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

(11) EP 0 809 270 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
26.11.1997 Bulletin 1997/48

(51) Int. Cl.[6]: **H01H 71/16**

(21) Application number: **97108306.8**

(22) Date of filing: **22.05.1997**

(84) Designated Contracting States:
DE ES FR

(30) Priority: **22.05.1996 JP 126171/96**
09.10.1996 JP 268208/96

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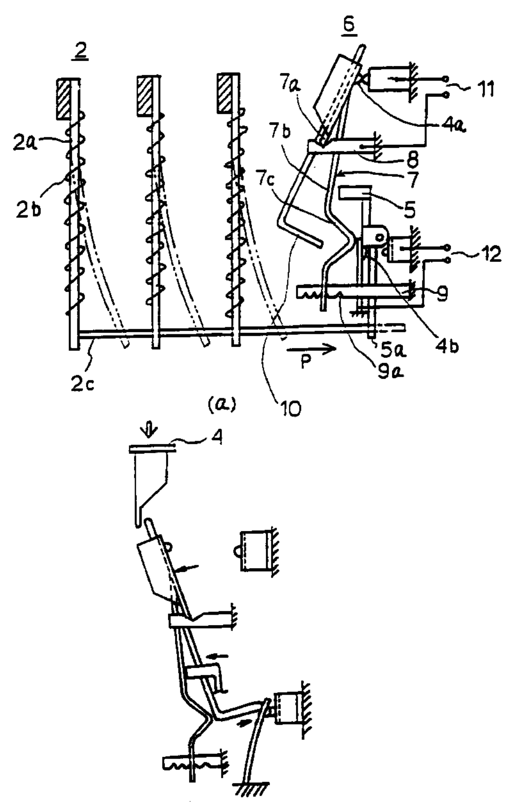
(54) Reversing spring contact switching mechanism and thermal overload relay

(57) A reversing spring contact switching mechanism (6) comprises: a single member reversing plate spring (7) in which a lateral pair of outer leg pieces (7a) and a central leg piece (7b) are formed, the central leg piece having a bent spring section (7c) therein; a supporting arm (8) for rollably supporting the tip edges of the outer leg pieces; a supporting arm 9 for applying tensile force to the spring section of the central leg piece while engaging and fixing the tip edge of the central leg piece; a normally closed contact (4a, 11); and a normally open contact (4b, 12). In a thermal overload relay combining this reversing spring contact switching mechanism (6) with a bimetal heat element 2 that responds to an overload current through a main circuit the displacement of a bimetal (2a) of the heat element (2) caused by an overload current is transmitted to the plate spring (7) via a shifter (2c) and a releasing lever (5) to cause the spring to be reversed in order to switch the contacts.

Fig. 1



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Description

The present invention relates to a reversing spring contact switching mechanism for opening and closing a contact using a reversing spring mechanism that responds to the operation of a releasing lever, and a thermal overload relay comprising a combination of the reversing spring contact switching mechanism and a trigger element that responds to an overload current.

As is well known, an electromagnetic contactor connected to a feeding circuit for an electric motor includes a thermal overload relay such as that described above for protecting the device from overloads.

Figure 4 illustrates a thermal overload relay using a conventional reversing spring contact switching mechanism which is disclosed in JP-A-2-86024. In the figure, 1 designates a resin case for a relay, in which a bimetal heat element 2 which responds to overload current in a main circuit (e.g. power circuit of a motor), a reversing spring mechanism 3, and a contact mechanism 4 are incorporated.

The bimetal heat element 2 which forms a trigger element includes a bimetal 2a wrapped with a heater wire 2b through which the load current from the main circuit passes, wherein one end of a shifter 2c coupled to the tip of the bimetal 2a is disposed opposite to a first end of a seesaw-like releasing lever 5 (only one bimetal heat element 2 is shown in the figure, but for a multiphase circuit there will be one such element for each phase).

In this prior art the reversing spring mechanism 3 is assembled from multiple parts. More particularly, the reversing spring mechanism 3 comprises a reversing plate spring 3a made of a thin metallic spring material and formed, as shown in Figures 5(a) and (b), using a punch-press or similar working process; a reversing drive spring 3b made of a metallic plate spring material, flexed to a "U"-like shape and engaged with the plate spring 3a; and a mounting substrate 3c. The drive spring 3b has a slit-like engagement hole at both ends thereof, and is locked and fixed between the tip of a central leg piece 3d protruding into a window in the plate spring 3a and a claw at the opposite window end. An engagement piece 3e formed on the mounting substrate 3c is fitted into a receiving groove 1a formed in the resin case 1 and rollably supported using as a supporting point the tip of the engagement piece 3e. The tip of the plate spring 3a is fitted and coupled to a contact mechanism 4 described below. The plate spring 3a is positioned so that the second end of the releasing lever 5 is opposite the central leg piece 3d. Reference numeral 3f designates an adjustment screw for an operation point, and 3g designates a compression spring for pressing and holding the plate spring 3a within the case.

The contact mechanism 4 has a normally closed contact 4a, 11 and a normally open contact 4b, 12. Each of the contacts comprises a fixed contact piece 11, 12 and a movable contact piece. The movable contact pieces 4a, 4b are incorporated in a slider 4c, which is supported so as to slide in the resin case 1. The tip of the plate spring 3a is inserted into a slot opened at one end of the slider 4c to interconnect the spring 3a with the slider 4c.

Reference numeral 4d designates a resetting push button.

The operational principle of the thermal overload relay of the above configuration is known. In a stationary state, the plate spring 3a is inclined upward to the right by the resiliency of the drive spring 3b to engage the contact mechanism 4 as shown in Figure 4. A load current flowing through the main circuit is passed through the heater wire 2b wrapped around the heat element 2 to heat the bimetal 2a, and when an overload current flows through the main circuit, the bimetal 2a is further bent as shown by the broken line in the figure to cause the shifter 2c to press the releasing lever 5 to the left. This causes the releasing lever 5 to roll clockwise and press the central leg piece 3d of the plate spring 3a to the right. When the coupling point between the central leg piece 3d and the drive spring 3b passes beyond a dead point of the plate spring 3a to the right of the plate spring, the spring force of the drive spring 3b drives the plate spring 3a to the left, and this snap action rapidly drives the slider 4c of the contact mechanism 4 to the left. This causes the normally closed contact 4a, 11 to be opened and the normally open contact 4b, 12 to be closed, thereby providing an interruption signal indicating the current through the main circuit should be interrupted. Based on this interruption signal, for example, an electromagnetic contactor connected to the main circuit is opened, interrupting the overload current. After the interruption, once the bending of the bimetal 2a of the heat element 2 has sufficiently recovered, the resetting push button 4d may be pressed to move the slider 4c of the contact mechanism 4 to the right, thereby causing the reversing spring mechanism 3 to return to its initial state and reset the relay.

The conventional reversing contact switching mechanism incorporated in the thermal overload relay, in particular, the reversing spring mechanism 3 for driving the contacts, has certain disadvantageous operational and assembling characteristics. That is, in the conventional reversing spring mechanism 3, the drive spring 3b flexed like a "U" is engaged and coupled with the plate spring 3a. Thus, when the reversing spring mechanism 3 is reversed, sliding friction between metallic members occurs at fitting engagement points A and B (see Fig. 5(a) and (b)), which are between the plate spring 3a and both ends of the drive spring 3b, thereby causing the reversing point of the relay to vary and the operational characteristics of the overload relay to become unstable.

The reversing spring mechanism 3 comprises the plate spring 3a and the drive spring 3b. During assembly, when the drive spring 3b is coupled to the plate spring 3a, the plate spring or the drive spring 3b must be flexed while both ends are coupled to the engagement claws of the plate spring 3a. This assembly step is cumbersome. Consequently, automatic assembly using robots is very difficult and assembly requires manual work.

It is an object of this invention to solve the above problems by providing a reversing spring contact switching mechanism that can be assembled easily and that improves the stability of the reversing points. Another object of the invention is to provide a thermal overload relay comprising a combination of the reversing spring contact switching mechanism and a bimetal heat element that can respond to an overload current.

These objects are achieved by the reversing spring contact switching mechanism of claim 1 and the relay of claim 8, respectively. Various advantageous embodiments are set forth in the dependent claims.

According to the reversing spring contact switching mechanism of the invention, the reversing spring mechanism comprises a singlespring part, thereby eliminating the need of a cumbersome assembly process for assembling two parts together as in conventional techniques, reducing the number of required parts, and enabling the mechanism to be automatically assembled into products without the need for manual work. Furthermore, the single spring part, namely a reversing plate spring has no portion that is subjected to friction during a reversing operation and no part that is buckled during such an operation, thereby making the reversing point more stable than that in conventional reversing spring mechanisms. This reversing spring contact switching mechanism can be applied to various contact relays that use a snap action to open and close a contact, or applied to contact switching mechanisms for switches.

Embodiments of this invention are described below with reference to Figures 1 to 3. In the drawings, like components are designated by like reference numerals.

Fig. 1 shows the configuration of a thermal overload relay according to one embodiment of this invention. Figure 1(a) shows the assembled configuration of a reversing spring contact switching mechanism combined with bimetal heat elements. Figure 1(b) shows the reversing operation of the reversing spring contact switching mechanism.

Fig. 2 shows the configuration of the plate spring in Figure 1. Figure 2(a) is a front view and Figure 2(b) is a side view.

Fig. 3 is a perspective view showing an assembled state in which the plate spring in Figure 2 is engaged with and fixed to a supporting arm.

Fig. 4 shows the structure of the integral part of a conventional thermal overload relay.

Fig. 5 shows the structure of a reversing spring mechanism used in a conventional contact switching mechanism. Figure 5(a) is a front view and Figure 5(b) is a side view.

In Figure 1, three bimetal heat elements 2 are the same as the conventional one shown in Figure 4. A shifter 2c is coupled to the free end of the three bimetals 2a each including a heater wire 2b and corresponding to a respective phase of a three-phase main circuit. Preferably the heat elements 2 are opposed to a temperature compensation bimetal 5a coupled to a seesaw-like releasing lever 5 at the tip of the shifter 2c.

A reversing spring contact switching mechanism 6 according to this invention which is linked with the heat elements 2 via the releasing lever 5 comprises an assembly of a reversing plate spring 7, the detailed structure of which is described below; first and second supporting arms 8, 9 for supporting the plate spring 7; a contact piece 4a directly formed on the plate spring 7, which is used as a movable contact piece and forms a normally closed contact together with a fixed contact piece 11; another movable contact piece 4b disposed separately from the plate spring 7, which forms a normally open contact together with a fixed contact piece 12; an L-shaped contact drive lever 10 with one end coupled to the plate spring 7 and its tip opposite the contact piece 4b; and a releasing lever 5 such as the one described above.

The plate spring 7 comprises a single thin plate member in which three leg pieces consisting of a lateral pair of outer leg pieces 7a and a central leg piece 7b that is longer than the outer leg pieces (three-prong fork shape) are formed by a process such as a punch-press process from a thin plate, and in which a bent tension spring section 7c is formed in a V shape in the intermediate portion of the central leg piece 7b, as shown in Figures 2(a) and (b). Preferably, the spring section 7c has a larger width D than the width d of the central leg piece 7b. The three leg pieces are connected at one end to a connecting base 7e. The free ends or tips of the outer leg pieces 7a are formed like the edge of a knife. A frame-like engagement section 7d with a window 7d-1 opened therein is formed at the free end or tip of the central leg piece 7b, and the lower inner edge of the window 7d-1 is machined so that it is as sharp as the tips of the outer leg pieces 7a. Preferably, at least the outer side edges of the right and left outer leg pieces are folded into an "L"-like shape to form reinforcement ribs 7a-1 as shown in the figure, and thereby increasing the rigidity of the outer leg pieces 7a. Furthermore, the plate spring 7 in this embodiment is used as a movable contact, and the contact piece 4a is coupled, by thermal caulking for example, to the connecting base 7e coupling the outer leg pieces 7a and the central leg piece 7b together.

The plate spring 7 is reversibly engaged and supported between the first and second arms 8 and 9 as shown in Figure 3. The tip edge of each outer leg 7a is engaged with and fixed to a respective V-shaped groove section 8a in the first supporting arm 8 as a hinge for a rolling supporting point. As shown in Figure 3, the supporting arm is U-shaped, one groove section 8a is provided in each of the lateral arm portions of the U-shape and the central leg piece 7b extends in between these two arm portions. With tensile force applied to the central leg piece 7b to stretch the spring section 7c, the window 7d-1 in the engagement section 7d at the tip of the central leg piece is caught in a V-shaped engagement groove 9a formed in the second supporting arm 9, and is engaged and fixed in a position displaced longitudinally (i.e., substantially vertically in Figure 1) relative to the supporting points at the tips of the outer leg pieces 7a. A plurality of grooves 9a are formed in the supporting arm 9 like sawteeth to permit adjustment of the engagement position of the central leg piece 7b along the horizontal direction of the arm. The plurality of adjustment grooves 9a formed in the second supporting arm 9 can be used to adjust the reversing point of the plate spring 7 on the second supporting arm or compensate for assembly errors and tolerances with respect to relative placement of the bimetal 2a of the heat element 2, the shifter 2c, and the releasing lever 5.

When the plate spring 7 is installed between the first and second supporting arms 8 and 9, the plate spring 7 has two stable positions, namely where the spring tension of the spring section 7c is equivalent to the spring drag of the leg pieces. In its stable positions the plate spring 7 is inclined to the right and left, respectively, relative to a plane including the supporting points on the first supporting arm 8 and the second supporting arm 9. In the present embodiment the movable contact 4a is fixed to the plate spring 7 and in the stationary state shown in Figure 1(a) a certain contact pressure between the contact pieces 4a and 11 is required. Thus, the position of the plate spring 7 in this stationary state should not be one of the stable positions mentioned above but a position in which the spring force of the spring section 7c is greater than the spring drag of the leg pieces and an equilibrium exists between the spring force of the spring section 7c, the spring drag of the leg pieces and the reaction force of the fixed contact piece 11. The plate spring 7, the first supporting arm 8, the second supporting arm 9, the movable contact piece 4b, the releasing leve 5 and the contact drive lever 10 may be assembled as a complete unit in advance; therefore, the assembly of the reversing plate spring mechanism 6 can be easily installed in the case of a device such as the thermal overload relay. Furthermore, although stress caused by tension is constantly applied to the spring section 7c formed on the central leg piece 7b, the spring section 7c can be formed to have a large width to reduce stress, thereby preventing the spring force from being reduced due to creep, thereby increasing the service life of the device.

The operation of the thermal overload relay comprising a combination of the reversing spring contact switching mechanism 6 with the heat elements 2 is described with reference to Figures 1(a) and (b). In the stationary state shown in Figure 1(a), the bimetals 2a of the heat elements 2 assume the position shown by the solid line and the releasing lever 5 is almost free of any contact with central leg piece 7b. In this state, the plate spring 7 is inclined upward to the right by the spring force of the spring section 7c using the tip edges of the leg pieces 7a as rolling supporting points or pivots, thereby closing the normally closed contact 4a, 11 and opening the normally open contact 4b, 12. When an overcurrent flows through a main circuit (for example, a feeding circuit for an electric motor) and significantly bends the bimetals 2a as shown by the broken lines in the figure, the shifter 2c is substantially displaced in the direction shown by arrow P to press and rotate the releasing lever 5 counterclockwise. The releasing lever 5 has an upper end and a lower end and is pivotally supported between the two ends. The counter-clockwise rotation of the releasing lever 5 causes the tip of its upper end to press against the central leg piece 7b of the plate spring 7. When the central leg piece 7b under pressure from releasing lever 5 moves against the spring force of the spring section 7c to the left beyond the rolling supporting point of the outer leg pieces 7a, that is, beyond the dead point of the plate spring 7, the direction of the moment applied by spring section 7c to plate spring 7 is reversed causing plate spring 7 to snap counterclockwise. This snap action causes the plate spring 7 to be inclined upward to the left using the tip of the outer leg pieces 7a as a supporting point, as shown in Figure 1(b). This causes the normally closed contact 4a, 11 to be opened and also causes, via the contact drive lever 10, the normally open contact 4b, 12 to be closed, and a signal available via this contact operation can be used to display the operation of the overload relay and to open an electromagnetic contactor connected to the main circuit to interrupt the overload current. As mentioned before, the lower end of the releasing lever 5, or at least part of it is formed by a compensating bimetal 5a which engages the shifter 2c. When bimetals 2a bend in response to a change in the ambient temperature, the compensating bimetal 5a bends in the same direction so that a shift of the shifter 2c resulting from such bending of bimetals 2a has no influence on the position of releasing lever 5.

After the interruption, when the bimetals 2a of the heat elements 2 have cooled and moved back to the stationary position and when the reset button 4d (incorporated in the resin case of the relay as in Figure 4) is pressed to force the plate spring 7 to the right, the plate spring 7 is reversed to return to its initial position shown in Figure 1(a). In addition to manual resetting using the reset button 4d, automatic resetting is available by using a stopper to regulate the reversing stop position of the plate spring 7 during an overcurrent state. In such an embodiment, when the bimetals 2a have returned to the stationary state and the shifter 2c has moved back, the plate spring 7 is automatically returned to its initial position by its own spring force. In this case the stopper must be positioned such that when plate spring 7 is turned counterclockwise it does not pass beyond its dead point.

Although the illustrated embodiment shows an example in which the movable contact piece 4a of the normally closed contact is directly mounted on the plate spring 7 to reduce the size of the contact switching mechanism, this invention is not limited to this aspect, and for example, the movable contact pieces of the normally closed and open contacts can be incorporated in a slider separately from the plate spring 7, and the contacts can be opened and closed by the reversal of the spring 7, as shown in Figure 4. In addition, although the illustrated embodiments show heat elements 2 comprising bimetals 2a, no particular means or method of sensing temperature or overcurrent conditions is critical to the practice of a relay according to the invention. Furthermore, the reversing spring contact switching mechanism can of course be used in devices other than thermal overload relays.

The constitution of the invention described above has the following advantages.

1) Since the plate spring of the reversing spring contact switching mechanism consists of a simple thin plate spring member which can be formed by punching and bending, it has fewer required parts, and it can be constructed more inexpensively than conventional configurations with two parts. It can also be assembled and incorporated into a relay simply, which enables automatic assembly. It does not include a sliding section between parts as do conventional reversing spring mechanisms with two parts, and it is configured to allow the bent spring section formed on the central leg piece to be reversed as a tension spring instead of the buckling reversal method, thereby preventing the reversing point from varying, thereby stabilizing operational characteristics.

2) The thermal overload relay according to this invention which comprises a combination of the reversing spring contact switching mechanism with a heat or other trigger element has fewer required parts and is smaller than conventional constitutions. It can also be automatically assembled easily and can provide stable operational characteristics, thereby further improving reliability.

Claims

1. A reversing spring switching mechanism for driving a movable contact piece (4a, 4b) into one of two switching states using a reversing spring mechanism (6) adapted to respond to the operation of a releasing lever (5), wherein

    the reversing spring mechanism comprises

    a single member reversing plate spring (7) in which three leg pieces consisting of a lateral pair of outer leg pieces (7a) and a central leg piece (7b) are coupled by a connecting base (7e), the central leg piece having a bent tension spring section (7c) formed therein;

    a first supporting arm (8) for pivotally supporting tip edges of the outer leg pieces (7a) as supporting points; and

    a second supporting arm (9) for applying tensile force to the spring section (7c) of the central leg piece (7b) while engaging a tip edge of the central leg piece to lock it in a specified position;

    and wherein

    the releasing lever (5) is disposed opposite the central leg piece (7b),

    the movable contact piece (4a, 4b) is linked to the connecting base (7e) and

    the movable contact (4a, 4b) is driven from a first switching state to a second switching state in response to the releasing lever being pressed to reverse the plate spring (7).

2. A mechanism according to Claim 1 wherein a plurality of engaging grooves (9a) for adjusting the position for engaging the tip of the central leg piece (7b) is formed in the second supporting arm (9).

3. A mechanism according to Claim 1 or 2 wherein the plate spring (7) is used as a movable contact, and wherein the movable contact piece (4a) is mounted on the connecting base (7e) of the plate spring.

4. A mechanism according to Claim 1, 2 or 3 wherein a contact lever (10) is coupled to the connecting base (7e) of the plate spring (7), and wherein a contact (4b; 12) separately disposed is opened and closed via the contact lever.

5. A mechanism according to any one of Claims 1 through 4 wherein side edges of the outer leg pieces (7a) are bent in an L shape to form reinforcing ribs to increase the rigidity of the outer leg pieces.

6. A mechanism according to any one of Claims 1 through 5 wherein a window (7d-1) is opened in the tip of the central leg piece (7b) of the plate spring (7) and wherein an edge of the window is formed so as to be sharp and to engage a groove (9a) in the second supporting arm (9).

7. A mechanism according to any one of Claims 1 through 6 wherein the spring section (7c) is formed so as to have a larger width than other portions the central leg piece (7b).

8. A thermal overload relay comprising a reversing

spring contact switching mechanism according to any one of Claims 1 through 7 and further comprising a bimetal heat element (2) adapted to respond to an overload current in a main circuit and a shifter (2c) for transmitting a displacement of the heat element (2) caused by an overload current, wherein the shifter is coupled to the releasing lever (5) so as to drive the movable contact (4a, 4b) from the first switching state to the second switching state in response to the overload current.

9. A relay according to Claim 8 wherein the shifter (2c) is coupled to the releasing lever (5) via a compensating bimetal element (5a).

Fig. 1

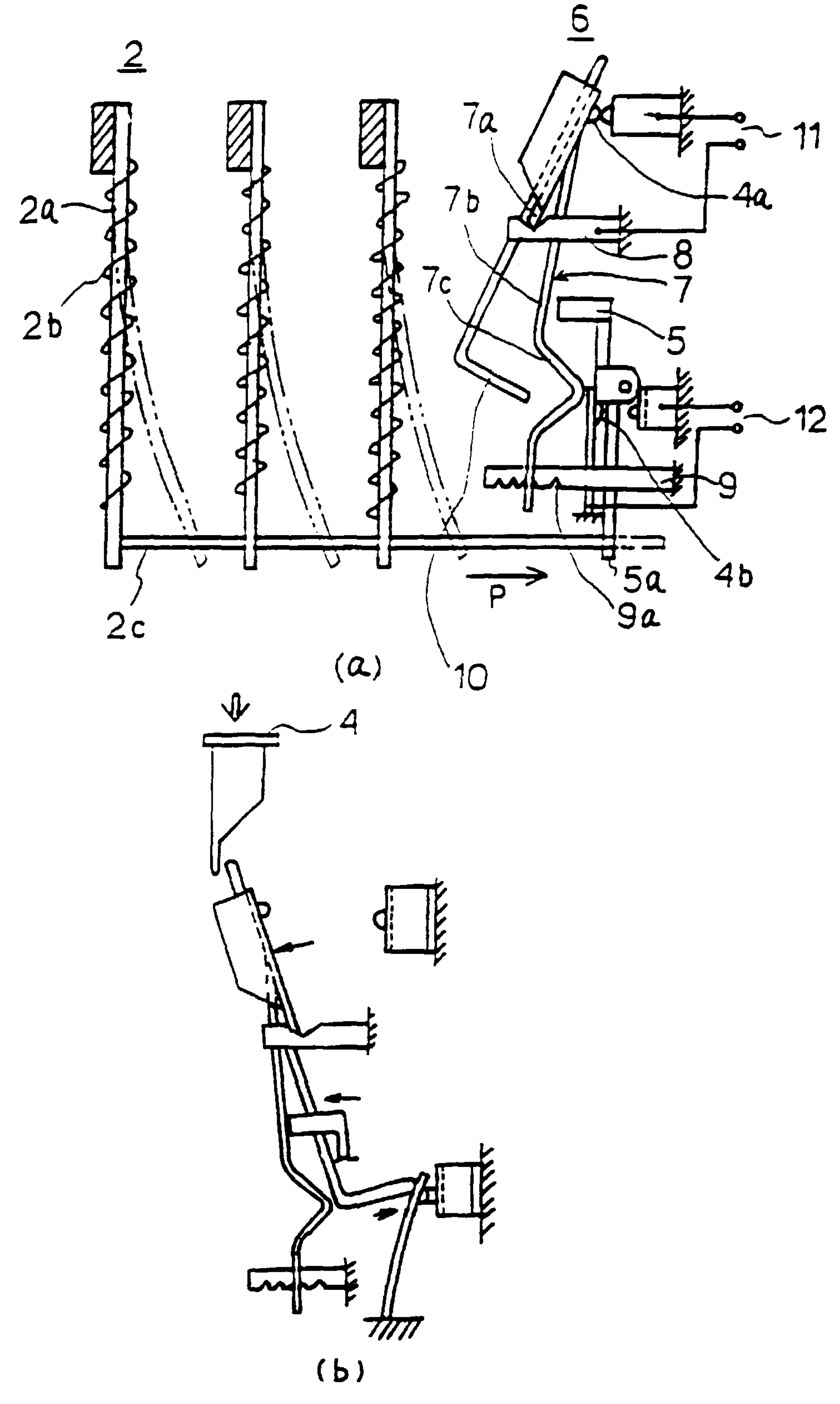
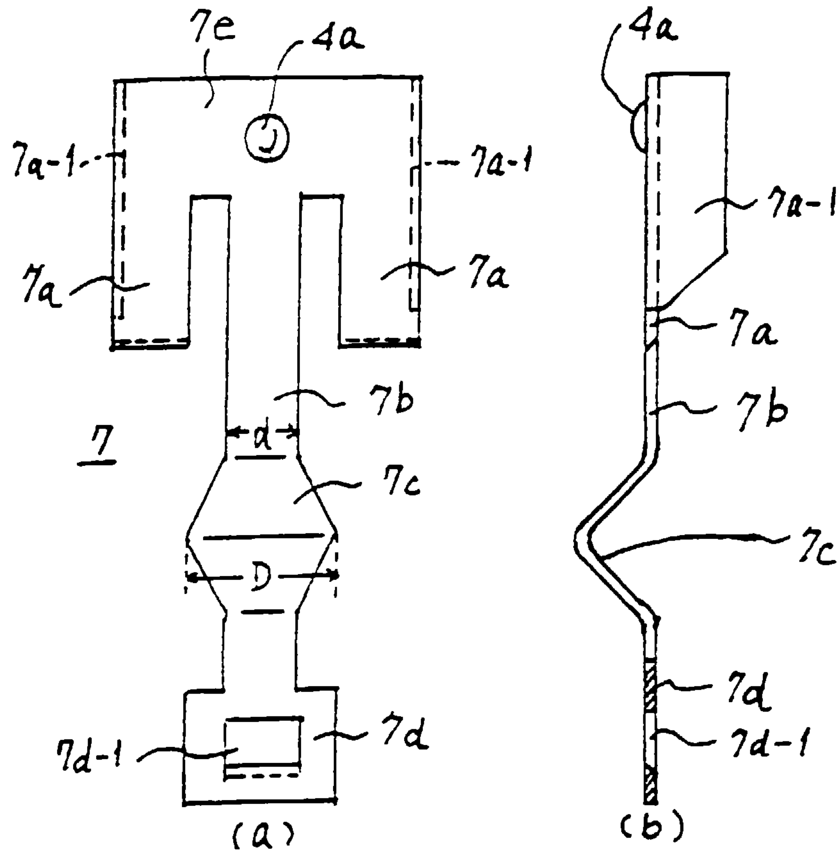


Fig. 2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7a-1
7a
7a
7b
d
7
7c
D
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7d
(a)
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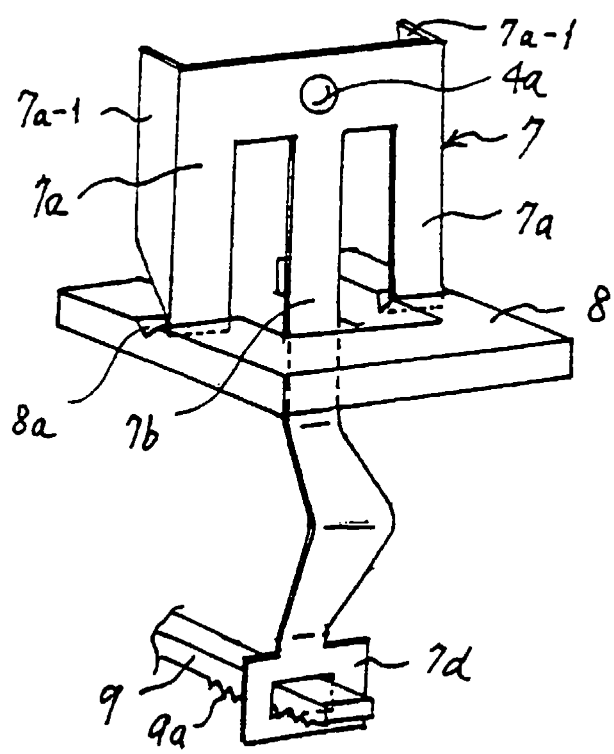
7d-1
(b)

Fig. 3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4a
7a-1
7
7a
7a
8
8a
7b
7d
9
9a

Fig. 4

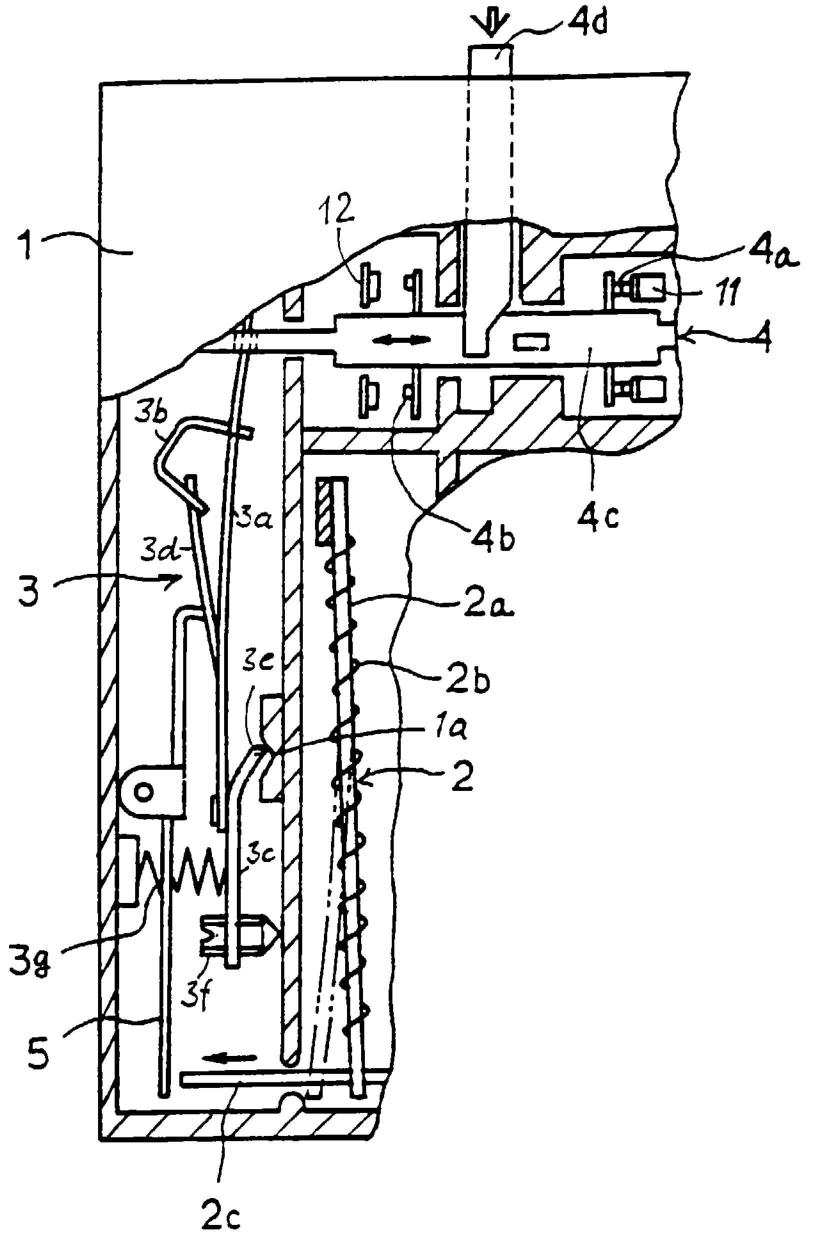

Fig. 5