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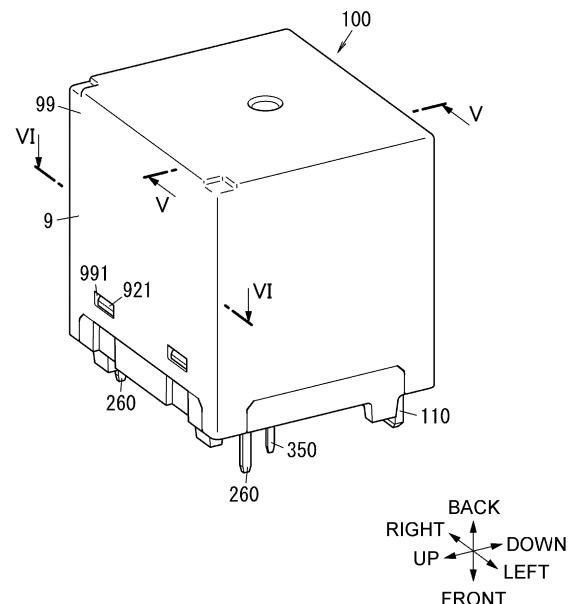
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(54) **CONTACT DEVICE**

(57) This contact device includes a fixed contact (F1), a movable contact (M1), and a movable contactor (13). The movable contactor (M1) moves into or out of contact with the fixed contact (F1) in the up-to-down direction. The movable contactor (13) is made of a metal, and the movable contact (M1) is disposed adjacent to a first end (131) of the movable contactor (13). The movable contact (M1) includes a first predetermined end (M11) that is closest to the first end (131) of the movable contactor (13) as viewed from above. In a closed state where the fixed contact (F1) and the movable contact (M1) are in contact, the first predetermined end (M11) is located between the first end (131) of the movable contactor (13) and the fixed contact (F1) as viewed from above.

FIG. 1



Description**BACKGROUND****1. Technical Field**

[0001] The present disclosure generally relates to contact devices. The present disclosure more specifically relates to a contact device including a contact provided at an end of a metal member.

2. Description of the Related Art

[0002] Patent Literature (PTL) 1 discloses an electromagnetic relay.

[0003] The electromagnetic relay disclosed in PTL 1 includes a fixed contact holding member, a fixed contact, a movable plate spring, a movable contact, an electromagnetic coil, a fixed iron core, and a movable iron piece. The fixed contact holding member is plate-shaped. The fixed contact is disposed on one surface of the fixed contact holding member so as to protrude. The movable plate spring is plate-shaped. The movable contact is disposed on one surface of the movable plate spring so as to protrude. The movable contact faces the fixed contact disposed on the fixed contact holding member. The electromagnetic coil, when energized, causes electromagnetic force to arise. The movable iron piece is disposed at a position facing the fixed iron core and when the coil is energized, is attracted toward the fixed iron core.

[0004] In the electromagnetic relay, when the electromagnetic coil is energized, the movable iron piece is attracted toward the fixed iron core by the electromagnetic force from the electromagnetic coil, the movable contact abuts the fixed contact, and thus an electrical circuit is closed. On the other hand, when the electromagnetic coil is de-energized, the movable contact moves away from the fixed contact by the elastic force of the movable plate spring, and the electrical circuit is opened.

Citation List**Patent Literature**

[0005] PTL 1: Unexamined Japanese Patent Publication No. 2021-157904

SUMMARY**Technical Problem**

[0006] In the electromagnetic relay disclosed in PTL 1, there is a possibility that the fixed contact and the movable contact may adhere to each other by the effects of an electric arc occurring between the fixed contact and the movable contact.

[0007] An object of the present disclosure is to reduce the possibility that the fixed contact and the movable contact may adhere to each other.

5 Solution to Problem

[0008] A contact device according to one aspect of the present disclosure includes a fixed contact, a movable contact, and a movable member. The movable contact moves into or out of contact with the fixed contact in an up-to-down direction. The movable member is made of a metal, and the movable contact is disposed adjacent to a first end of the movable member. The movable contact includes a first predetermined end that is closest to the first end of the movable member as viewed from above. In a closed state where the fixed contact and the movable contact are in contact, the first predetermined end is located between the first end of the movable member and the fixed contact as viewed from above.

[0009] A contact device according to one aspect of the present disclosure includes a fixed contact, a movable contact, and a fixed terminal. The movable contact moves into or out of contact with the fixed contact in an up-to-down direction. The fixed terminal is made of a metal, and the fixed contact is disposed adjacent to a first end of the fixed terminal. The fixed contact includes a predetermined end that is closest to the first end of the fixed terminal as viewed from above. In a closed state where the fixed contact and the movable contact are in contact, the predetermined end of the fixed contact is located between the first end of the fixed terminal and the movable contact as viewed from above. Advantageous Effects

[0010] According to the present disclosure, there is the advantage of being able to reduce the possibility that the fixed contact and the movable contact may adhere to each other.

BRIEF DESCRIPTION OF THE DRAWINGS**[0011]**

Fig. 1 is a perspective view of an electromagnetic relay including a contact device according to Embodiment 1.

Fig. 2 is an exploded perspective view of the electromagnetic relay.

Fig. 3 is an exploded perspective view of main components of the electromagnetic relay.

Fig. 4 is a side view of main components of the electromagnetic relay.

Fig. 5 is a cross-sectional view of the electromagnetic relay viewed along arrow V-V in Fig. 1.

Fig. 6 is a cross-sectional view of the electromagnetic relay viewed along arrow VI-VI in Fig. 1.

Fig. 7 is a cross-sectional view of a contact included in the contact device.

Fig. 8 is a bottom view of a movable contactor and a

movable contact included in the contact device.

Fig. 9 is an explanatory diagram for showing the positional relationship between a movable contactor, a movable contact, and a fixed contact included in the contact device, as viewed from below.

Fig. 10 is a perspective view of an electromagnetic relay including a contact device according to Embodiment 2.

Fig. 11 is an exploded perspective view of the electromagnetic relay.

Fig. 12 is an exploded perspective view of main components of the electromagnetic relay.

Fig. 13 is a side view of main components of the electromagnetic relay in an open state.

Fig. 14 is a cross-sectional view of the electromagnetic relay in the open state viewed along arrow XIV-XIV in Fig. 10.

Fig. 15 is a side view of main components of the electromagnetic relay in a closed state.

Fig. 16 is a front view of main components of the electromagnetic relay in a closed state.

Fig. 17 is a cross-sectional view of the electromagnetic relay in the closed state viewed along arrow XVII-XVII in Fig. 10.

Fig. 18 is an explanatory diagram schematically illustrating an electric arc occurring in the electromagnetic relay.

Fig. 19 is an explanatory diagram for showing the positional relationship between a movable spring, a movable contact, and a fixed contact included in the contact device, as viewed from below.

Fig. 20 is an explanatory diagram for showing the positional relationship between a fixed terminal, a fixed contact, and a movable contact included in a contact device according to Variation 1.

Fig. 21A is a perspective view of a contact included in a contact device according to one variation.

Fig. 21B is a side view of a contact included in the contact device.

Fig. 21C is a front view of the contact included in the contact device.

DETAILED DESCRIPTIONS

[0012] Contact devices according to exemplary embodiments of the present disclosure will be described with reference to the drawings. Each figure described in the following embodiments is a schematic diagram, meaning that the ratio between the sizes of structural elements in each figure and the ratio between the thicknesses of structural elements in each figure do not necessarily reflect an actual dimension ratio.

(1) Embodiment 1

[0013] Contact device 10 according to Embodiment 1 will be described with reference to Fig. 1 to Fig. 9.

(1. 1) Overall Configuration

[0014] Contact device 10 is a device that is inserted into an electrical circuit and opens and closes the electrical circuit. The electrical circuit may be a direct-current circuit in which a direct current flows or may be an alternating-current circuit in which an alternating-current flows.

[0015] As illustrated in Fig. 3 to Fig. 6, contact device 10 according to the present exemplary embodiment includes fixed contact F1 (hereinafter also referred to as "first fixed contact F1"), movable contact M1 (hereinafter also referred to as "first movable contact M1"), fixed terminal 11 (hereinafter also referred to as "first fixed terminal 11"), and movable contactor 13 (a movable member).

[0016] First movable contact M1 faces first fixed contact F1 in one direction. First movable contact M1 moves into or out of contact with first fixed contact F1 in this one direction. In the following description, for the sake of explanation, an area in which first movable contact M1 is located with respect to first fixed contact F1 will also be referred to as "up/upper/top/above," the area opposite thereto will also be referred to as "down/lower/bottom/-below," and a direction in which first movable contact M1 moves into or out of contact with first fixed contact F1 will also be referred to as "the up-to-down direction." This means that movable contact (first movable contact) M1 moves into or out of contact with fixed contact (first fixed contact) F1 in the up-to-down direction. Movable contact M1, which is located above fixed contact F1, moves into contact with fixed contact F1 from above. Note that the phrase "as viewed from above" in the present disclosure refers to viewing the internal structure of each member (focusing on the contour of each member) in a direction (up-to-down direction) in which fixed contact (first fixed contact) F1 and movable contact (first movable contact) M1 move into or out of contact with each other.

[0017] As illustrated in Fig. 3 to Fig. 6, first fixed contact F1 is provided on first fixed terminal 11. First movable contact M1 is provided on movable contactor 13. Movable contactor 13 can move in the up-to-down direction. When movable contactor 13 moves in the up-to-down direction with respect to first fixed terminal 11, first movable contact M1 moves into or out of contact with first fixed contact F1.

[0018] As illustrated in Fig. 3 and Fig. 6, contact device 10 further includes second fixed contact F2, second movable contact M2, and second fixed terminal 12.

[0019] Second movable contact M2 is provided on movable contactor 13. Second fixed contact F2 is provided on second fixed terminal 12. Second movable contact M2 faces second fixed contact F2 in the up-to-down direction. Second movable contact M2 moves into or out of contact with second fixed contact F2 in the up-to-down direction. Second fixed terminal 12 is disposed side by side with first fixed terminal 11 in one direction perpendicular to the up-to-down direction. In the following

description, for the sake of explanation, a direction in which first fixed terminal 11 and second fixed terminal 12 are arranged will also be referred to as "the left-to-right direction," an area in which first fixed terminal 11 is located with respect to second fixed terminal 12 will also be referred to as "left," and the area opposite thereto will also be referred to as "right." The direction perpendicular to both the up-to-down direction and the left-to-right direction will also be referred to "the front-to-back direction." As illustrated in Fig. 3, first fixed contact F1 is provided at a rear end of first fixed terminal 11. In the figures referred to in the description of the exemplary embodiments, the up-to-down, front-to-back, and left-to-right directions are indicated by virtual arrows, but these directions are merely for the sake of convenience to describe the positional relationship between members and do not limit the directions, etc., of contact device 10 when in use.

[0020] Contact device 10 according to the present exemplary embodiment constitutes at least a part of electromagnetic relay 100. Electromagnetic relay 100 is a device that performs electrical control to release and close an electrical contact in order to open and close an electrical circuit. Electromagnetic relay 100 according to the present exemplary embodiment is a hinged relay. Electromagnetic relay 100 is used for applications such as a photovoltaic system, an uninterruptible power supply (UPS), an inverter, and a vehicle, for example. Elements included in contact device 10 and elements included in other parts of electromagnetic relay 100 than contact device 10 are described separately below for the sake of explanation, but some or all of the elements included in the other parts of electromagnetic relay 100 than contact device 10 may be included in contact device 10.

[0021] As illustrated in Fig. 1 to Fig. 3, electromagnetic relay 100 further includes electromagnet device 20, auxiliary contact device 30, and casing 9, in addition to contact device (main contact device) 10.

(1. 2) Electromagnet Device

[0022] As illustrated in Fig. 2 to Fig. 6, electromagnet device 20 includes coil 21, armature 22, bobbin 23, iron core 24, yoke 25, and a pair of coil terminals 26.

[0023] Bobbin 23 is made of a resin, for example. As illustrated in Fig. 3 to Fig. 6, bobbin 23 integrally includes cylinder 230 (refer to Fig. 6), first flange 231, and second flange 232.

[0024] Cylinder 230 is in the shape of a hollow circular cylinder extending in the front-to-back direction.

[0025] First flange 231 is in the shape of a rectangular plate extending in the up-to-down and left-to-right directions from a rear edge of cylinder 230. First pedestal 233 is provided on a left portion of the upper end of first flange 231, and second pedestal 234 is provided on a right portion of the upper end of first flange 231.

[0026] Second flange 232 is in the shape of a rectan-

gular plate extending in the up-to-down and left-to-right directions from a front edge of cylinder 230. A pair of holding grooves 235, which hold the pair of coil terminals 26, are provided on opposite left and right portions of the upper end of second flange 232.

[0027] Coil 21 is formed of a conducting wire wound on cylinder 230 of bobbin 23. A first end of coil 21 is connected to one of the pair of coil terminals 26, and a second end of coil 21 is connected to the other of the pair of coil terminals 26. Each coil terminal 26 integrally includes: connecting piece 261 to which coil 21 is connected; and terminal piece 260.

[0028] Iron core 24 is formed from a magnetic material. Iron core 24 is in the shape of a circular column elongated in the front-to-back direction. Iron core 24 is inserted into the space within cylinder 230 of bobbin 23. Flange 241 is provided at the rear end of iron core 24.

[0029] Yoke 25 is formed from a magnetic material. Yoke 25 integrally includes first yoke 251 and second yoke 252. First yoke 251, which is plate-shaped, is located on the front surface of second flange 232 of bobbin 23 and is fixed to a front end of iron core 24. Second yoke 252, which is in the shape of a plate extending rearward from the lower end of first yoke 251, covers the lower side surface of coil 21 from below.

[0030] As illustrated in Fig. 3, projections 253 are formed at opposite left and right ends of the rear edge of second yoke 252. Recessed portion 254, which is U-shaped, is formed between two left and right projections 253.

[0031] Armature 22 is formed from a magnetic material. Armature 22 integrally includes first portion 221 and second portion 222. First portion 221 is plate-shaped. Second portion 222 is plate-shaped. First portion 221 and second portion 222 intersect at a predetermined angle (an obtuse angle). With first portion 221 and second portion 222, armature 22 is formed into the approximate shape of the letter "L." Armature 22 is disposed so that the front surface of first portion 221 faces the rear surface of flange 241 of iron core 24 and the upper surface of second portion 222 is located below second yoke 252.

[0032] Recesses 223 are formed at the left edge and the right edge of first portion 221 in an area close to the lower end thereof. Armature 22 is positioned with respect to yoke 25 by positioning two projections 253 of yoke 25 in two recesses 223.

[0033] As illustrated in Fig. 5, a portion of the front surface of first portion 221 of armature 22 that connects two recesses 223 comes into contact with the rear end of recessed portion 254 of yoke 25. Armature 22 can rotate at the portion thereof that comes into contact with yoke 25 as an axis of rotation (a fulcrum). Armature 22 can be displaced between a first posture in which first portion 221 is away from iron core 24 and a second posture in which first portion 221 is close to iron core 24 (refer to Fig. 4 and Fig. 5).

[0034] As illustrated in Fig. 3, through-hole 229 is formed in a portion of armature 22 that connects first

portion 221 and second portion 222. Return spring 27, which is in the form of an L-shaped leaf spring, is disposed in through-hole 229. Return spring 27 applies the elastic force thereof to armature 22 in a direction in which armature 22 assumes the first posture.

[0035] In the state where coil 21 is not energized, armature 22 assumes the first posture in which first portion 221 is away from iron core 24 by the elastic force of return spring 27. When a voltage is applied between the pair of coil terminals 26 and thus coil 21 is energized and excited, armature 22 has first portion 221 attracted to iron core 24 and rotates around the axis of rotation so that first portion 221 moves forward. As a result, armature 22 assumes the second posture. In this manner, armature 22 is displaced between the first posture and the second posture according to whether coil 21 is energized or de-energized.

(1. 3) Contact Device

[0036] Contact device 10 includes first fixed terminal 11, second fixed terminal 12, and movable contactor 13, as described above.

[0037] As illustrated in Fig. 3 to Fig. 6, first fixed terminal 11 is in the shape of a plate having a thickness in the up-to-down direction. First fixed terminal 11 extends in the front-to-back direction. First fixed terminal 11 integrally includes: fixed piece 111 in the shape of a rectangular plate; and terminal piece 110 protruding forward from the front edge of fixed piece 111.

[0038] Second fixed terminal 12 is in the shape of a plate having a thickness in the up-to-down direction. Second fixed terminal 12 extends in the front-to-back direction. Second fixed terminal 12 integrally includes: fixed piece 121 in the shape of a rectangular plate; and terminal piece 120 protruding forward from the front edge of fixed piece 121. Second fixed terminal 12 is shaped so that first fixed terminal 11 and second fixed terminal 12 are symmetrical in the left-to-right direction. Second fixed terminal 12 is disposed to the right of first fixed terminal 11.

[0039] Movable contactor 13 is in the shape of a plate having a thickness in the up-to-down direction and elongated in the left-to-right direction. As illustrated in Fig. 4 to Fig. 6, a left end portion of movable contactor 13 faces a right rear end portion of first fixed terminal 11. A right end portion of movable contactor 13 faces a left rear end portion of second fixed terminal 12.

[0040] Each of first fixed terminal 11, second fixed terminal 12, and movable contactor 13 is made of a metal. The material of each of first fixed terminal 11, second fixed terminal 12, and movable contactor 13 is preferably highly conductive. The material of each of first fixed terminal 11, second fixed terminal 12, and movable contactor 13 is copper or a copper alloy, for example. Examples of the copper alloy as the material of first fixed terminal 11 include phosphor bronze, Corson copper, tin-containing copper, brass, beryllium copper, magnesium

copper, zirconium copper, and titanium copper. The material of first fixed terminal 11, the material of second fixed terminal 12, and the material of movable contactor 13 are the same in the present exemplary embodiment, but this is not limiting; these may be different.

[0041] As illustrated in Fig. 3 to Fig. 6, contact device 10 further includes coupling body 141, supporting body 142, and coupling spring 143.

[0042] Coupling body 141 is in the shape of a block elongated in the left-to-right direction. Coupling body 141 is joined to armature 22 in such a manner that a front end portion of second portion 22 of armature 22 is inserted into the rear surface of coupling body 141.

[0043] Supporting body 142 is in the shape of a plate elongated in the front-to-back direction. The thickness direction of the supporting body is the up-to-down direction. Supporting body 142 has a rear end embedded in the front surface of coupling body 141 and thus is held on coupling body 141.

[0044] Coupling spring 143 is a leaf spring having a thickness in the up-to-down direction and elongated in the front-to-back direction. Coupling spring 143 is disposed above supporting body 142 (on the side on which movable contactor 13 is located with respect to first fixed terminal 11) so that a rear portion of coupling spring 143 overlaps supporting body 142. The rear end of coupling spring 143 is fixed to supporting body 142. Movable contactor 13 is fixed to the front end of coupling spring 143.

[0045] Movable contactor 13 is coupled to armature 22 via coupling body 141, supporting body 142, and coupling spring 143, and moves up and down according to displacement of armature 22. Movable contactor 13 is located at a relatively higher position when armature 22 assumes the first posture, and is located at a relatively lower position when armature 22 assumes the second posture (refer to Fig. 4 and Fig. 5).

[0046] As illustrated in Fig. 3 to Fig. 6, contact device 10 further includes first fixed contact member 16, first movable contact member 17, second fixed contact member 18, and second movable contact member 19.

[0047] First fixed contact member 16 is held on (fixed to) first fixed terminal 11. First fixed contact member 16 is fixed to a right rear end of fixed piece 111 of first fixed terminal 11. First fixed contact member 16 is fixed to a portion of first fixed terminal 11 that faces movable contactor 13.

[0048] As illustrated in Fig. 5 and Fig. 6, first fixed contact member 16 includes head portion 161 and body portion 162.

[0049] Head portion 161 is a portion of first fixed contact member 16 that is exposed upward from first fixed terminal 11. Head portion 161 is disc-shaped.

[0050] Body portion 162 is a portion extending downward from head portion 161. Body portion 162 is in the shape of a circular column. The material of body portion 162 is copper, for example. Body portion 162 is inserted into a through-hole provided in fixed piece 111 of first fixed

terminal 11. With body portion 162 passing through the through-hole, first fixed contact member 16 is fixed to fixed piece 111 of first fixed terminal 11 by riveting. Thus, first fixed contact member 16 is electrically connected to first fixed terminal 11.

[0051] Out of first fixed contact member 16, head portion 161 functions as first fixed contact F1 described above.

[0052] First movable contact member 17 is held on (fixed to) movable contactor 13. First movable contact member 17 is fixed to a left end of movable contactor 13. First movable contact member 17 is fixed to a portion of movable contactor 13 that faces first fixed terminal 11.

[0053] As illustrated in Fig. 5 and Fig. 6, first movable contact member 17 includes head portion 171 and body portion 172.

[0054] Head portion 171 is a portion of first movable contact member 17 that is exposed downward from movable contactor 13. Head portion 171 is disc-shaped.

[0055] Body portion 172 is a portion extending upward from head portion 171. Body portion 172 is in the shape of a circular column. The material of body portion 172 is copper, for example. Body portion 172 is inserted into a through-hole provided at the left end of movable contactor 13. With body portion 172 passing through the through-hole, first movable contact member 17 is fixed to movable contactor 13 by riveting. Thus, first movable contact member 17 is electrically connected to movable contactor 13.

[0056] Head portion 171 of first movable contact member 17 faces head portion 161 of first fixed contact member 16 in the up-to-down direction. Out of first movable contact member 17, head portion 171 functions as first movable contact M1 described above.

[0057] As illustrated in Fig. 8, first movable contact M1 is provided on movable contactor 13, near first end 131 of movable contactor 13. In the present disclosure, the sentence "first movable contact M1 is provided on movable contactor 13, near first end 131 of movable contactor 13" means that first movable contact M1 is provided on movable contactor 13 so that the ratio of predetermined distance L0 to first distance L1 fits within a predetermined range. Predetermined distance L0 is the distance between first end 131 of movable contactor 13 and first predetermined end M11 of first movable contact M1. First distance L1 is the distance between first predetermined end M11 and second predetermined end M12 of first movable contact M1. First predetermined end M11 is an end of first movable contact M1 that is closest to first end 131 of movable contactor 13 as viewed from above. Second predetermined end M12 is an end of first movable contact M1 that is farthest from first end 131 of movable contactor 13 as viewed from above. For example, when first movable contact M1 is disc-shaped, first distance L1 is the diameter of first movable contact M1. The upper limit of the predetermined range is a half (1/2), for example, and may be one third (1/3) or may be one fifth (1/5). The lower limit of the predetermined range

is one hundredth (1/100), for example, and may be one fiftieth (1/50) or may be one twentieth (1/20).

[0058] Second fixed contact member 18 is held on (fixed to) second fixed terminal 12. Second fixed contact member 18 is fixed to a left rear end of fixed piece 121 of second fixed terminal 12. Second fixed contact member 18 is fixed to a portion of second fixed terminal 12 that faces movable contactor 13.

[0059] As illustrated in Fig. 6, second fixed contact member 18 includes head portion 181 and body portion 182.

[0060] Head portion 181 is a portion of second fixed contact member 18 that is exposed upward from second fixed terminal 12. Head portion 181 is disc-shaped.

[0061] Body portion 182 is a portion extending downward from head portion 181. Body portion 182 is in the shape of a circular column. The material of body portion 182 is copper, for example. Body portion 182 is inserted into a through-hole provided in fixed piece 121 of second fixed terminal 12. With body portion 182 passing through the through-hole, second fixed contact member 18 is fixed to second fixed terminal 12 by riveting. Thus, second fixed contact member 18 is electrically connected to second fixed terminal 12.

[0062] Out of second fixed contact member 18, head portion 181 functions as second fixed contact F2 described above.

[0063] Second movable contact member 19 is held on (fixed to) movable contactor 13. Second movable contact member 19 is fixed to a right end of movable contactor 13. Second movable contact member 19 is fixed to a portion of movable contactor 13 that faces second fixed terminal 12.

[0064] As illustrated in Fig. 6, second movable contact member 19 includes head portion 191 and body portion 192.

[0065] Head portion 191 is a portion of second movable contact member 19 that is exposed downward from movable contactor 13. Head portion 191 is disc-shaped.

[0066] Body portion 192 is a portion extending upward from head portion 191. Body portion 192 is in the shape of a circular column. The material of body portion 192 is copper, for example. Body portion 192 is inserted into a through-hole provided at the right end of movable contactor 13. With body portion 192 passing through the through-hole, second movable contact member 19 is fixed to movable contactor 13 by riveting. Thus, second movable contact member 19 is electrically connected to movable contactor 13.

[0067] Head portion 191 of second movable contact member 19 faces head portion 181 of second fixed contact member 18 in the up-to-down direction. Out of second movable contact member 19, head portion 191 functions as second movable contact M2 described above.

[0068] As illustrated in Fig. 8, second movable contact M2 is provided on movable contactor 13, near second end 132 of movable contactor 13. In the present disclosure, the sentence "second movable contact M2 is pro-

vided on movable contactor 13, near second end 132 of movable contactor 13" means that second movable contact M2 and second end 132 have substantially the same positional relationship as the positional relationship between first movable contact M1 and first end 131.

[0069] In the present exemplary embodiment, each of first fixed contact F1 and first movable contact M1 is disc-shaped, and the diameter of first movable contact M1 is less than the diameter of first fixed contact F1. Each of second fixed contact F2 and second movable contact M2 is disc-shaped, and the diameter of second movable contact M2 is less than the diameter of second fixed contact F2.

[0070] In the following description, for the sake of explanation, first fixed contact F1, first movable contact M1, second fixed contact F2, and second movable contact M2 (specifically, head portion 161 of first fixed contact member 16, head portion 171 of first movable contact member 17, head portion 181 of second fixed contact member 18, and head portion 191 of second movable contact member 19) will also be referred to as "contact C1" when these are not particularly distinguished from each other.

[0071] As illustrated in Fig. 7, contact C1 includes pedestal member 101, surface member 102, and plated portion 103.

[0072] Pedestal member 101 is formed in the shape of a circular column. The material of pedestal member 101 is copper, for example. Pedestal member 101 may be formed integrally with body portion 162 (172, 182, 192), for example.

[0073] Surface member 102 is formed in the shape of a dome. Surface member 102 covers the entirety of one surface 1011 (the upper surface or the lower surface) of pedestal member 101 that is on the side on which said contact faces another corresponding contact. The phrase "another corresponding contact" refers to a contact facing contact C1 of interest in the up-to-down direction; for example, this is first movable contact M1 when contact C1 of interest is first fixed contact F1, and is first fixed contact F1 when contact C1 of interest is first movable contact M1. Surface member 102 may further cover side surface 1012 of pedestal member 101 partially or entirely. The material of surface member 102 is silver, a silver alloy, gold, or a gold alloy, for example. Surface member 102 is preferably made of a material that is less likely to be fused than the material of pedestal member 101.

[0074] Plated portion 103 is a coating that covers exposed surface 1021 of surface member 102. Plated portion 103 may cover the entirety of exposed surface 1021 of surface member 102. Plated portion 103 may further cover side surface 1012 of pedestal member 101 partially or entirely. The material of plated portion 103 is silver or gold, for example. Plated portion 103 is preferably made of a material that is less likely to be fused than the material of pedestal member 101.

[0075] Contact C1 (each of first fixed contact F1, first

movable contact M1, second fixed contact F2, and second movable contact M2) moves into contact with another corresponding contact at plated portion 103 or surface member 102 (mainly plated portion 103). The material of a portion of contact C1 that moves into contact with another corresponding contact (plated portion 103 or surface member 102) is different from the material of a metal member (first fixed terminal 11, second fixed terminal 12, or movable contactor 13) to which contact C1 of interest is fixed. Specifically, the material of a portion of first movable contact M1 that moves into contact with first fixed contact F1 (plated portion 103 or surface member 102) is different from the material of movable contactor 13. Furthermore, the material of a portion of first fixed contact F1 that moves into contact with first movable contact M1 (plated portion 103 or surface member 102) is different from the material of first fixed terminal 11. The same applies to second fixed contact F2 and second movable contact M2. A portion of contact C1 that moves into contact with another corresponding contact is preferably made of a material that is less likely to be fused than the material of the metal member to which contact C1 is fixed.

(1. 4) Auxiliary Contact Device

[0076] As illustrated in Fig. 2 and Fig. 3, auxiliary contact device 30 includes card 31, auxiliary fixed contact member 32, auxiliary movable contact member 33, auxiliary fixed terminal 34, auxiliary movable terminal 35, and auxiliary movable spring 36.

[0077] Card 31 is made of a resin, for example. Card 31 is fixed to first portion 221 of armature 22. Card 31 moves in the front-to-back direction together with first portion 221 of armature 22 according to displacement of armature 22. Card 31 is located relatively rearward when armature 22 assumes the first posture, and is located relatively forward when armature 22 assumes the second posture (refer to Fig. 4 and Fig. 5).

[0078] Card 31 integrally includes fixed portion 311 and projection 312.

[0079] Fixed portion 311 is a portion of card 31 that is fixed to armature 22. Fixed portion 311, which is U-shaped, includes claws at the front ends of opposite left and right arms of the letter U. When these claws of fixed portion 311 are hooked onto the front surface of first portion 221, card 31 is fixed to armature 22.

[0080] Projection 312 protrudes upward from fixed portion 311. As illustrated in Fig. 3, projection 312 protrudes to a level higher than the upper end of armature 22.

[0081] Auxiliary fixed terminal 34 is made of a conductive metal. Auxiliary fixed terminal 34 is in the shape of an approximately L-shaped plate. Auxiliary fixed terminal 34 integrally includes first piece 341, second piece 342, and terminal piece 340. Auxiliary fixed contact member 32 is provided at the left end of first piece 341, which is in the shape of a plate elongated in the left-to-right direction. Second piece 342 is in the shape of a plate extending

forward from the right end of first piece 341. Terminal piece 340 extends forward from the front end of second piece 342.

[0082] Auxiliary movable terminal 35 integrally includes connecting piece 351 and terminal piece 350. Connecting piece 351 is in the shape of a plate elongated in the front-to-back direction. Terminal piece 350 extends forward from the front end of connecting piece 351.

[0083] Auxiliary movable spring 36 is in the shape of a plate elongated in the left-to-right direction. The left end of auxiliary movable spring 36 is fixed to the rear end of connecting piece 351 of auxiliary movable terminal 35. Auxiliary movable contact member 33 is provided at the right end of auxiliary movable spring 36. Auxiliary movable contact member 33 faces auxiliary fixed contact member 32 in the front-to-back direction. As illustrated in Fig. 2, projection 312 of card 31 is located forward of auxiliary movable spring 36.

(1. 5) Casing

[0084] As illustrated in Fig. 1 and Fig. 2, casing 9 includes body 90 and cover 99.

[0085] As illustrated in Fig. 1 and Fig. 2, cover 99 is in the shape of a box, and more specifically is in the shape of a hollow rectangular box with one side (the front side) open. Cover 99 is made of a resin, for example. Cover 99 includes two rectangular engagement holes 991 at one end (the front end) of each of an upper wall and a lower wall (four rectangular engagement holes 991 in total).

[0086] Body 90 is made of a resin, for example. Body 90 holds contact device 10, electromagnet device 20, and auxiliary contact device 30.

[0087] As illustrated in Fig. 3, body 90 integrally includes bottom wall 91, peripheral wall 92, and partition wall 93.

[0088] Bottom wall 91 is in the shape of a rectangular plate having a thickness in the front-to-back direction.

[0089] Peripheral wall 92 is in the shape of a rectangular frame protruding rearward from an outer peripheral portion of bottom wall 91.

[0090] Partition wall 93 is in the form of an approximately U-shaped plate as viewed from the front. Partition wall 93 integrally includes: first wall 931 in the shape of a plate having a thickness in the up-to-down direction; two second walls 932 extending upward from opposite left and right ends of first wall 931; and two third walls 933 extending toward peripheral wall 92 in the left-to-right direction from the upper ends of two second walls 932. Partition wall 93 divides a rear space on bottom wall 91 as a first space at an upper level and a second space at a lower level. Coil 21 of electromagnet device 20 is disposed in the first space. Contact device 10 is disposed in the second space. Coil 21 and contact device 10 are spatially separated by partition wall 93.

[0091] Body 90 includes two engagement projections 921 on each of the upper and lower side surfaces of peripheral wall 92 (four engagement projections 921 in

total). Four engagement projections 921 of body 90 are inserted into four corresponding engagement holes 991 of cover 99, and thus cover 99 is joined to body 90.

[0092] As illustrated in Fig. 1 and Fig. 2, terminal piece 110 of first fixed terminal 11, terminal piece 120 of second fixed terminal 12, terminal pieces 260 of the pair of coil terminals 26, terminal piece 340 of auxiliary fixed terminal 34, and terminal piece 350 of auxiliary movable terminal 35 protrude forward from the front surface of body 90. These terminal pieces 110, 120, 260, 260, 340, 350 function as terminals that are connected to an external electrical circuit.

(1. 6) Operation of Electromagnetic Relay

[0093] In electromagnetic relay 100 according to the present exemplary embodiment, in the state where coil 21 is not energized, armature 22 assumes the first posture in which first portion 221 is away from iron core 24 by the elastic force of return spring 27. At this time, in contact device 10, movable contactor 13 is located at a relatively higher position, and first movable contact M1 and second movable contact M2 are separate from first fixed contact F1 and second fixed contact F2, respectively (the open state of contact device 10). Therefore, an electrical path (a main electrical path) between first fixed terminal 11 and second fixed terminal 12 is cut. Meanwhile, in auxiliary contact device 30, projection 312 of card 31 comes into contact with the front surface of auxiliary movable spring 36 and pushes up auxiliary movable spring 36 rearward. Thus, auxiliary movable contact member 33 is in contact with auxiliary fixed contact member 32. This forms an electrical path (an auxiliary electrical path) between auxiliary fixed terminal 34 and auxiliary movable terminal 35.

[0094] In electromagnetic relay 100, when coil 21 is energized and excited, first portion 221 of armature 22 is attracted to iron core 24 by magnetic force. As a result, armature 22 is displaced to the second posture in which first portion 221 is close to iron core 24 (refer to Fig. 4 and Fig. 5). At this time, in contact device 10, movable contactor 13 moves downward, and first movable contact M1 and second movable contact M2 move into contact with first fixed contact F1 and second fixed contact F2, respectively (the closed state of contact device 10). Thus, the electrical path (the main electrical path) between first fixed terminal 11 and second fixed terminal 12 is formed. At this time, movable contactor 13 is pushed down by the elastic force of coupling spring 143, meaning that the contact pressure of first movable contact M1 and second movable contact M2 against first fixed contact F1 and second fixed contact F2 improves. Meanwhile, in auxiliary contact device 30, projection 312 of card 31 is displaced forward and moves away from auxiliary movable spring 36. The right end of auxiliary movable spring 36 is displaced forward by the elastic force of auxiliary movable spring 36. As a result, auxiliary movable contact member 33 moves away from auxiliary fixed contact member 32, and the electrical path (the auxiliary elec-

trical path) between auxiliary fixed terminal 34 and auxiliary movable terminal 35 is cut.

[0095] In electromagnetic relay 100, when coil 21 is de-energized, iron core 24 is demagnetized, and armature 22 is displaced from the second posture to the first posture by the elastic force of return spring 27. At this time, in contact device 10, movable contactor 13 moves upward, and first movable contact M1 and second movable contact M2 move away from first fixed contact F1 and second fixed contact F2, respectively (the open state of contact device 10). Furthermore, in auxiliary contact device 30, projection 312 of card 31 is displaced rearward and pushes up the front surface of auxiliary movable spring 36 rearward from the front, bringing auxiliary movable contact member 33 into contact with auxiliary fixed contact member 32.

(1. 7) Details of Contact Device (Main Contact Device)

[0096] As described above, in electromagnetic relay 100, the electrical path (the main electrical path) between first fixed terminal 11 and second fixed terminal 12 is formed in the closed state of contact device 10. In the closed state, when a voltage is applied between first fixed terminal 11 and second fixed terminal 12, an electric current flows in the main electrical path.

[0097] In electromagnetic relay 100, in the state where the electric current flows in the main electrical path, when coil 21 is de-energized and first movable contact M1 moves away from first fixed contact F1, an electric arc may be generated between first fixed contact F1 and first movable contact M1. Furthermore, in electromagnetic relay 100, in the state where the electric current flows in the main electrical path, when coil 21 is de-energized and second movable contact M2 moves away from second fixed contact F2, an electric arc may be generated between second fixed contact F2 and second movable contact M2.

[0098] On the surface of contact C1, an area where an electric arc is generated first is basically a portion that has been in contact with the corresponding contact until the end of the displacement from the closed state to the open state, which may vary depending on the shape, etc., of the surface of the contact and thus cannot be uniquely determined. However, once an electric arc is generated, the Lorentz force due to a magnetic field produced by the electric current flowing in the main electrical path acts on the generated electric arc. Therefore, this electric arc moves along the surface of contact C1 in the direction of action of the Lorentz force. For example, when electric current I1 flows from first fixed terminal 11 toward second fixed terminal 12 through movable contactor 13 as illustrated in Fig. 9, the Lorentz force directed to the left due to the magnetic field directed forward that is produced by electric current I1 flowing to the right in movable contactor 13 acts on the electric arc (the electric current flowing upward) generated between first fixed contact F1 and first movable contact M1. Furthermore, also when an

electric current flows in movable contactor 13 in a direction opposite to the direction of electric current I1, the Lorentz force directed to the left that is due to the magnetic field directed rearward that is produced by the electric current flowing to the left in movable contactor 13 acts on the electric arc (the electric current flowing downward) generated between first fixed contact F1 and first movable contact M1. Therefore, the electric arc moves to the left on the surface of first fixed contact F1 and the surface of first movable contact M1 and reaches the left end of first fixed contact F1 and the left end of first movable contact M1. Since an electric arc is characterized by staying in an edge area, the electric arc that is generated between first fixed contact F1 and first movable contact M1 continues to be generated mainly between the left end of first fixed contact F1 and the left end of first movable contact M1. Therefore, the left end of first fixed contact F1 and the left end of first movable contact M1 are likely to be fused due to the electric arc, and the adherence due to the fusion of the contacts is likely to occur between the left end of first fixed contact F1 and the left end of first movable contact M1.

[0099] Furthermore, when the electric arc reaches movable contactor 13 beyond the end of first movable contact M1, movable contactor 13 may be fused. Moreover, when the electric arc reaches first fixed terminal 11 beyond the end of first fixed contact M1, first fixed terminal 11 may be fused. The metal material of movable contactor 13 or first fixed terminal 11 fused due to the electric arc may adhere to a surface of first movable contact M1 and/or a surface of first fixed contact F1. The metal material adhering to the surface of first movable contact M1 and/or the surface of first fixed contact F1 may cause first movable contact M1 and first fixed contact F1 to adhere to each other. Particularly, when the electric arc reaches movable contactor 13 or the end of first fixed terminal 11 (for example, first end 131 of movable contactor 13), the electric arc continues to act on an edge area at the boundary between a main surface and a side surface of movable contactor 13 or first fixed terminal 11, and therefore movable contactor 13 or first fixed terminal 11 is likely to be fused. Thus, when the electric arc reaches movable contactor 13 or the end of first fixed terminal 11, movable contactor 13 or first fixed terminal 11 is likely to be fused, and first fixed contact F1 and first movable contact M1 are likely to adhere to each other. Note that the term "adherence" in the present disclosure refers to the state where contacts remain in contact by the fusion of the contact materials or other materials (for example, movable contactor 13 and fixed terminal 11) between the contacts.

[0100] Thus, in order to reduce the possibility that first fixed contact F1 and first movable contact M1 may adhere to each other, contact device 10 according to the present exemplary embodiment uses the following structure.

[0101] Specifically, in contact device 10 according to the present exemplary embodiment, first movable con-

tact M1 is provided on movable contactor 13 (the movable member) so as to be located adjacent to first end 131 of movable contactor 13, as illustrated in Fig. 8. Furthermore, first movable contact M1 includes first predetermined end M11 that is closest to first end 131 of movable contactor 13 as viewed from above. As illustrated in Fig. 9, in the closed state, first predetermined end M11 is located between first end 131 of movable contactor 13 and first fixed contact F1 as viewed from above. Note that in Fig. 9, first fixed terminal 11 located below first fixed contact F1 (at the forward end of Fig. 9) is indicated by an imaginary line. More specifically, in the closed state, first predetermined end M11 of first movable contact M1 is located between first end 131 of movable contactor 13 and end F11 of first fixed contact F1 that is closest to first predetermined end M11 as viewed from above. In other words, a portion of first movable contact M1 in which the electric arc mainly stays (a portion on which the electric arc continues to act; an area near first predetermined end M11) is offset from a portion of first movable contact M1 that moves into contact with first fixed contact F1 (a portion that overlaps first fixed contact F1) as viewed from above. Thus, even when an electric arc is generated between first fixed contact F1 and first movable contact M1, a portion of first movable contact M1 where the electric arc mainly stays (continues to act on), near first predetermined end M11, is not in contact with first fixed contact F1, and therefore first fixed contact F1 and first movable contact M1 are less likely to be fused, meaning that first fixed contact F1 and first movable contact M1 are less likely to adhere to each other. Note that in the present disclosure, the sentence "the first element is located between the second element and the third element as viewed from above" means that the first element is located between the second element and the third element in a direction connecting the second element and the third element as viewed from above; the first element may be offset from the second element and the third element in a direction perpendicular to the direction connecting the second element and the third element as viewed from above.

[0102] Furthermore, as described above, the electric arc generated between first fixed contact F1 and first movable contact M1 when the state changes from the closed state to the open state may move on the surface of first movable contact M1 toward first end 131 of movable contactor 13 and reach movable contactor 13 beyond first predetermined end M11 of first movable contact M1. However, first fixed contact F1 (end F11 of first fixed contact F1) is at a distance of at least second distance L2 from first end 131 of movable contactor 13. Second distance L2 is the distance between first predetermined end M11 of first movable contact M1 and said end F11 of first fixed contact F1 in the closed state as viewed above. Therefore, even when the electric arc reaches first end 131 of movable contactor 13 beyond first predetermined end M11 of first movable contact M1 and movable contactor 13 is fused, the fused metal material is less likely to

reach first fixed contact F1. This reduces the likelihood that first fixed contact F1 and first movable contact M1 will adhere to each other even when first movable contact M1 is disposed adjacent to first end 131 of movable contactor 13.

[0103] To describe from another perspective, in contact device 10 according to the present exemplary embodiment, movable contactor 13 is formed long in one direction (the left-to-right direction), and first movable contact M1 is disposed adjacent to a longitudinal end (first end 131) of movable contactor 13. First predetermined end M11 of first movable contact M1 that is closest to first end 131 of movable contactor 13 as viewed from above is located between first end 131 of movable contactor 13 and first fixed contact F1 in the closed state as viewed from above. Specifically, in contact device 10, the positions of first fixed contact F1 and first movable contact M1 are offset in the left-to-right direction so that first predetermined end M11 of first movable contact M1 (the leading end of first movable contact M1 in a direction in which movable contactor 13 extends) is located between first end 131 of movable contactor 13 and first fixed contact F1 in the closed state as viewed from above. This reduces the likelihood that first fixed contact F1 and first movable contact M1 will adhere to each other.

[0104] Note that even in contact device 10 according to the present exemplary embodiment, part of the electric arc generated between first fixed contact F1 and first movable contact M1 may reach movable contactor 13 and fuse movable contactor 13. Therefore, after repeated changes between the closed state and the open state, the surface of a portion of first movable contact M1 that is closest to first end 131 of movable contactor 13 (near first predetermined end M11) is covered by a material that is the same as the material of movable contactor 13. When the state changes from the closed state to the open state while a large electric current having at least a predetermined value is flowing, even one change may cause movable contactor 13 to be fused. Therefore, the phrase "repeated changes between the closed state and the open state" in the present disclosure refers to at least one change from the closed state to the open state.

[0105] From the perspective of reducing the possibility that first fixed contact F1 and first movable contact M1 may adhere to each other, second distance L2 described above may be in the range of one twentieth ($1/20$) to a half ($1/2$) of first distance L1 described above. In contact device 10 according to the present exemplary embodiment, particularly, each of first fixed contact F1 and first movable contact M1 is disc-shaped. Second distance L2 described above is in the range of one twentieth ($1/20$) to a half ($1/2$) of the diameter of first movable contact M1. This makes it possible to further reduce the possibility that first fixed contact F1 and first movable contact M1 may adhere to each other.

[0106] As illustrated in Fig. 9, in contact device 10 according to the present exemplary embodiment, center of gravity G2 of the surface of first movable contact M1 is

located between center of gravity G1 of the surface of first fixed contact F1 and first end 131 of movable contactor 13 in the closed state as viewed from above. This makes it possible to further reduce the possibility that first fixed contact F1 and first movable contact M1 may adhere to each other. Note that in the present disclosure, the phrase "the center of gravity of the surface of a predetermined member as viewed from above" refers to the center of gravity of a geometric shape defined by the contour of the predetermined member as viewed from above, and matches the center of the surface of the predetermined member when the predetermined member is disc-shaped, for example.

[0107] In contact device 10 according to the present exemplary embodiment, third distance L3 is in the range of one twentieth (1/20) to a half (1/2) of first distance L1 described above. Third distance L3 is the distance between center of gravity G1 of the surface of first fixed contact F1 and center of gravity G2 of the surface of first movable contact M1 in the closed state as viewed from above (refer to Fig. 9). In contact device 10 according to the present exemplary embodiment, particularly, each of first fixed contact F1 and first movable contact M1 is disc-shaped, and third distance L3 is in the range of one twentieth (1/20) to a half (1/2) of the diameter of first movable contact M1. This makes it possible to further reduce the possibility that first fixed contact F1 and first movable contact M1 may adhere to each other.

[0108] In contact device 10 according to the present exemplary embodiment, in addition to the Lorentz force directed to the left that is due to the magnetic field produced by the electric current flowing in movable contactor 13 (for example, electric current I11 flowing to the right), the Lorentz force directed rearward that is due to the magnetic field by the electric current flowing in first fixed terminal 11 (for example, electric current I12 flowing rearward) acts on the electric arc generated between first fixed contact F1 and first movable contact M1. In view of this, in contact device 10 according to the present exemplary embodiment, first movable contact M1 is disposed adjacent to one end (rear end 133) of movable contactor 13 that is located in a direction in which first fixed terminal 11 formed long in one direction (the front-to-back direction) extends, as illustrated in Fig. 8 and Fig. 9. End M13 of first movable contact M1 that is closest to said one end (rear end 133) of movable contactor 13 as viewed from above is located between said one end (refer end 133) of movable contactor 13 and first fixed contact F1 in the closed state as viewed from above. Specifically, in contact device 10, the positions of first fixed contact F1 and first movable contact M1 are offset in the front-to-back direction so that rear end M13 of first movable contact M1 (the leading end of first movable contact M1 in the direction in which first fixed terminal 11 extends) is located between rear end 133 of movable contactor 13 and first fixed contact F1 in the closed state as viewed from above. This further reduces the likelihood that first fixed contact F1 and first movable contact M1 will adhere

to each other.

[0109] Furthermore, as illustrated in Fig. 8 and Fig. 9, in contact device 10 according to the present exemplary embodiment, the positions of second fixed contact F2 and second movable contact M2 are also set in consideration of the electric arc generated between second fixed contact F2 and second movable contact M2, similar to the positions of first fixed contact F1 and first movable contact M1. Specifically, in consideration of the Lorentz force directed to the right due to the electric current (for example, electric current I11) flowing in movable contactor 13 and acting on the electric arc generated between second fixed contact F2 and second movable contact M2, end M21 of second movable contact M2 that is closest to second terminal 132 of movable contactor 13 as viewed from above is located between second end 132 of movable contactor 13 and second fixed contact F2 in the closed state as viewed from above. Furthermore, in consideration of the Lorentz force directed rearward due to an electric current flowing in second fixed terminal 12 (for example, electric current I13 flowing forward) and acting on the electric arc described above, the positions of second movable contact M2 and second fixed contact F2 are offset in the front-to-back direction so that rear end M23 of second movable contact M2 (the leading end of second movable contact M2 in a direction in which second fixed terminal 12 extends) is located between rear end 134 of movable contactor 13 and second fixed contact F2 in the closed state as viewed from above. This reduces the likelihood that second fixed contact F2 and second movable contact M2 will adhere to each other.

[0110] Furthermore, in contact device 10 according to the present exemplary embodiment, distance L10 between center of gravity G1 of the surface of first fixed contact F1 and center of gravity G3 of the surface of second fixed contact F2 is less than distance L20 between center of gravity G2 of the surface of first movable contact M1 and center of gravity G2 of the surface of second movable contact M2, as illustrated in Fig. 8 and Fig. 9. This makes it possible to position first predetermined end M11 of first movable contact M1 between first end 131 of movable contactor 13 and first fixed contact F1 and position end M21 of second movable contact M2 between second end 132 of movable contactor 13 and second fixed contact F2. This further reduces the likelihood that first fixed contact F1 and first movable contact M1 will adhere to each other and second fixed contact F2 and second movable contact M2 will adhere to each other.

(2) Embodiment 2

[0111] Contact device 10 according to Embodiment 2 will be described with reference to Fig. 10 to Fig. 18. In contact device 10 according to the present exemplary embodiment, elements that are substantially the same as those in contact device 10 according to Embodiment 1 are assigned the same reference signs and description

thereof may be omitted.

(2. 1) Overall Configuration

[0112] As illustrated in Fig. 10 to Fig. 14, contact device 10 according to the present exemplary embodiment includes fixed contact F1, movable contact M1, fixed terminal 11, and movable spring 15 (the movable member).

[0113] Movable contact M1 moves into or out of contact with fixed contact F1 in the up-to-down direction. Movable contact M1 moves into contact with fixed contact F1 from above.

[0114] As illustrated in Fig. 10 to Fig. 14, fixed contact F1 is provided on fixed terminal 11. Movable contact M1 is provided on movable spring 15. Movable spring 15 includes movable portion 151 that is movable in the up-to-down direction. When movable portion 151 is displaced in the up-to-down direction with respect to fixed terminal 11, movable contact M1 moves into or out of contact with fixed contact F1.

[0115] Contact device 10 according to the present exemplary embodiment also constitutes at least a part of electromagnetic relay 100. As illustrated in Fig. 10 to Fig. 14, electromagnetic relay 100 further includes electromagnet device 20, auxiliary contact device 30, and casing 9, in addition to contact device (main contact device) 10.

(2. 2) Electromagnet Device

[0116] As illustrated in Fig. 11 to Fig. 14, electromagnet device 20 includes coil 21, armature 22, bobbin 23, iron core 24, yoke 25, a pair of coil terminals 26, and insulating member 28.

[0117] Bobbin 23 integrally includes cylinder 230, first flange 231, and second flange 232.

[0118] Cylinder 230 is in the shape of a hollow circular cylinder extending in the up-to-down direction.

[0119] First flange 231 is in the shape of a rectangular plate extending in the front-to-back and left-to-right directions from an upper edge of cylinder 230. Wall 236 protruding upward is provided at each of the right, left, and rear edges of the upper surface of first flange 231. Furthermore, protruding rib 237 elongated in the front-to-back direction is formed on the upper surface of each of left and right walls 236.

[0120] Second flange 232 is connected to the lower edge of cylinder 230. Second flange 232 is formed in the shape of a rectangular hollow box with the front side open.

[0121] Coil 21 is formed of a conducting wire wound on cylinder 230 of bobbin 23. The first end of coil 21 is connected to one of the pair of coil terminals 26, and the second end of coil 21 is connected to the other of the pair of coil terminals 26. Each of the pair of coil terminals 26 is held on second flange 232 of bobbin 23.

[0122] Iron core 24 is inserted into the space within cylinder 230 of bobbin 23. Flange 241 is provided at the

upper end of iron core 24, and small-diameter portion 242 is provided at the lower end of iron core 24.

[0123] Yoke 25 integrally includes first yoke 251 and second yoke 252. First yoke 251, which is plate-shaped, is located on the lower surface of second flange 232 of bobbin 23 and fixed to small-diameter portion 242 of iron core 24. Second yoke 252 is in the shape of a plate extending upward from the front end of first yoke 251.

[0124] Insulating member 28 is formed from a resin material. Insulating member 28 is disposed between bobbin 23 and yoke 25.

[0125] Insulating member 28 integrally includes: main body 281 located between the front side surface of coil 21 and second yoke 252 in the front-to-back direction; first cover 282 that covers a front end portion of first flange 231 of bobbin 23 from above; and second cover 283 that covers first yoke 251 from above, as illustrated in Fig. 14. Second cover 283 is inserted into the space within second flange 232 of bobbin 23 together with first yoke 251.

[0126] Armature 22 is plate-shaped. Armature 22 includes, at the front end thereof, projection 225 that protrudes forward.

[0127] Armature 22 is disposed so as to face the upper surface of flange 241 of iron core 24. Armature 22 is fixed to the lower surface of movable portion 151 of movable spring 15. As illustrated in Fig. 14, a portion of the lower surface of armature 22 comes into contact with the upper edge of second yoke 252.

[0128] In the state where coil 21 is not energized, armature 22 assumes the first posture in which armature 22 is away from iron core 24 by the elastic force of movable spring 15 (refer to Fig. 13). When a voltage is applied between the pair of coil terminals 26 and thus coil 21 is energized and excited, armature 22 is attracted to iron core 24 and rotates around an area in which armature 22 is in contact with second yoke 252. As a result, armature 22 assumes the second posture in which armature 22 is close to iron core 24 (refer to Fig. 15). According to whether coil 21 is energized or de-energized, armature 22 is displaced between the first posture and the second posture.

(2. 3) Contact Device (Main Contact Device)

[0129] Contact device 10 includes fixed terminal 11 and movable spring 15, as described above.

[0130] As illustrated in Fig. 11 to Fig. 13 and Fig. 16, fixed terminal 11 integrally includes: fixed piece 111 in the shape of a plate having a thickness in the up-to-down direction; center piece 112 extending downward from the rear end of fixed piece 111; and a pair of terminal pieces 110 extending downward from the lower end of center piece 112.

[0131] Through-hole 113 (refer to Fig. 16) is formed at the center of the connecting area between fixed piece 111 and center piece 112 of fixed terminal 11.

[0132] As illustrated in Fig. 11 to Fig. 13, movable

spring 15 integrally includes: movable portion 151 in the shape of a plate elongated in the front-to-back direction; extended portion 152 in the shape of a plate extending downward from the front end of movable portion 151; and a pair of terminal pieces 150 extending downward from the lower end of extended portion 152.

[0133] As illustrated in Fig. 12 and Fig. 13, armature 22 is fixed to the lower surface of movable portion 151, and movable portion 151 is displaced together with armature 22. A rear end area of movable portion 151 of movable spring 15 faces the upper surface of fixed piece 111 of fixed terminal 11. Extended portion 152 is fixed to the front surface of second yoke 252.

[0134] Through-hole 153 is formed at the center of the connecting area between movable portion 151 and extended portion 152 of movable spring 15.

[0135] Each of fixed terminal 11 and movable spring 15 is made of a metal. The material of each of first fixed terminal 11 and movable spring 15 is copper or a copper alloy, for example.

[0136] As illustrated in Fig. 11 to Fig. 14, contact device 10 further includes fixed contact member 16 and movable contact member 17.

[0137] Fixed contact member 16 is held on (fixed to) fixed terminal 11. Fixed contact member 16 is fixed to fixed piece 111 of fixed terminal 11. Fixed contact member 16 is fixed to a portion of fixed terminal 11 that faces movable portion 151 of movable spring 15.

[0138] Movable contact member 17 is held on (fixed to) movable spring 15. Movable contact member 17 is fixed to the rear end of movable portion 151 of movable spring 15. Movable contact member 17 is fixed to a part of movable portion 151 that faces fixed terminal 11.

[0139] In the present exemplary embodiment, each of head portion 161 of fixed contact member 16 that constitutes fixed contact F1 and head portion 171 of movable contact member 17 that constitutes movable contact M1 is disc-shaped. As illustrated in Fig. 13 and Fig. 15, the diameter of movable contact M1 is greater than the diameter of fixed contact F1. Therefore, the amount of displacement of fixed contact member 16 inward (forward) of movable contact member 17 can be reduced, as compared to when the diameter of movable contact M1 and the diameter of fixed contact F1 are the same or when the diameter of fixed contact F1 is greater than the diameter of movable contact M1.

[0140] The structures and materials of fixed contact member 16 and movable contact member 17 are substantially the same as those of first fixed contact member 16 and first movable contact member 17 of contact device 10 according to Embodiment 1 and therefore, description thereof will be omitted.

(2. 4) Auxiliary Contact Device

[0141] As illustrated in Fig. 11 to Fig. 14 and Fig. 17, auxiliary contact device 30 includes card 31, auxiliary fixed contact member 32, auxiliary movable contact

member 33, auxiliary fixed terminal 34, auxiliary movable terminal 35, and auxiliary movable spring 36.

[0142] Card 31 is fixed to projection 225 of armature 22. Card 31 moves in the up-to-down direction according to displacement of armature 22. Card 31 is located at a relatively lower position when armature 22 assumes the first posture (refer to Fig. 13), and is located at a relatively higher position when armature 22 assumes the second posture (refer to Fig. 15).

[0143] Card 31 integrally includes fixed portion 311, projection 312, and card wall 313.

[0144] Fixed portion 311 is a portion of card 31 that is fixed to projection 225 of armature 22. Fixed portion 311 is in the shape of a cylinder with the rear side open. When projection 225 is pressed into fixed portion 311, card 31 is fixed to armature 22.

[0145] Card wall 313 is in the shape of a rectangular plate. Card wall 313 is formed in the shape of a rectangular flange at the front end of fixed portion 311.

[0146] Projection 312 protrudes forward from the front surface of card wall 313.

[0147] Auxiliary fixed terminal 34 integrally includes first piece 341, second piece 342, and terminal piece 340. First piece 341 is in the shape of a plate having a thickness in the up-to-down direction, and auxiliary fixed contact member 32 is provided thereon. Second piece 342, which is L-shaped, is in the shape of a plate extending downward from the right end of first piece 341. Terminal piece 340 extends downward from the left end of second piece 342.

[0148] Auxiliary movable terminal 35 integrally includes connecting piece 351 and terminal piece 350. Connecting piece 351 is in the shape of a plate elongated in the up-to-down direction. Terminal piece 350 extends downward from the lower end of connecting piece 351.

[0149] Auxiliary movable spring 36 is in the shape of a plate elongated in the left-to-right direction. The right end of auxiliary movable spring 36 is fixed to the upper end of connecting piece 351 of auxiliary movable terminal 35. Auxiliary movable contact member 33 is provided at the left end of auxiliary movable spring 36. Auxiliary movable contact member 33 faces auxiliary fixed contact member 32 in the up-to-down direction. As illustrated in Fig. 11, projection 312 of card 31 is located below auxiliary movable spring 36. In order to increase the spatial distance between auxiliary fixed contact member 32 and contact point P1 between auxiliary movable spring 36 and projection 312 of card 31 (refer to Fig. 17), protrusion 361 that protrudes downward is provided on auxiliary movable spring 36.

(2. 5) Casing

[0150] Casing 9 includes first holding mount 94, second holding mount 95, and cover 99.

[0151] As illustrated in Fig. 12, first holding mount 94 is in the shape of a box with the front side open. First holding mount 94 holds fixed terminal 11. Fixed terminal 11 is held

on first holding mount 94 so that fixed piece 111 is located on the upper surface of first holding mount 94 and center piece 112 extends along the rear surface of first holding mount 94.

[0152] First holding mount 94 is joined to bobbin 23 in such a manner as to house the rear end of bobbin 23 via the open front side. Specifically, as illustrated in Fig. 14, engagement claw 238 provided at the rear end of the lower surface of second flange 232 of bobbin 23 is hooked into engagement hole 941 provided at the front end of the lower wall of first holding mount 94, and thus first holding mount 94 is joined to bobbin 23.

[0153] As illustrated in Fig. 12 to Fig. 14, second holding mount 95 is in the shape of a box with the rear side open. Second holding mount 95 holds auxiliary fixed terminal 34 and auxiliary movable terminal 35. Specifically, second piece 342 of auxiliary fixed terminal 34 is inserted into first holding groove 951 formed on the front surface of second holding mount 95, and thus auxiliary fixed terminal 34 is held on second holding mount 95. Furthermore, connecting piece 351 of auxiliary movable terminal 35 is inserted into second holding groove 952 formed on the front surface of second holding mount 95, and thus auxiliary movable terminal 35 is held on second holding mount 95. As illustrated in Fig. 17, second holding mount 95 includes wall 953 to increase the spatial distance between auxiliary fixed contact member 32 and contact point P1 between auxiliary movable spring 36 and projection 312 of card 31.

[0154] When engagement claws provided on the lower surface of the pair of projections 284 (refer to Fig. 12) protruding forward from the front surface of insulating member 28 are hooked into engagement holes 954 provided at the opposite left and right ends of the rear end of the lower wall of second holding mount 95, second holding mount 95 is joined to insulating member 28.

[0155] First holding mount 94, second holding mount 95, bobbin 23, and insulating member 28 are joined together and in this state, are fixed by resin member 96 (refer to Fig. 11 and Fig. 13). Resin member 96 is an adhesive, for example. First holding mount 94, second holding mount 95, bobbin 23, insulating member 28, and resin member 96 constitute body 90 that holds contact device 10, electromagnet device 20, and auxiliary contact device 30. The pair of terminal pieces 110 of fixed terminal 11, the pair of terminal pieces 150 of movable spring 15, terminal pieces 260 of the pair of coil terminals 26, terminal piece 340 of auxiliary fixed terminal 34, and terminal piece 350 of auxiliary movable terminal 35 protrude forward from the front surface of body 90.

[0156] As illustrated in Fig. 10 and Fig. 11, cover 99 is in the shape of a hollow box with the lower side open. Cover 99 is attached to body 90 so as to cover contact device 10, electromagnet device 20, and auxiliary contact device 30.

[0157] As illustrated in Fig. 14, cover wall 992 is provided on the lower surface of the upper wall of cover 99. With cover wall 992, auxiliary fixed contact member 32

and auxiliary movable contact member 33 can be separated from fixed contact F1 and movable contact M1, and the spatial distance and the total distance between auxiliary fixed contact member 32 (or auxiliary movable contact member 33) and fixed contact F1 (or movable contact M1) can be increased.

[0158] As illustrated in Fig. 17, first rib 993, second rib 994, and third rib 995 that connect the rear surface of the front wall of cover 99 and the front surface of cover wall 992 are provided on the upper surface of a front end of cover 99.

[0159] First rib 993 is provided between auxiliary fixed contact member 32 and contact point P1 between auxiliary movable spring 36 and projection 312 of card 31. First rib 993 faces wall 953 of second holding mount 95 in the up-to-down direction.

[0160] Second rib 994 and third rib 995 are provided on the left side and the right side, respectively, of the upper end of connecting piece 351 of auxiliary movable terminal 35 (the portion to which auxiliary movable spring 36 is fixed).

[0161] For example, if electromagnetic relay 100 with the upper or lower side surface facing vertically down falls to the ground, auxiliary movable spring 36 may deform and be curved in the up-to-down direction due to the impact of the fall. In this regard, in electromagnetic relay 100, as a result of first rib 993 and second rib 994 being provided on cover 99, when auxiliary movable spring 36 is curved upward, at least one of first rib 993 and second rib 994 comes into contact with auxiliary movable spring 36 to prevent auxiliary movable spring 36 from being excessively curved upward. Thus, deformation of auxiliary movable spring 36 is reduced. From the perspective of reducing the deformation of auxiliary movable spring 36 that occurs when electromagnetic relay 100 falls, it is sufficient that electromagnetic relay 100 include at least one of first rib 993 and second rib 994.

[0162] Furthermore, if electromagnetic relay 100 with the right or left side surface facing vertically down falls to the ground, auxiliary movable terminal 35 may deform and be curved in the left-to-right direction due to the impact of the fall. In this regard, in electromagnetic relay 100, as a result of second rib 994 and third rib 995 being provided on cover 99, when auxiliary movable terminal 35 is about to be curved in the left-to-right direction, second rib 994 or third rib 995 comes into contact with auxiliary movable terminal 35 to prevent auxiliary movable terminal 35 from being curved. Thus, deformation of auxiliary movable terminal 35 is reduced.

[0163] Note that although third rib 995 is formed integrally with a right side wall of cover 99, there may be spacing between third rib 995 and the right side wall of cover 99.

(2. 6) Operation of Electromagnetic Relay

[0164] In electromagnetic relay 100 according to the present exemplary embodiment, when coil 21 is not

energized, armature 22 assumes the first posture in which armature 22 is away from iron core 24 by the elastic force of movable spring 15 (refer to Fig. 13). At this time, in contact device 10, movable contact M1 is away from fixed contact F1 (the open state of contact device 10). Therefore, the electrical path (the main electrical path) between fixed terminal 11 and movable spring 15 is cut. Meanwhile, in auxiliary contact device 30, auxiliary movable contact member 33 is located at a relatively lower position by the elastic force of auxiliary movable spring 36, and auxiliary movable contact member 33 is in contact with auxiliary fixed contact member 32. This forms the electrical path (the auxiliary electrical path) between auxiliary fixed terminal 34 and auxiliary movable terminal 35.

[0165] In electromagnetic relay 100, when coil 21 is energized and excited, armature 22 is attracted to iron core 24 by magnetic force. As a result, armature 22 is displaced to the second posture in which armature 22 is close to iron core 24 (refer to Fig. 15). At this time, in contact device 10, the rear end of movable portion 151 of movable spring 15 moves downward, and movable contact M1 moves into contact with fixed contact F1 (the closed state of contact device 10). Therefore, the electrical path (the main electrical path) between first fixed terminal 11 and movable spring 15 is formed. Meanwhile, in auxiliary contact device 30, projection 312 of card 31 is displaced upward, comes into contact with auxiliary movable spring 36 from below, and pushes up auxiliary movable spring 36. Accordingly, auxiliary movable contact member 33 provided at the left end of auxiliary movable spring 36 moves away from auxiliary fixed contact member 32, and the electrical path (the auxiliary electrical path) between auxiliary fixed terminal 34 and auxiliary movable terminal 35 is cut.

[0166] In electromagnetic relay 100, when coil 21 is de-energized, iron core 24 is demagnetized, and armature 22 is displaced from the second posture to the first posture by the elastic force of movable spring 15. At this time, in contact device 10, the rear end of movable portion 151 of movable spring 15 moves upward, and movable contact M1 moves away from fixed contact F1 (the open state of contact device 10). Furthermore, in auxiliary contact device 30, projection 312 of card 31 is displaced downward and moves away from auxiliary movable spring 36, and auxiliary movable contact member 33 moves into contact with auxiliary fixed contact member 32 from above by the elastic force of auxiliary movable spring 36.

[0167] As illustrated in Fig. 11 to Fig. 14, electromagnetic relay 100 further includes auxiliary member 98. Auxiliary member 98, which is in the approximate shape of letter "L," is held on first holding mount 94. Dummy member D1 is provided on the lower surface of auxiliary member 98 so that movable contact member 17 is located between fixed contact member 16 and auxiliary member 98. At the time when movable contact M1 moves away from fixed contact F1 as a result of displacement of

armature 22 from the second posture to the first posture, dummy member D1 comes into contact with the upper surface of movable contact member 17 and prevents further upward movement of movable contact member 17. Thus, dummy member D1 defines an open position that is farthest away from fixed contact F1 within the range of movement of movable contact M1.

(2. 7) Details of Contact Device (Main Contact Device)

[0168] Even in electromagnetic relay 100 according to the present exemplary embodiment, in the state where the electric current flows in the main electrical path, when coil 21 is de-energized and movable contact M1 moves away from fixed contact F1, electric arc A1 (refer to Fig. 18) may be generated between fixed contact F1 and movable contact M1.

[0169] In electromagnetic relay 100 according to the present exemplary embodiment, for example, when electric current I2 directed to movable spring 15 flows from fixed terminal 11 through fixed contact F1 and movable contact M1 as illustrated in Fig. 15, the Lorentz force directed rearward that is due to the magnetic field directed to the left that is produced by electric current I21 flowing upward in center piece 112 of fixed terminal 11 and the Lorentz force directed rearward that is due to the magnetic field directed to the left that is produced by electric current I22 flowing forward in movable portion 151 of movable spring 15 act on electric arc A1 generated between fixed contact F1 and movable contact M1 (the electric current flowing upward). Furthermore, when an electric current flows in fixed terminal 11 and movable spring 15 in a direction opposite to the direction of electric current I2, the Lorentz force directed rearward acts on electric arc A1 generated between fixed contact F1 and movable contact M1 (the electric current flowing downward). Therefore, in the area between fixed contact F1 and movable contact M1, electric arc A1 is continuously generated mainly between the rear end of fixed contact F1 and the rear end of movable contact M1, as illustrated in Fig. 18.

[0170] In view of this, in contact device 10 according to the present exemplary embodiment, movable contact M1 is provided on movable spring 15 so as to be adjacent to first end 155 of movable spring 15 (the movable member), as illustrated in Fig. 19. Out of movable contact M1, first predetermined end M11 located closest to first end 155 of movable spring 15 as viewed from above is located between first end 155 of movable spring 15 and fixed contact F1 in the closed state as viewed from above. As a result, even when electric arc A1 is generated between fixed contact F1 and movable contact M1, because a portion of movable contact M1 that is located near first predetermined end M11 on which electric arc A1 mainly stays (continuously acts) is not in contact with fixed contact F1, movable contact M1 and fixed contact F1 are less likely to be fused, meaning that fixed contact F1 and movable contact M1 are less likely to adhere to each

other. Note that in Fig. 19, fixed terminal 11 located below fixed contact F1 (at the forward end of Fig. 19) is indicated by an imaginary line.

[0171] Furthermore, since an electric arc is characterized by staying in an edge area and movable contact M1 is located outside (rearward) of fixed contact F1, electric arc A1 stays in such a manner as to connect the end (rear end) of fixed contact F1 and movable contact M1. In other words, in contact device 10 according to the present exemplary embodiment, electric arc A1 is less likely to travel to movable spring 15 as a result of the end of movable contact M1 being offset outward (rearward) from the end of fixed contact F1. As a result, movable spring 15 is less likely to be fused, meaning that fixed contact F1 and movable contact M1 are even less likely to adhere to each other.

[0172] Furthermore, electric arc A1 generated between fixed contact F1 and movable contact M1 at the time of change from the closed state to the open state may move on the surface of movable contact M1 toward first end 155 of movable spring 15 and reach movable spring 15 beyond first predetermined end M11 of movable contact M1. However, fixed contact F1 is at a distance of at least second distance L2 from first end 155 of movable spring 15. Second distance L2 is the distance between first predetermined end M11 of movable contact M1 and end F1 1 of fixed contact F1 that is closest to first predetermined end M11 in the closed state as viewed from above (refer to Fig. 19). Therefore, even when electric arc A1 reaches first end 155 of movable spring 155 beyond first predetermined end M11 of movable contact M1 and movable spring 15 is fused, the fused metal material is less likely to reach fixed contact F1. This reduces the likelihood that fixed contact F1 and movable contact M1 will adhere to each other even when movable contact M1 is disposed adjacent to first end 155 of movable spring 15.

[0173] From the perspective of reducing the possibility that fixed contact F1 and movable contact M1 may adhere to each other, second distance L2 may be in the range of one twentieth ($1/20$) to a half ($1/2$) of first distance L1. First distance L1 is the distance between first predetermined end M11 of movable contact M1 and second predetermined end M12 of movable contact M1 that is farthest from first end 155 of movable spring 15 as viewed from above (refer to Fig. 19).

[0174] Center of gravity G2 of the surface of movable contact M1 is preferably located between center of gravity G1 of the surface of fixed contact F1 and first end 155 of movable spring 15 in the closed state as viewed from above. Third distance L3 is preferably in the range of one twentieth ($1/20$) to a half ($1/2$) of first distance L1. Third distance L3 is the distance between center of gravity G1 of the surface of fixed contact F1 and center of gravity G2 of the surface of movable contact M1 in the closed state as viewed from above.

[0175] Even in contact device 10 according to the present exemplary embodiment, part of electric arc A1

generated between fixed contact F1 and movable contact M1 reaches movable spring 15 and causes movable spring 15 to be fused. Therefore, after repeated changes between the closed state and the open state, a portion of movable contact M1 that is closest to first end 155 of movable spring 15 (near first predetermined end M11) is covered by a material that is the same as the material of movable spring 15.

[0176] Note that in contact device 10 according to the present exemplary embodiment, fixed contact F1 is provided in an area of fixed piece 111 that is at the center in the left-to-right direction, and through-hole 113 is formed in fixed terminal 11. Therefore, fixed piece 111 passes an electric current directed to the right, for example, that flows in a portion of fixed piece 111 that is on the left side of fixed contact F1, and an electric current directed to the left, for example, that flows in a portion of fixed piece 111 that is on the right side of fixed contact F1. As a result, in the Lorentz force that acts on electric arc A1 due to the electric current flowing in fixed piece 111, a component based on the electric current flowing in a portion of fixed piece 111 that is on the right side of fixed contact F1 and a component based on the electric current flowing in a portion of fixed piece 111 that is on the left side of fixed contact F1 are canceled out. For this reason, in contact device 10 according to the present exemplary embodiment, movable contact M1 and fixed contact F1 are arranged so that in the left-to-right direction, the positions thereof are not offset and the centers thereof match each other, as illustrated in Fig. 16.

(3) Variations

[0177] Each of the above-described exemplary embodiments is merely one of various exemplary embodiments of the present disclosure. Various changes can be made to the above-described exemplary embodiments according to the design or the like as long as the object of the present disclosure can be achieved. Variations of the exemplary embodiments will be described below. The above-described exemplary embodiments and the variations described below can be combined and used, as appropriate.

(3. 1) Variation 1

[0178] Contact device 10 according to the present variation will be described with reference to Fig. 20. There are cases where elements of contact device 10 according to the present variation that are substantially the same as those of contact device 10 according to Embodiment 1 described above will be omitted, as appropriate.

[0179] In contact device 10 according to the present variation, movable contactor 13 is located below fixed terminal 11, and movable contact M1 moves into contact with fixed contact F1 from below. Fixed contact F1 is provided on fixed terminal 11 so as to be adjacent to first end 115 of fixed terminal 11. Fixed contact F1 includes

predetermined end F101 that is closest to first end 115 of fixed terminal 11 as viewed from above. As illustrated in Fig. 20, in the closed state where fixed contact F1 and movable contact M1 are in contact, predetermined end F101 is located between first end 115 of fixed terminal 11 and movable contact M1 as viewed from above. Note that in Fig. 20, movable contactor 13 located below movable contact M1 (at the forward end of Fig. 20) is indicated by an imaginary line.

[0180] In other words, in contact device 10 according to the present variation, fixed terminal 11 is formed long in one direction (the front-to-back direction), and fixed contact F1 is disposed adjacent to a longitudinal end (first end 155) of fixed terminal 11. Out of fixed contact F1, predetermined end F101 that is closest to first end 155 of fixed terminal 11 as viewed from above is located between first end 155 of fixed terminal 11 and movable contact M1 in the closed state as viewed from above. Specifically, in contact device 10, the positions of fixed contact F1 and movable contact M1 are offset in the front-to-back direction so that predetermined end F101 of fixed contact F1 (the leading end of fixed contact F1 in a direction in which fixed terminal 11 extends) is located between first end 155 of fixed terminal 11 and movable contact M1 in the closed state as viewed from above. This reduces the likelihood that fixed contact F1 and movable contact M1 will adhere to each other.

[0181] As illustrated in Fig. 20, center of gravity G1 of the surface of fixed contact F1 is located between center of gravity G2 of the surface of movable contact M1 and first end 115 of fixed terminal 11 in the closed state as viewed from above.

[0182] In contact device 10 according to the present variation, fixed contact F1 is disposed adjacent to one end (left end 116) of fixed terminal 11 in the direction in which movable contactor 13 formed long in one direction (the left-to-right direction) extends. End F 102 of fixed contact F1 that is closest to said one end (left end 116) of fixed terminal 11 as viewed from above is located between said one end (left end 116) of fixed terminal 11 and movable contact M1 in the closed state as viewed from above. Specifically, in contact device 10, the positions of fixed contact F1 and movable contact M1 are offset in the left-to-right direction so that left end F102 of fixed contact F1 (the leading end of fixed contact F1 in the direction in which movable contactor 13 extends) is located between left end 116 of fixed terminal 11 and movable contact M1 in the closed state as viewed from above. This further reduces the likelihood that fixed contact F1 and movable contact M1 will adhere to each other.

[0183] In essence, contact device 10 preferably has the following structure. Specifically, contact device 10 includes: a first contact (one of fixed contact F1 and movable contact M1); a second contact (the other of fixed contact F1 and movable contact M1); and a first member made of a metal (movable contactor 13, movable spring 15, or fixed terminal 11). The second contact moves into or out of contact with the first contact in the up-to-down

direction. On the first member, a second contact is disposed adjacent to a first end (131, 151, or 116) of the first member. The second contact includes a first predetermined end (M11 or F101) that is closest to the first end of the first member as viewed from above. In the closed state where the first contact and the second contact are in contact, the first predetermined end of the second contact is located between the first end of the first member and the first contact as viewed from above.

(3. 2) Other Variations

[0184] In one variation, the diameter of movable contact M1 may be set greater than the diameter of fixed contact F1 so that first predetermined end M11 of movable contact M1 is located between first end 131 or 155 of the movable member (movable contactor 13 or movable spring 15) and fixed contact F1 in the closed state as viewed from above. In this case, center of gravity G2 of the surface of movable contact M1 may overlap (match) center of gravity G1 of the surface of fixed contact F1 in the closed state as viewed from above.

[0185] In one variation, contact C1 (fixed contacts F1, F2 and movable contacts M1, M2) is not limited to being disc-shaped and may have another shape. For example, contact C1 may be in the shape of a plate that is rectangular as viewed from above with lower surface 105 being flat and upper surface 106 approaching lower surface 105 toward opposite left and right (or front and rear) ends 107, 108 so that the thickness of the plate is reduced, as illustrated in Fig. 21A to Fig. 21C. Even in this case, contact C1 may include pedestal member 101, surface member 102, and plated portion 103.

[0186] In one variation, each of first fixed contact F1, first movable contact M1, second fixed contact F2, and second movable contact M2 does not necessarily need to include both surface member 102 and plated portion 103 and may include only one of surface member 102 and plated portion 103.

[0187] In one variation, the structure of electromagnetic relay 100 including contact device 10 is not limited to the structures according to Embodiments 1, 2, and electromagnetic relay 100 may have any appropriate structure.

(4) Aspects

[0188] As is clear from the embodiments and variations described above, the present specification discloses the following aspects.

[0189] A contact device (10) according to the first aspect includes a fixed contact (F 1), a movable contact (M1), and a movable member (movable contactor 13; movable spring 15). The movable contactor (M1) moves into or out of contact with the fixed contact (F1) in an up-to-down direction. The movable member is made of a metal, and the movable contact (M1) is disposed adjacent to a first end (131; 155) of the movable member. The

movable contact (M1) includes a first predetermined end (M11) that is closest to the first end (131; 155) of the movable member as viewed from above. In a closed state where the fixed contact (F1) and the movable contact (M1) are in contact with each other, the first predetermined end (M11) of the movable contact (M1) is located between the first end (131; 155) of the movable member and the fixed contact (F1) as viewed from above.

[0190] According to this aspect, it is possible to reduce the possibility that the fixed contact (F1) and the movable contact (M1) may adhere to each other.

[0191] In the contact device (10) according to the second aspect, in the first aspect, a material of a portion of the movable contact (M1) that moves into contact with the fixed contact (F1) is different from a material of the movable member (movable contactor 13; movable spring 15).

[0192] According to this aspect, it is possible to further reduce the possibility that the fixed contact (F1) and the movable contact (M1) may adhere to each other.

[0193] In the contact device (10) according to the third aspect, in the first or second aspect, an electric arc generated between the fixed contact (F1) and the movable contact (M1) upon changing from the closed state to an open state moves on a surface of the movable contact (M1) toward the first end (131; 155). The open state is a state where the fixed contact (F1) and the movable contact (M1) are out of contact with each other.

[0194] According to this aspect, it is possible to further reduce the possibility that the fixed contact (F1) and the movable contact (M1) may adhere to each other.

[0195] In the contact device (10) according to the fourth aspect, in any one of the first to third aspects, a center of gravity (G2) of a surface of the movable contact (M1) is located between a center of gravity (G1) of a surface of the fixed contact (F1) and the first end (131; 155) of the movable member (movable contactor 13; movable spring 15) in the closed state as viewed from above.

[0196] According to this aspect, it is possible to further reduce the possibility that the fixed contact (F1) and the movable contact (M1) may adhere to each other.

[0197] In the contact device (10) according to the fifth aspect, in the fourth aspect, the movable contact (M1) includes a second predetermined end (M12) that is farthest from the first end (131; 155) of the movable member (movable contactor 13; movable spring 15) as viewed from above. A distance (third distance L3) between the center of gravity (G1) of the surface of the fixed contact (F1) and the center of gravity (G2) of the surface of the movable contact (M1) is in the range of one twentieth (1/20) to a half (1/2) of a distance (first distance L1) between the first predetermined end (M11) of the movable contact (M1) and the second predetermined end (M12) of the movable contact (M1) in the closed state as viewed from above.

[0198] According to this aspect, it is possible to further reduce the possibility that the fixed contact (F1) and the movable contact (M1) may adhere to each other.

[0199] In the contact device (10) according to the sixth aspect, in the fifth aspect, each of the fixed contact (F1) and the movable contact (M1) is disc-shaped. A distance (third distance L3) between a center of the surface of the fixed contact (F1) and a center of the surface of the movable contact (M1) is in the range of one twentieth (1/20) to a half (1/2) of a diameter of the movable contact (M1) in the closed state as viewed from above.

[0200] According to this aspect, it is possible to further reduce the possibility that the fixed contact (F1) and the movable contact (M1) may adhere to each other.

[0201] In the contact device (10) according to the seventh aspect, in any one of the first to fourth aspects, the movable contact (M1) includes a second predetermined end (M12) that is farthest from the first end (131; 155) of the movable member (movable contactor 13; movable spring 15) as viewed from above. A distance (second distance L2) between an end (F11) of the fixed contact (F1) that is closest to the first predetermined end and the first predetermined end (M11) of the movable contact (M1) is in the range of one twentieth (1/20) to a half (1/2) of a distance (first distance L1) between the first predetermined end (M11) and the second predetermined end (M12) of the movable contact (M1) in the closed state as viewed from above.

[0202] According to this aspect, it is possible to further reduce the possibility that the fixed contact (F1) and the movable contact (M1) may adhere to each other.

[0203] In the contact device (10) according to the eighth aspect, in the seventh aspect, each of the fixed contact (F1) and the movable contact (M1) is disc-shaped. The distance (second distance L2) between the first predetermined end (M11) of the movable contact (M1) and the end (F11) of the fixed contact (F1) that is closest to the first predetermined end (M11) is in the range of one twentieth (1/20) to a half (1/2) of a diameter of the movable contact (M1) in the closed state as viewed from above.

[0204] According to this aspect, it is possible to further reduce the possibility that the fixed contact (F1) and the movable contact (M1) may adhere to each other.

[0205] In the contact device (10) according to the ninth aspect, in any one of the first to eighth aspects, each of the fixed contact (F1) and the movable contact (M1) is disc-shaped. A diameter of the movable contact (M1) is greater than a diameter of the fixed contact (F1).

[0206] According to this aspect, it is possible to further reduce the possibility that the fixed contact (F1) and the movable contact (M1) may adhere to each other. Furthermore, the amount of displacement of the fixed contact member (16) inward of the movable contact member (17) can be reduced, as compared to when the diameter of the movable contact (M1) is the same as the diameter of the fixed contact (F1) or when the diameter of the fixed contact (F1) is greater than the diameter of the movable contact (M1).

[0207] The contact device (10) according to the tenth aspect further includes a second fixed contact (F2) and a

second movable contact (M2) in any one of the first to ninth aspects. The second fixed contact (F2) is disposed side by side with the first fixed contact (F1). The second movable contact (M2) moves into or out of contact with the second fixed contact (F2) in the up-to-down direction. The second movable contact (M2) is disposed adjacent to a second end of the movable member (movable contactor 13) that is located on an opposite side from the first end (131; 155). A distance (L10) between a center of gravity (G1) of a surface of the first fixed contact (F1) and a center of gravity (G3) of a surface of the second fixed contact (F2) is less than a distance (L20) between a center of gravity (G2) of a surface of the first movable contact (M1) and a center of gravity (G4) of a surface of the second movable contact (M2).

[0208] According to this aspect, it is possible to reduce the possibility that the first fixed contact (F1) and the first movable contact (M1) may adhere to each other and the second fixed contact (F2) and the second movable contact (M2) may adhere to each other.

[0209] In the contact device (10) according to the eleventh aspect, in any one of the first to tenth aspects, a portion of the movable contact (M1) that is closest to the first end (131; 155) is covered by a material that is the same as a material of the movable member (movable contactor 13; movable spring 15).

[0210] According to this aspect, it is possible to further reduce the possibility that the fixed contact (F1) and the movable contact (M1) may adhere to each other.

[0211] A contact device (10) according to the twelfth aspect includes: a fixed contact (F1); a movable contact (M1); and a fixed terminal (11). The movable contact (M1) moves into or out of contact with the fixed contact (F1) in an up-to-down direction. The fixed terminal (11) is made of a metal, and the fixed contact (F1) is disposed adjacent to a first end (115) of the first terminal (11). The fixed contact (F1) includes a predetermined end (F101) that is closest to the first end (115) of the first terminal (11) as viewed from above. In a closed state where the fixed contact (F1) and the movable contact (M1) are in contact, the predetermined end (F101) of the fixed contact (F1) is located between the first end (115) of the fixed terminal (11) and the movable contact (M1) as viewed from above.

[0212] According to this aspect, it is possible to reduce the possibility that the fixed contact (F1) and the movable contact (M1) may adhere to each other.

Reference Signs List

[0213]

10	contact device (main contact device)
11	fixed terminal
115	first end
13	movable contactor (movable member)
131	first end
15	movable spring (movable member)
155	first end

F1	fixed contact (first fixed contact)
F11	end
F101	predetermined end
F2	second fixed contact
5 M1	movable contact (first movable contact)
M11	first predetermined end
M12	second predetermined end
M2	second movable contact
G1	center of gravity
10 G2	center of gravity
G3	center of gravity
G4	center of gravity
L1	distance (first distance)
L2	distance (second distance)
15 L3	distance (third distance)
L10	distance
L20	distance

Claims

1. A contact device comprising:

a first fixed contact;
a first movable contact that moves into or out of contact with the first fixed contact in an up-to-down direction; and
a movable member made of a metal and including a first end adjacent to which the first movable contact is disposed, wherein
the first movable contact includes a first predetermined end that is closest to the first end of the movable member as viewed from above, and
in a closed state where the first fixed contact and the first movable contact are in contact with each other, the first predetermined end of the first movable contact is located between the first end of the movable member and the first fixed contact as viewed from above.

2. The contact device according to claim 1, wherein a material of a portion of the first movable contact that moves into contact with the first fixed contact is different from a material of the movable member.

3. The contact device according to claim 1 or 2, wherein an electric arc generated between the first fixed contact and the first movable contact upon changing from the closed state to an open state where the first fixed contact and the first movable contact are out of contact with each other moves on a surface of the first movable contact toward the first end of the movable member.

4. The contact device according to any one of claims 1 to 3, wherein a center of gravity of a surface of the first movable contact is located between a center of gravity of a surface of the first fixed contact and the first end of

the movable member in the closed state as viewed from above.

5. The contact device according to claim 4, wherein

the first movable contact includes a second predetermined end that is farthest from the first end of the movable member as viewed from above, and
a distance between the center of gravity of the surface of the first fixed contact and the center of gravity of the surface of the first movable contact is in a range of one twentieth to a half of a distance between the first predetermined end of the first movable contact and the second predetermined end of the first movable contact in the closed state as viewed from above.

6. The contact device according to claim 5, wherein

each of the first fixed contact and the first movable contact is disc-shaped, and
a distance between a center of the surface of the first fixed contact and a center of the surface of the first movable contact is in a range of one twentieth to a half of a diameter of the first movable contact in the closed state as viewed from above.

7. The contact device according to any one of claims 1 to 4, wherein

the first movable contact includes a second predetermined end that is farthest from the first end of the movable member as viewed from above, and
a distance between an end of the first fixed contact that is closest to the first predetermined end and the first predetermined end of the first movable contact is in a range of one twentieth to a half of a distance between the first predetermined end and the second predetermined end of the first movable contact in the closed state as viewed from above.

8. The contact device according to claim 7, wherein

each of the first fixed contact and the first movable contact is disc-shaped, and
the distance between the first predetermined end of the first movable contact and the end of the first fixed contact that is closest to the first predetermined end is in a range of one twentieth to a half of a diameter of the first movable contact in the closed state as viewed from above.

9. The contact device according to any one of claims 1 to 8, wherein

each of the first fixed contact and the first movable contact is disc-shaped, and
a diameter of the first movable contact is greater than a diameter of the first fixed contact.

10. The contact device according to any one of claims 1 to 9, further comprising:

a second fixed contact disposed side by side with the first fixed contact; and
a second movable contact that moves into or out of contact with the second fixed contact in the up-to-down direction, wherein
the second movable contact is disposed adjacent to a second end of the movable member, the second end being located on an opposite side from the first end, and
a distance between a center of gravity of a surface of the first fixed contact and a center of gravity of a surface of the second fixed contact is less than a distance between a center of gravity of a surface of the first movable contact and a center of gravity of a surface of the second movable contact.

11. The contact device according to any one of claims 1 to 10, wherein

a portion of the first movable contact that is closest to the first end of the movable member is covered by a material that is the same as a material of the movable member.

12. A contact device comprising:

a fixed contact;
a movable contact that moves into or out of contact with the fixed contact in an up-to-down direction; and
a fixed terminal made of a metal and including a first end adjacent to which the fixed contact is disposed, wherein
the fixed contact includes a predetermined end that is closest to the first end of the fixed terminal as viewed from above, and
in a closed state where the fixed contact and the movable contact are in contact, the predetermined end of the fixed contact is located between the first end of the fixed terminal and the movable contact as viewed from above.

FIG. 1

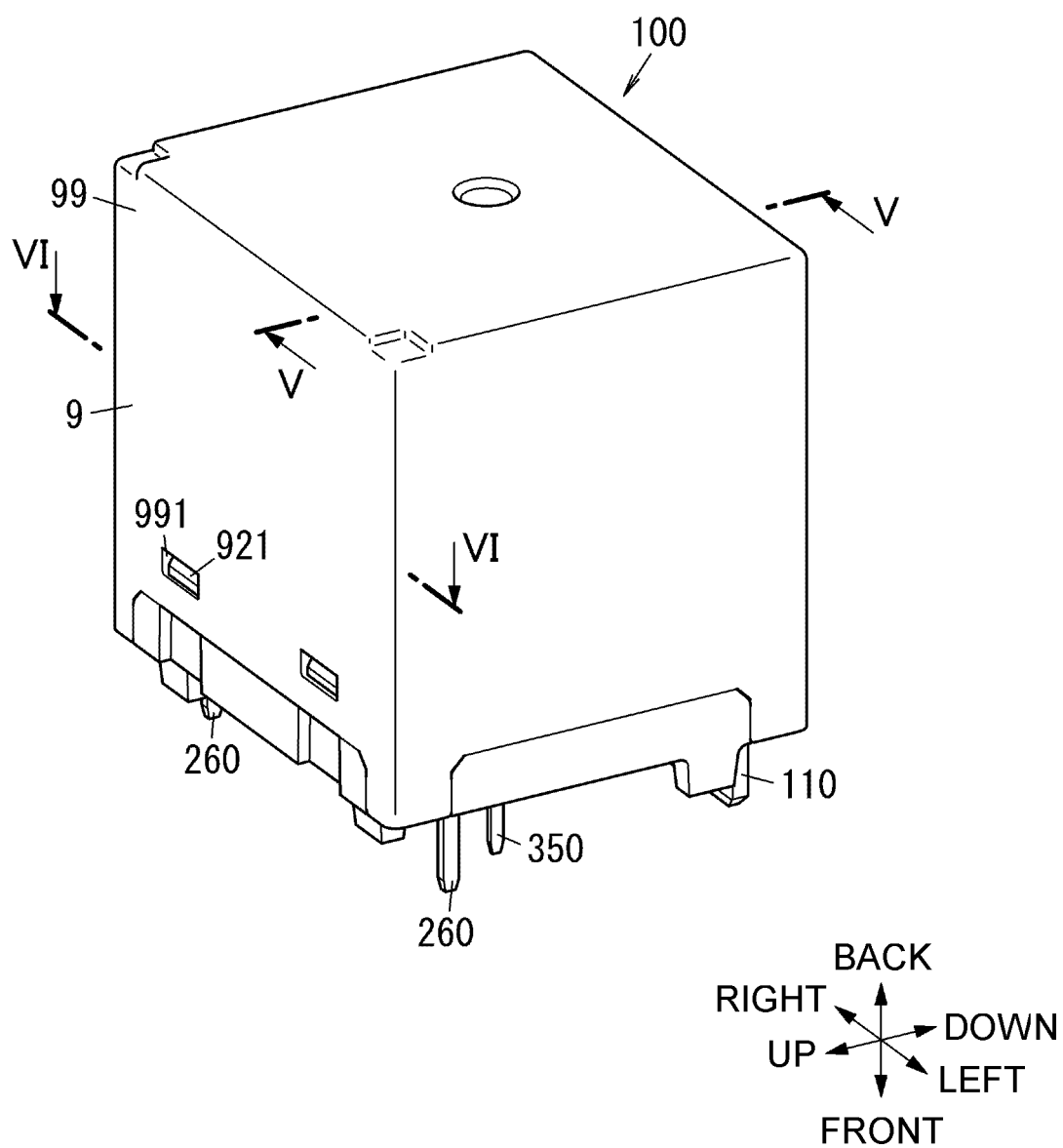


FIG. 2

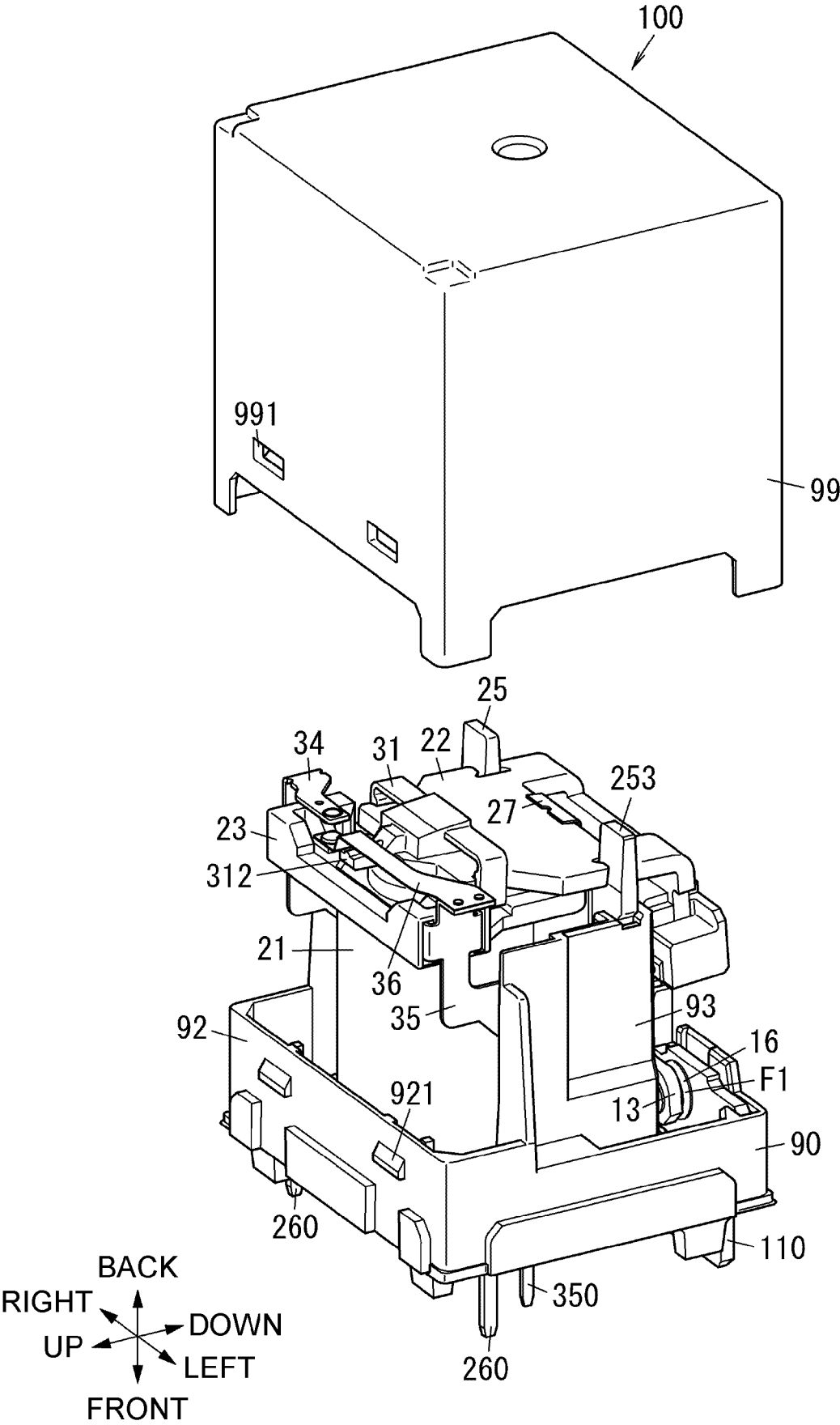


FIG. 3

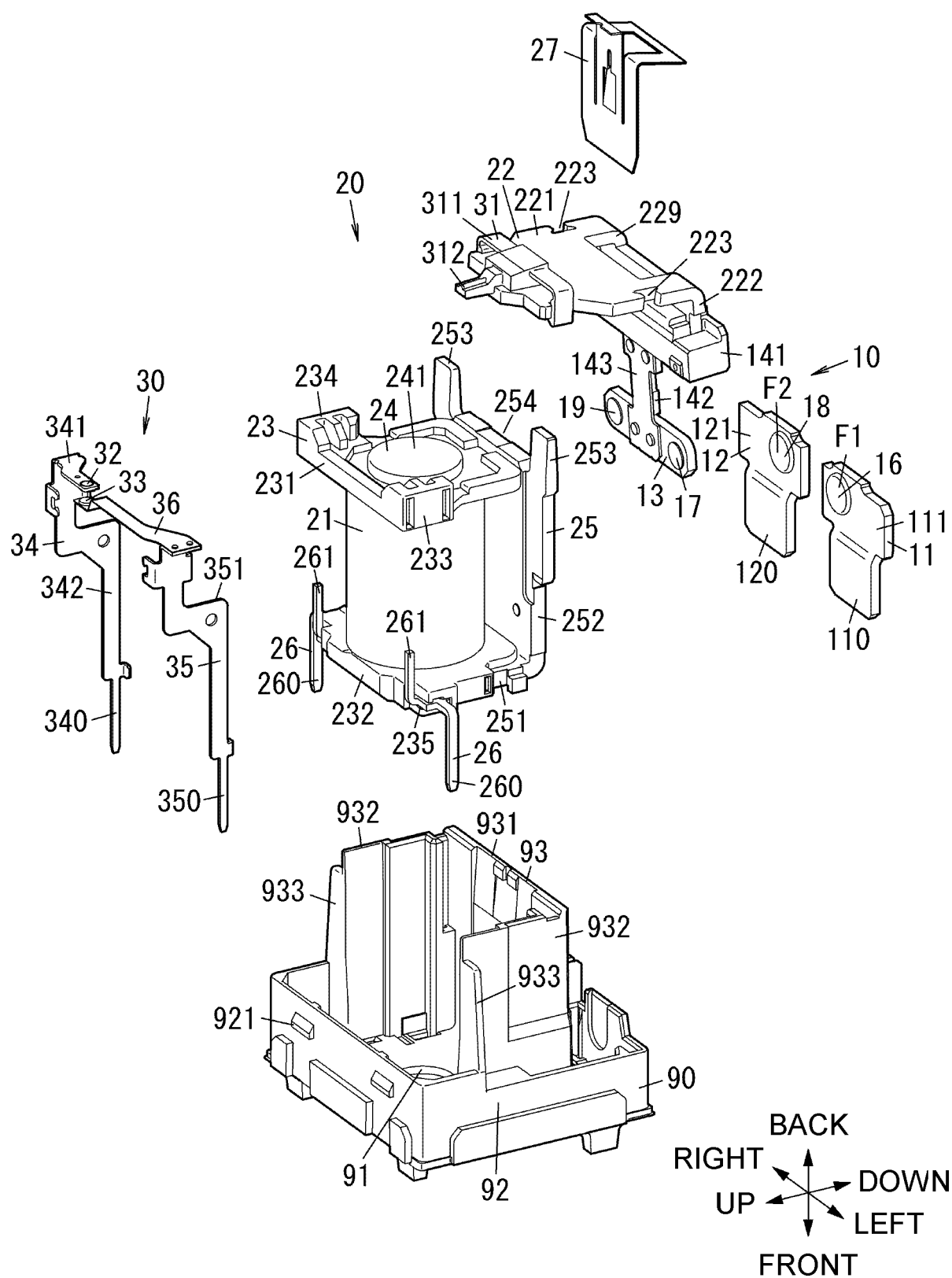


FIG. 4

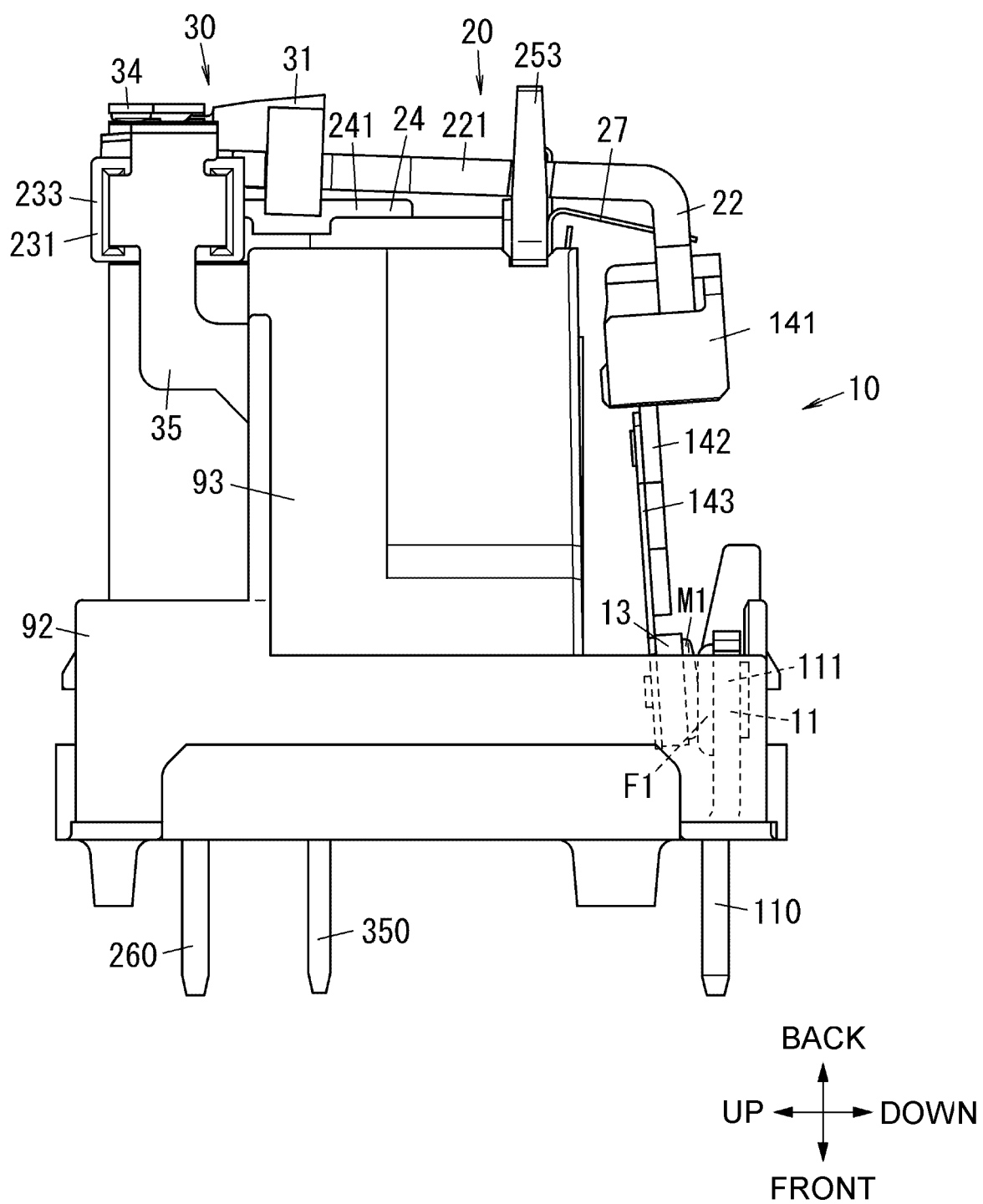


FIG. 5

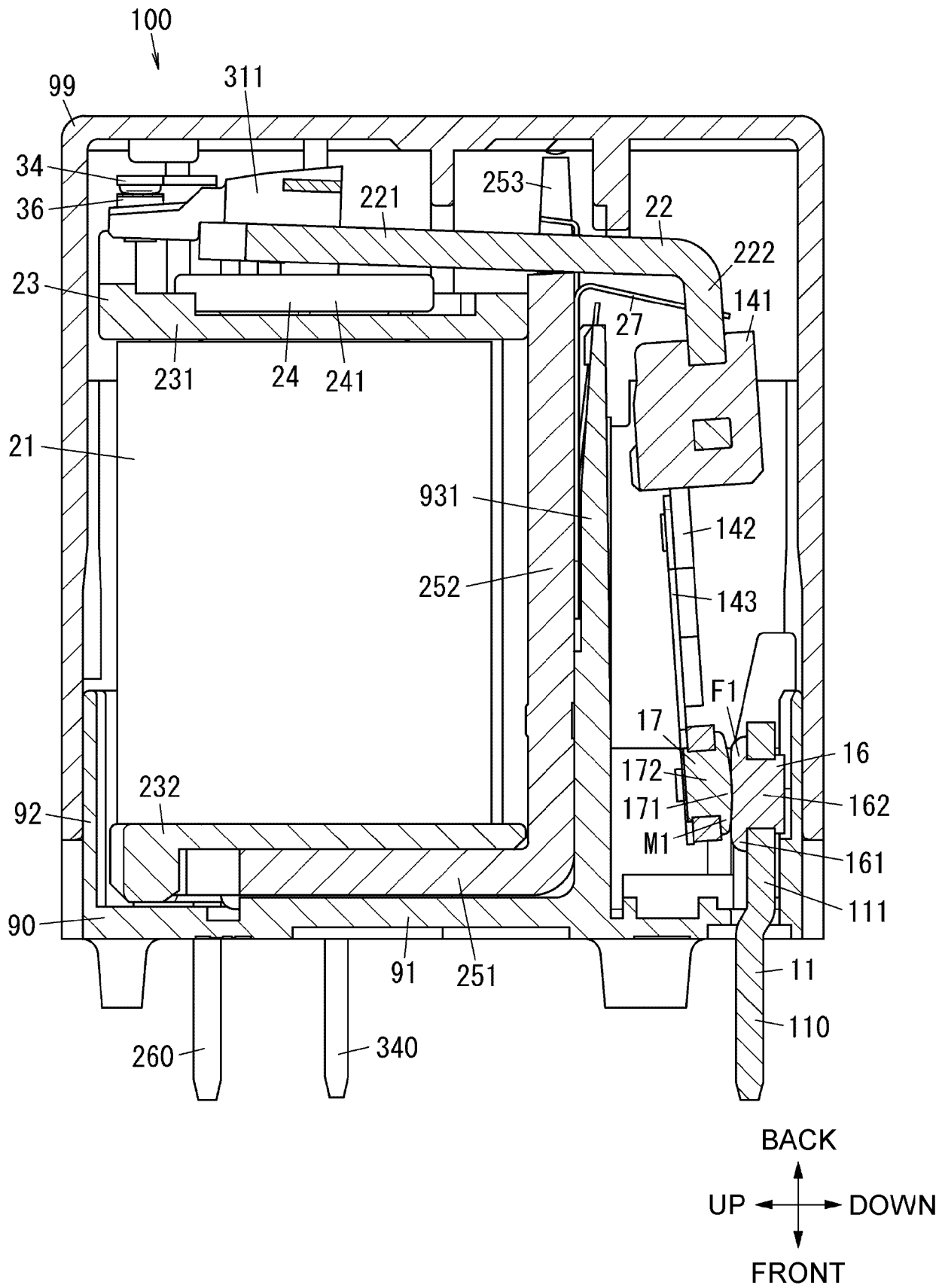


FIG. 6

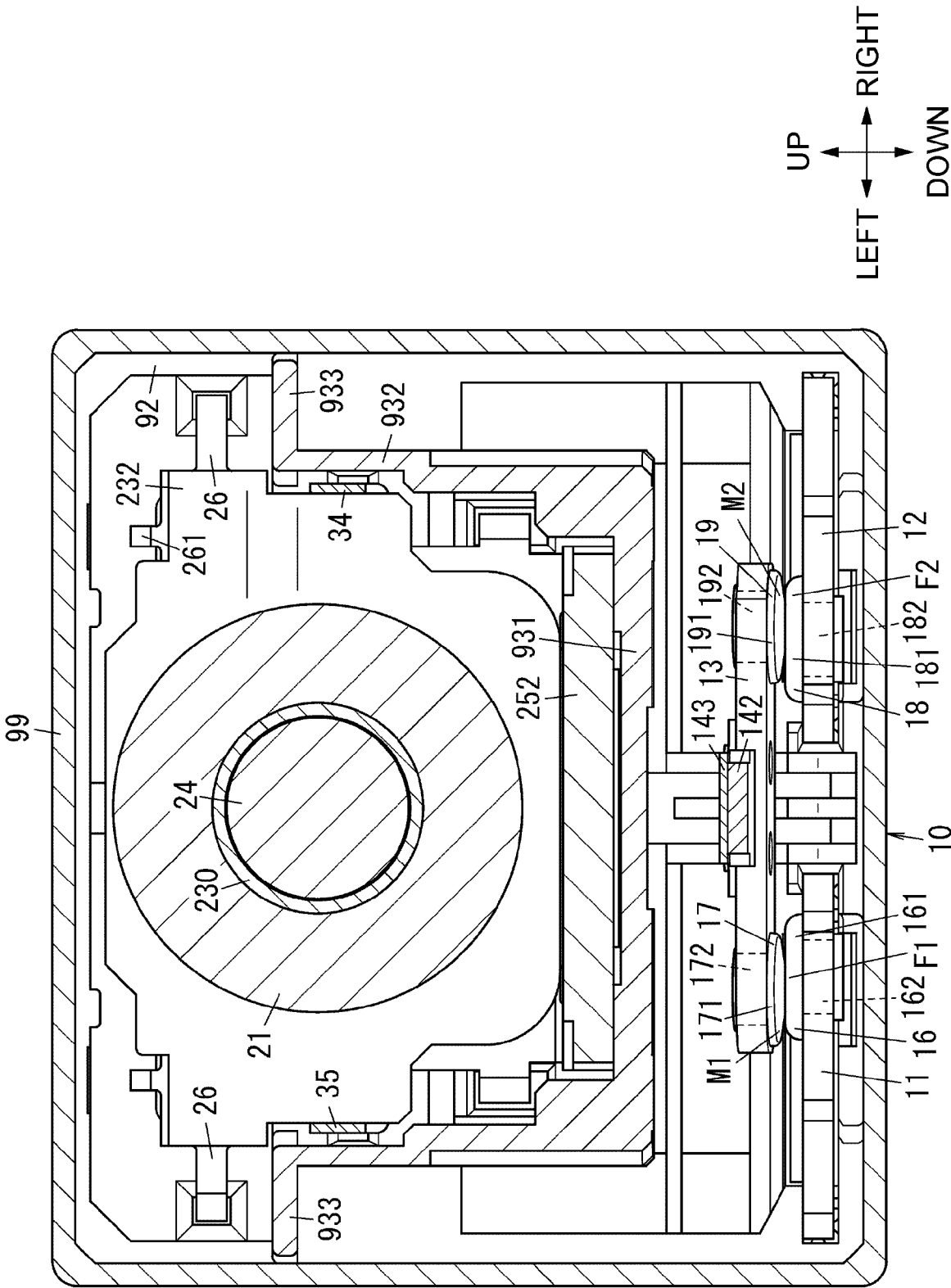


FIG. 7

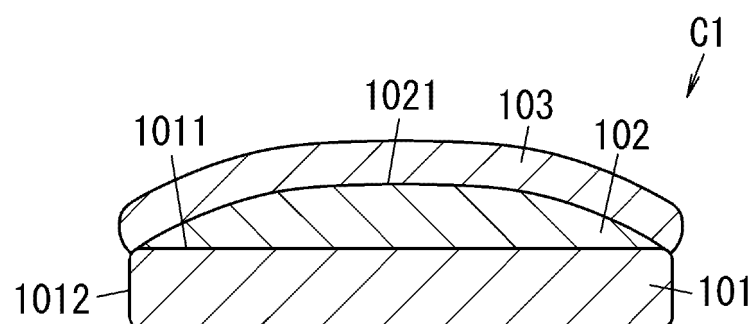


FIG. 8

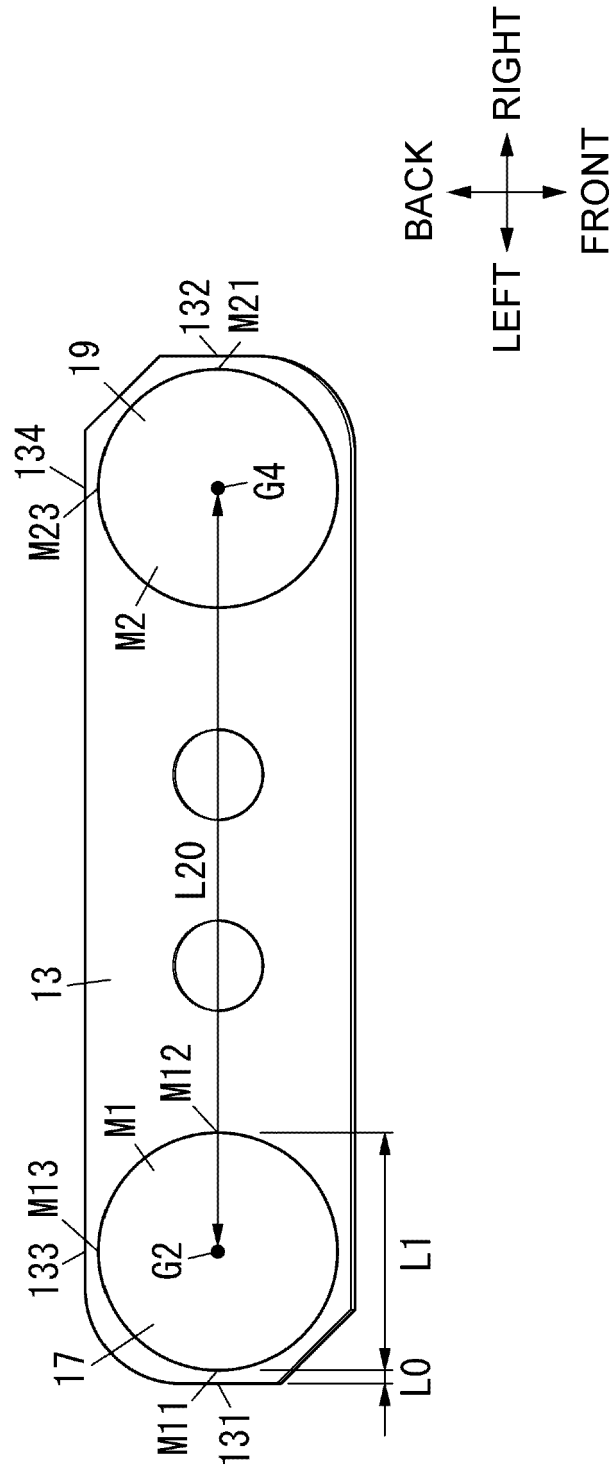


FIG. 9

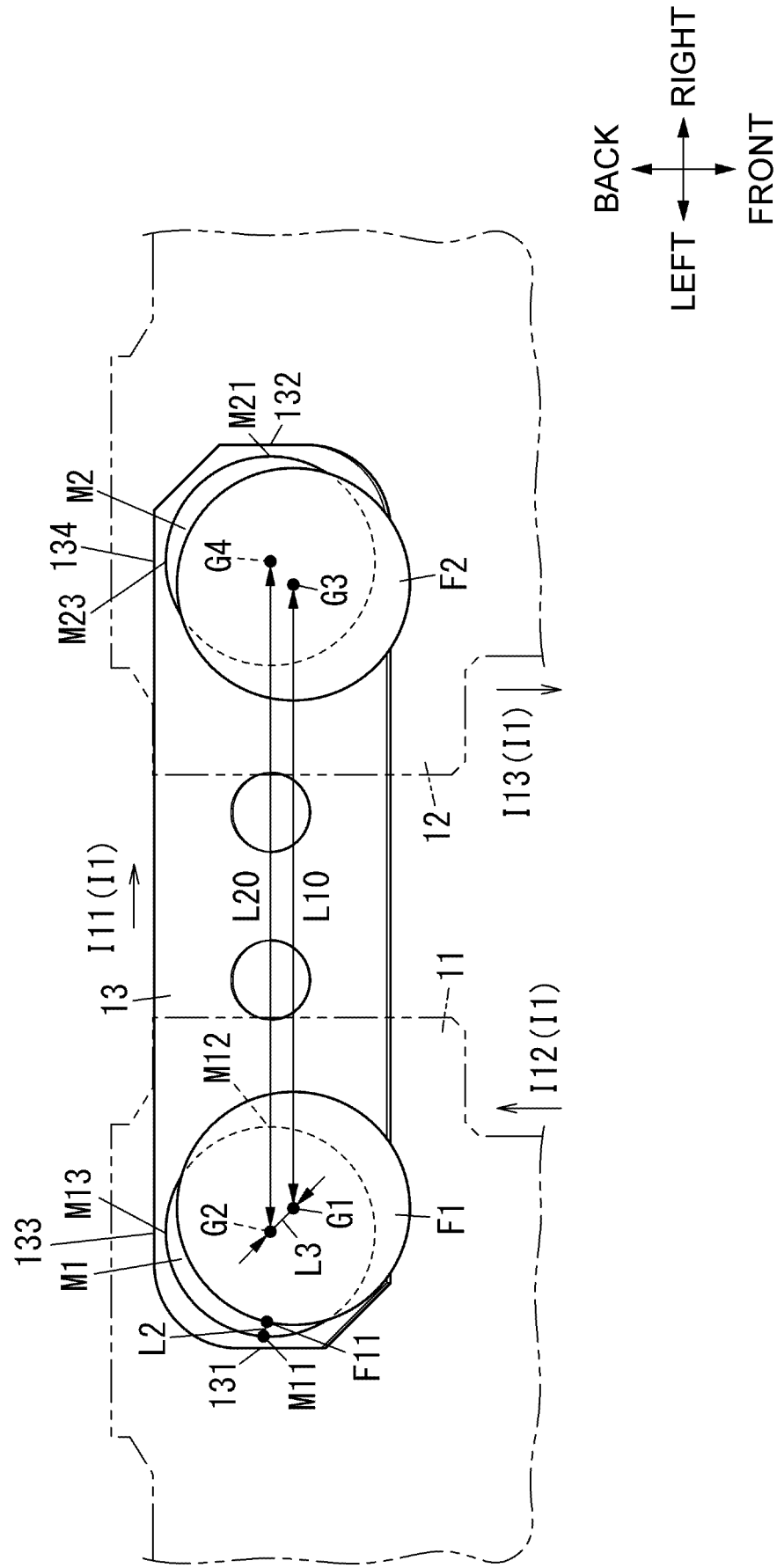


FIG. 10

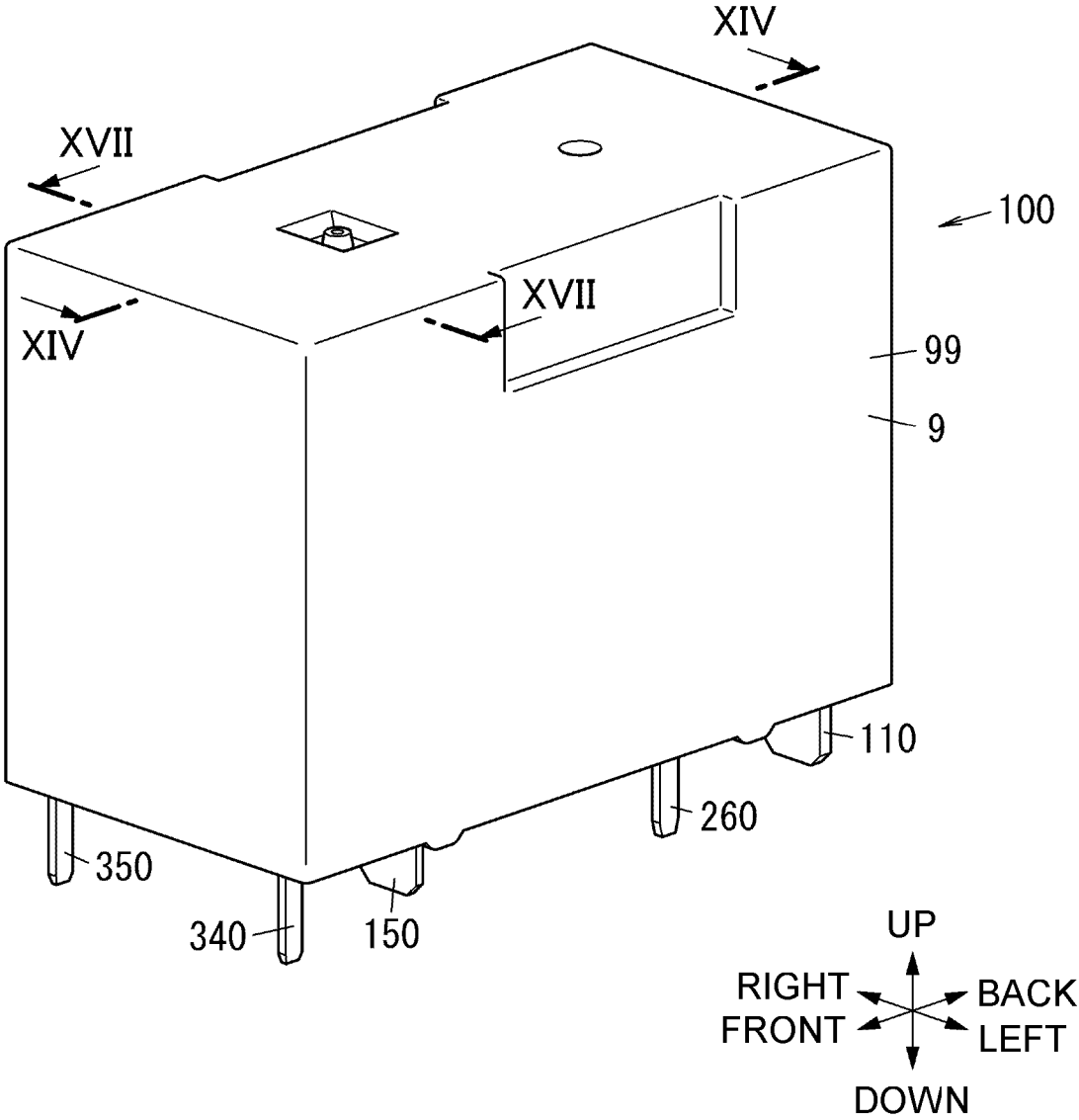
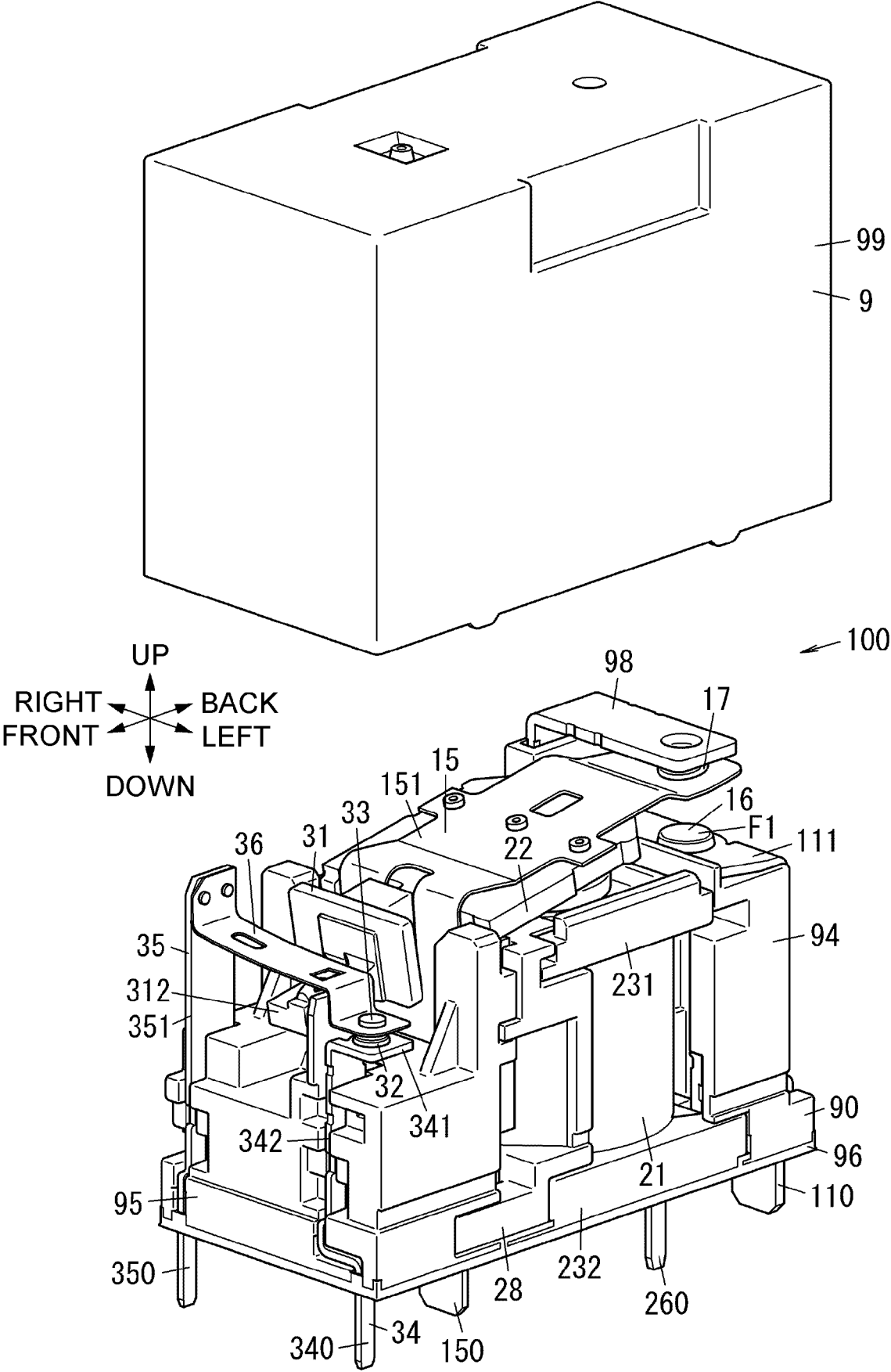


FIG. 11



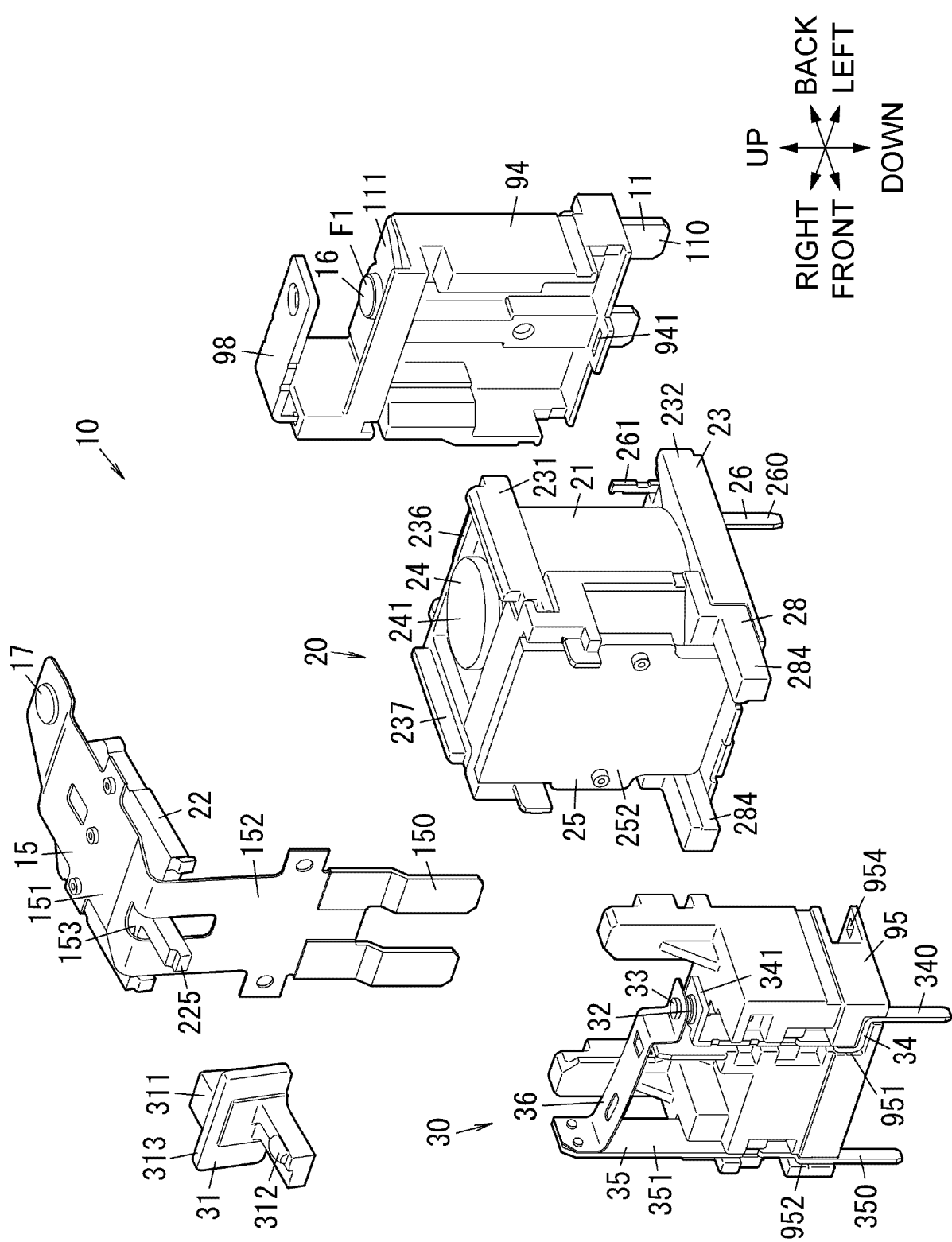
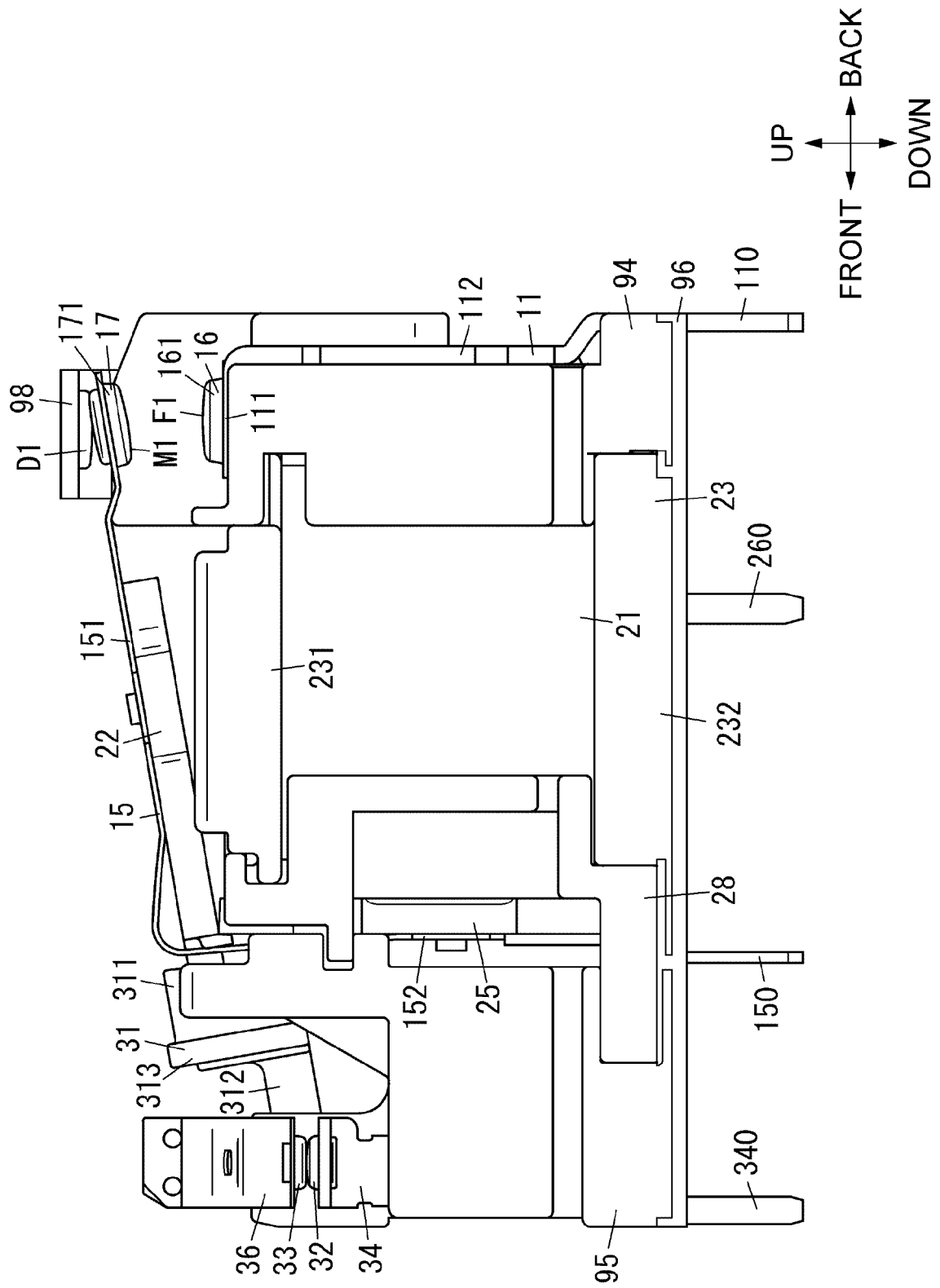


FIG. 13



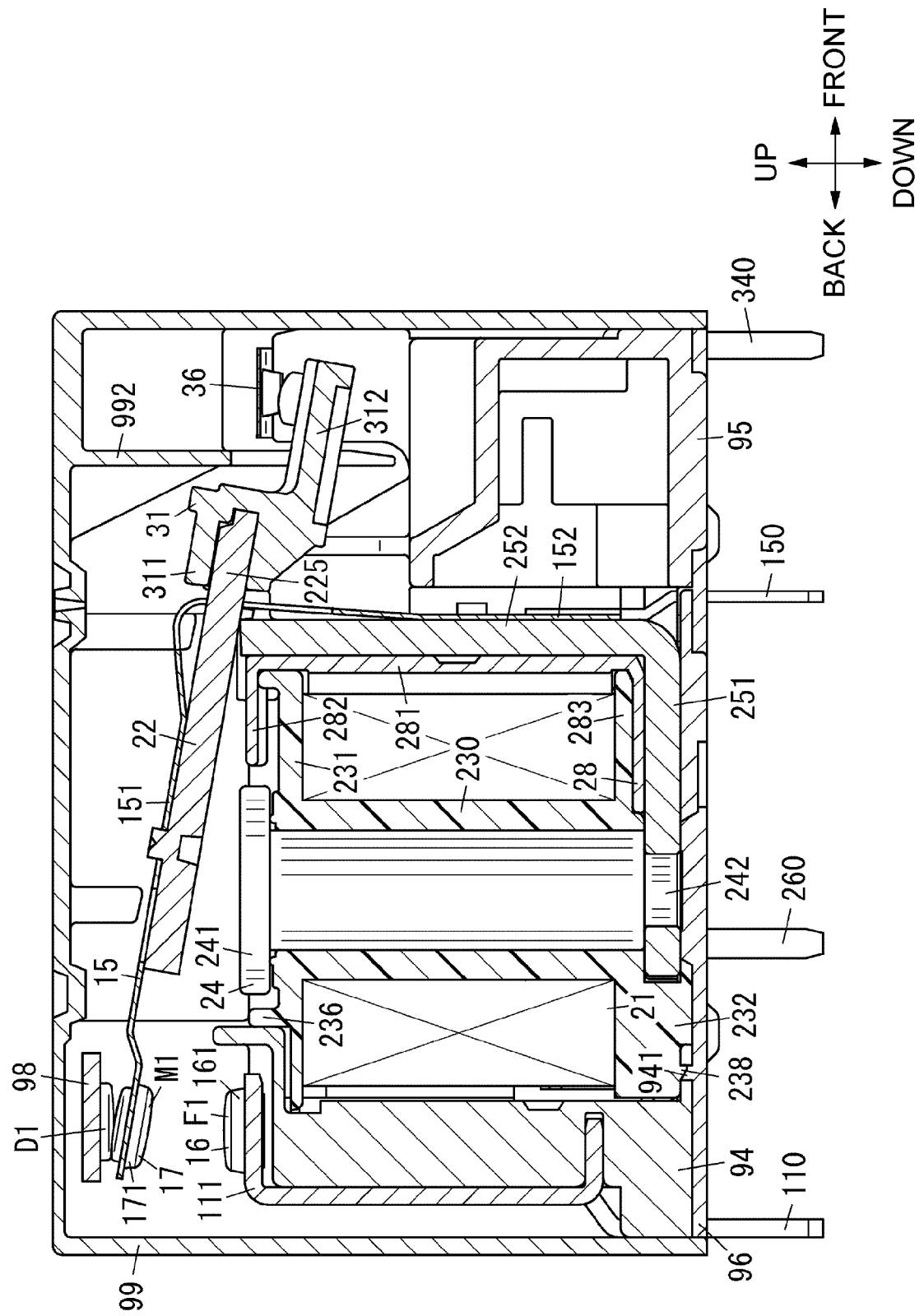


FIG. 14

FIG. 15

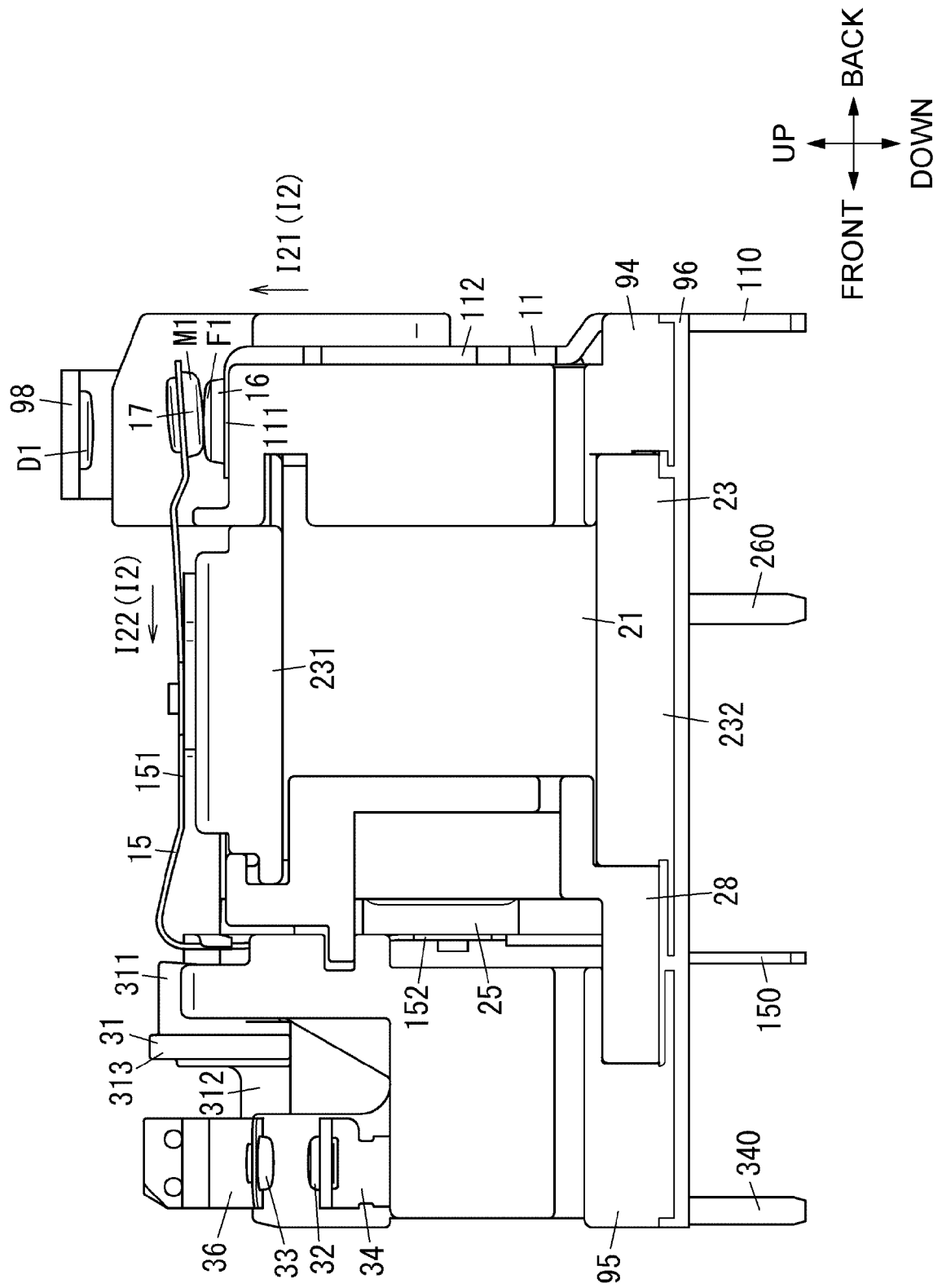


FIG. 16

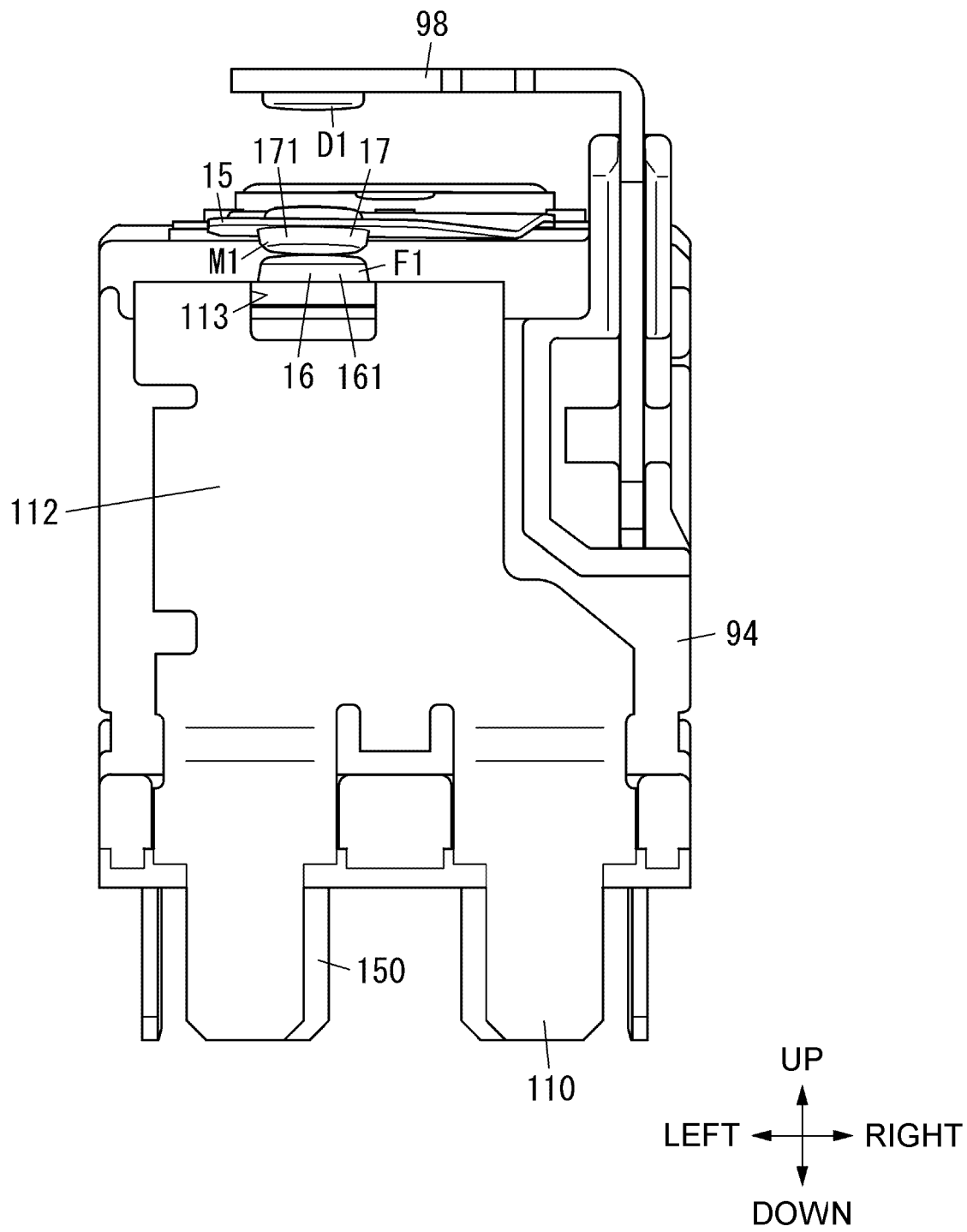


FIG. 17

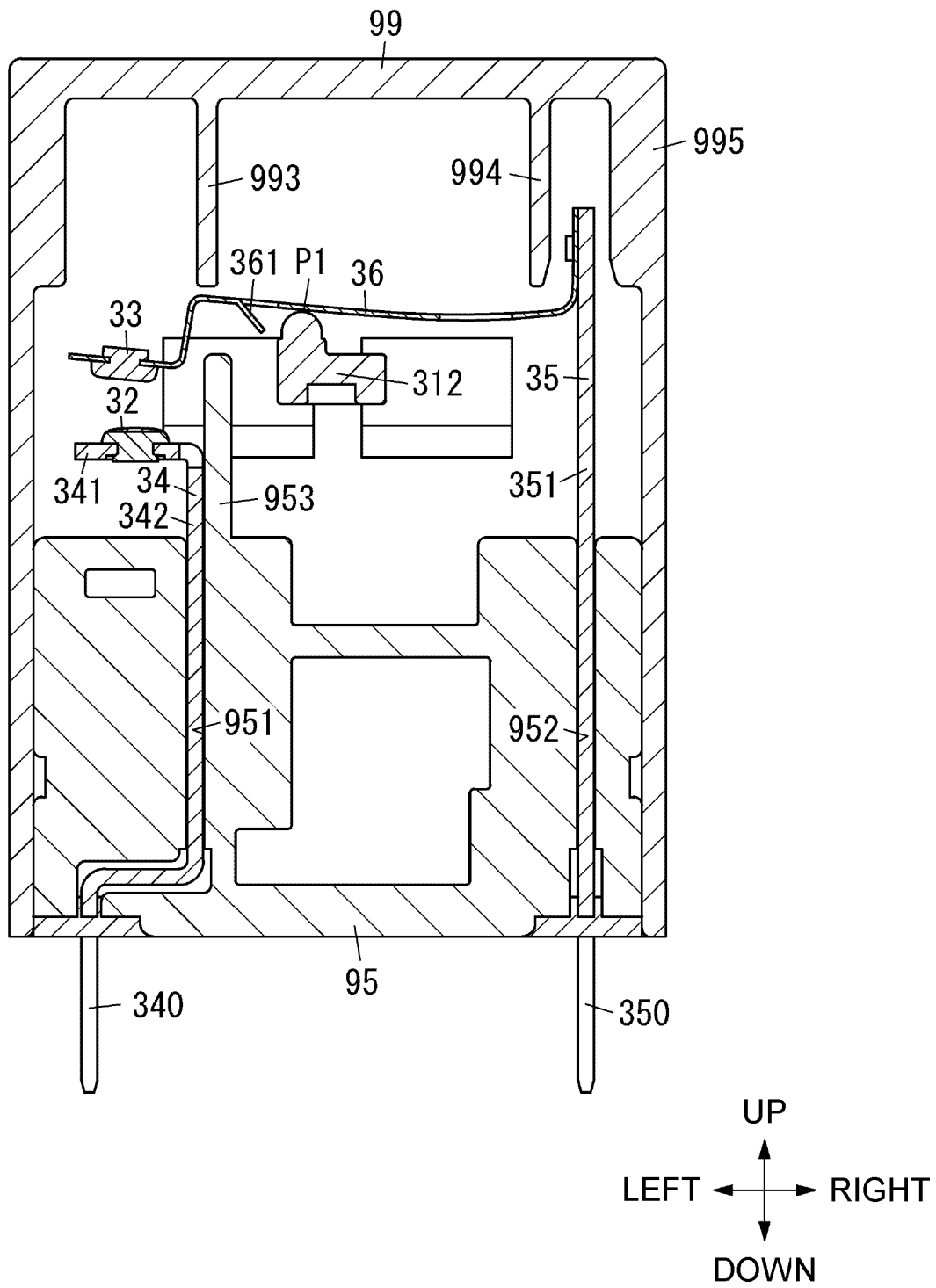


FIG. 18

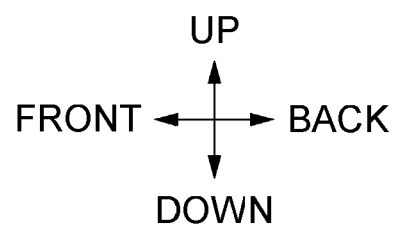
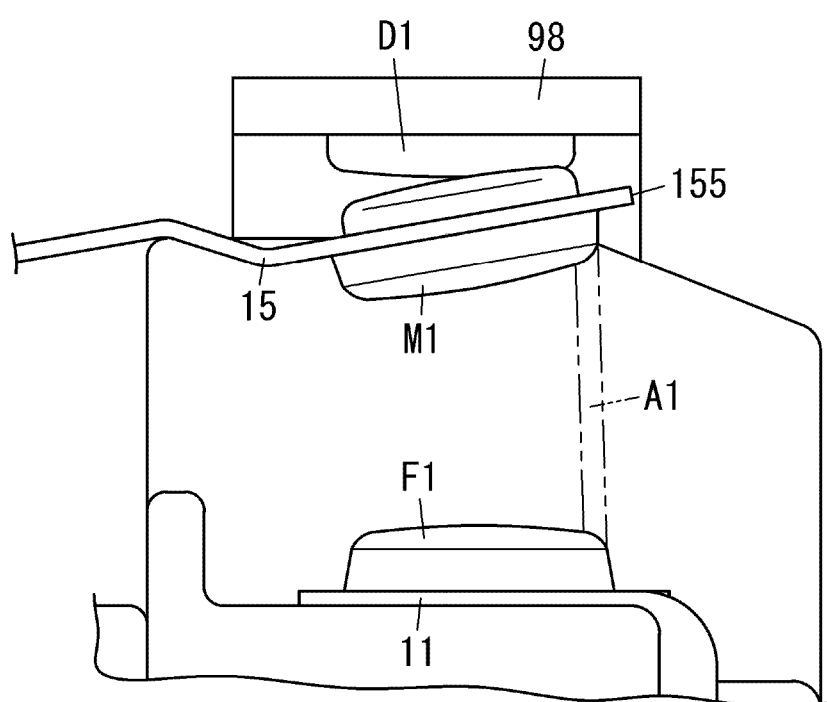


FIG. 19

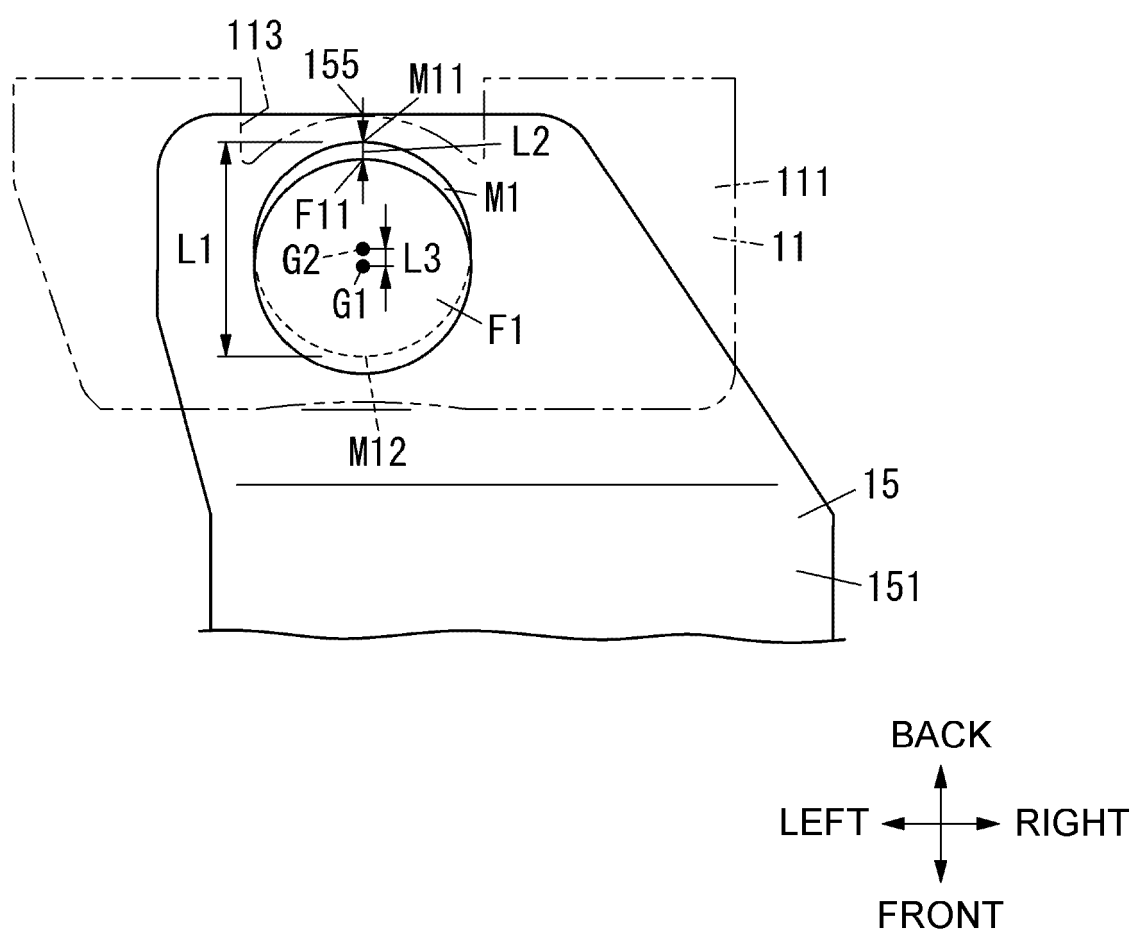


FIG. 20

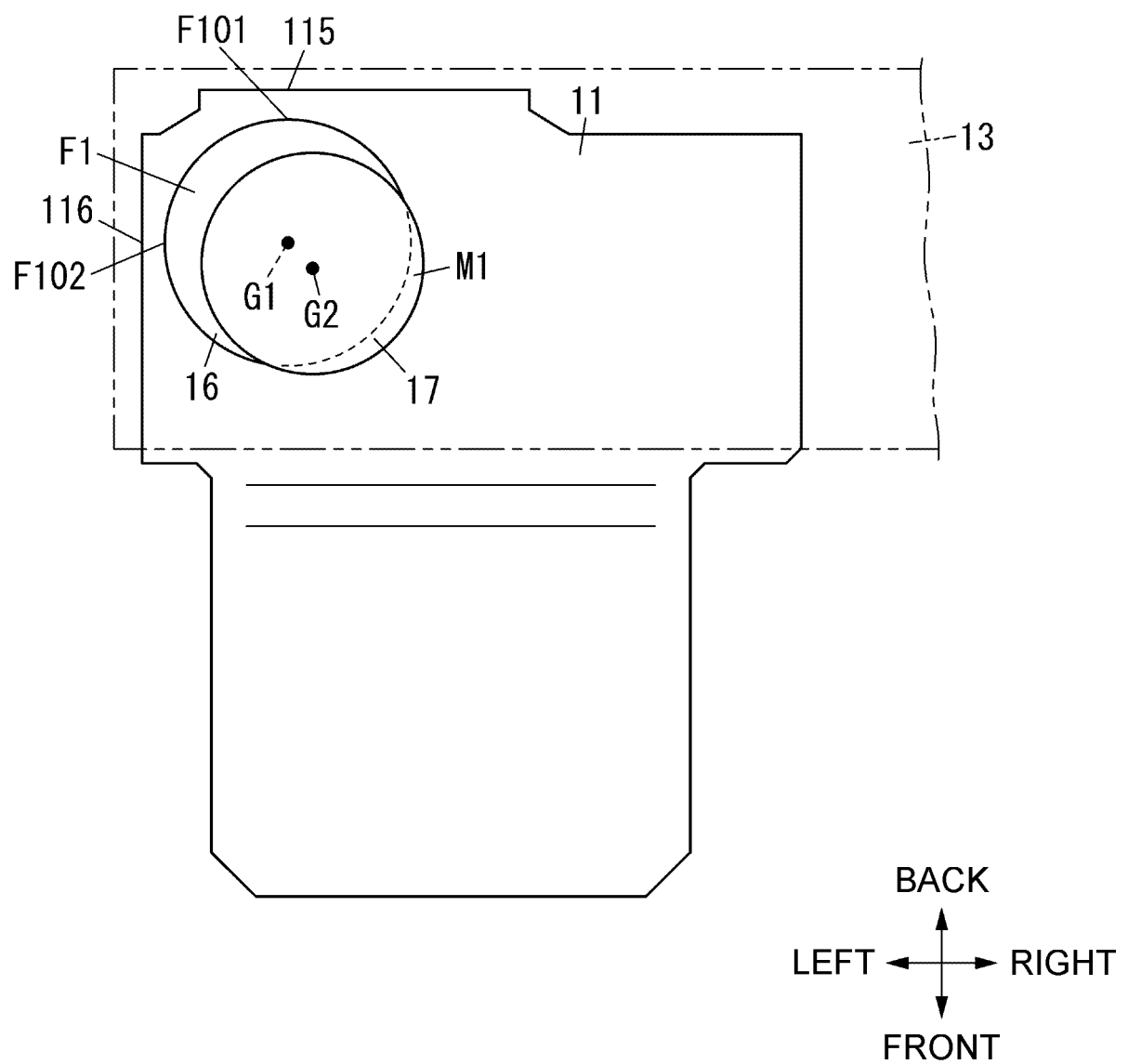


FIG. 21A

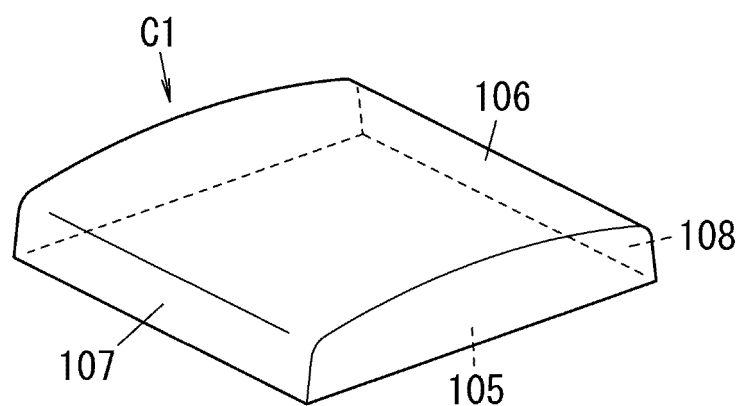


FIG. 21B

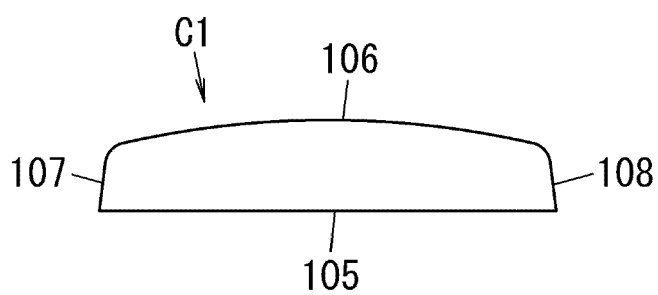
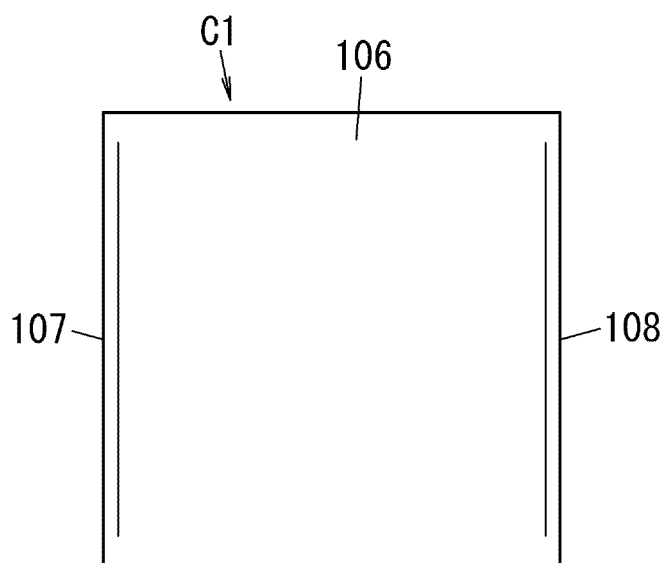


FIG. 21C





EUROPEAN SEARCH REPORT

Application Number

EP 24 19 8378

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	JP S57 48541 U (X) 18 March 1982 (1982-03-18) * figure 3 *	1-12	INV. H01H1/14
X	US 2021/090836 A1 (OTSUKA KOHEI [JP] ET AL) 25 March 2021 (2021-03-25) * figure 4 *	1	
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A,D	JP 2021 157904 A (DENSO ELECTRONICS CORP; TOYOTA MOTOR CORP) 7 October 2021 (2021-10-07) * the whole document *	1-12	
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			H01H
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
Munich		20 January 2025	Socher, Günther
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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