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(54) CONTACT POINT OPENING-CLOSING DEVICE

(57) A contact opening and closing device includes a driven contact, a driving contact, and a solenoid actuator. The driving contact is configured to move with respect to the driven contact. The solenoid actuator includes a movable component configured to move to an off position and an on position. When the movable component is in the off position, the driving contact and the driven contact are in a state of non-contact. When the movable component is in the on position, the driving contact and the driven contact are in a state of contact. When the driving contact and the driven contact are switched from a state of non-contact to a state of contact, the movable component moves from the off position to the on position through an overshoot position located beyond the on position.

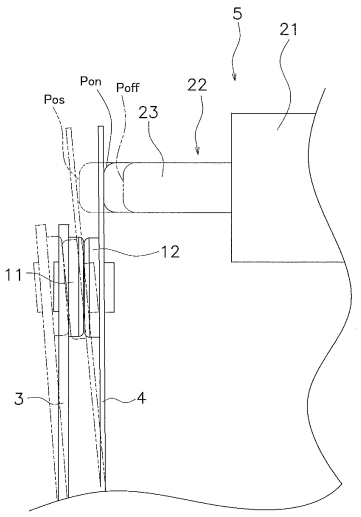


FIG. 3

EP 3 193 349 A1

Description

FIELD

[0001] The present invention relates to a contact opening and closing device.

BACKGROUND

[0002] There are known contact opening and closing devices that open and close contacts by moving a driving contact with respect to a driven contact. For example, Patent Literature 1 discloses a relay that is a type of contact opening and closing device. With this relay, voltage is applied to a coil so that a working piece is attracted to an iron core within the coil. Consequently, when the working piece moves and presses on the driving contact, the driving contact touches the driven contact.

CITATION LIST

PATENT LITERATURE

[0003] Patent Literature 1: Japanese Laid-Open Patent Application 2006-196357

SUMMARY

TECHNICAL PROBLEM

[0004] With the above-mentioned relay, the stroke of the driving contact is restricted by the gap between the iron core and the working piece. If there is a large gap between the iron core and the working piece, a high voltage will be needed to move the working piece. In this case, a problem is that the relay operating voltage is higher, so there is a limit to how much the gap between the iron core and the working piece can be increased. Therefore, it is not easy to increase the stroke of the driving contact.

[0005] Meanwhile, it is preferable for the stroke of the driving contact to be long in order to improve the fusion resistance of the contacts. This is because even if the driven contact and the driving contact should be fused, the driving contact can be easily separated from the driven contact by moving the driving contact far enough. With the above-mentioned relay, however, the short stroke of the driving contact makes it difficult to improve the fusion resistance of the contacts.

[0006] It is also preferable for the stroke of the driving contact to be long in order to increase the wiping action of the contacts. The "wiping action of the contacts" means that the contacts rub against each other when the driving contact touches the driven contact. This wiping action of the contacts allows the contacts to be cleaned, which improves contact reliability. However, with the above relay, since the stroke of the driving contact is short, it is difficult to improve contact reliability by increasing the wiping action of the contacts.

[0007] It is an object of the present invention to provide a contact opening and closing device with which contact fusion resistance and contact reliability can be improved.

SOLUTION TO PROBLEM

[0008] The contact opening and closing device according to one aspect of the present invention includes a driven contact, a driving contact, and a solenoid actuator. The driving contact is configured to move with respect to the driven contact. The solenoid actuator includes a movable component configured to move to an off position and an on position. When the movable component is in the off position, the driving contact and the driven contact are in a state of non-contact. When the movable component is in the on position, the driving contact and the driven contact are in a state of contact. When the driving contact and the driven contact are switched from a state of non-contact to a state of contact, the movable component moves from the off position to the on position through an overshoot position located beyond the on position.

[0009] With the contact opening and closing device according to this aspect, when the driving contact and the driven contact are switched from a state of non-contact to a state of contact, the movable component moves to the on position after moving to an overshoot position that lies beyond the on position. Therefore, the driving contact can be moved farther, which means that the fusion resistance of the contacts can be improved. Also, since the wiping action of the contacts is increased, the contact reliability of the contacts can be improved.

[0010] Preferably, when the driving contact and the driven contact are switched from a state of contact to a state of non-contact, the movable component moves from the on position to the off position through the overshoot position. In this case, the contacts can be cleaned while being switched to a state of non-contact.

[0011] Preferably, the solenoid actuator further includes a coil component. The movable component include a plunger disposed inside the coil component. The movable component moves in the axial direction of the plunger, between the off position, the on position, and the overshoot position. In this case, the stroke of the movable component can be easily lengthened. Consequently, the fusion resistance of the contacts and the contact reliability can be easily improved.

[0012] Preferably, the contact opening and closing device further includes a holding member that holds the movable component in the on position by latching the movable component. In this case, the movable component will be held in the on position by the holding member even if no voltage is being applied to the solenoid actuator. Therefore, the contacts can be maintained in a state of contact even though the voltage to the solenoid actuator is cut off. Consequently, the contact opening and closing device will consume less power. Also, since the contacts are kept in a state of contact by having the hold-

ing member latch the movable component, impact resistance is better than when the contacts are kept in a state of contact by electromagnetic force from a coil or by elastic force from a spring.

[0013] Preferably, the movable component further includes a latching member. The latching member is configured to be switched between a latched state of being latched to the holding member, and an unlatched state of being unlatched from the holding member. When the movable component moves from the off position to the overshoot position, the latching member is switched from the unlatched state to the latched state. In this case, when the contacts are switched from a state of non-contact to a state of contact, the movable component will move from the off position to the overshoot position, switching the latching member from the unlatched state to the latched state. When the movable component reaches the on position from the overshoot position, the latching member is in the latched state, so it is latched to the holding member. As a result, the movable component is held in the on position. Consequently, after the contacts have been switched from the state of non-contact to the state of contact, the contacts can be maintained in the state of contact.

[0014] Preferably, when the voltage is applied to the solenoid actuator in a state in which the movable component is in the off position, the solenoid actuator moves the movable component from the off position to the overshoot position. In this case, the movable component is moved from the off position to the overshoot position, and the latching member is switched to the latched state, by applying voltage to the solenoid actuator. Therefore, even if the voltage to the solenoid actuator is subsequently cut off, the latching member will be latched to the holding member and the movable component will be held in the on position, so the contacts will be maintained in a state of contact. Thus, when the contacts are in a state of non-contact, the contacts can be switched to and kept in a state of contact by applying voltage just once to the solenoid actuator.

[0015] Preferably, when the movable component moves from the on position to the overshoot position, the latching member is switched from the latched state to the unlatched state. In this case, when the contacts are switched from a state of contact to a state of non-contact, the movable component moves from the on position to the overshoot position, which switches the latching member from the latched state to the unlatched state. Therefore, latching to the latching member by the holding member is released, and the movable component is able to move from the overshoot position to the off position. Consequently, the contacts can be switched from a state of contact to a state of non-contact.

[0016] Preferably, when voltage is applied to the solenoid actuator in a state in which the movable component is in the on position, the solenoid actuator moves the movable component from the on position to the overshoot position. In this case, when voltage is applied to the solenoid actuator while the contacts are in a state of contact, the movable component moves from the on position to the overshoot position, which switches the latching member to the unlatched state. Therefore, even if voltage to the solenoid actuator is subsequently cut off, the movable component will still be able to move from the overshoot position to the off position. Consequently, the contacts can be switched from a state of contact to a state of non-contact. Thus, when the contacts are in a state of contact, the contacts can be switched to a state of non-contact by applying voltage just once to the solenoid actuator.

[0017] Preferably, the solenoid actuator further includes an elastic member. The elastic member biases the movable component in a direction facing from the on position toward the off position. In this case, when the latching member is switched to the unlatched state, allowing the movable component to move from the overshoot position to the off position, the movable component can be moved to the off position by the biasing force of the elastic member. This allows the contacts to be easily switched to a state of non-contact.

[0018] Preferably, the solenoid actuator further includes a main body component including a through-hole. The movable component is inserted into the through-hole. The movable component includes a first end and a second end. The first end protrudes from the main body component in the axial direction and moves the driving contact. The second end protrudes from the main body component in the opposite direction from the first end, in the axial direction. In this case, since the second end protrudes from the main body component, the user can manipulate the second end manually, and can therefore move the movable component manually by manipulating the second end. This allows the contact state to be switched manually.

[0019] Preferably, the movable component further includes a stroke adjustment member that is attached to the second end. The external size of the stroke adjustment member is larger than that of the through-hole. In this case, the stroke of the movable component is restricted by latching the stroke adjustment member to the main body component. Therefore, the overshoot position of the movable component can be adjusted by adjusting the attachment position of the stroke adjustment member.

[0020] Preferably, the contact opening and closing device further includes a movable contact piece that supports the driving contact. The movable component presses on the movable contact piece at a location that is away from the driving contact. In this case, the fusion resistance and contact reliability of the contacts can be further improved by bending the movable contact piece.

[0021] Preferably, the contact opening and closing device further includes a cover member. The cover member covers the driven contact, the driving contact, and the solenoid actuator. The cover member includes a window that is disposed at a position that is opposite at least part of the movable component. At least part of the movable

component is visible through the window. In this case, the position of the movable component can be checked visually through the window. The contact state is determined according to the position of the movable component. Therefore, the contact state can be easily checked by checking the position of the movable component through the window.

ADVANTAGEOUS EFFECTS

[0022] The present invention provides a contact opening and closing device with which the fusion resistance and contact reliability of contacts can be improved.

BRIEF DESCRIPTION OF DRAWINGS

[0023]

FIG. 1 is an oblique view of the contact opening and closing device according to an embodiment;
FIG. 2 is a side view of the contact opening and closing device;
FIG. 3 is a detail view of a solenoid actuator and contacts;
FIG. 4 is a cross section of the configuration of the solenoid actuator;
FIG. 5 is an exploded oblique view of the configuration of a movable component;
FIG. 6 is an oblique view of a holding member;
FIG. 7 is a cross section of the holding member;
FIG. 8 is a diagram of the holding member as seen in the axial direction;
FIG. 9 is a developed view of the inner face of the holding member;
FIG. 10 is an oblique view of a pressing member;
FIG. 11 is a cross section along the XI-XI line in FIG. 4;
FIG. 12 is an oblique view of a latching member;
FIG. 13 is a cross section along the XIII-XIII line in FIG. 4;
FIG. 14 is a detail view of part of the pressing member and the latching member;
FIG. 15 is a diagram of the end of the latching member as seen in the off direction;
FIG. 16 consists of developed views of the operation of holding convex components of the holding member, guide grooves, and latching convex components of the latching member;
FIG. 17 is a cross section of the configuration of the solenoid actuator;
FIG. 18 is a cross section of the configuration of the solenoid actuator;
FIG. 19 consists of developed views of the operation of the holding convex components of the holding member, the guide grooves, and the latching convex components of the latching member;
FIG. 20 is a side view of the contact opening and closing device according to a first modification example;
FIG. 21 is a plan view of the contact opening and closing device according to a second modification example;
FIG. 22 is a plan view of the contact opening and closing device according to a third modification example;
FIG. 23 is a plan view of the contact opening and closing device according to a fourth modification example;
FIG. 24 consists of diagrams of the contact opening and closing device according to a fifth modification example;
FIG. 25 is a side view of the contact opening and closing device according to a sixth modification example;
FIG. 26 is a side view of the contact opening and closing device according to a seventh modification example; and
FIG. 27 consists of plan views of the contact opening and closing device according to the seventh modification example.

DETAILED DESCRIPTION

[0024] The contact opening and closing device according to an embodiment will now be described through reference to the drawings. FIG. 1 is an oblique view of the contact opening and closing device 1 according to an embodiment. FIG. 2 is a side view of the contact opening and closing device 1. The contact opening and closing device 1 in this embodiment is a latched relay. As shown in FIGS. 1 and 2, the contact opening and closing device 1 includes a base 2, a driven contact piece 3, a driving contact piece 4, and a solenoid actuator 5.

[0025] The base 2 supports the driven contact piece 3, the driving contact piece 4, and the solenoid actuator 5. The driven contact piece 3 is made of copper or another such conductive material. The driven contact piece 3 extends upward from the base 2. The driven contact piece 3 is connected to a terminal 13 protruding from the base 2. A driven contact 11 is attached to the driven contact piece 3. The driven contact 11 is supported by the driven contact piece 3.

[0026] In this embodiment, the direction in which the solenoid actuator 5 is disposed with respect to the base 2 is called upward, and the opposite direction is called downward. However, these directional terms are not intended to limit the direction in which the contact opening and closing device 1 is disposed.

[0027] The driving contact piece 4 is made of copper or another such conductive material. The driving contact piece 4 extends upward from the base 2. The driving contact piece 4 is connected to a terminal 14 protruding from the base 2. A driving contact 12 is attached to the driven contact piece 3. The driving contact 12 is supported by the driving contact piece 4. The driving contact 12 is provided movably with respect to the driven contact

11. More precisely, the driving contact piece 4 elastically deforms and bends when the solenoid actuator 5 is pushed against the driving contact piece 4. Consequently, the driving contact 12 moves toward the driven contact 11. Also, when the driving contact piece 4 is pulled by the solenoid actuator 5, the driving contact 12 moves away from the driven contact 11. Alternatively, the driving contact 12 may be moved away from the driven contact 11 under the elastic force of the driving contact piece 4.

[0028] The solenoid actuator 5 includes a main body component 21 and a movable component 22. As will be discussed below, the main body component 21 includes a through-hole. The movable component 22 is inserted into this through-hole, and is able to move in the axial direction of the movable component 22 with respect to the main body component 21 (hereinafter referred to simply as "the axial direction").

[0029] The movable component 22 includes a first end 23 and a second end 24. The first end 23 protrudes from the main body component 21 in the axial direction. The second end 24 protrudes from the main body component 21 in the opposite direction from that of the first end 23, in the axial direction.

[0030] The first end 23 is connected to the upper end of the driving contact piece 4. The driving contact 12 is moved when the first end 23 moves with respect to the main body component 21. More precisely, the connection 25 between the first end 23 and the driving contact piece 4 is located more to the distal end side of the driving contact piece 4 than the driving contact 12. Specifically, the connection 25 between the first end 23 and the driving contact piece 4 is located above the driving contact 12. Therefore, the movable component 22 presses on the driving contact piece 4 at a position that is above and away from the driving contact 12.

[0031] FIG. 3 is a detail view of the solenoid actuator 5 and the contacts 11 and 12. As shown in FIG. 3, the movable component 22 moves in the axial direction between the off position Poff, the on position Pon, and the overshoot position Pos. If the movable component 22 is in the off position Poff, the driving contact 12 and the driven contact 11 are in a state of non-contact (see FIG. 2). If the movable component 22 is in the on position Pon, the driving contact 12 and the driven contact 11 are in a state of contact as shown in FIG. 3.

[0032] In this embodiment, the direction facing toward the on position Pon from the off position Poff in the axial direction is called the "on direction." That is, the on direction is a direction facing toward the first end 23 from the second end 24 in the axial direction. Also, the opposite direction from the on position in the axial direction is called the "off direction." That is, the off direction is a direction facing toward the off position Poff from the on position Pon in the axial direction. In other words, the off direction is a direction facing toward the second end 24 from the first end 23 in the axial direction.

[0033] If voltage is applied to the solenoid actuator 5 in a state in which the movable component 22 is in the off position Poff, the movable component 22 moves from the off position Poff in the on direction, and moves to the overshoot position Pos beyond the on position Pon. When the voltage to the solenoid actuator 5 is then cut off, the movable component 22 moves from the overshoot position Pos to the on position Pon, and is held in the on position Pon. That is, with the contact opening and closing device 1 according to this embodiment, when the driving contact 12 and the driven contact 11 are switched from a state of non-contact to a state of contact, the movable component 22 moves from the off position Poff to the on position Pon through the overshoot position Pos beyond the on position Pon.

[0034] Also, when voltage is applied to the solenoid actuator 5 in a state in which the movable component 22 is in the on position Pon, the movable component 22 moves in the on direction from the on position Pon, and moves to the overshoot position Pos. When the voltage to the solenoid actuator 5 is then cut off, the movable component 22 moves from the overshoot position Pos to the off position Poff, and is held in the off position Poff. That is, when the driving contact 12 and the driven contact 11 are switched from a state of contact to a state of non-contact, the movable component 22 moves from the on position Pon, through the overshoot position Pos, to the off position Poff.

[0035] Next, the configuration of the solenoid actuator 5 will be described in detail. FIG. 4 is a cross section of the configuration of the solenoid actuator 5. FIG. 5 is an exploded oblique view of the configuration of the movable component 22.

[0036] As shown in FIG. 4, the main body component 21 includes a first cover member 26, a holding member 27, a case member 28, and a second cover member 29. The first cover member 26, the holding member 27, the case member 28, and the second cover member 29 are disposed aligned in the axial direction. The case member 28 houses a coil 31. The coil 31 is fixed to the case member 28. The coil 31 includes a bobbin 32 and a winding 33. The winding 33 is wound around the bobbin 32. The winding 33 is connected via the wire 16 shown in FIGS. 1 and 2 to a terminal 15 protruding from the base 2.

[0037] The holding member 27 is attached to one end of the case member 28 in the axial direction. The second cover member 29 is attached to the other end of the case member 28 in the axial direction. The second cover member 29 includes a through-hole 291, and the second end 24 of the movable component 22 protrudes from the through-hole 291 of the second cover member 29. A stroke adjustment member 34 is attached to the second end 24. The stroke adjustment member 34 has an external size that is larger than the through-hole 291 of the second cover member 29. The first cover member 26 is attached to the holding member 27. The first cover member 26 includes a through-hole 261, and the first end 23 of the movable component 22 protrudes from the through-hole 261 of the first cover member 26.

[0038] FIG. 6 is an oblique view of the holding member

27. FIG. 7 is a cross section of the holding member 27. FIG. 8 is a diagram of the holding member 27 as seen in the axial direction. As shown in FIGS. 6 and 7, the holding member 27 includes a through-hole 271. The holding member 27 also includes a plurality of holding convex components 35. The holding convex components 35 protrude inward in the radial direction from the inner face of the holding member 27. The holding convex components 35 extend in the axial direction. The holding convex components 35 are disposed aligned in the peripheral direction of the holding member 27. The holding convex components 35 are disposed at regular intervals in the peripheral direction of the holding member 27. In this embodiment, the holding member 27 includes three holding convex components 35.

[0039] FIG. 9 is a developed view of the inner face of the holding member 27. As shown in FIG. 9, the ends of the holding convex components 35 in the on direction (upward in FIG. 9) each include a first sloped part 351, a second sloped part 352, and a stepped part 353. The first sloped parts 351 and the second sloped parts 352 are sloped with respect to the peripheral direction. The first sloped parts 351 and the second sloped parts 352 are sloped with respect to the axial direction. The stepped parts 353 are disposed between the first sloped parts 351 and the second sloped parts 352. The stepped parts 353 extend in the axial direction.

[0040] The inner face of the holding member 27 includes a plurality of guide grooves 36 and 37. The guide grooves 36 and 37 extend in the axial direction. The guide grooves 36 and 37 pass through the holding convex components 35 in the axial direction. The guide grooves 36 and 37 are disposed aligned in the peripheral direction. The guide grooves 36 and 37 are also disposed at regular intervals in the peripheral direction. In this embodiment, the holding member 27 includes six guide grooves 36 and 37. More precisely, the guide grooves 36 and 37 consist of three first guide grooves 36 and three second guide grooves 37. The first guide grooves 36 and the second guide grooves 37 are disposed in an alternating pattern in the peripheral direction.

[0041] As shown in FIG. 8, the first guide grooves 36 are disposed at regular intervals in the peripheral direction. The first guide grooves 36 are disposed between the holding convex components 35 in the peripheral direction. The second guide grooves 37 are also disposed at regular intervals in the peripheral direction. The second guide grooves 37 are provided to the holding convex components 35. The first guide grooves 36 are deeper than the second guide grooves 37. That is, the depth of the first guide grooves 36 in the radial direction of the holding member 27 is greater than the depth of the second guide grooves 37 in the radial direction of the holding member 27.

[0042] As shown in FIGS. 4 and 5, the movable component 22 includes a plunger 41, a pressing member 42, and a latching member 43. The plunger 41, the pressing member 42, and the latching member 43 are disposed aligned in the axial direction. The plunger 41 is disposed inside the coil 31. More precisely, the plunger 41 is disposed inside a through-hole 321 of the bobbin 32. The plunger 41 is made of a magnetic material. The above-mentioned second end 24 is one end of the plunger 41.

[0043] When voltage is applied to the coil 31, an electromagnetic force acts on the plunger 41 in the on direction. This causes the movable component 22 to move in the on direction.

[0044] The pressing member 42 is connected to the other end of the plunger 41. The pressing member 42 is disposed in the through-hole 271 of the holding member 27. The pressing member 42 moves in the axial direction along with the plunger 41. The pressing member 42 presses on the latching member 43 by moving in the on direction.

[0045] FIG. 10 is an oblique view of the pressing member 42. As shown in FIG. 10, the pressing member 42 includes a hole 421. The hole 421 extends in the axial direction from the end of the pressing member 42. The end of the pressing member 42 includes a plurality of sloped parts 44 and 45. The sloped parts 44 and 45 are disposed around the outside of the hole 421.

[0046] The sloped parts includes a plurality of first sloped parts 44 and a plurality of second sloped parts 45. The first sloped parts 44 and the second sloped parts 45 are disposed in an alternating pattern in the peripheral direction of the pressing member 42. The first sloped parts 44 and the second sloped parts 45 are sloped with respect to the peripheral direction. The sloping directions of the first sloped parts 44 and the second sloped parts 45 are opposite to one another.

[0047] More precisely, the first sloped parts 44 slope in the off direction and counter-clockwise as seen from the on direction (upward in FIG. 10). The second sloped parts 45 slope in the on direction and counter-clockwise as seen from the on direction. In this embodiment, the pressing member 42 includes six first sloped parts 44. The pressing member 42 includes six second sloped parts 45.

[0048] The pressing member 42 includes a plurality of guide convex components 46. The guide convex components 46 protrude from the outer peripheral face of the pressing member 42. The guide convex components 46 are spaced apart in the peripheral direction of the pressing member 42. The guide convex components 46 are disposed at equidistant intervals in the peripheral direction of the pressing member 42. The guide convex components 46 extend in the axial direction. In this embodiment, the pressing member 42 includes six guide convex components 46 (see FIG. 11).

[0049] As shown in FIG. 4, the pressing member 42 is disposed inside the holding member 27. FIG. 11 is a cross section along the XI-XI line in FIG. 4. As shown in FIG. 11, the guide convex components 46 are disposed in the guide grooves 36 and 37 of the holding member 27. Therefore, the pressing member 42 is able to move in the axial direction within the holding member 27, but ro-

tation around the axis is prohibited.

[0050] The latching member 43 is a separate member from the pressing member 42. The latching member 43 is disposed in the through-hole 261 of the first cover member 26 and the through-hole 271 of the holding member 27, and is able to move in the axial direction. The latching member 43 is not fixed to the pressing member 42. Therefore, the latching member 43 is able to move in the axial direction with respect to the pressing member 42. Also, the latching member 43 is able to rotate around the axis with respect to the pressing member 42.

[0051] FIG. 12 is an oblique view of the latching member 43. As shown in FIG. 12, the latching member 43 includes a cylindrical part 47, a latching component 48, and the above-mentioned first end 23. The first end 23, the latching component 48, and the cylindrical part 47 are aligned in the axial direction. The latching component 48 is located between the first end 23 and the cylindrical part 47 in the axial direction. The outside diameter of the cylindrical part 47 is smaller than the latching component 48. The cylindrical part 47 is inserted into the above-mentioned hole 421 of the pressing member 42.

[0052] The outside diameter of the first end 23 is smaller than the outside diameter of the end of the latching component 48. Therefore, as shown in FIG. 4, a step 49 is provided between the first end 23 and the latching component 48. Also, the inner face of the above-mentioned first cover member 26 includes a flange 51 that protrudes inward in the radial direction. The solenoid actuator 5 includes an elastic member 52. In this embodiment, the elastic member 52 is a coil spring. The elastic member 52 is disposed between the step 49 of the latching member 43 and the flange 51 of the first cover member 26. Consequently, the elastic member 52 biases the latching member 43 in the off direction.

[0053] The latching component 48 includes a plurality of latching convex components 53. The latching convex components 53 protrude from the outer peripheral face of the latching component 48. The latching convex components 53 are spaced apart in the peripheral direction of the latching component 48. The latching convex components 53 are disposed at equidistant intervals in the peripheral direction of the latching component 48. The latching convex components 53 extend in the axial direction. In this embodiment, the latching component 48 includes three latching convex components 53. The ends of the latching convex components 53 in the off direction includes sloped parts 531. The sloped parts 531 are sloped with respect to the peripheral direction. The sloped parts 531 of the latching convex components 53 slope in the same direction as the sloped parts 351 and 352 of the holding convex components 35.

[0054] The latching member 43 is disposed so as to be able to move in the axial direction inside the holding member 27. FIG. 13 is a cross section along the XIII-XIII line in FIG. 4. As shown in FIG. 13, the latching convex components 53 are disposed in the first guide grooves 36 of the holding member 27. The latching convex components 53 move in the axial direction, guided by the first guide grooves 36. Therefore, in a state in which the latching convex components 53 are located in the first guide grooves 36, the latching member 43 is able to move in the axial direction inside the holding member 27, but rotation around the axis is prohibited.

[0055] FIG. 14 is a detail view of part of the pressing member 42 and the latching member 43. As shown in FIG. 43, the end of the latching component 48 is disposed opposite the end of the pressing member 42. FIG. 15 is a diagram of the end of the latching member 43 as seen in the off direction. As shown in FIGS. 12, 14, and 15, the end of the latching component 48 includes sloped parts 54 and 55. The sloped parts 54 and 55 are disposed more to the outside in the radial direction than the cylindrical part 47. The sloped parts 54 and 55 are located more to the inside in the radial direction than the latching convex components 53. The sloped parts 54 and 55 slope in the peripheral direction of the latching component 48. The sloped parts 54 and 55 include a plurality of third sloped parts 54 and a plurality of fourth sloped parts 55. The third sloped parts 54 and the fourth sloped parts 55 are disposed alternating in the peripheral direction of the latching component 48. The sloping directions of the third sloped parts 54 and the fourth sloped parts 55 are opposite to each other. More precisely, the third sloped parts 54 slope in the same direction of the first sloped parts 44, while the fourth sloped parts 55 slope in the same direction as the second sloped parts 45. In this embodiment, the latching component 48 includes six third sloped parts 54. The latching component 48 also includes six fourth sloped parts 55.

[0056] Next, the operation of the solenoid actuator 5 will be described. In FIG. 4, the movable component 22 is located in the off position Poff. In this state, when voltage is applied to the solenoid actuator 5, the coil 31 generates an electromagnetic force in the on direction at the plunger 41. Consequently, the plunger 41 moves in the on direction, and the pressing member 42 pushes the latching member 43 in the on direction against the biasing force of the elastic member 52. At this point, as shown in FIG. 14, the first sloped parts 44 of the pressing member 42 press on the third sloped parts 54 of the latching member 43. The first sloped parts 44 and the third sloped parts 54 are mutually offset in the peripheral direction, so when the third sloped parts 54 is pushed by the first sloped parts 44, a force that moves the latching member 43 in the on direction and a force in the sloping direction, that is, a force that tries to rotate the latching member 43, are exerted on the latching member 43. However, in this state, as shown in FIG. 13, the latching convex components 53 of the latching member 43 are guided by the first guide grooves 36, and rotation of the latching member 43 is prohibited. Therefore, the latching member 43 does not rotate, and moves in the on direction along the first guide grooves 36.

[0057] FIG. 16 consists of developed views of the operation of the holding convex components 35 of the hold-

ing member 27, the guide grooves 36 and 37, and the latching convex components 53 of the latching member 43. As shown in FIG. 14, when the latching member 43 is pushed in the on direction by the pressing member 42, the latching convex components 53 are guided by the first guide grooves 36 as shown in FIG. 16A, and the latching member 43 moves in the on direction (see the arrow A1).

[0058] Once the latching convex components 53 has gone past the holding convex components 35 in the on direction, the above-mentioned restriction of rotation by the first guide grooves 36 is released. Therefore, as shown in FIG. 14, the third sloped parts 54 slide along the first sloped parts 44 (see the arrow A2), causing the latching member 43 to rotate around the axis. Consequently, as shown in FIG. 16B, the sloped parts 531 of the latching convex components 53 move to a position opposite the first sloped parts 351 of the holding convex components 35 (see the arrow A3). The state of the latching member 43 at this point is called a latched state.

[0059] Since FIG. 16 is developed views of the inner face of the holding member 27, the movement direction of the third sloped parts 54 in FIG. 14, that is, the rotational direction A2 of the latching member 43, is shown as being the opposite of the movement direction A3 of the latching convex components 53 in FIG. 16B.

[0060] From the state shown in FIG. 16B, the pressing member 42 further pushes the latching member 43, causing the movable component 22 to move further in the on direction. As shown in FIG. 17, the stroke adjustment member 34 attached to the second end 24 then latches the second cover member 29, causing the movable component 22 to stop at the overshoot position Pos.

[0061] When voltage to the solenoid actuator 5 is stopped, the latching member 43 is moved in the off direction by the biasing force of the elastic member 52. At this point, the latching member 43 is in the above-mentioned latched state. Therefore, as shown in FIG. 16C, the latching convex components 53 move in the off direction and come into contact with the first sloped parts 351 of the holding convex components 35. The biasing force of the elastic member 52 then causes the latching member 43 to be pushed in the off direction, causing the latching convex components 53 to slide along the first sloped parts 351 of the holding convex components 35, and to be latched and stopped by the first sloped parts 351 and the stepped parts 353 (see the arrow A4). In this state, the movable component 22 is in the on position Pon. As shown in FIG. 18, even if the pressing member 42 and the plunger 41 then return in the off direction, the latching member 43 will not move in the off direction because it is latched to the holding member 27. Consequently, the first end 23 is held in the on position Pon.

[0062] As discussed above, when voltage is applied in a state in which the movable component 22 is in the off position Poff, the solenoid actuator 5 moves the movable component 22 from the off position Poff to the overshoot position Pos. This move by the movable component 22 from the on position Pon to the overshoot position Pos switches the latching member 43 to a latched state. When voltage to the solenoid actuator 5 is then stopped, the movable component 22 moves to the off position Poff, and the latching member 43 latches the holding member 27 and is held in the on position Pon.

[0063] As shown in FIG. 18, in a state in which the movable component 22 is in the on position Pon, if voltage is then applied to the solenoid actuator 5, the coil 31 generates electromagnetic force in the on direction at the plunger 41. Consequently, the plunger 41 moves in the on direction, and the pressing member 42 pushes the latching member 43 in the on direction from the on position Pon against the biasing force of the elastic member 52. Consequently, the latching convex components 53 moves in the on direction (see the arrow A5) as shown in FIG. 19A.

[0064] When the latching convex components 53 go past the stepped parts 353 of the holding convex components 35 in the on direction, as shown in FIG. 19B, just as with the above-mentioned latching member 43, the latching member 43 rotates around the axis, causing the sloped parts 531 of the latching convex components 53 to move to a position opposite the second sloped parts 352 of the holding convex components 35 (see the arrow A6). The state of the latching member 43 at this point is called an unlatched state.

[0065] Then, when the voltage to the solenoid actuator 5 is stopped, the latching member 43 is pushed in the off direction by the biasing force of the elastic member 52. Consequently, as shown in FIG. 19C, the sloped parts 531 of the latching convex components 53 slide along the second sloped parts 352 of the holding convex components 35 and move to a position opposite the first guide grooves 36. The latching convex components 53 then move in the off direction along the first guide grooves 36. Consequently, the latching member 43 moves in the off direction, and the movable component 22 returns to the off position Poff.

[0066] As discussed above, when voltage is applied in a state in which the movable component 22 is in the on position Pon, the solenoid actuator 5 moves the movable component 22 from the on position Pon to the overshoot position Pos. This move by the movable component 22 from the on position Pon to the overshoot position Pos switches the latching member 43 to the unlatched state. When voltage to the solenoid actuator 5 is then stopped, the movable component 22 moves in the off direction and thereby moves to the off position Poff.

[0067] The contact opening and closing device 1 according to this embodiment has the following characteristics.

[0068] When the driving contact 12 and the driven contact 11 are switched from a state of non-contact to a state of contact, as shown in FIG. 3, the movable component 22 moves to the on position Pon only after first moving to the overshoot position Pos, which lies beyond the on position Pon. Therefore, the driving contact 12 can be

moved a long distance, so even if the contacts should become fused, they can still be easily pulled apart. Consequently, the fusion resistance of the contacts can be improved even in high-load opening and closing in which there is a large amount of rush current.

[0069] Also, since the contact wiping action can be increased, there is a good contact cleaning action. This improves the reliability with which the contacts make contact.

[0070] When the driving contact 12 and the driven contact 11 are switched from a state of contact to a state of non-contact, the movable component movable component 22 moves from the on position Pon, through the overshoot position Pos, to the off position Poff. Accordingly, the contacts can be put in a state of non-contact after being activated. This allows the contacts to be cleaned.

[0071] The solenoid actuator 5 holds the movable component 22 in the on position Pon by having the latching member 43 latch the holding member 27. Therefore, the movable component 22 can be held in the on position Pon even if no voltage is applied to the solenoid actuator 5. Accordingly, the contacts are maintained in a state of contact even if the voltage to the solenoid actuator 5 is stopped. Also, the movable component 22 is held in the off position Poff by the biasing force of the elastic member 52. Therefore, even though no voltage is being applied to the solenoid actuator 5, the movable component 22 can be held in the off position Poff. Accordingly, the contacts can be maintained in a state of non-contact even though the voltage to the solenoid actuator 5 is stopped.

[0072] As discussed above, with the contact opening and closing device 1 according to this embodiment, every time a pulse signal is inputted to the solenoid actuator 5, the contacts are switched between a state of contact and a state of non-contact. If no signal is inputted, the contacts are maintained in their current state. Therefore, the state of the contacts can be maintained even if the application of voltage to the solenoid actuator 5 is not maintained. This reduces the power consumption of the contact opening and closing device 1.

[0073] Also, since the contacts are maintained in a state of contact by latching the holding member 27 and the latching member 43, impact resistance is better than when the contacts are maintained in a state of contact by elastic force with a spring or by electromagnetic force with a coil.

[0074] The second end 24 protrudes from the main body component 21 in the opposite direction from the first end 23, in the axial direction. Therefore, the movable component 22 can be moved manually by manipulating the second end 24. Specifically, the movable component 22 can be switched from the on position Pon to the off position Poff by manually moving the second end 24 in the on direction. Consequently, the contacts can be manually switched between a state of contact and a state of non-contact.

[0075] The stroke of the movable component 22 can be adjusted by adjusting the attachment position of the stroke adjustment member 34 at the second end 24. This allows the amount of overshoot of the movable component 22 to be adjusted. For example, if the amount of overshoot is to be made smaller, the stroke adjustment member 34 should be moved in the on direction (to the left in FIG. 4). If the amount of overshoot is to be made larger, the stroke adjustment member 34 should be moved in the off direction (to the right in FIG. 4).

[0076] An embodiment of the present invention was described above, but the present invention is not limited to or by the above embodiment, and various modifications are possible without departing from the gist of the invention.

[0077] The contact opening and closing device 1 according to the above embodiment is a relay, but the present invention may be applied to a switch or some other such device.

[0078] The configuration of the solenoid actuator 5 is not limited to that in the above embodiment, and may be modified. For example, the elastic member 52 may be omitted. In this case, a restoration force that returns the contacts to a state of non-contact can be obtained, for example, by means of the elastic force of the driving contact piece 4. The stroke adjustment member 34 may be omitted. The second end 24 need not protrude from the main body component 21. That is, the second end 24 may be disposed inside the main body component 21.

[0079] The shape latching member 43 and the holding member 27 may be modified. The number of the latching convex components 53, the holding convex components 35, and the guide grooves may also be changed. Also, the number of the first sloped parts 351 and the second sloped parts 352 of the pressing member 42, and the third sloped parts 54 and the fourth sloped parts 55 of the latching member 43 may be changed.

[0080] The configuration of the contact opening and closing device 1 may be modified. For instance, the number of the driven contact 11 and the driving contact 12 is not limited to one each, and there may be two or more of each. The configuration related to the driven contact piece 3 and the driving contact piece 4 is not limited to the configuration in the above embodiment, and may be modified.

[0081] FIG. 20 is a side view of the contact opening and closing device 1a according to a first modification example. As shown in FIG. 20, the movable component 22 of the solenoid actuator 5 may push the portion of the driving contact piece 4 between the driving contact 12 and a connected part 61 with the base 2.

[0082] FIG. 21 is a plan view of the contact opening and closing device 1 b according to a second modification example. As shown in FIG. 21, the driving contact piece 4 and the driven contact piece 3 may extend in a direction that is perpendicular to the up and down direction. In other words, the driving contact piece 4 and the driven contact piece 3 may extend along the surface of the base 2. With the contact opening and closing device 1b ac-

cording to the second modification example, the movable component 22 of the solenoid actuator 5 pushes a portion of the driving contact piece 4 that is further to the distal end side than the driving contact 12.

[0083] FIG. 22 is a plan view of the contact opening and closing device 1c according to a third modification example. As shown in FIG. 22, the movable component 22 of the solenoid actuator 5 may push the portion of the driving contact piece 4 between the driving contact 12 and the connected part 61 with the base 2. The rest of the configuration of the contact opening and closing device 1 c according to the third modification example is the same as that of the contact opening and closing device 1 b according to the second modification example.

[0084] FIG. 23 is a plan view of the contact opening and closing device 1d according to a fourth modification example. As shown in FIG. 23, the contact opening and closing device 1d FIG. 23 according to the fourth modification example includes a first driven contact 11 a, a second driven contact 11 b, a first driving contact 12a, and a second driving contact 12b. The first driving contact 12a and the second driving contact 12b are attached to the driving contact piece 4. The driving contact piece 4 is not attached to the base 2, and is supported by the movable component 22 of the solenoid actuator 5. The movable component 22 pushes the portion of the driving contact piece 4 between the first driving contact 12a and the second driving contact 12b. The solenoid actuator 5 moves the entire driving contact piece 4 in the axial direction. Consequently, the opening and closing of the first driven contact 11 a and the first driving contact 12a, and the opening and closing of the second driven contact 11 b and the second driving contact 12b are switched.

[0085] FIG. 24A is a plan view of the contact opening and closing device 1e according to a fifth modification example. FIG. 24B is a side view of the contact opening and closing device 1 e according to the fifth modification example. As shown in FIGS. 24A and 24B, the contact opening and closing device 1e according to the fifth modification example includes a plurality of driven contacts 11, a plurality of driving contacts 12, and a plurality of driving contact pieces 4. In FIG. 24, only some of the driven contacts 11 and the driving contacts 12 are labeled 11 and 12, and the rest are not. The driving contact pieces 4 are connected to a link member 62, and the movable component 22 of the solenoid actuator 5 moves the link member 62. Consequently, the contacts 11 and 12 are opened and closed when the driving contact pieces 4 all move at the same time.

[0086] FIG. 25 is a side view of the contact opening and closing device 1f according to a sixth modification example. The contact opening and closing device 1f according to the sixth modification example includes a first support 63 and a second support 64. The first support 63 is disposed on the base 2. The second support 64 is pivotably attached to the first support 63 via a hinge 65. The driving contact 12 is supported by the second support 64. The movable component 22 of the solenoid actuator 5 moves the driving contact 12 by moving the second support 64. This switches between a state of contact in which the driving contact 12 is touching the first driven contact 11 a, and a state of non-contact in which the driving contact 12 is not touching the first driven contact 11 a. In a state of non-contact, the driving contact 12 is touching the second driven contact 11 b.

[0087] FIG. 26 is a side view of the contact opening and closing device 1g according to a seventh modification example. FIG. 27 consists of plan views of the contact opening and closing device 1g according to the seventh modification example. As shown in FIG. 26, the contact opening and closing device 1g further includes a cover member 66. The cover member 66 covers the driven contact 11, the driving contact 12, and the solenoid actuator 5. As shown in FIG. 27, the cover member 66 includes a window 67. The window 67 is disposed at a location opposite at least part of the movable component 22. The window 67 is formed from a transparent material, for example, so that at least part of the movable component 22 can be seen through the window 67. The part of the cover member 66 other than the window 67 is preferably opaque. The color of the movable component 22 is preferably different from the color of the base 2 or the main body component 21.

[0088] With the contact opening and closing device 1g according to the seventh modification example, the location of the movable component 22 can be visually confirmed through the window 67. The contact state is determined according to the location of the movable component 22. For instance, FIG. 27A shows the movable component 22 in the off position Poff. In this case, the user can confirm that the contacts are in a state of non-contact. FIG. 27C shows the movable component 22 in the on position Pon. In this case, the user can confirm that the contacts are in a state of contact. FIG. 27B shows the movable component 22 in the overshoot position Pos. Thus, the user can easily confirm the contact state by confirming the location of the movable component 22 through the window 67.

INDUSTRIAL APPLICABILITY

[0089] The present invention provides a contact opening and closing device with which contact fusion resistance and contact reliability can be improved.

REFERENCE SIGNS LIST

[0090]

11	driven contact
12	driving contact
5	solenoid actuator
31	coil
41	plunger
27	holding member
43	latching member

21 main body component
23 first end
24 second end
34 stroke adjustment member
66 cover member

Claims

1. A contact opening and closing device, comprising:

a driven contact;
a driving contact configured to move with respect to the driven contact; and
a solenoid actuator including a movable component, the movable component configured to move between an off position and an on position, the off position in which the driving contact and the driven contact are in a state of non-contact, the on position in which the driving contact and the driven contact are in a state of contact,
wherein, when the driving contact and the driven contact are switched from a state of non-contact to a state of contact, the movable component moves from the off position to the on position through an overshoot position located beyond the on position.

2. The contact opening and closing device according to Claim 1,
wherein, when the driving contact and the driven contact are switched from a state of contact to a state of non-contact, the movable component moves from the on position to the off position through the overshoot position.

3. The contact opening and closing device according to Claim 1 or 2,
wherein the solenoid actuator further includes a coil component,
the movable component includes a plunger disposed inside the coil component, and
the movable component moves in an axial direction of the plunger, between the off position, the on position, and the overshoot position.

4. The contact opening and closing device according to Claim 3, further comprising:

a holding member holding the movable component in the on position by latching the movable component.

5. The contact opening and closing device according to Claim 4,
wherein the movable component further includes a latching member,
the latching member is configured to be switched between a latched state of being latched to the holding member, and an unlatched state of being unlatched from the holding member, and
when the movable component moves from the off position to the overshoot position, the latching member is switched from the unlatched state to the latched state.

6. The contact opening and closing device according to Claim 5,
Wherein, when the voltage is applied to the solenoid actuator in a state in which the movable component is in the off position, the solenoid actuator moves the movable component from the off position to the overshoot position.

7. The contact opening and closing device according to Claim 5 or 6,
Wherein, when the movable component moves from the on position to the overshoot position, the latching member is switched from the latched state to the unlatched state.

8. The contact opening and closing device according to Claim 7,
Wherein, when voltage is applied to the solenoid actuator in a state in which the movable component is in the on position, the solenoid actuator moves the movable component from the on position to the overshoot position.

9. The contact opening and closing device according to Claim 7 or 8,
wherein the solenoid actuator further includes an elastic member that biases the movable component in a direction facing from the on position toward the off position.

10. The contact opening and closing device according to any of Claims 5 to 9,
wherein the solenoid actuator further includes a main body component including a through-hole into which the movable component is inserted, and
the movable component includes:

a first end protruding from the main body component in the axial direction, the first end being configured to move the driving contact; and
a second end protruding from the main body component in an opposite direction from the first end, in the axial direction.

11. The contact opening and closing device according to Claim 10,
wherein the movable component further includes a stroke adjustment member attached to the second end, and
an external size of the stroke adjustment member is

larger than that of the through-hole.

12. The contact opening and closing device according to any of Claims 1 to 11, further comprising:

a driving contact piece supporting the driving contact,
wherein the movable component presses on the driving contact piece at a location that is away from the driving contact.

13. The contact opening and closing device according to any of Claims 1 to 12, further comprising:

a cover member covering the driven contact, the driving contact, and the solenoid actuator,
wherein the cover member includes a window disposed at a position that is opposite at least part of the movable component, and
at least part of the movable component is visible through the window.

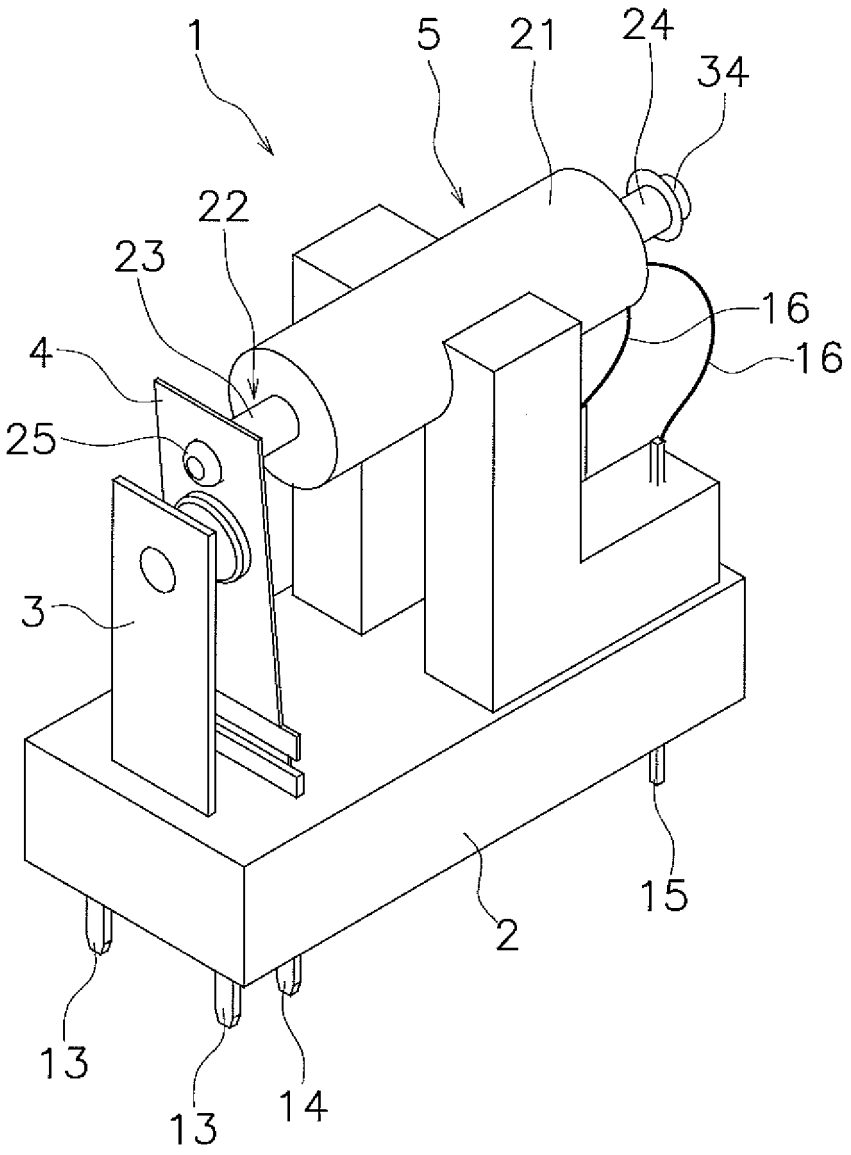


FIG. 1

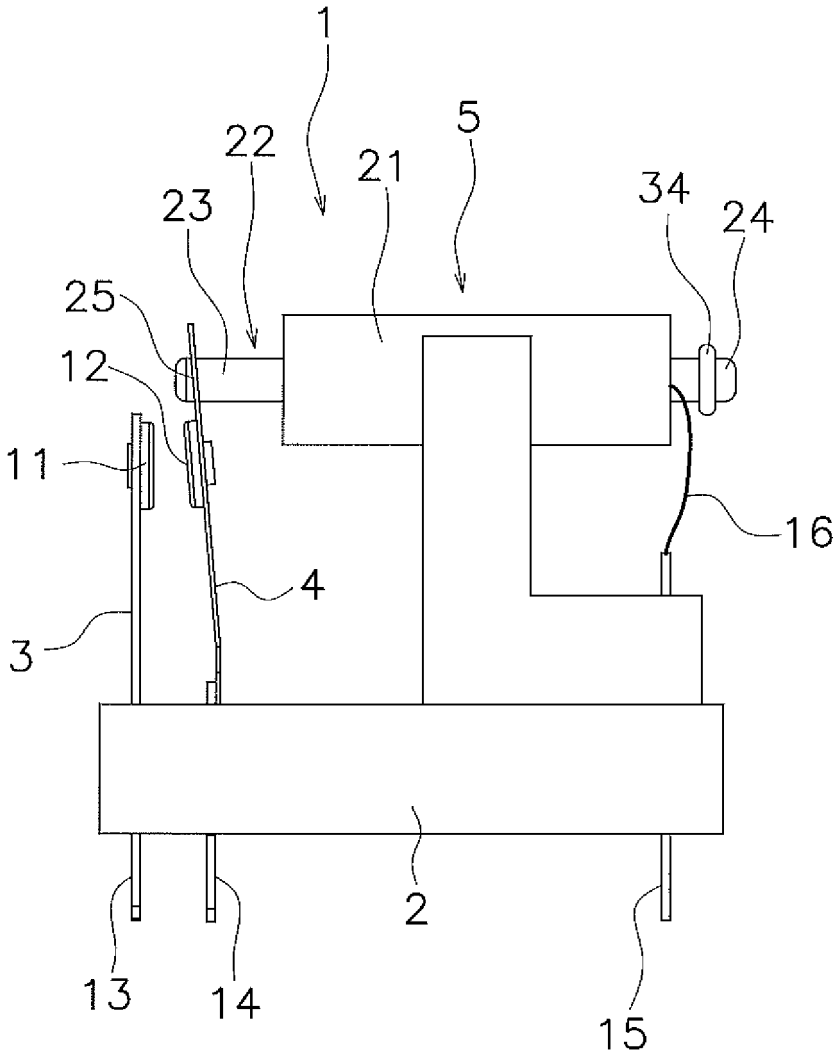


FIG. 2

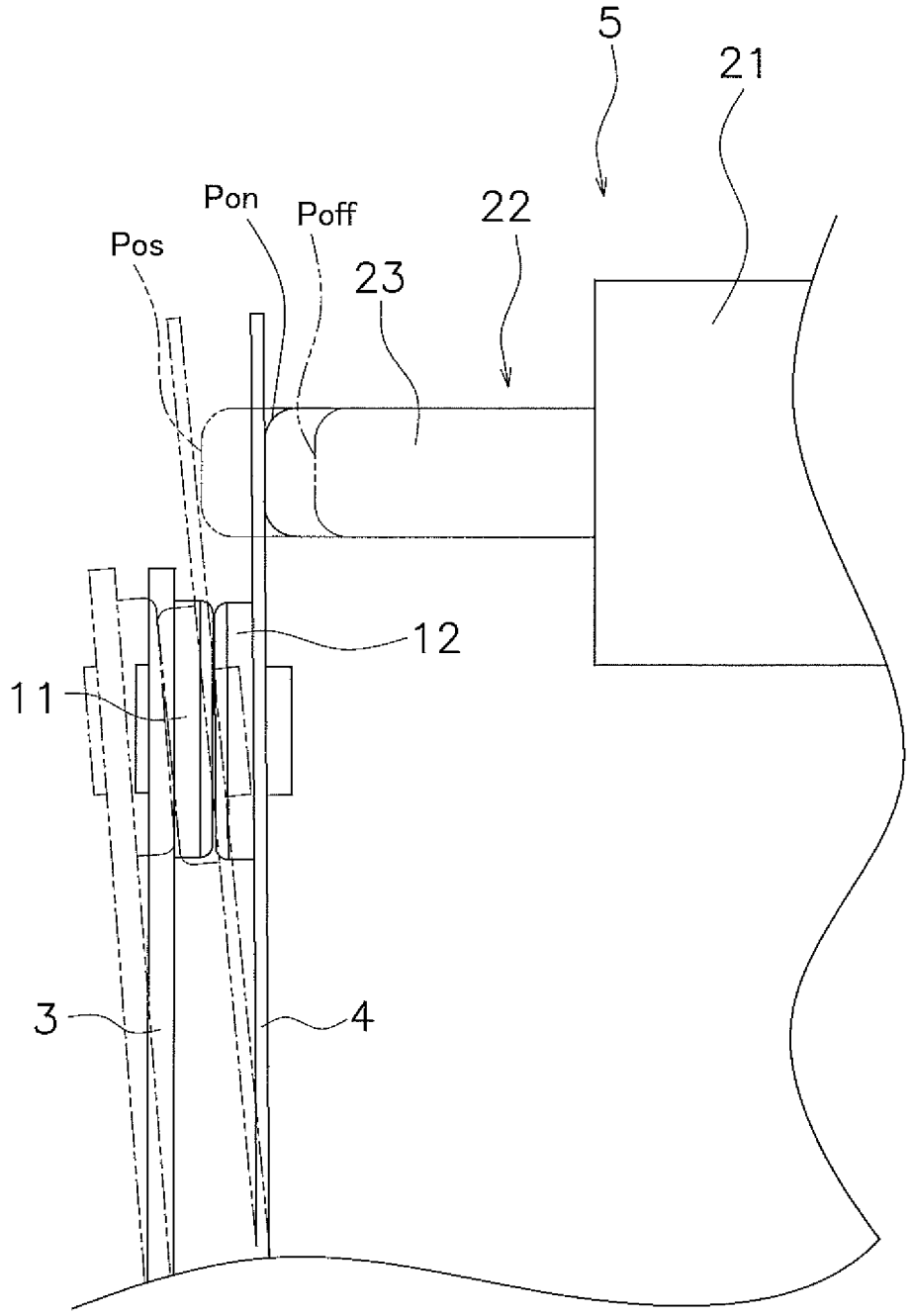
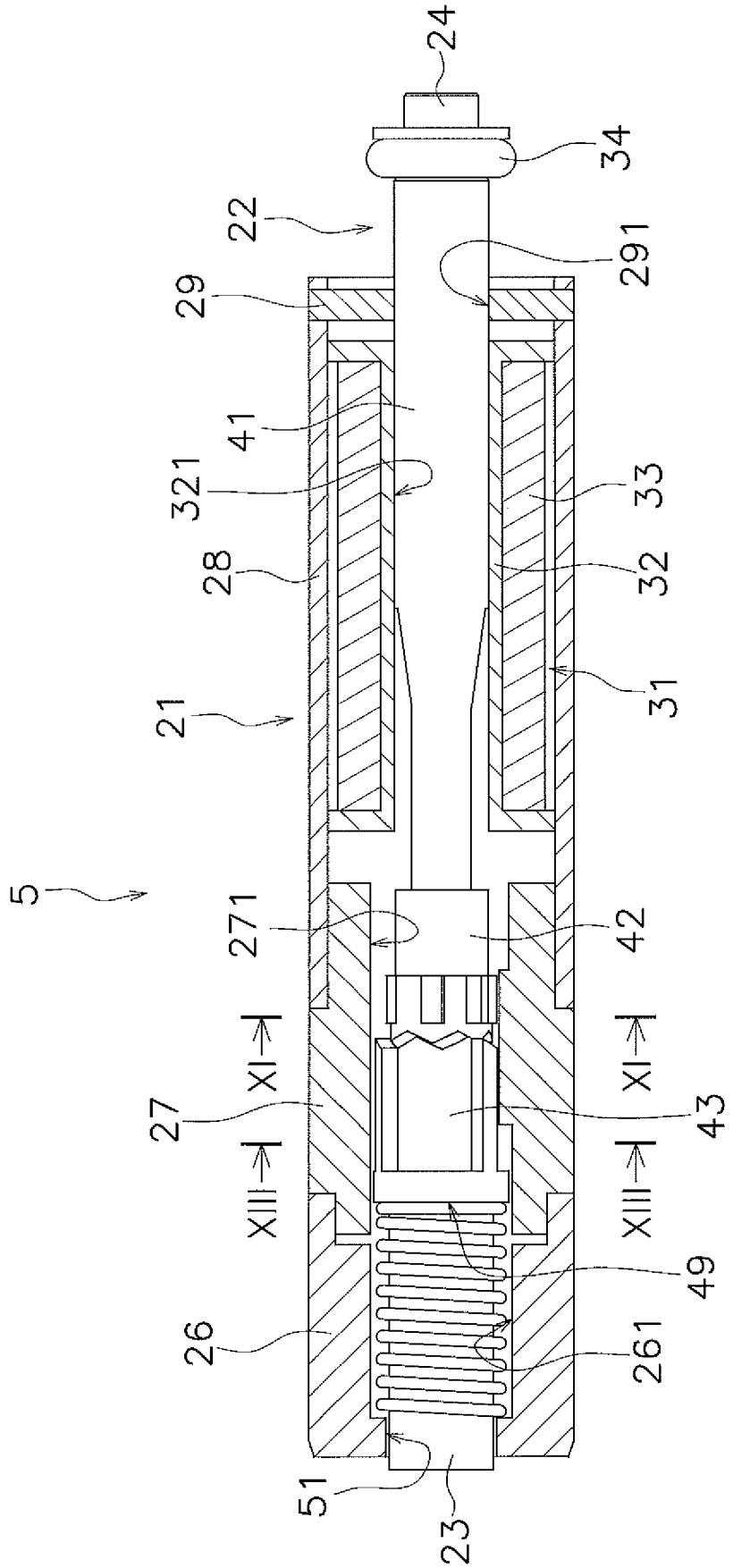


FIG. 3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321
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XI
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27
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XIII
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51
23

FIG. 4

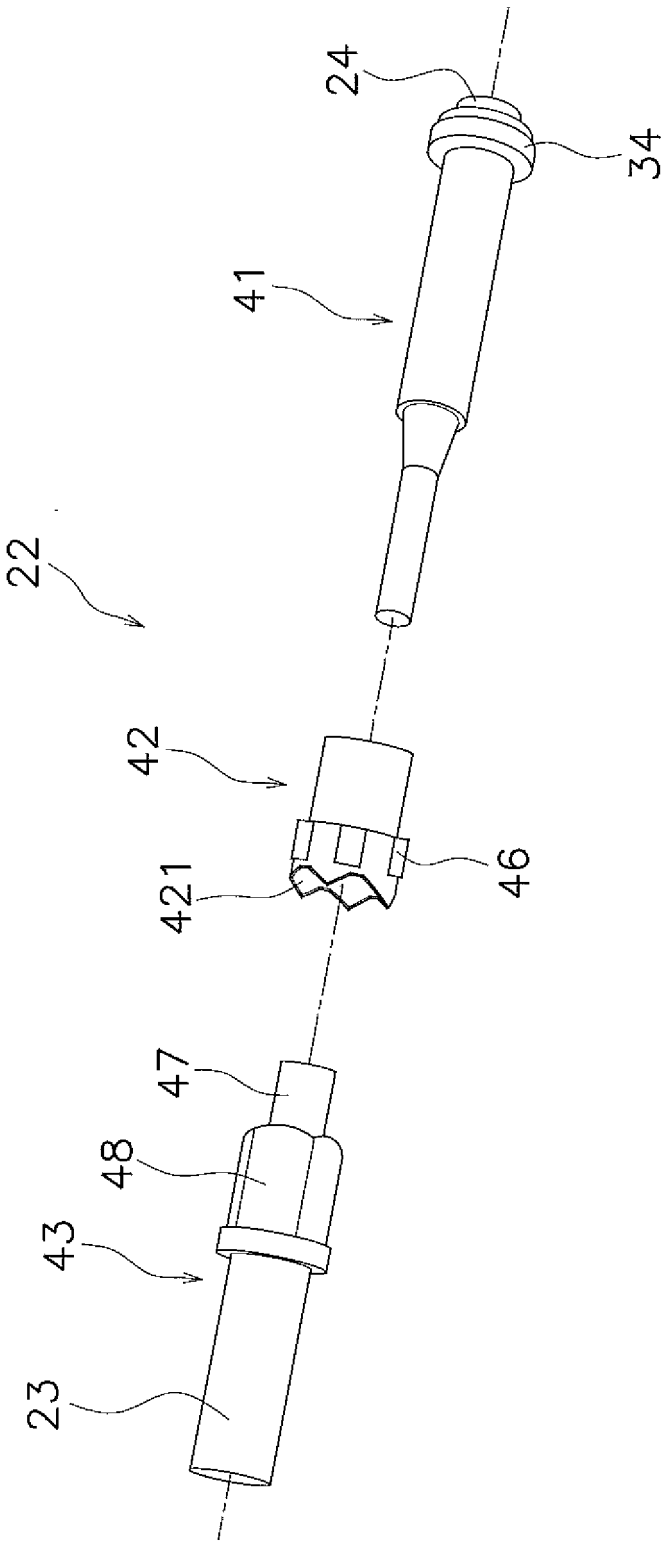


FIG. 5

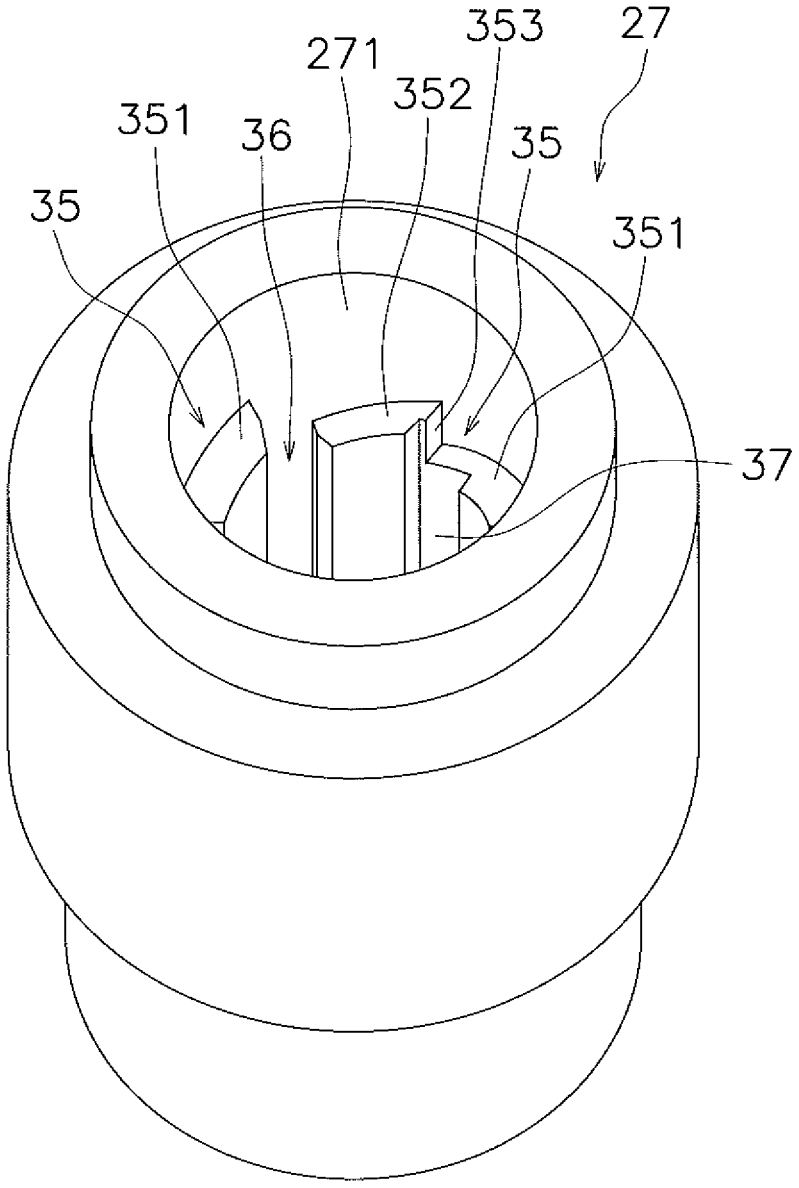


FIG. 6

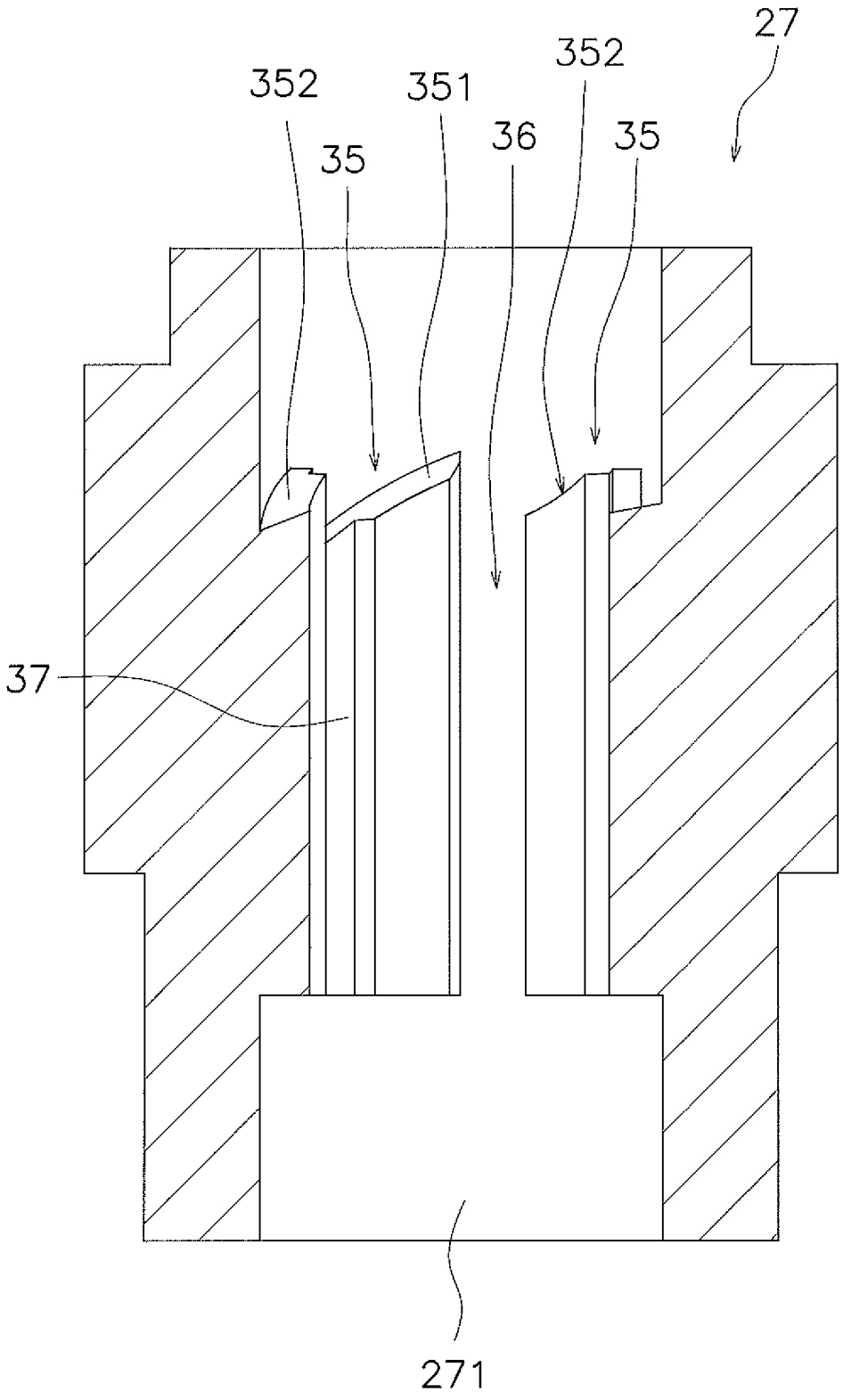


FIG. 7

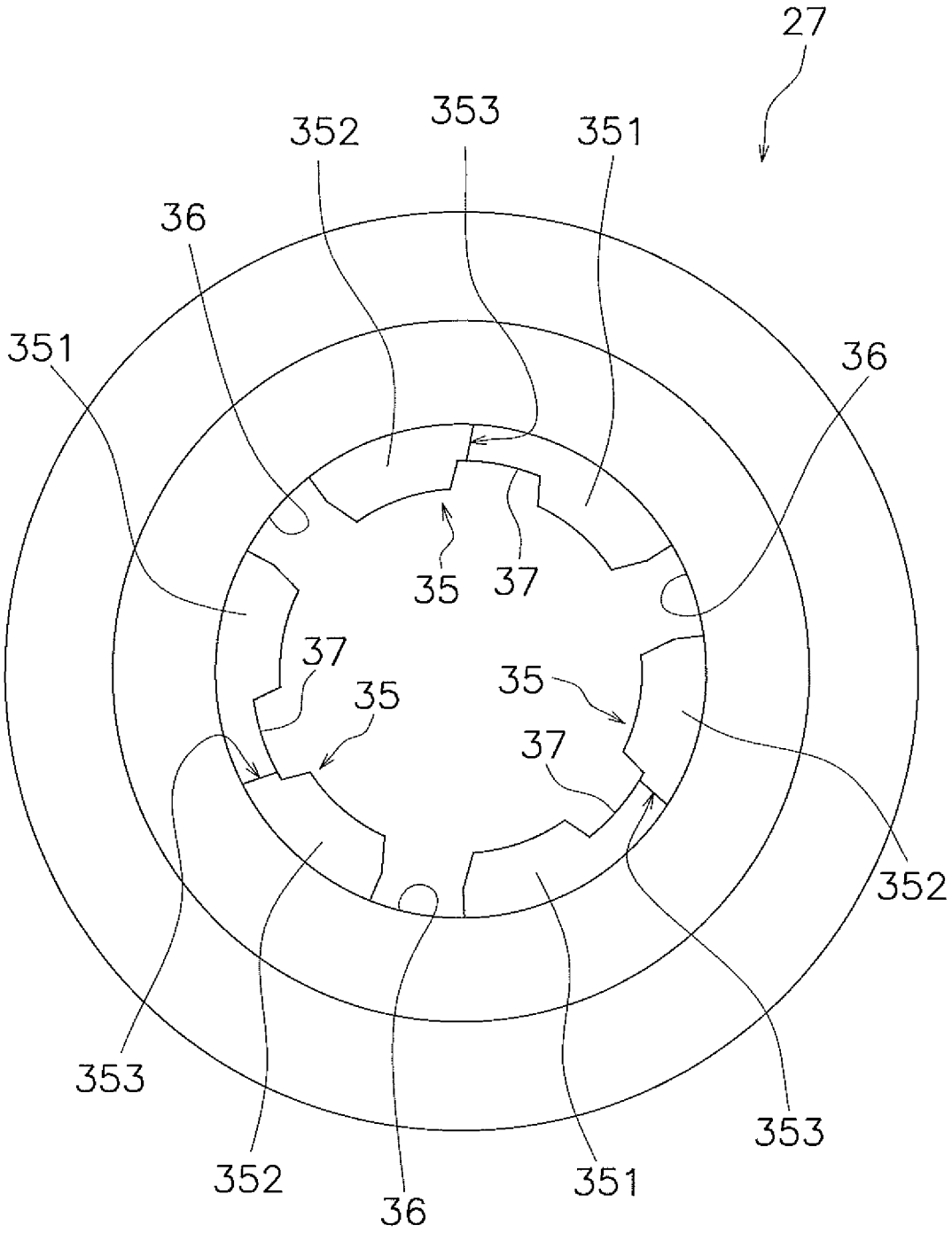


FIG. 8

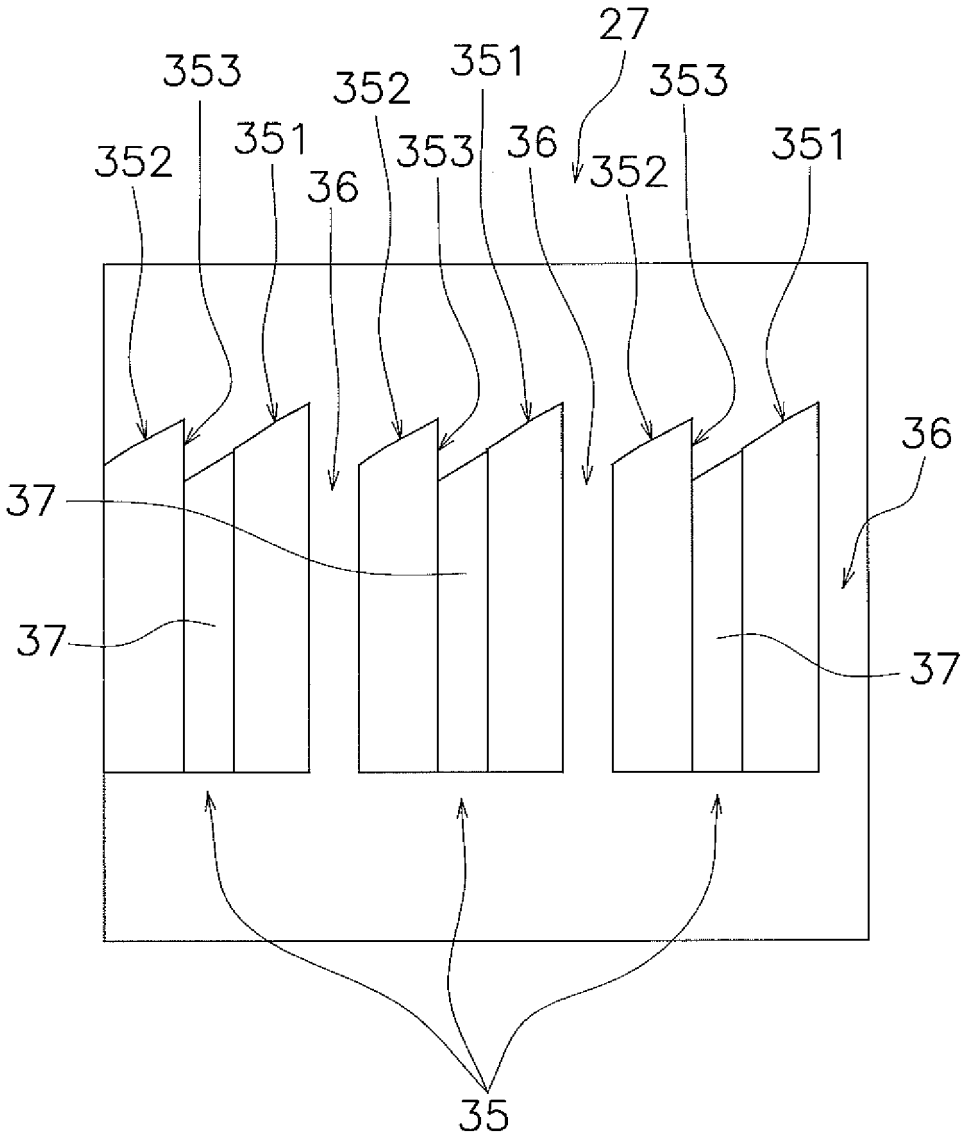


FIG. 9

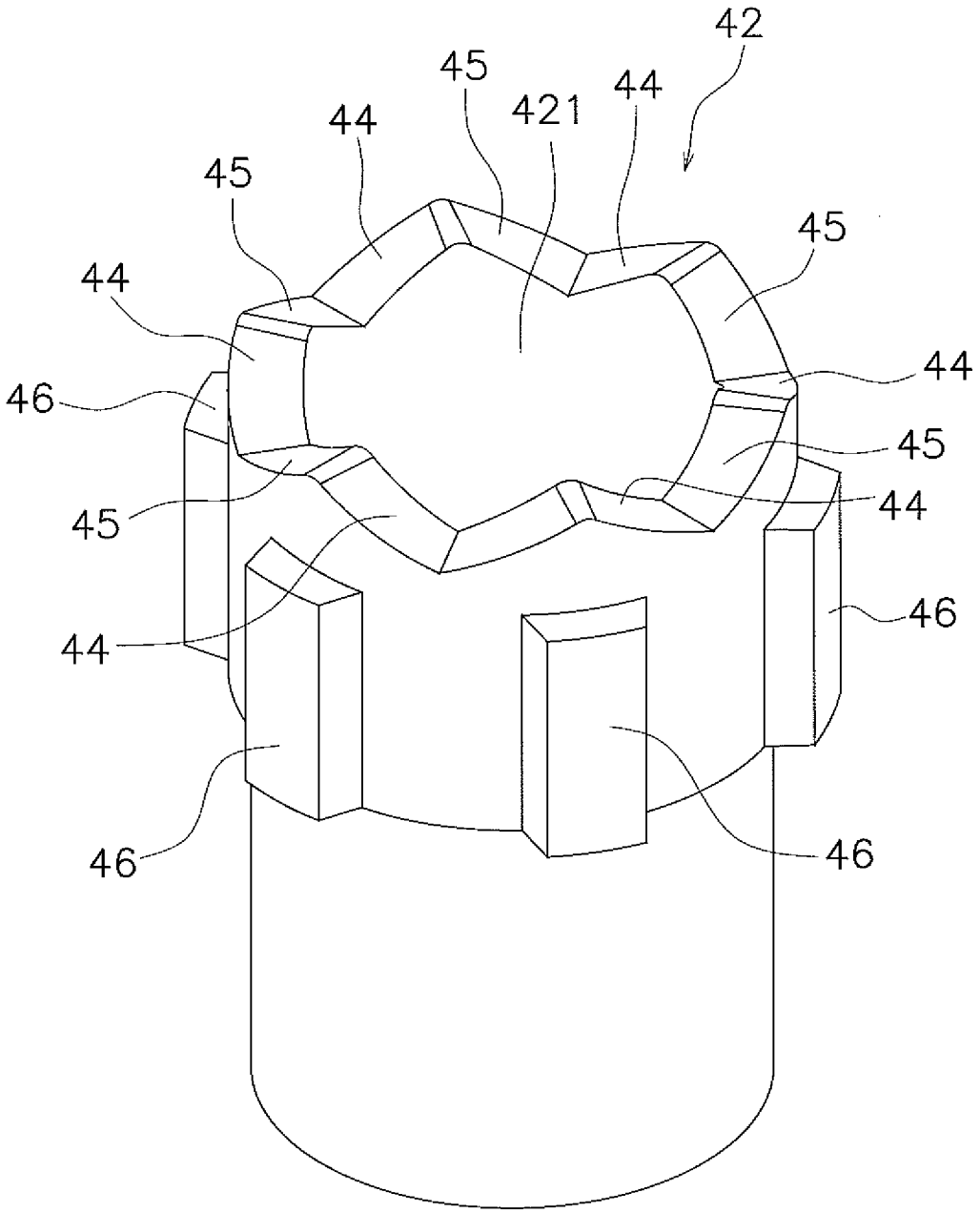


FIG. 10

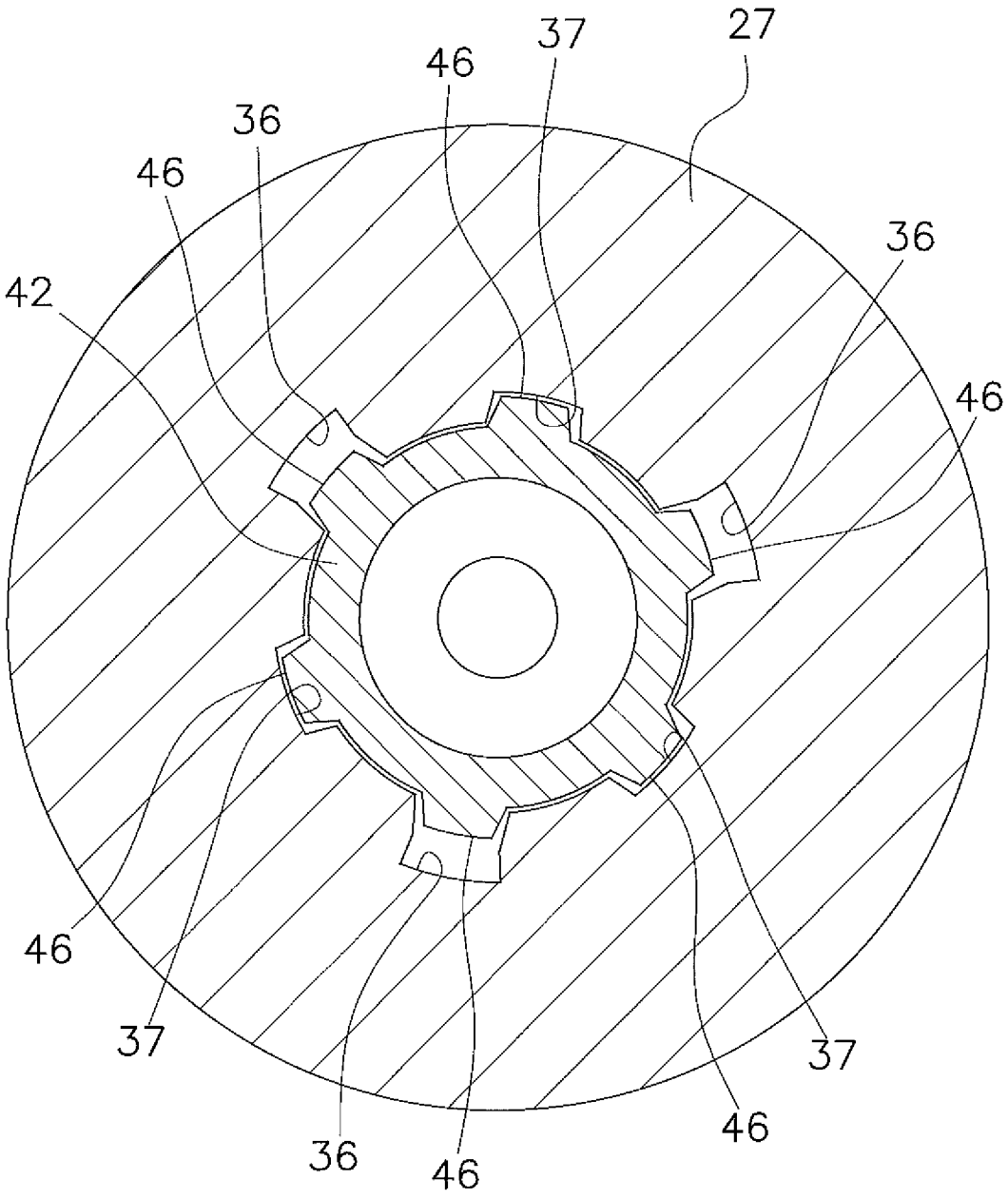


FIG. 11

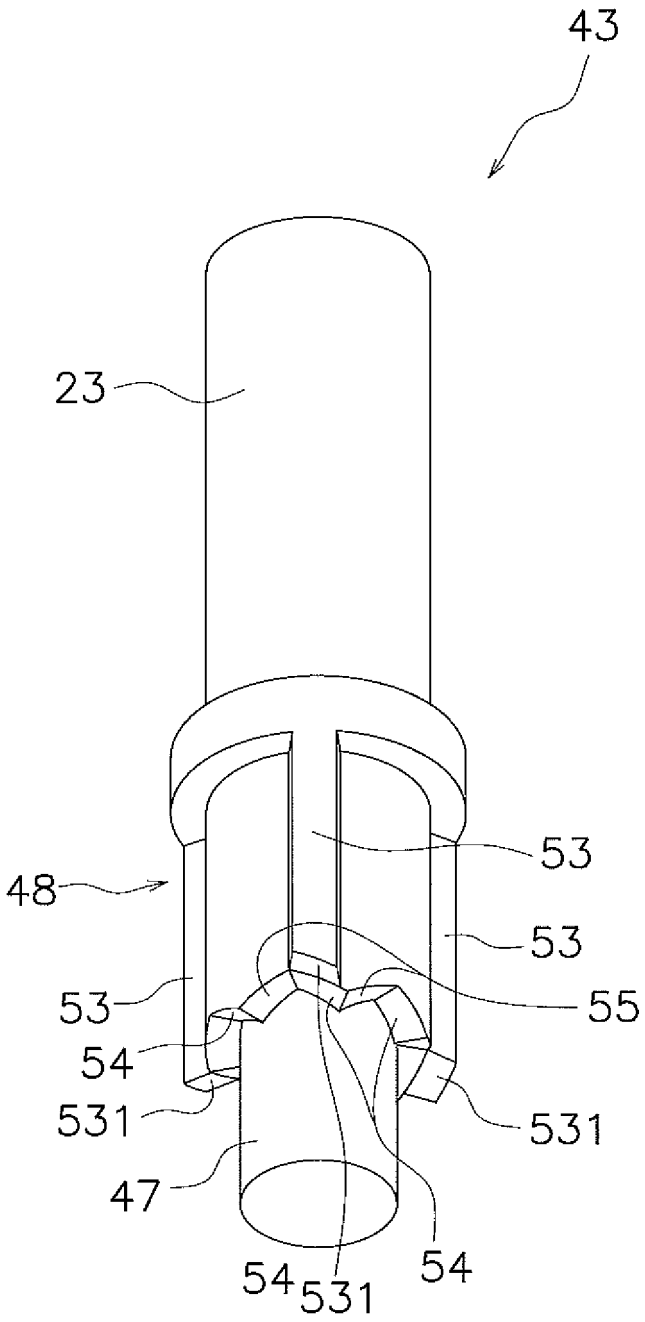


FIG. 12

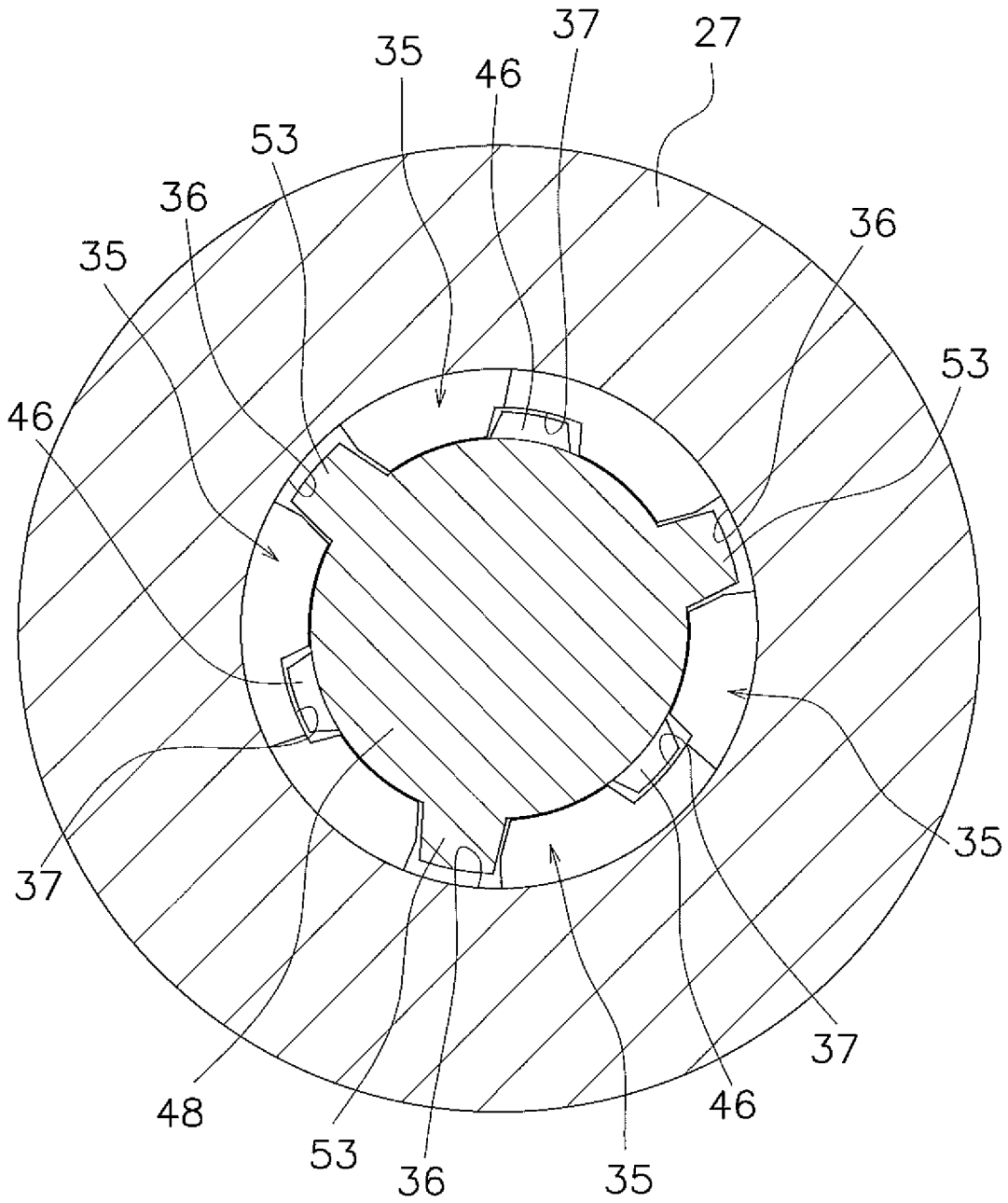


FIG. 13

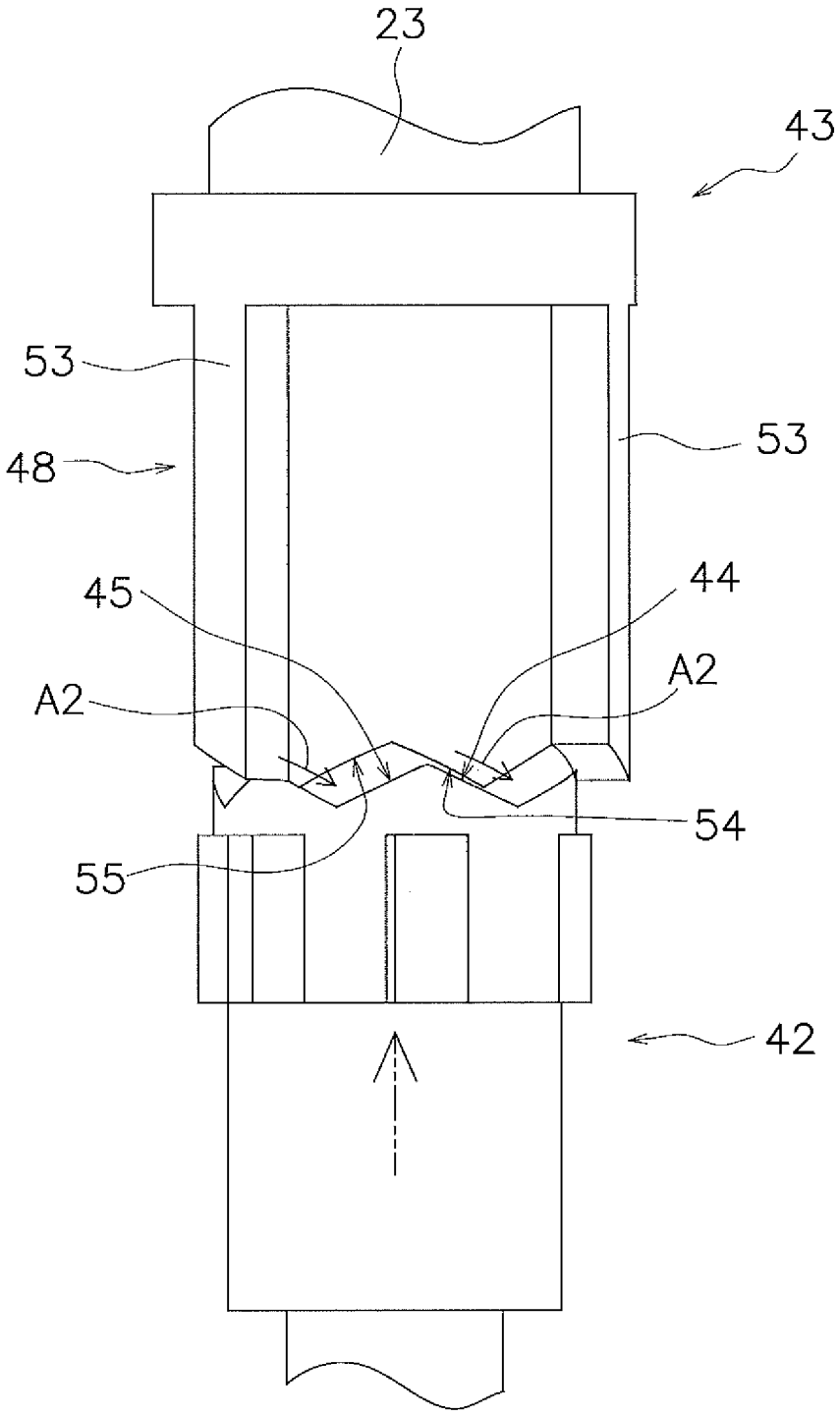


FIG. 14

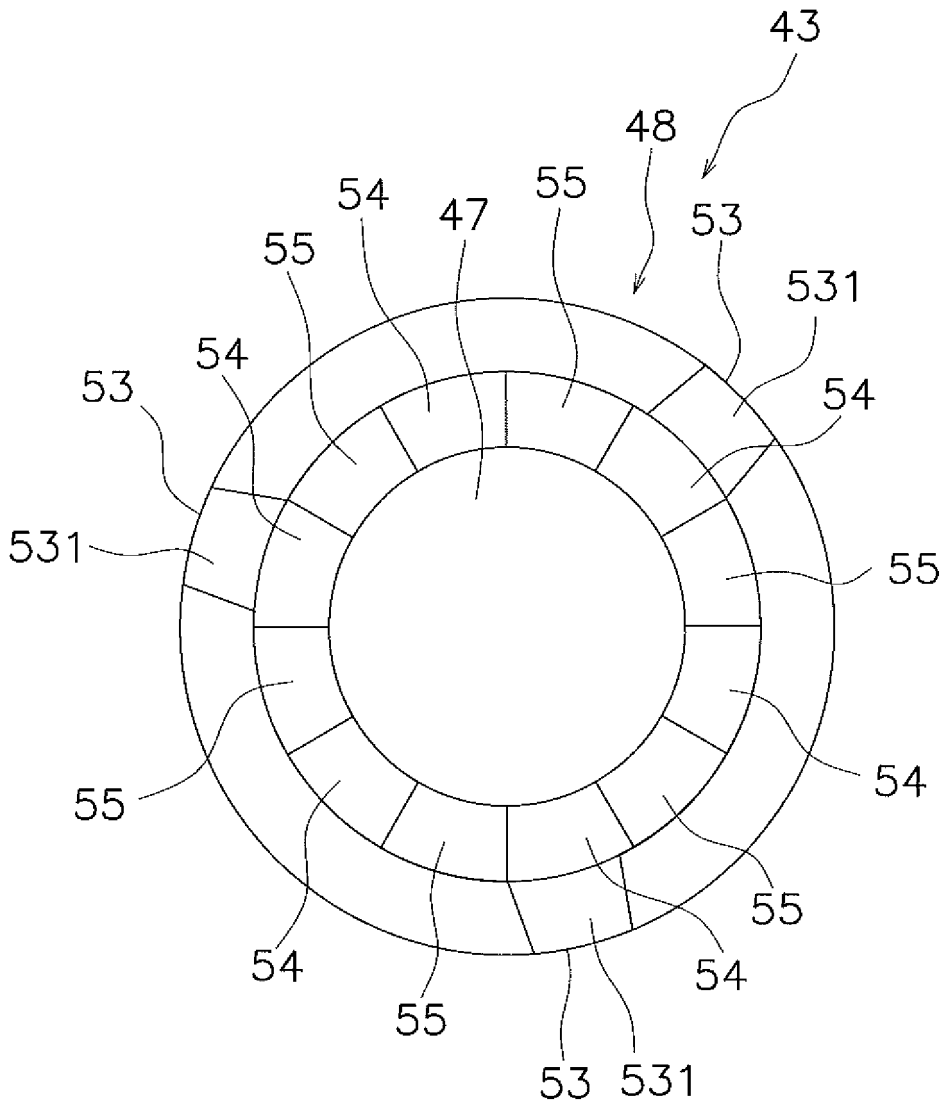
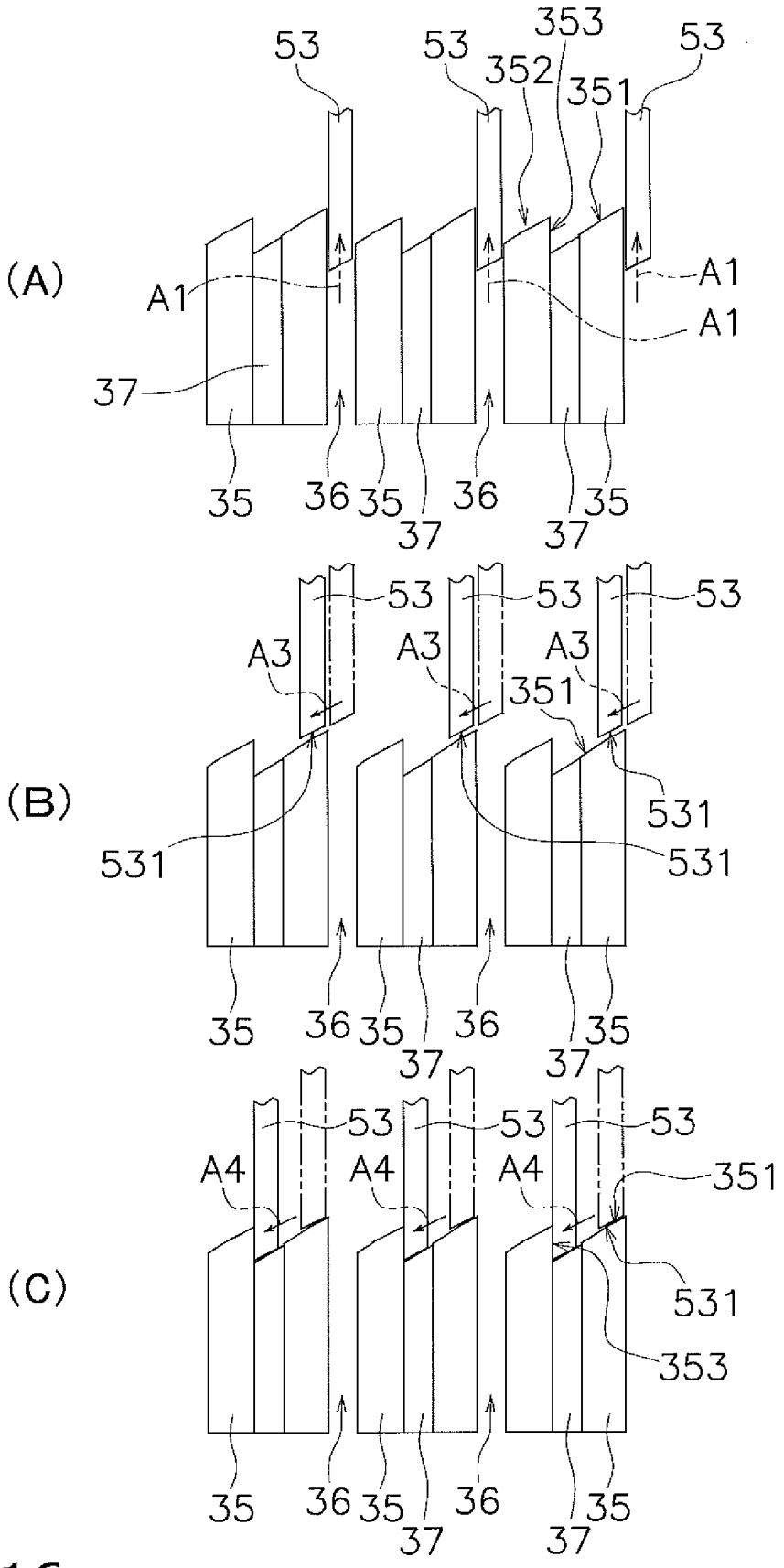


FIG. 15


(A)
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(C)
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FIG. 16

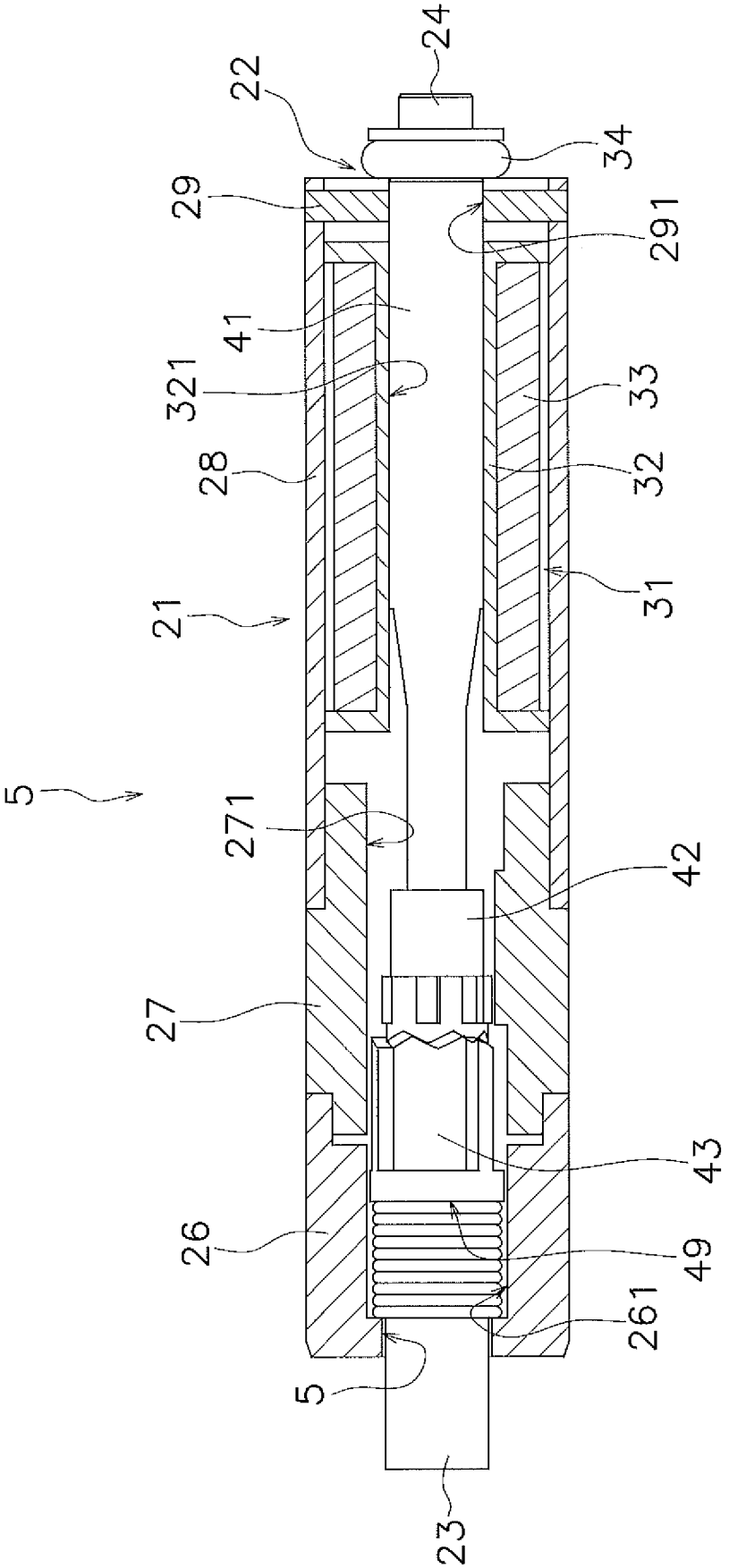


FIG. 17

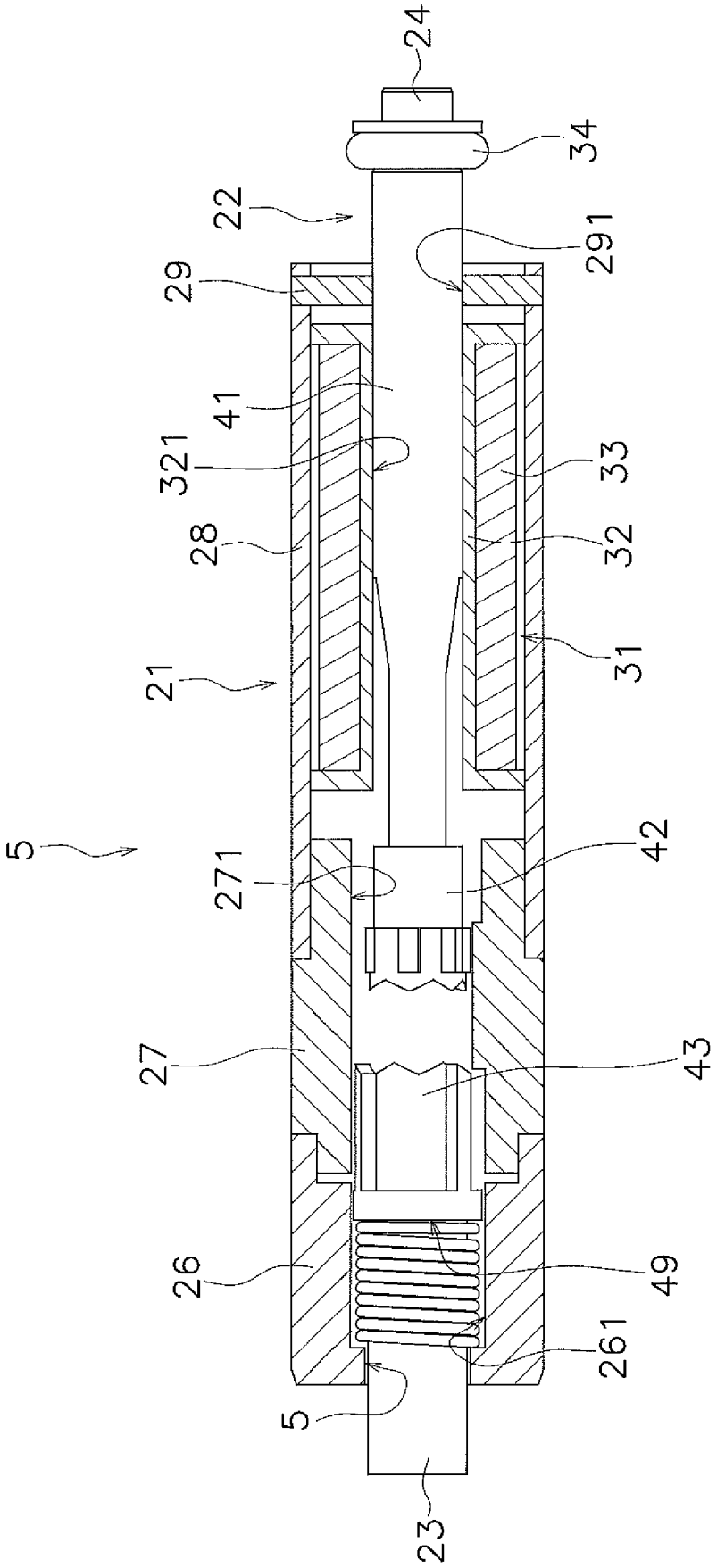
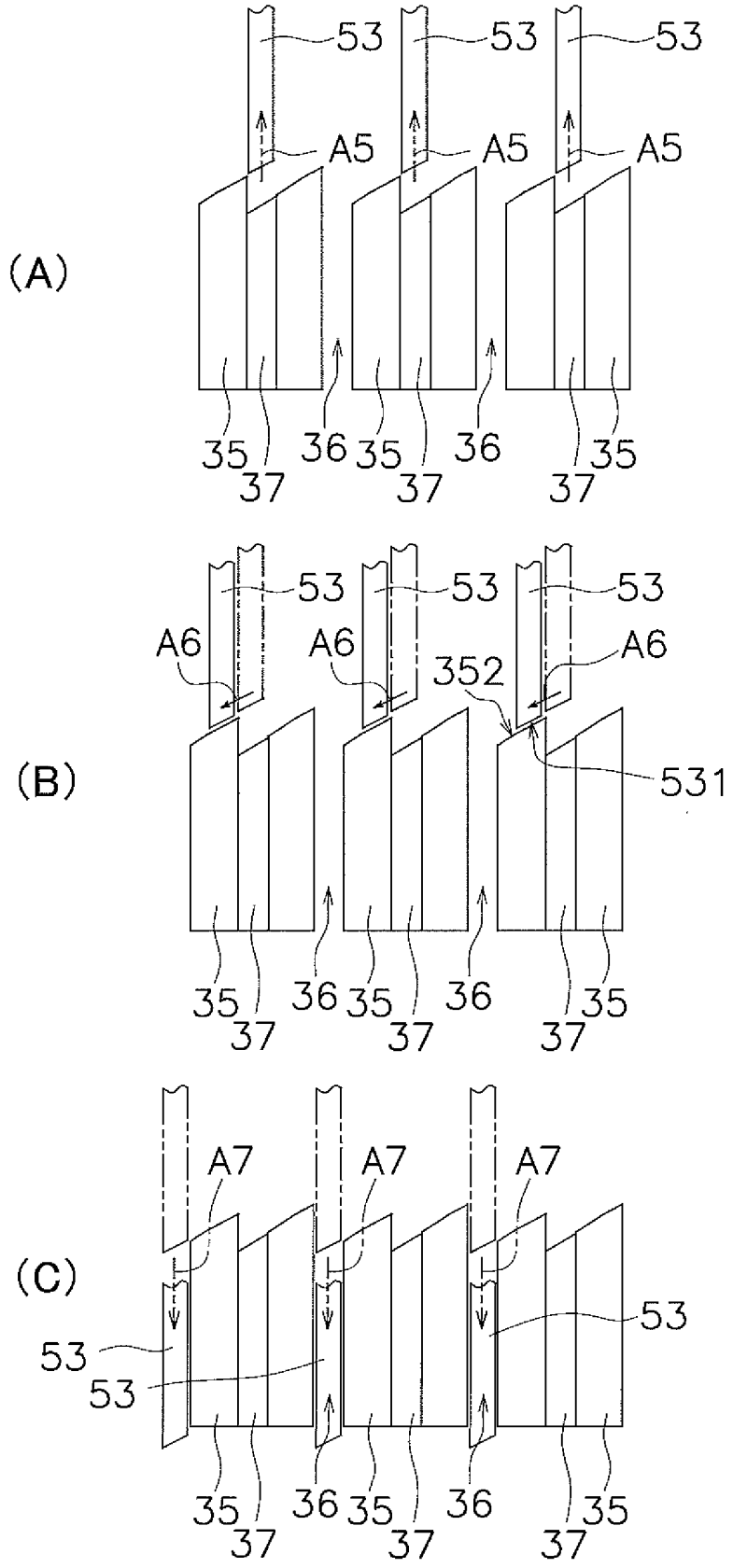


FIG. 18


(A)
53
53
53
A5
A5
A5
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37
36
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37
(B)
53
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A6
A6
352
A6
531
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(C)
A7
A7
A7
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FIG. 19

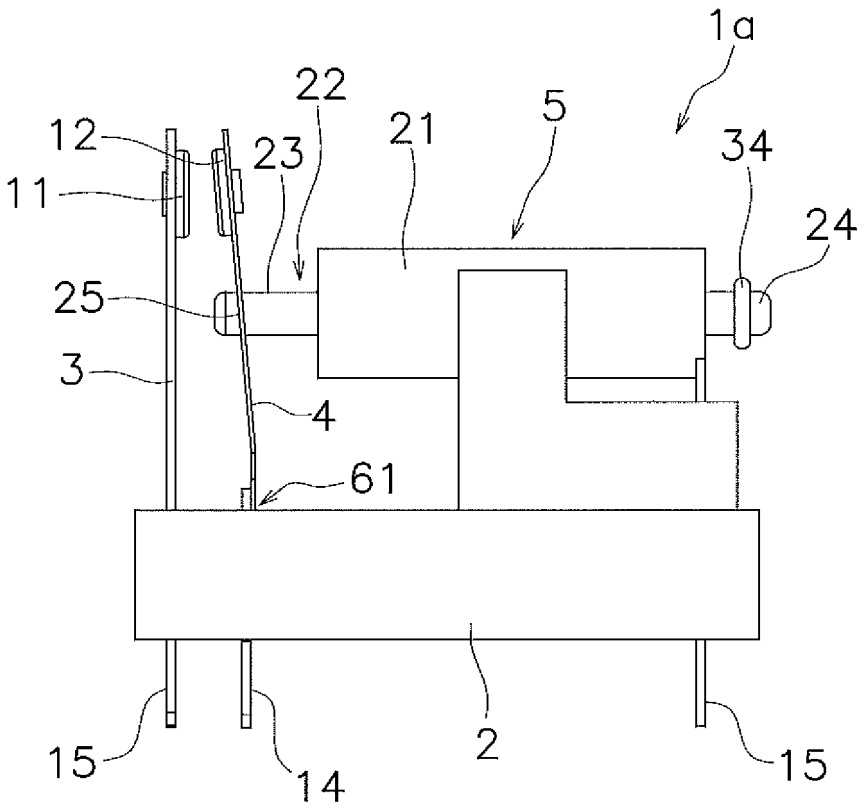


FIG. 20

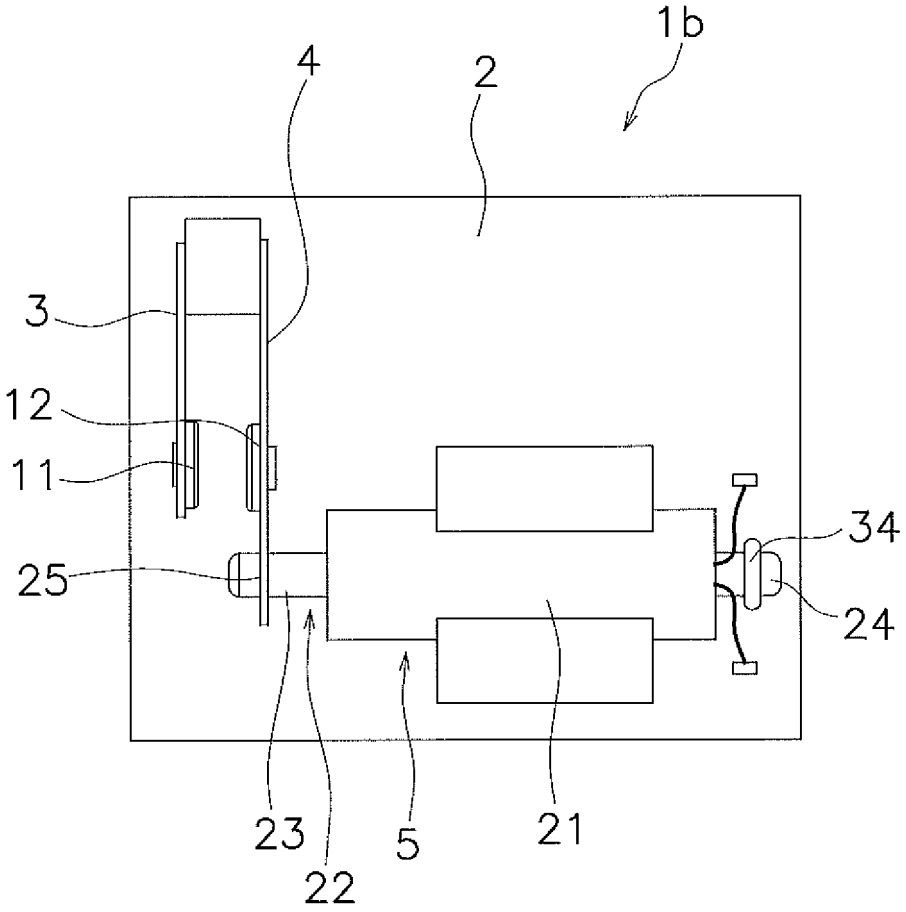


FIG. 21

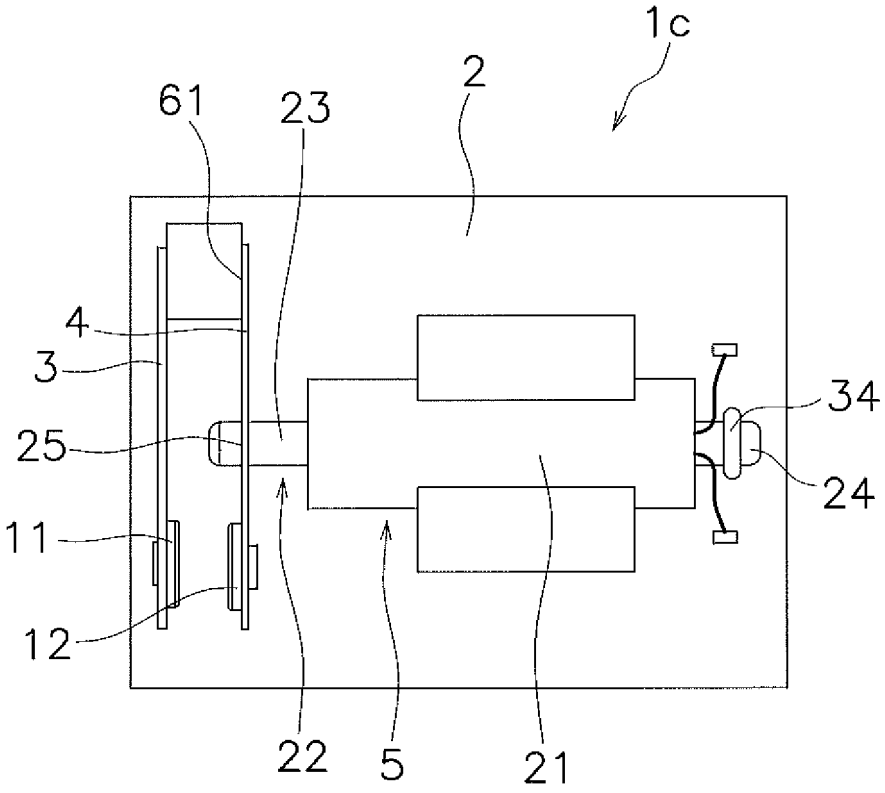


FIG. 22

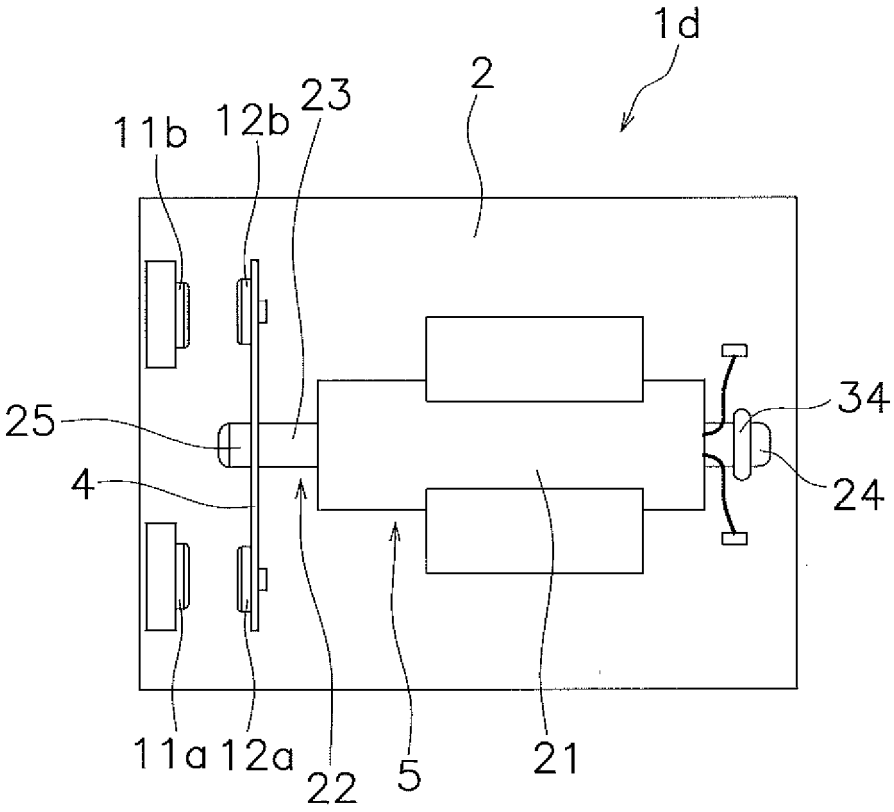
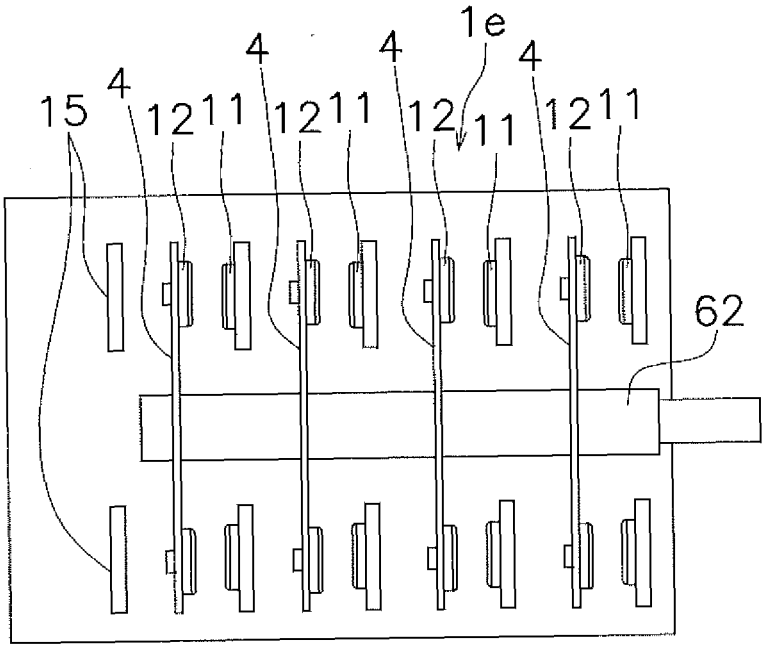


FIG. 23

(A)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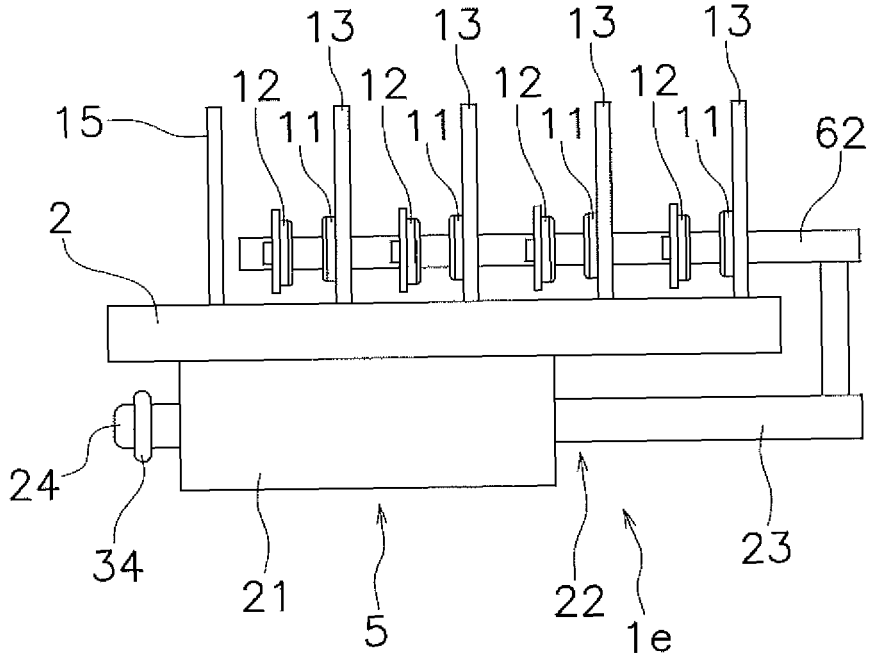
62

(B)


13
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62
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1e
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FIG. 24

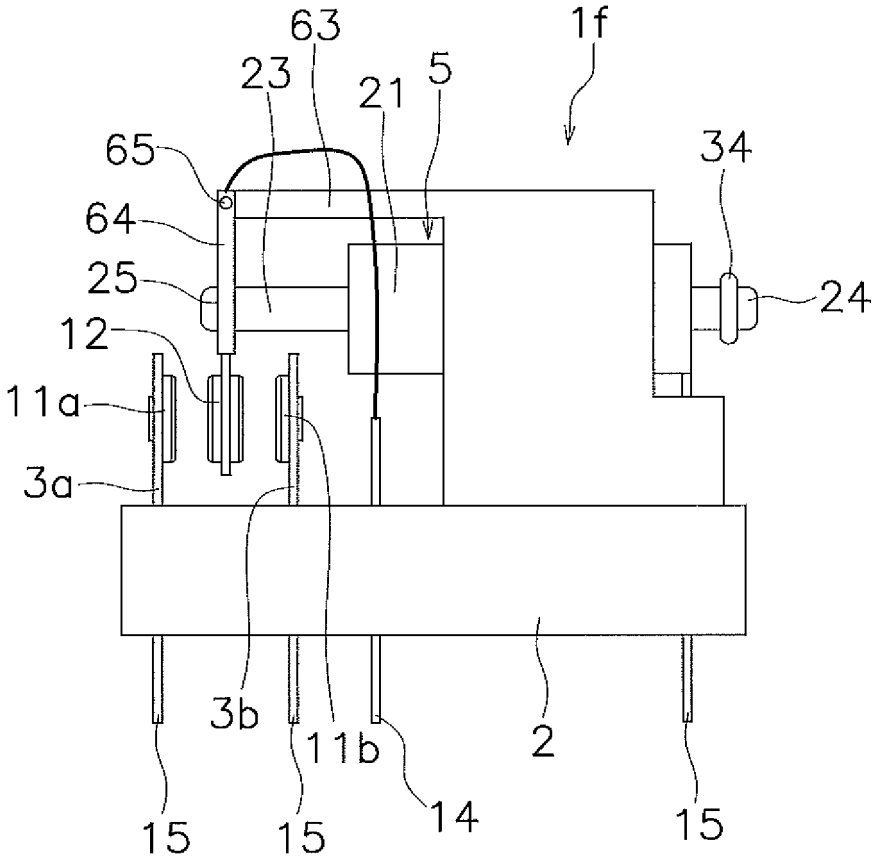

FIG. 25

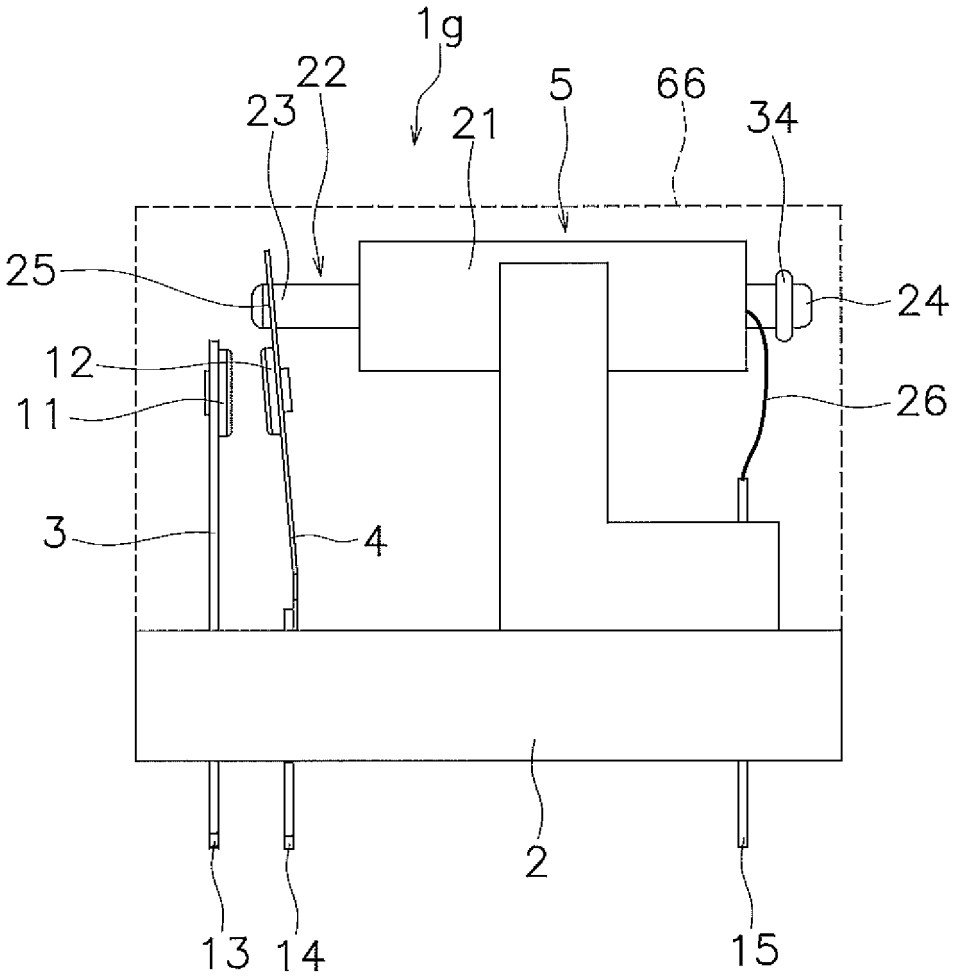

FIG. 26

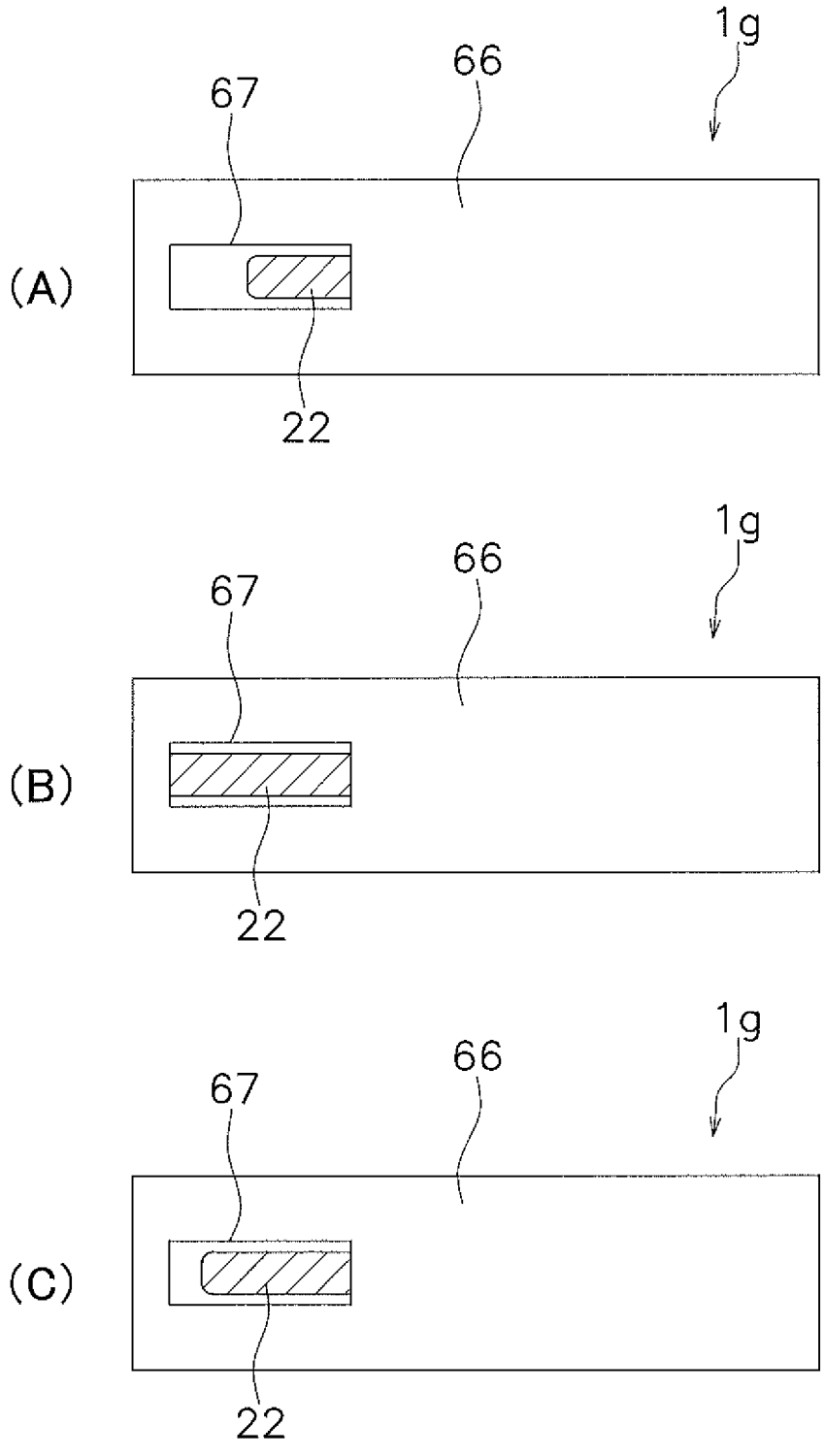

FIG. 27

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/074837

A. CLASSIFICATION OF SUBJECT MATTER
H01H50/56(2006.01)i, *H01H50/08*(2006.01)i, *H01H50/32*(2006.01)i, *H01H50/34*(2006.01)i, *H01H50/64*(2006.01)i, *H01H51/06*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01H50/56, H01H50/08, H01H50/32, H01H50/34, H01H50/64, H01H51/06

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2015
Kokai Jitsuyo Shinan Koho 1971-2015 Toroku Jitsuyo Shinan Koho 1994-2015

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 067723/1989(Laid-open No. 007248/1991) (Jidosha Denki Kogyo Co., Ltd.), 24 January 1991 (24.01.1991), entire text; all drawings (Family: none)	1-13
A	JP 64-031315 A (Matsushita Electric Works, Ltd.), 01 February 1989 (01.02.1989), entire text; all drawings (Family: none)	1-13

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 November 2015 (12.11.15)	24 November 2015 (24.11.15)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/074837

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 63-018182 A (Nippondenso Co., Ltd.), 26 January 1988 (26.01.1988), entire text; all drawings (Family: none)	1-13
A	JP 2006-196357 A (Matsushita Electric Works, Ltd.), 27 July 2006 (27.07.2006), entire text; all drawings (Family: none)	1-13

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2006196357 A **[0003]**