, the terminals are then folded of 90 degrees. All the parts are formed from a single stamping press. Therefore, no gluing process is needed to fix the terminals into the base. In a last step, two metal springs are pressed against the base and glued to it.

Differently, standard available processes employ two stamping tools producing each two terminals which are then glued on a plastic base. Additionally two springs have to be produced with a stamping tool.

[0036] The electromagnetic relay described in this invention shows significant reduction of size, i.e. up to 30% smaller than the smallest TE automotive relay, due to the fact that the volume occupied by one of two windings is omitted reducing the overall size and PCB surface area. Since one coil winding only is being used, frame size, core, coil body and copper windings usage are reduced allowing reducing weight, part count and cost.

BRIEF DESCRIPTION OF THE FIGURES

[0037] Further features and advantages will become apparent from the following and more detailed description of the invention as illustrated in the accompanying drawings, in which:

Fig. 1 Shows a first embodiment of the single three state relay with a three pole single magnet in a resting/neutral position

Fig. 2 Shows a second embodiment of the three state relay with two magnets aligned in a resting position

Fig. 3 Shows a third embodiment of the three state relay with two magnets reversely polarised in a resting position

Fig. 4 Is a view of the three state relay with energized coil with the card positioned to the right

Fig. 5 Is a view of the three state relay with energized coil with the card positioned to the left

Fig. 6 Is the graph representing the force vs distance curves

Fig. 7 Is a detailed view of the spring arrangement (NO, CO, NC) from a single metal strip with two output terminal, and four internal spring terminals

Fig. 8 Zoom view of the CO spring with a base protruding plastic element

DETAILED DESCRIPTION OF THE INVENTION

[0038] The present invention will now be more fully described hereinafter with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown. The present invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein.

[0039] Referring to Fig. 1, a schematic view of the electromagnetic relay according to the present invention is shown. The relay 1 comprises a magnetic system consisting of a three pole single magnet 100 located at the base of the system. The core 110 is located in the middle, between the two armatures 115. The single coil 105 is winded around the coil body. The iron core in Fig.1 has a T-shape.

[0040] To activate the motor 160, the coil has to be energized, generating an asymmetric magnetic field that attracts mainly one of the armatures to the pole.

[0041] In Fig. 2 and 3, the relay is shown in the alternative configuration with two magnets 165 or 175 which are located at the base of the system and can be inversely polarized, North South with South North (165) or not, North South with North South (175). The core is located in the center in respect to the two magnets.

[0042] Both the alternative with the single three pole magnet of Fig. 1 and the alternative with the two magnets positioned on the two magnetic flux paths of Figs. 2 and 3 will have similar effects in terms of attractive force generated on the rotating armatures 115 with the exception that the single three pole magnet requires flux asymmetry between sides.

[0043] The armatures will rotate around a fixed axis, giving rise to a hybrid rotational/translational motion of the card 150 towards the right side as can be seen in Fig. 4 or the left side, as in Fig. 5. The armatures are connected to the card 150 by mean of connections 155, which can be metallic connections, plastic connections, flexible or rigid. The connections can be built with different shapes.

[0044] The card is then further connected to the spring arrangements 120. The central spring or CO spring 125 of the arrangement is in contact with the card. The central spring is located within the two terminal springs 130 and 135. Fig. 1 shows the relay in the resting position. When the relay is in a resting position, the CO spring is in contact with the terminal spring 130, to establish a NC configuration or connection, while the other terminal 135 is in a NO configuration.

[0045] Next to the terminal springs also the additional elements 140 and 145 are shown. The elements 140 and 145 are stopper elements, or base stoppers, which help to prevent terminals from bouncing back at the CO spring. Element 140 and 145 act as a stopper preventing terminal springs from moving towards the CO spring. A further detail of a stopper element is shown in Fig 8. The element 147 is a plastic element located at the base of the CO spring that increases global spring stiffness, therefore helping maintaining the CO in a central position. The element 147 is protruding from the base and acts as support when the CO spring is in a pre-tensioned state. The dimension and shape of the element 147 can be modified in dependence of the desired overall system stiffness.

[0046] The situation in which the card moves to the right is illustrated in Fig. 4. When the coil is energized, a magnetic field is generated adding up to the magnetic field generated by the magnets in the magnetic loop. Coil operation polarity affects the flux direction added to the magnet generated flux, when using a three pole approach the magnet polarization intensity has to be different on each side of the flux path to generate an offset in force between the two armatures. Using a different approach with two magnets and aligned polarity (North to South aligned with North to South means asymmetric) we can use magnets with the same intensity polarization. In both cases the objective is to generate a differential in attraction force from the magnet resulting in the armature 115 on the left side to be attracted to the pole. As the armature is connected to the card 150 this causes a shift of the card in the right direction which further pushes the CO spring 125 on the right side up to the point of getting in contact with the NO right terminal 135. The armature is also moved away from the pole on this side to reduce even further attraction on this branch of the magnetic circuit. The plastic stopper 140 at this point ensures that the NO terminal spring 135 will at the end come back to the original relaxing position. On the right side, the armature will have a weaker magnetic force since the corresponding flux is less intense. Thus in the spring arrangement on left side, the CO spring will push furthermore the NC terminal 130 increasing the distance from the NO terminal 135. This situation translates in a movement of the slider 150 to the right direction towards the right side NO terminal. When the two contacts on the right side, i.e. CO and NO, get in touch, the over-travel zone situation is reached, meaning that the armature on the left still has a certain travel until a full contact to the core/pole part is established. The stiffness of the over-travel zone is generated by the NO spring terminal design; the travel will end by contact to a fixed plastic stopper.

[0047] When the coil is reversely energized the card will lean to the left side as shown in Fig. 5, corresponding to reversing the rotation of the motor. To move the card sideways, left or right, the magnetic system has to be stronger then the two coupled mechanical contact arrangements.

[0048] Fig. 4 shows the three pole magnet configuration and the related generated magnetic flux path. In that case the magnetic flux generated by the coil polarization is stronger on the left side and as result the force will be stronger in the path aligned with the generated flux. The armatures on the opposite side will have a weaker magnetic force since the corresponding flux is less intense due to the increased distance, thus moving the card sideways, opening more on one side the magnetic circuit and closing it on the other. Both armatures will have a residual attraction to the pole, but as they are connected together by the card the system will remain stable due to the stiffness of the mechanical spring elements. The magnetic flux behavior has been also verified by magnetic simulation.

[0049] Fig 6 is the graph representing the force vs distance curves. The initial distance between the armatures and the core, corresponds to a neutral position. When the distance between the right armature and the core decreases, the distance between the left armature and the core increases. To a decrease of distance between armature and core on the right side corresponds an increase of the magnetic force acting on the right armature. At the meantime, when the magnetic force on the right side will reach the highest values, on the left side there will be a residual magnetization.

[0050] Fig. 7 shows two NO terminal springs (135), two NC terminals springs (130) and two CO terminal springs (125). The two NO and NC terminal springs are formed by a single copper alloy sheet. The shape is stamped, and afterwards over molded in plastic to make the base part in an un-bended state. Afterwards the contacts are soldered to the terminals and finally the terminals are bended towards their final shape. The main advantages of this approach are that we don't have to assembly several individual parts independently, the copper alloy strip is optimized since we don't need to cut off material to extract four spring terminals out of the sheet and handle them and it is possible to obtain a single solid part instead of having four very small loose parts. The two NO terminals are connected together and the two NC terminals are also connected together. The advantage of this is that we use only one output connection for each pair (NO and NC).

[0051] To test the functionality of the mechanical and magnetic system, a prototype was built.

[0052] Coil energizing was performed with a standard voltage drop of 12V. After proving the functionality of the concept in general, the design work was initiated to fit everything into a smaller, marketable size. The resulting design is about 30% smaller then smallest motor reverse relay available in the market and has considerably less components as it is using one magnetic system only instead of two.

Reference Signs

[0053]

1	electromagnetic relay
100	three pole magnet
105	coil
110	core/pole
115	armatures
120	springs arrangements
125	central springs
130	NC terminal springs
135	NO terminal spring
140	stopper element for NO
145	stopper element for NC
147	Pretension CO base element
150	card
155	connections between the card and the armatures
160	motor
165	two single magnets with N-S with S-N orientation
165	two single magnets with N-S with N-S orientation

Claims

1. An electromagnetic relay, especially for motor reverse relays applications having a single magnetic system to achieve three switching positions, the magnetic system comprising two armatures, at least one magnet, one core/pole
and a mechanical system consisting of two spring arrangements comprising each one central spring and two terminal springs **characterized in that** the relay has a non-conductive card used to bridge together the two central springs, and having the function to couple the two central spring motion and the two armature motion

2. A relay according to claim 1 **characterized in that** the least one magnet of the **magnetic system** is a three poles system

3. A relay according to claim 1 or claim 2 **characterized in that** the **magnetic system** comprises two inversely polarized magnets having the core in the middle

4. A relay according to claim 3 **characterized in that** the magnets will have a North South with South North configuration or North South with North South configuration

5. A relay according to claims 1 to 4 **characterized in that** the core of the **magnetic system** can have a circular or rectangular section

6. A relay according to claim 1 to 5 **characterized in that** the **armatures** rotate in respect to a rotation hinge at a certain angle in clockwise or counter clockwise direction

7. A relay according to claim 1 to 6 **characterized in that** the armatures are coupled to the non-conductive card each by a metal connection

8. A relay according to one of the claims from 1 to 7 **characterized in that** the armatures are in direct contact with the **non-conductive card**

9. A relay according to one of the claims 1 to 8 **characterized in that** the **non-conductive card** can be rigid or flexible

10. A relay according to claim 1 to 9 **characterized in that** the central spring of each **spring arrangement** is a spring which can contact two terminals

11. A relay according to claim 1 to 10 **characterized in that** when the relay is in a resting position, the central spring of each **spring arrangement** is in contact with one terminal spring on one side in a normally closed configuration and is simultaneously not in contact with the other terminal spring on the other side in a normally open configuration

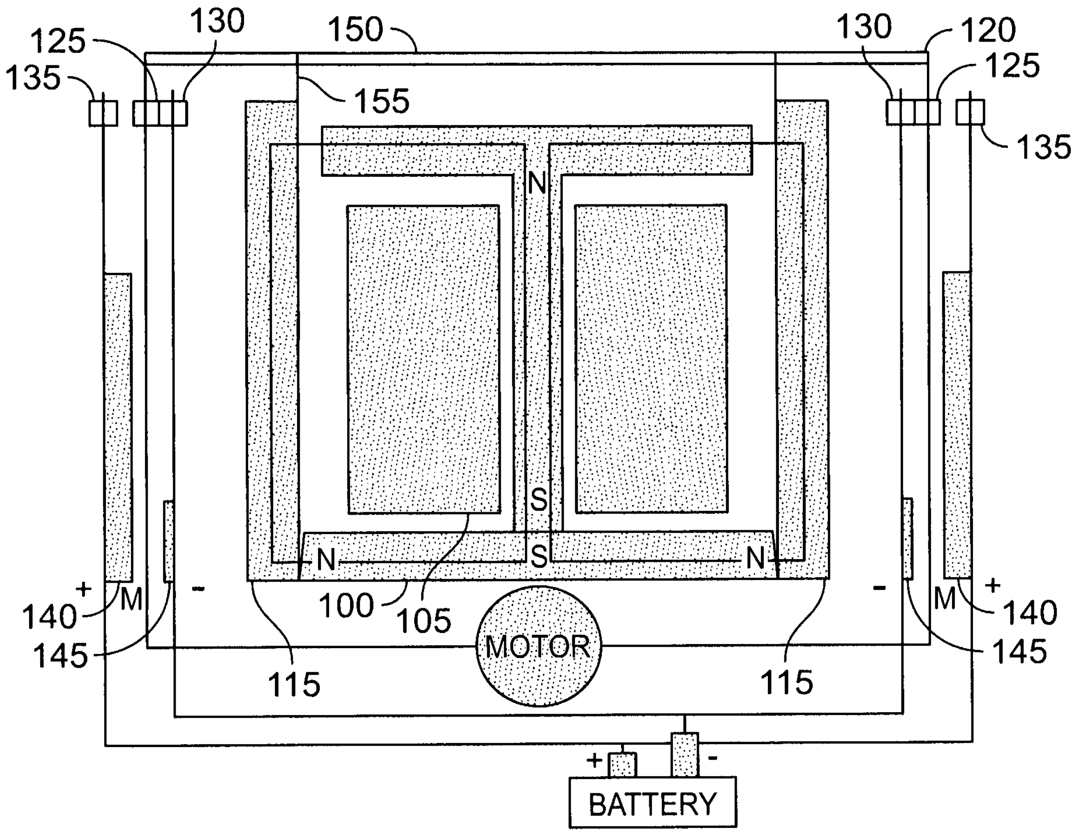
12. A relay according to according to claim 1 to 11 **characterized in that** the two central springs are connected to the non-conductive card

13. A relay according to claim 1 to 12 **characterized in that** the **springs arrangements** make simultaneous movement in the left or right direction coupled to the armatures movement

14. A relay according to claim 1 to 13 **characterized in that** each **springs arrangement** includes one stopper element to keep the contact spring in a pre-tensioned rest position

15. A relay according to claim 1 to 14 **characterized in that** the left and right normally open terminals are connected together with a single output terminal and are stamped from a single metal strip and/or **in that** the left and right normally closed terminals connected together with a different single output terminal, stamped from a single metal strip

16. A relay according to claim 1 to 15 **characterized in that** all terminal springs, normally open and normally closed can be produced from one single copper strip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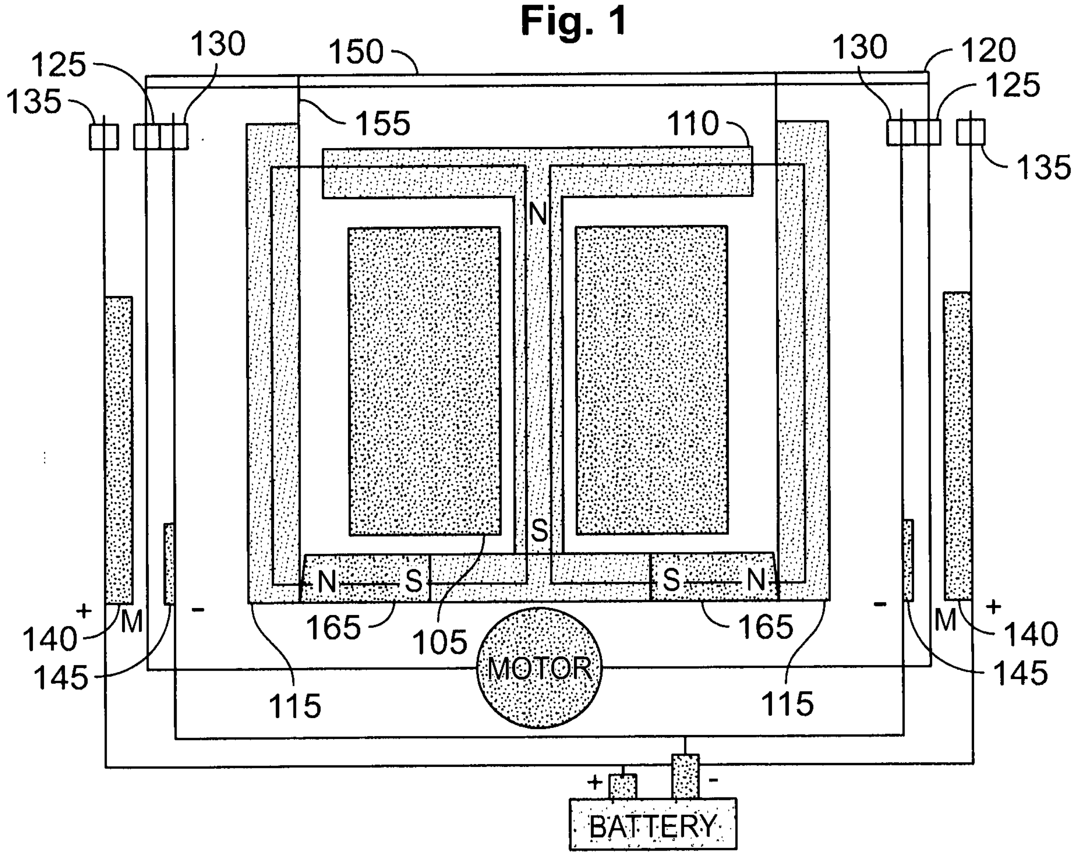
BATTERY

Fig. 1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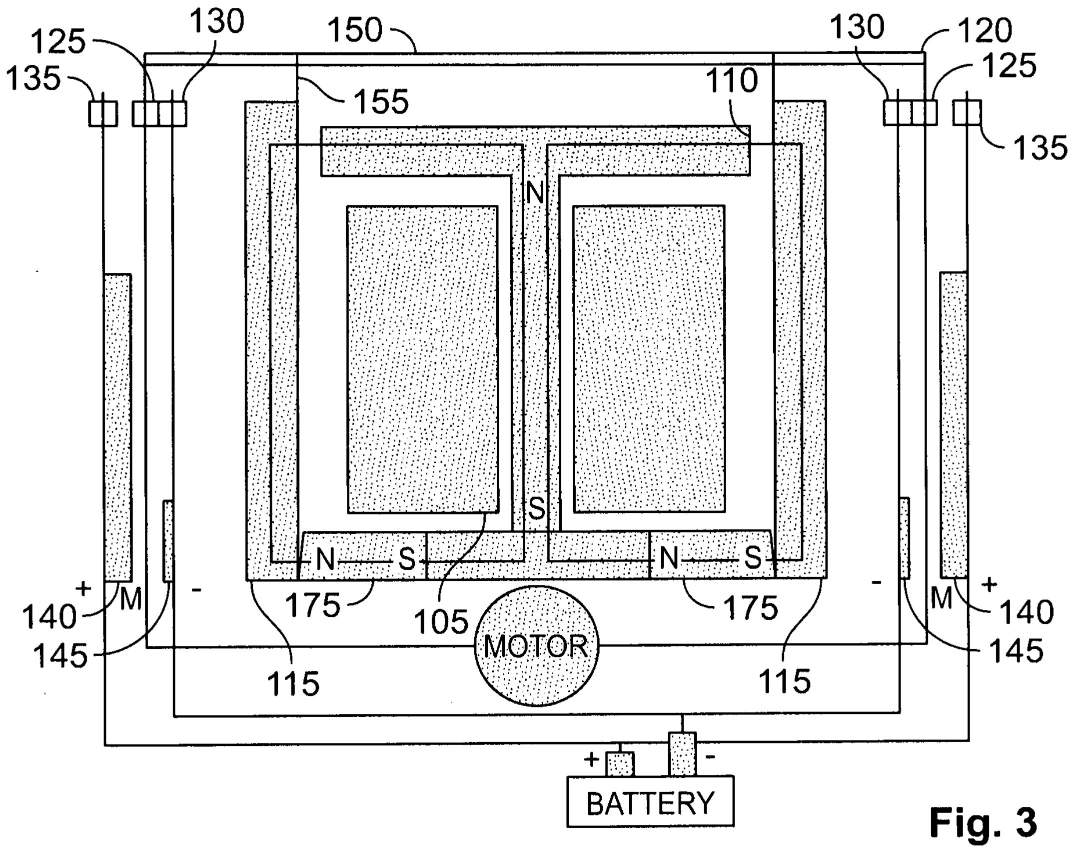
BATTERY

Fig. 2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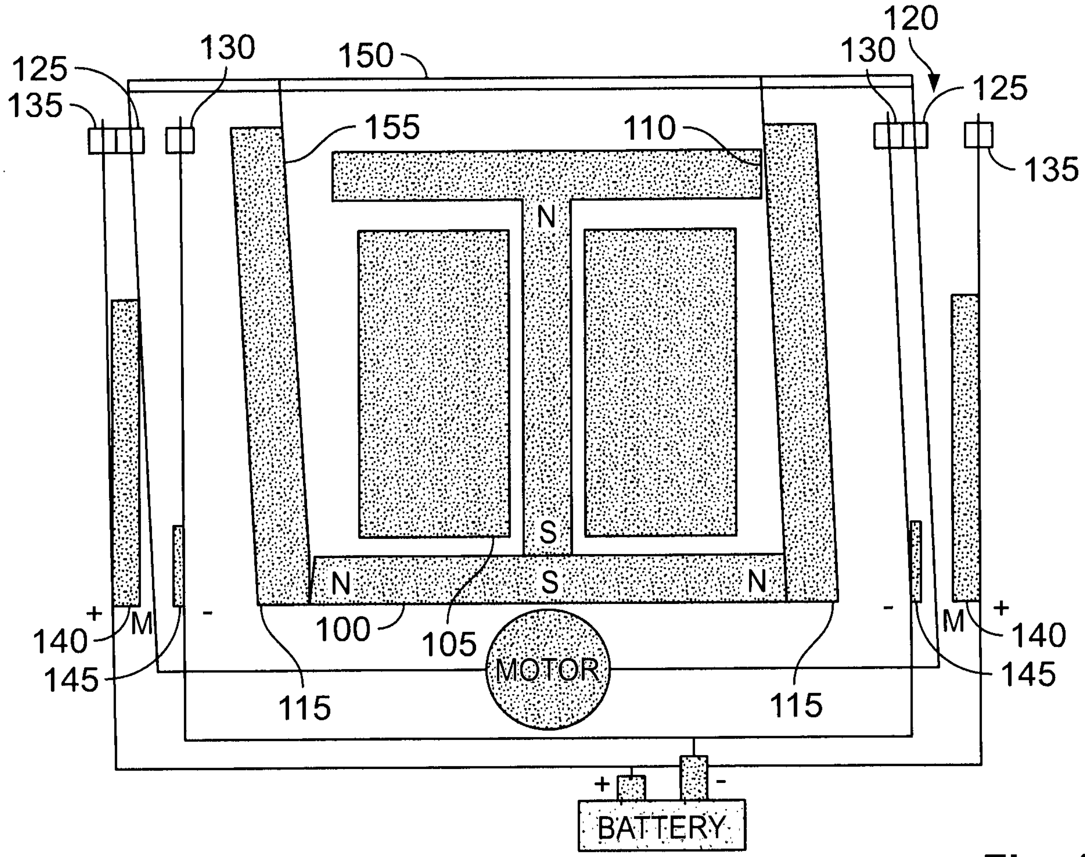
BATTERY

Fig. 3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125
130
150
130
125
135
155
110
135
N
S
N
S
N
+
140
M
-
100
105
-
M
+
140
145
MOTOR
145
115
115
+
-
BATTERY

Fig. 4

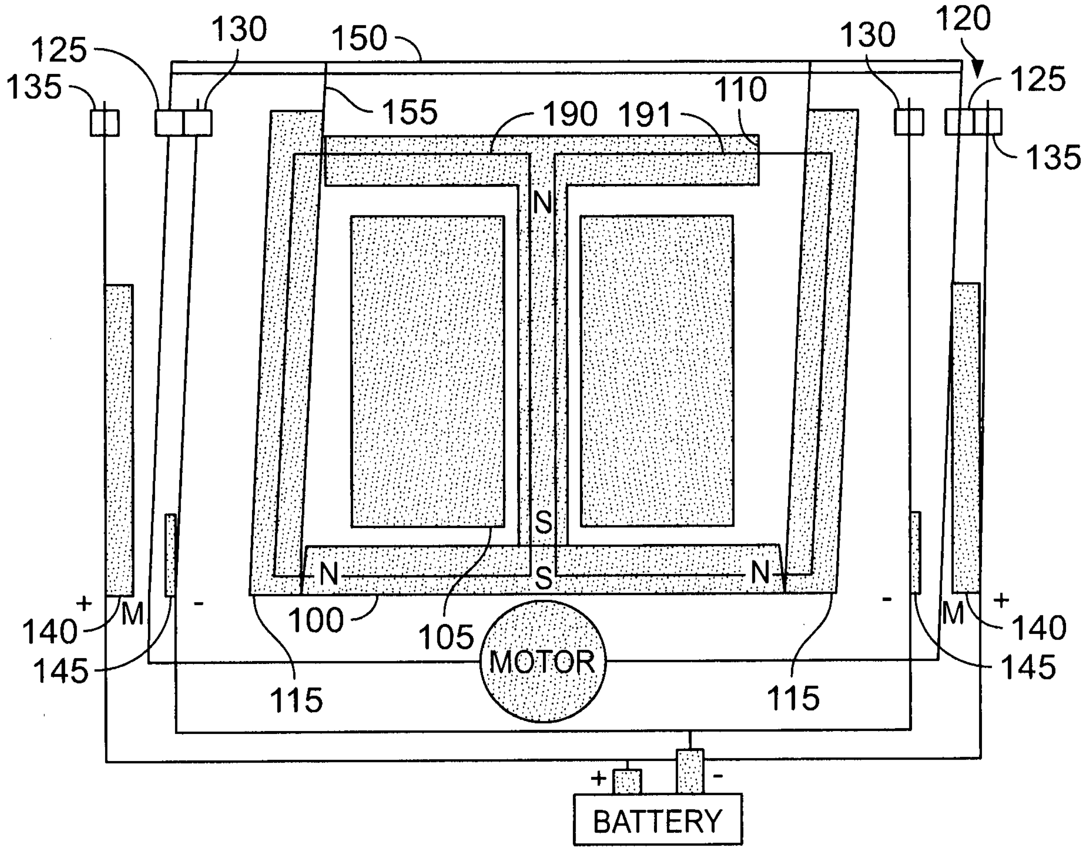
125
135
130
150
155
190
191
110
130
120
125
135
N
S
N
S
N
+
140
M
-
100
105
MOTOR
115
115
-
M
+
140
145
145
+
-
BATTERY

Fig. 5

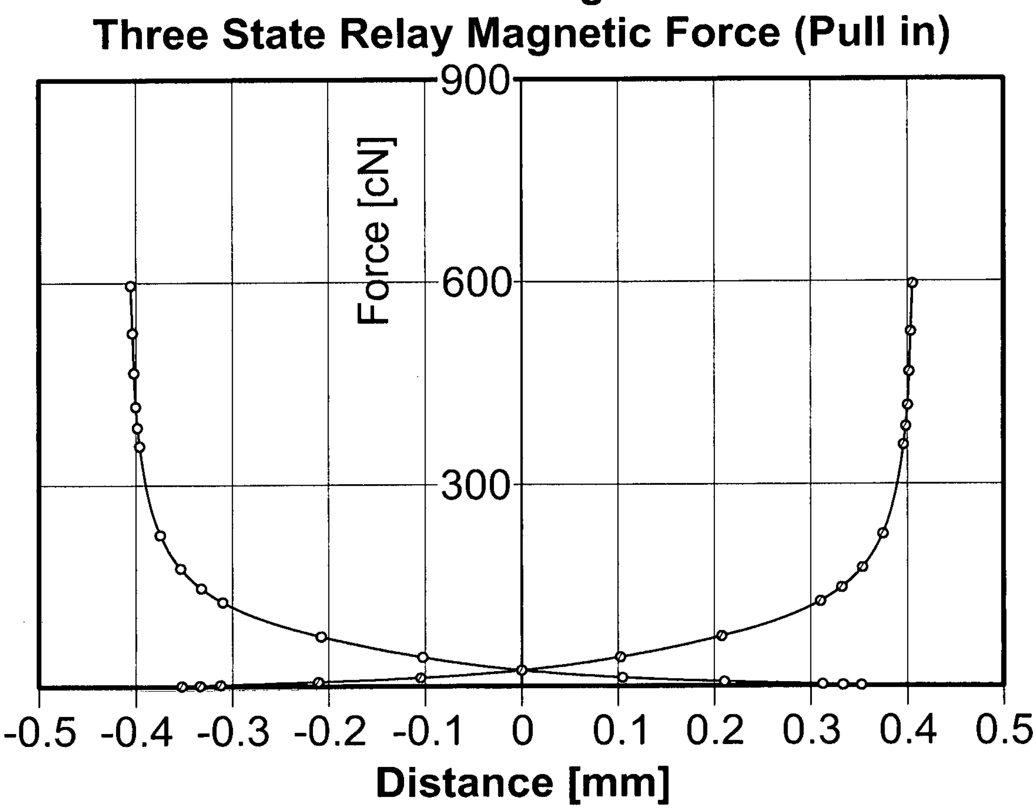
Three State Relay Magnetic Force (Pull in)
Force [cN]
900
600
300
-0.5
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
0.4
0.5
Distance [mm]

Fig. 6

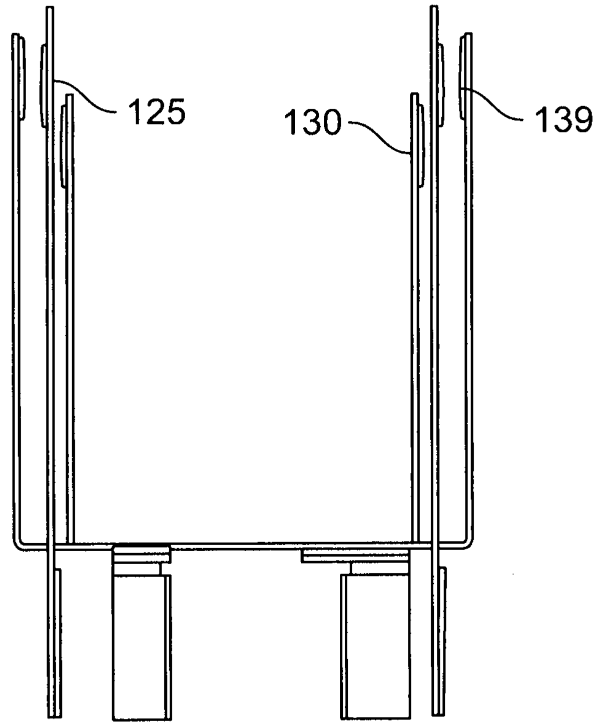

Fig. 7

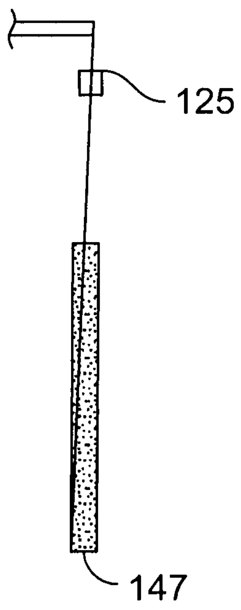

Fig. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 16 39 8001

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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	18 August 2016	Bilard, Stêphane

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