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(54) **TUBE EXPANSION TOOL**

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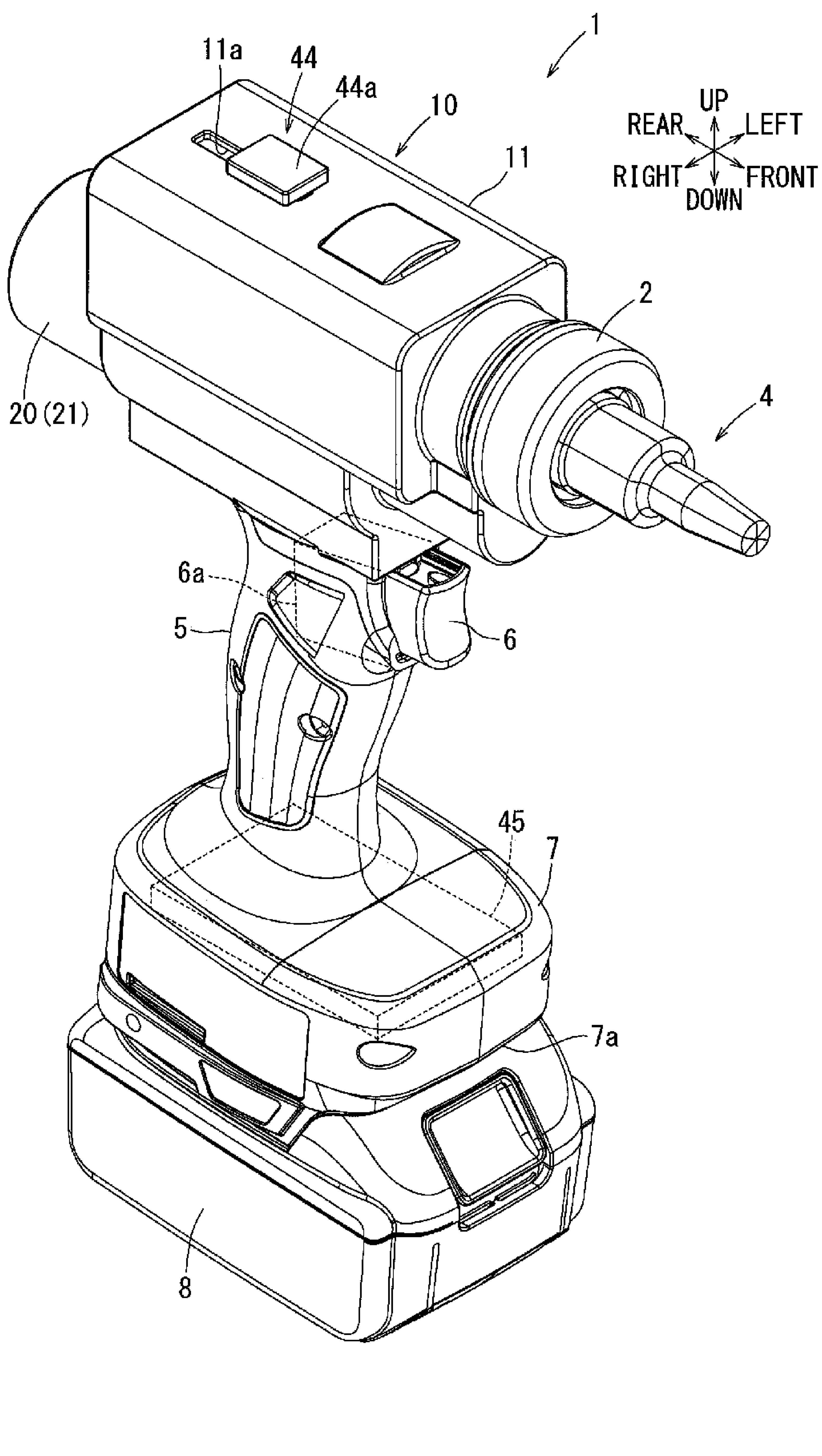
(57) **ABSTRACT**

A tube expansion tool that expands an end portion of a synthetic resin made fluid pipe includes an electric motor that is housed in a main body housing. A screw shaft is located in the main body housing and is movable in a front-rear direction. A female screw member is configured to move the screw shaft in the front-rear direction by engaging with and rotating around the screw shaft. A gear that engages the female screw member transmits a rotation output of the output shaft of the electric motor to the female screw member. A wedge extends forward from the screw shaft. A plurality of jaws are coupled to the main body housing so as to be openable/closable. When the wedge moves forward integrally with the screw shaft, the plurality of jaws are pushed by the wedge so as to be opened radially outward relative to each other.



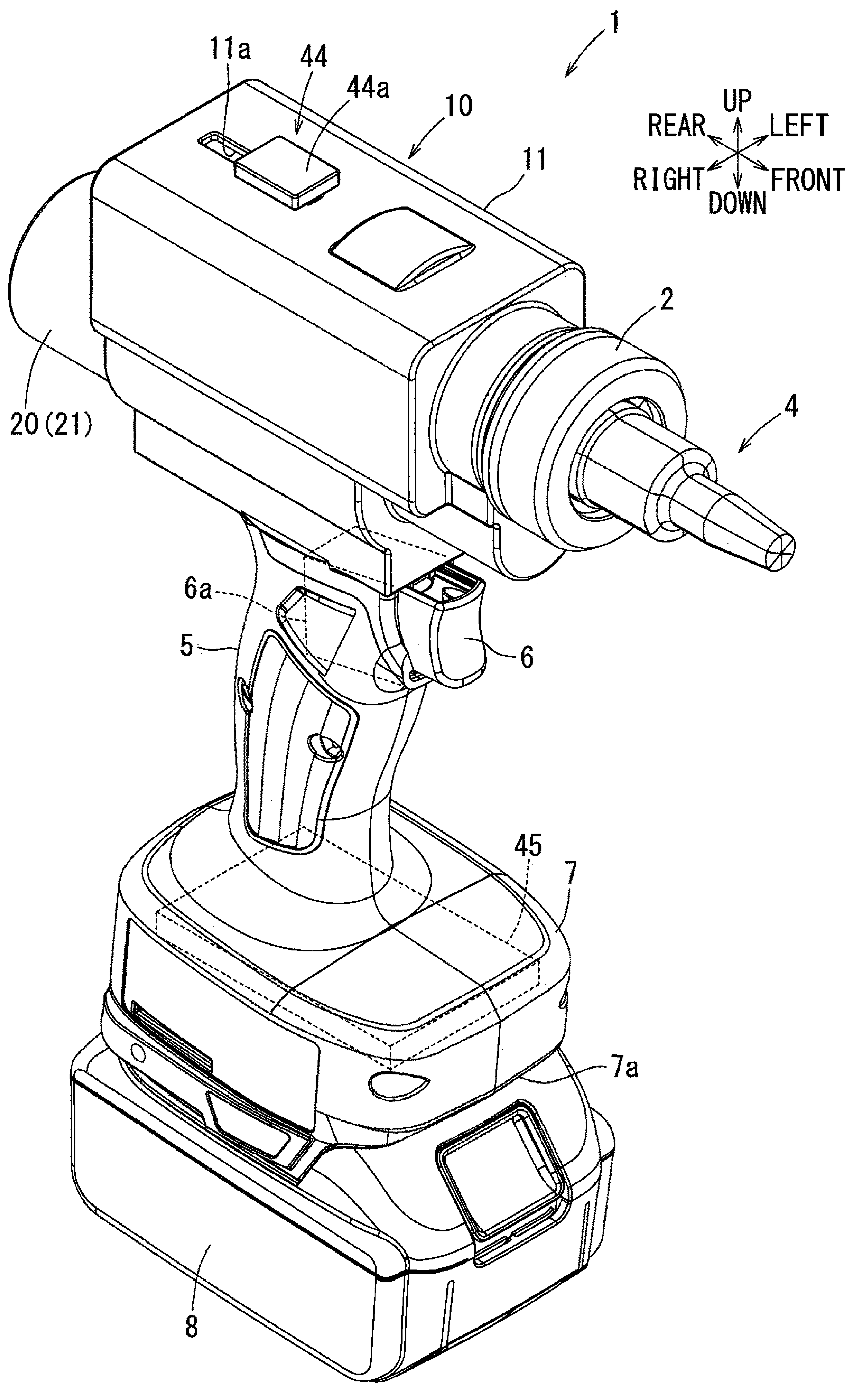

1
11a
44
44a
10
11
UP
REAR
LEFT
RIGHT
FRONT
DOWN
2
4
20(21)
6a
5
6
45
7
7a
8

FIG. 1

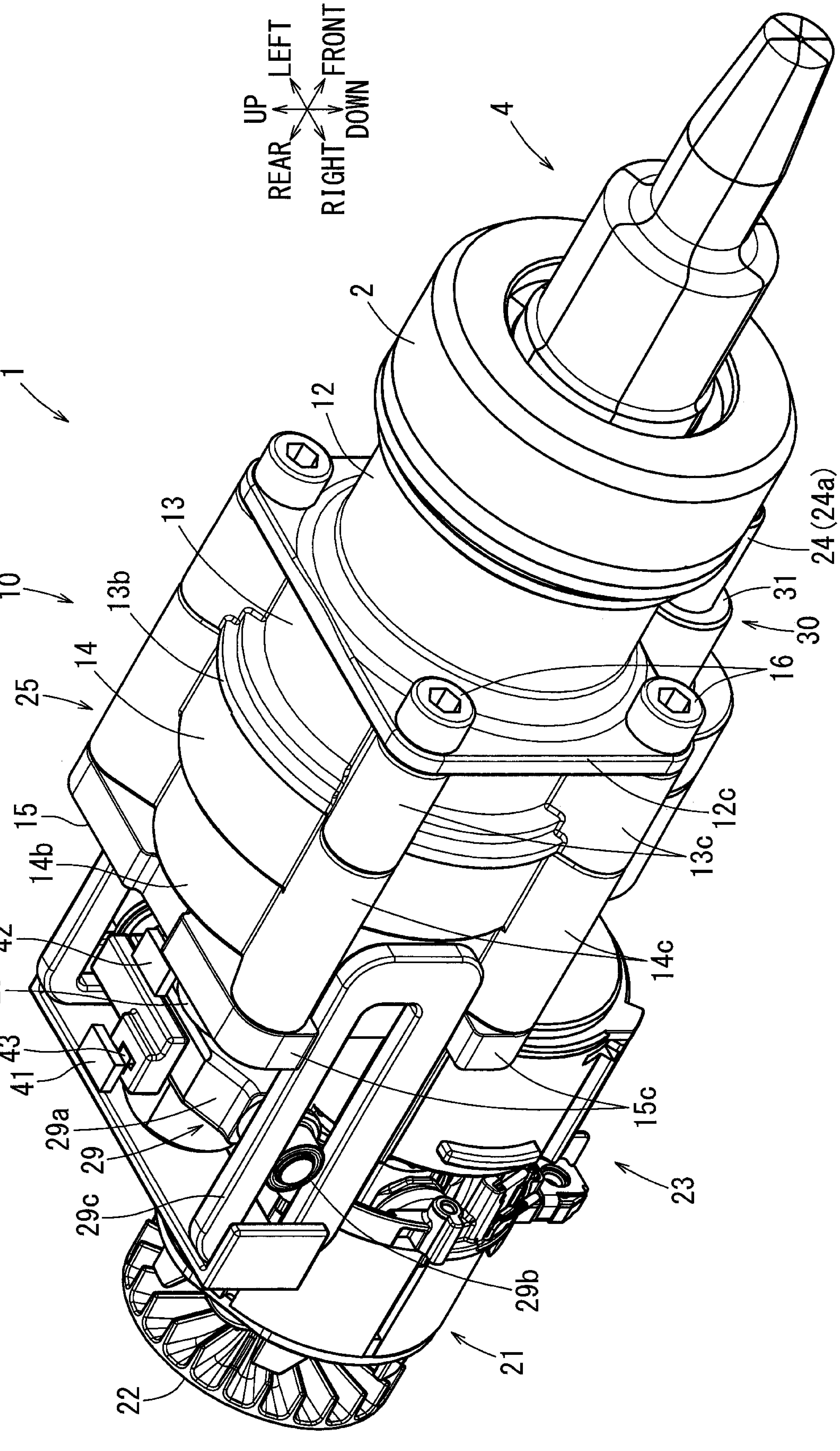

UP
LEFT
FRONT
REAR
RIGHT
DOWN
1
4
2
10
12
12c
13
13b
13c
14
14b
14c
15
15c
16
21
22
23
24 (24a)
25
28
29
29a
29b
29c
30
31
41
42
43

FIG. 2

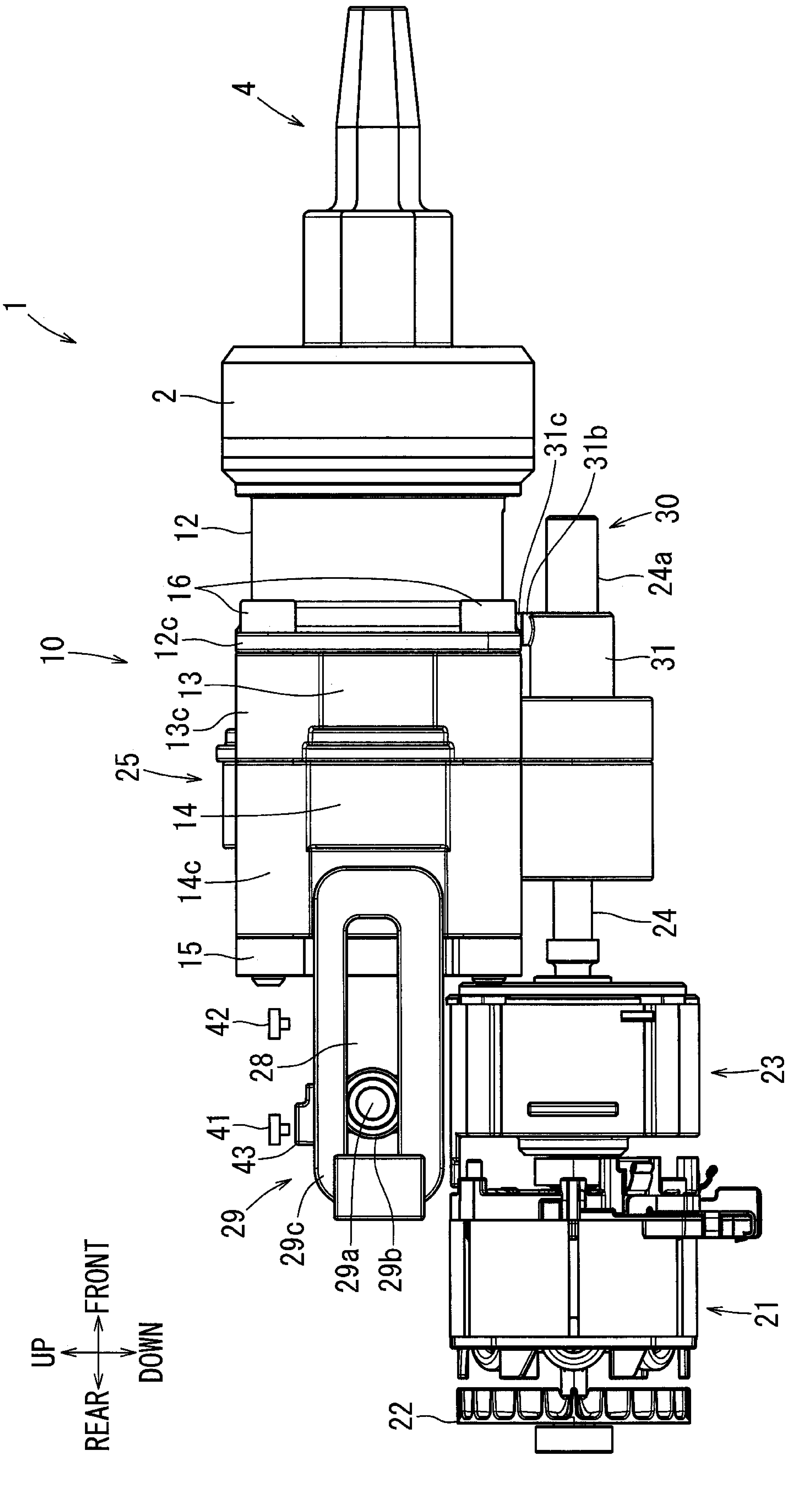

4
1
2
31c
31b
30
12
24a
16
12c
31
10
13
13c
25
14
14c
24
15
42
23
28
41
43
29
29c
29a
29b
21
UP
FRONT
REAR
DOWN
22

FIG. 3

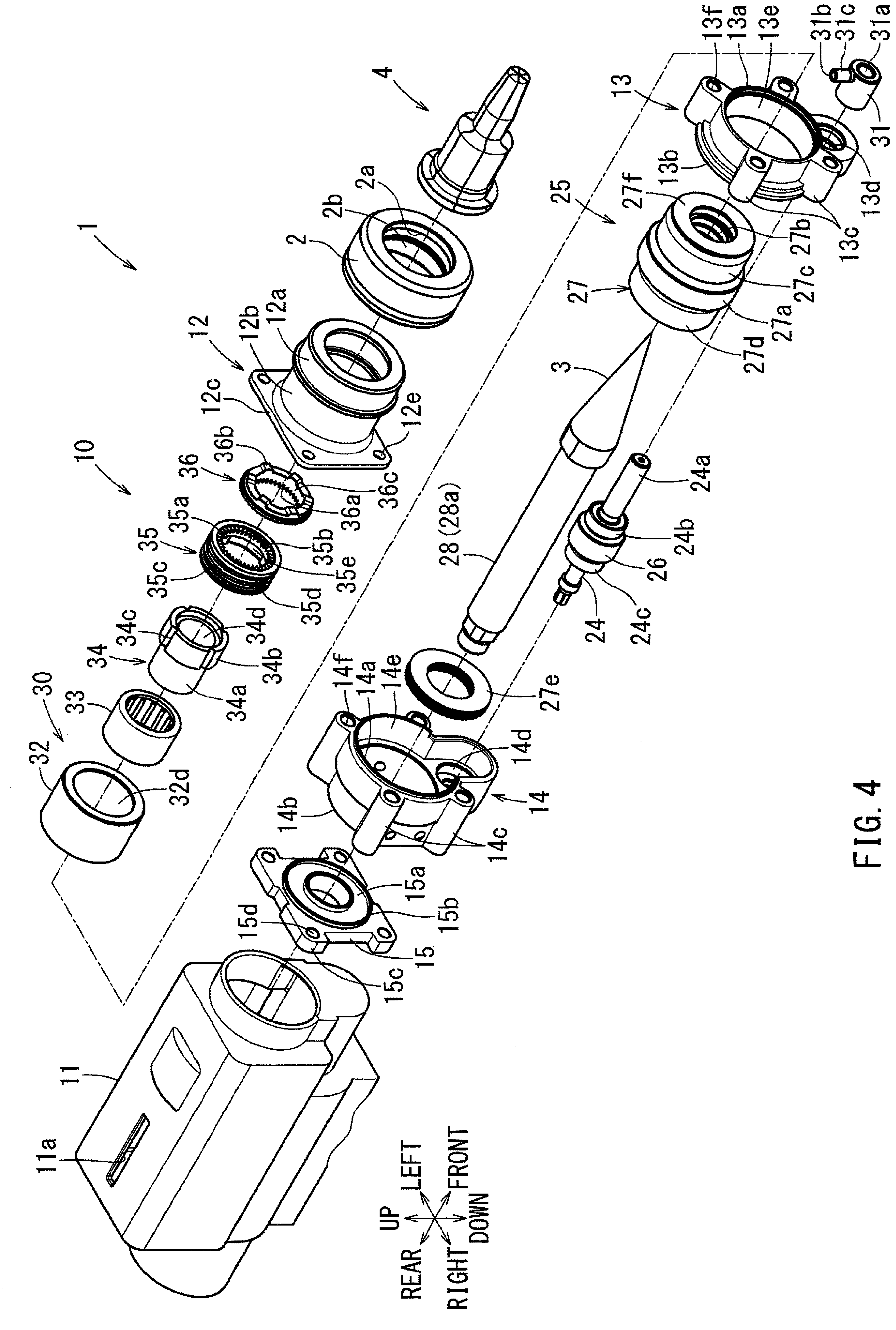

1
2
2a
2b
3
4
10
11
11a
12
12a
12b
12c
12e
13
13a
13b
13c
13d
13e
13f
14
14a
14b
14c
14d
14e
14f
15
15a
15b
15c
15d
24
24a
24b
24c
25
26
27
27a
27b
27c
27d
27e
27f
28 (28a)
30
31
31a
31b
31c
32
32d
33
34
34a
34b
34c
34d
35
35a
35b
35c
35d
35e
36
36a
36b
36c
UP
LEFT
FRONT
REAR
RIGHT
DOWN

FIG. 4

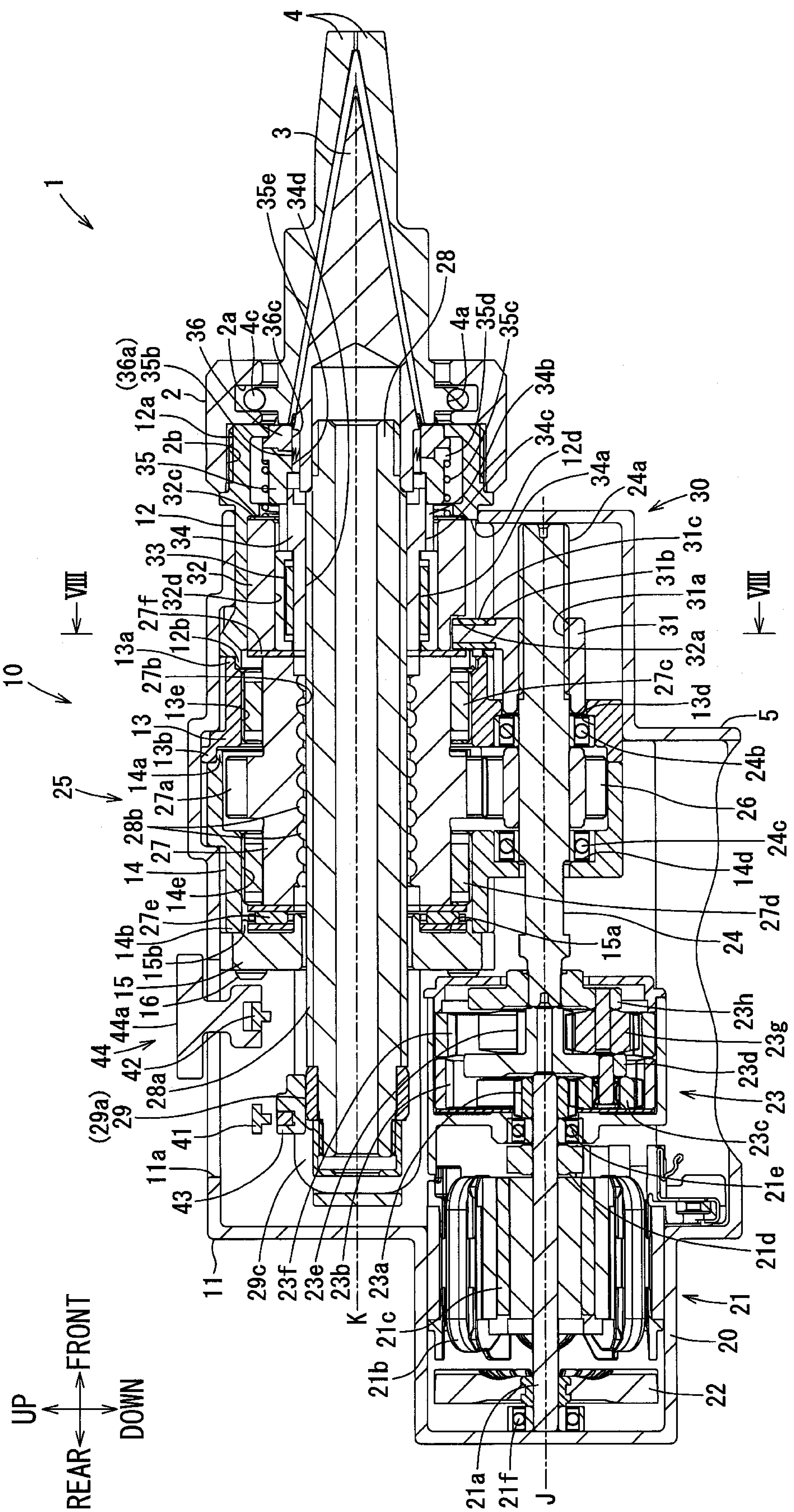

1
4
3
35e
34d
28
2a
4c
36c
4a
35d
35c
36
(36a)
35b
2
12a
2b
35
32c
34b
34c
12d
34a
24a
30
12
34
33
32
32d
27f
12b
13a
27b
13e
31c
31b
31a
31
32a
27c
13d
VIII
10
13
13b
14a
27a
28b
27
14
14e
27e
14b
15b
15
16
44a
44
42
28a
(29a)
29
41
11a
43
11
29c
23f
23e
23b
K
23a
21c
21b
21a
21f
J
22
20
21
21d
21e
23c
23
23d
23g
23h
15a
24
27d
14d
24c
26
24b
5
25
UP
FRONT
REAR
DOWN

FIG. 5

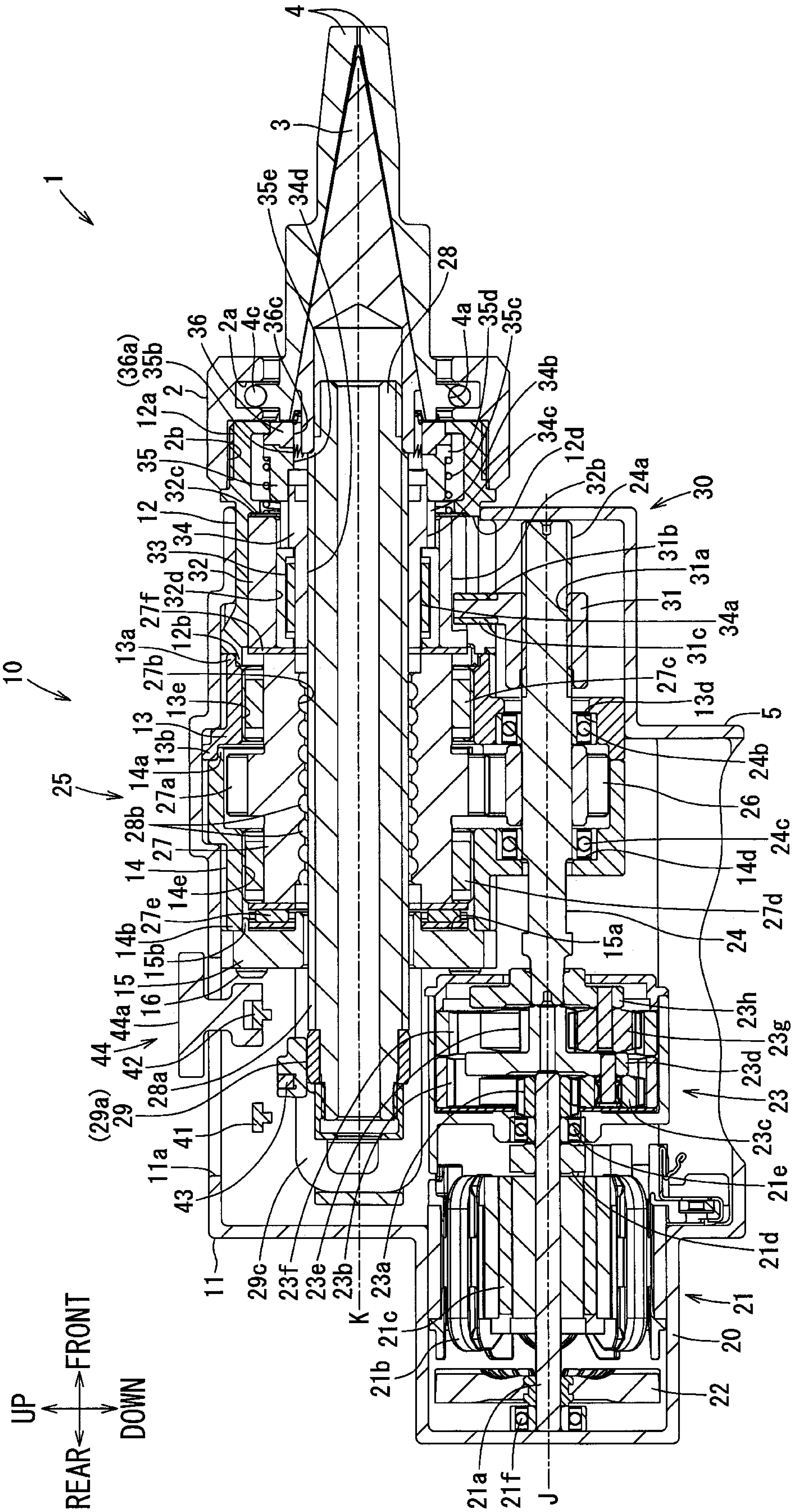


FIG. 6

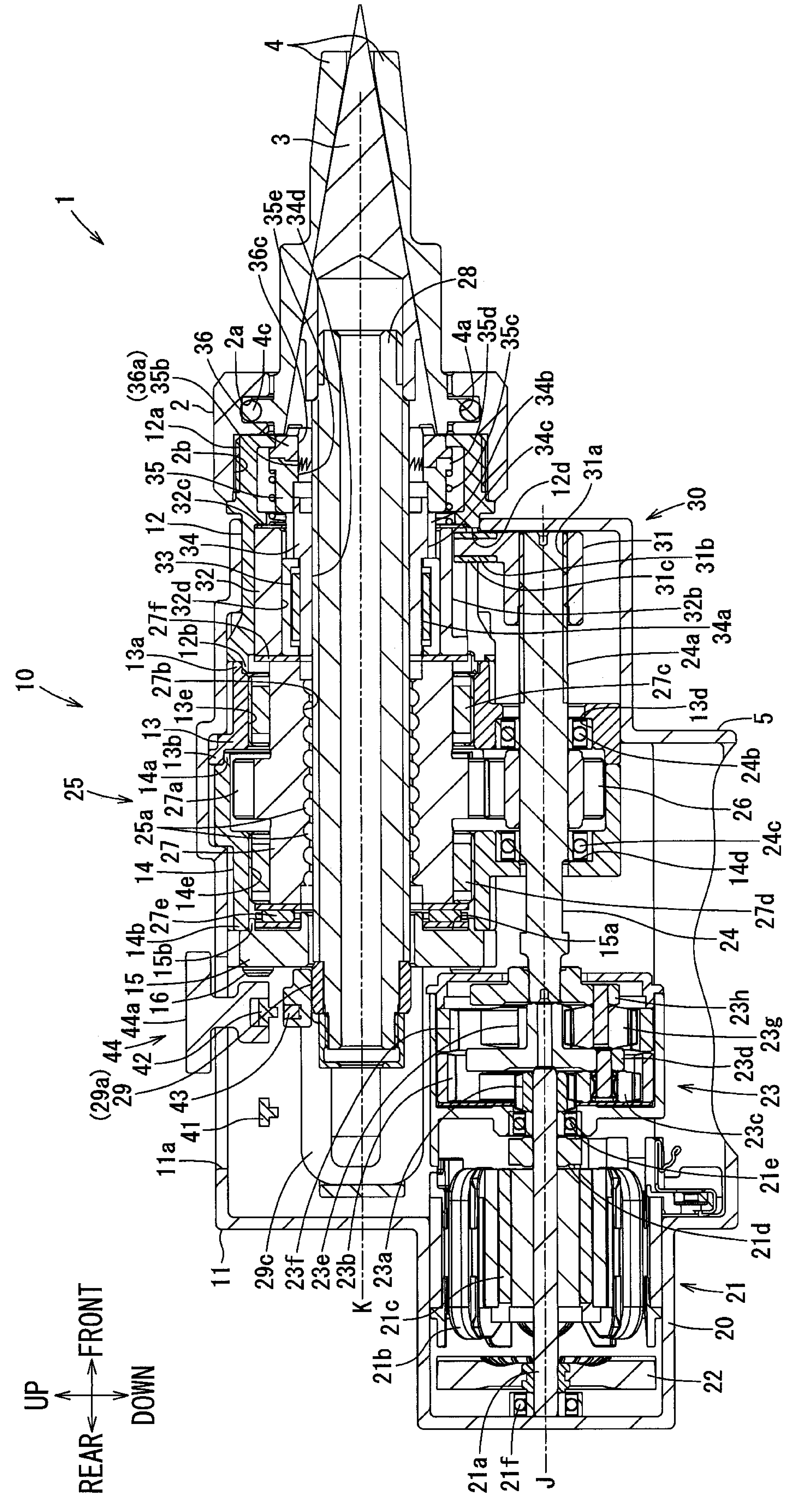


FIG. 7

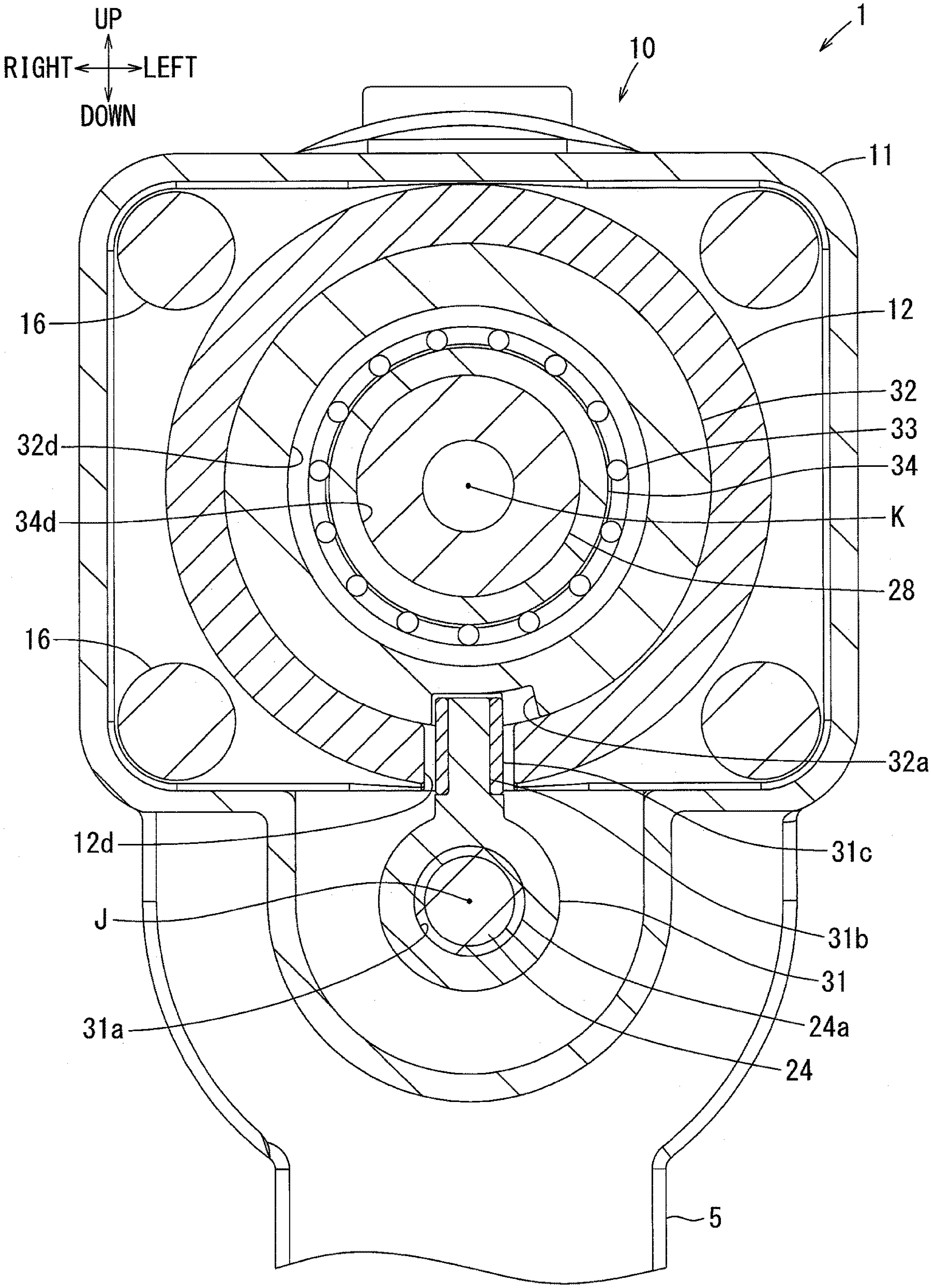

UP
RIGHT
LEFT
DOWN
1
10
11
16
12
32
33
32d
34
34d
K
28
16
32a
12d
31c
J
31b
31
31a
24a
24
5

FIG. 8

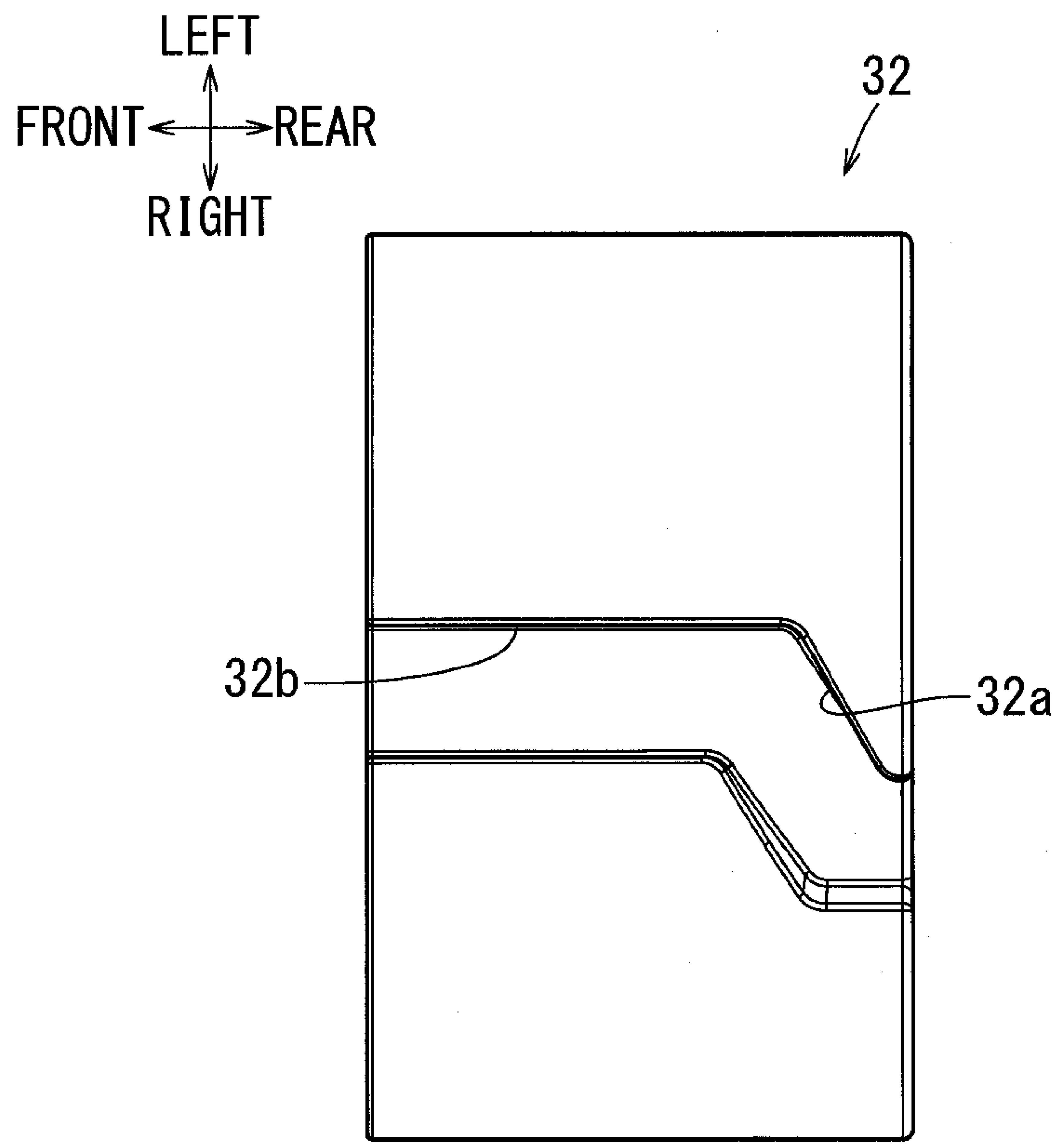


FIG. 9

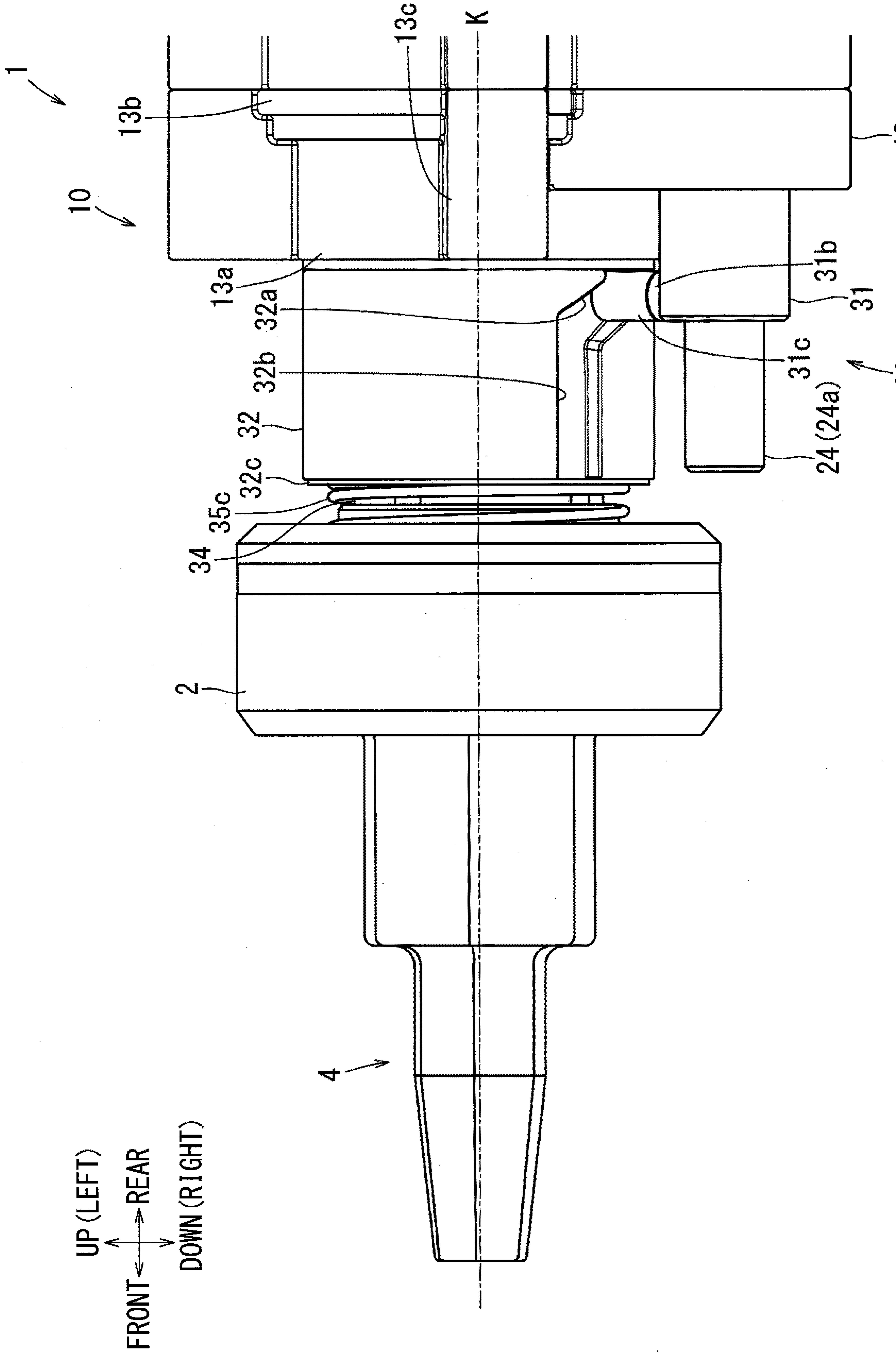

1
10
13b
13c
K
13
13a
32a
31b
31
31c
30
32b
32
24(24a)
32c
35c
34
2
4
UP(LEFT)
REAR
FRONT
DOWN(RIGHT)

FIG. 10

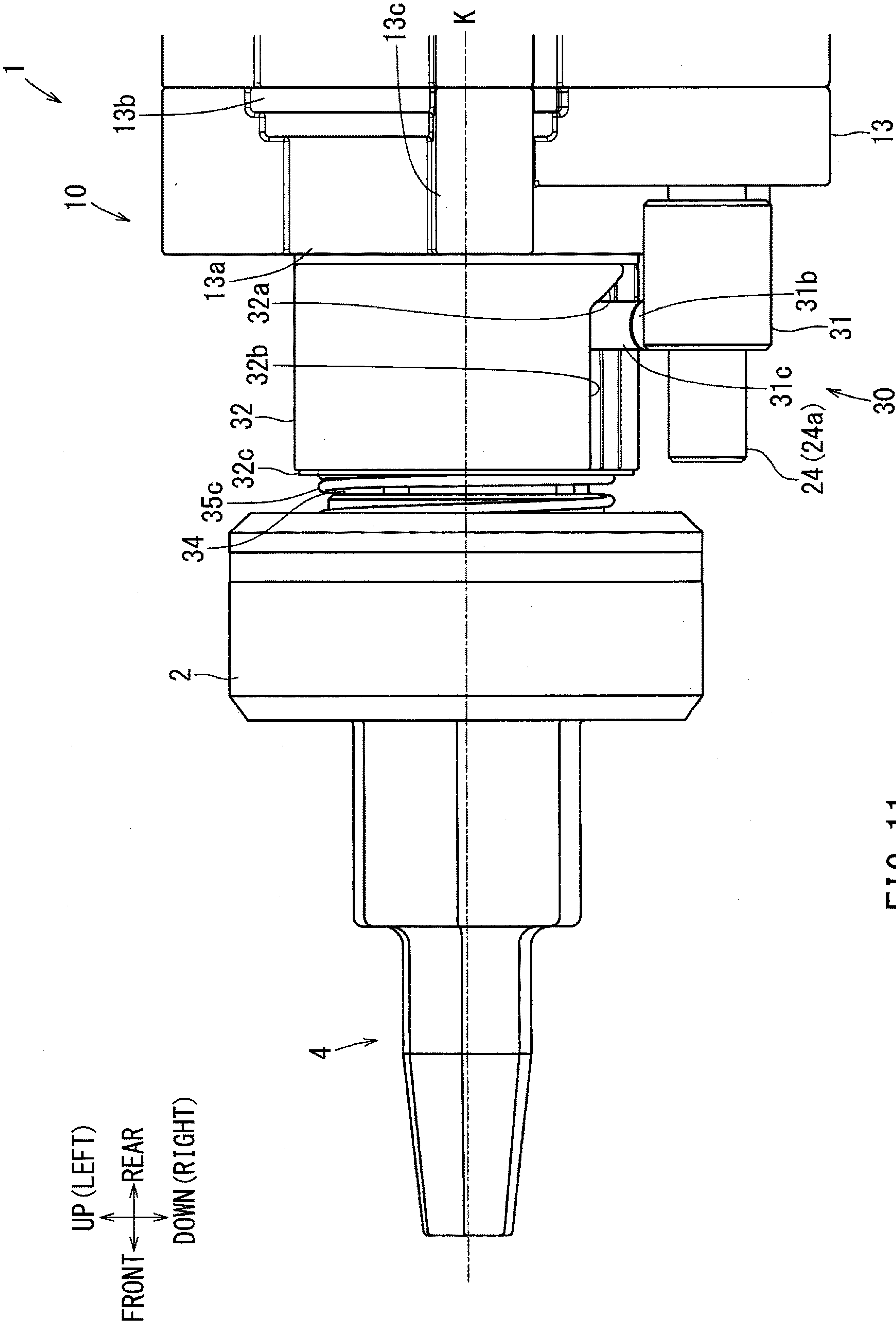

1
10
13b
13c
K
13
13a
32a
31b
31
32b
31c
30
32
24 (24a)
32c
35c
34
2
4
UP (LEFT)
REAR
DOWN (RIGHT)
FRONT

FIG. 11

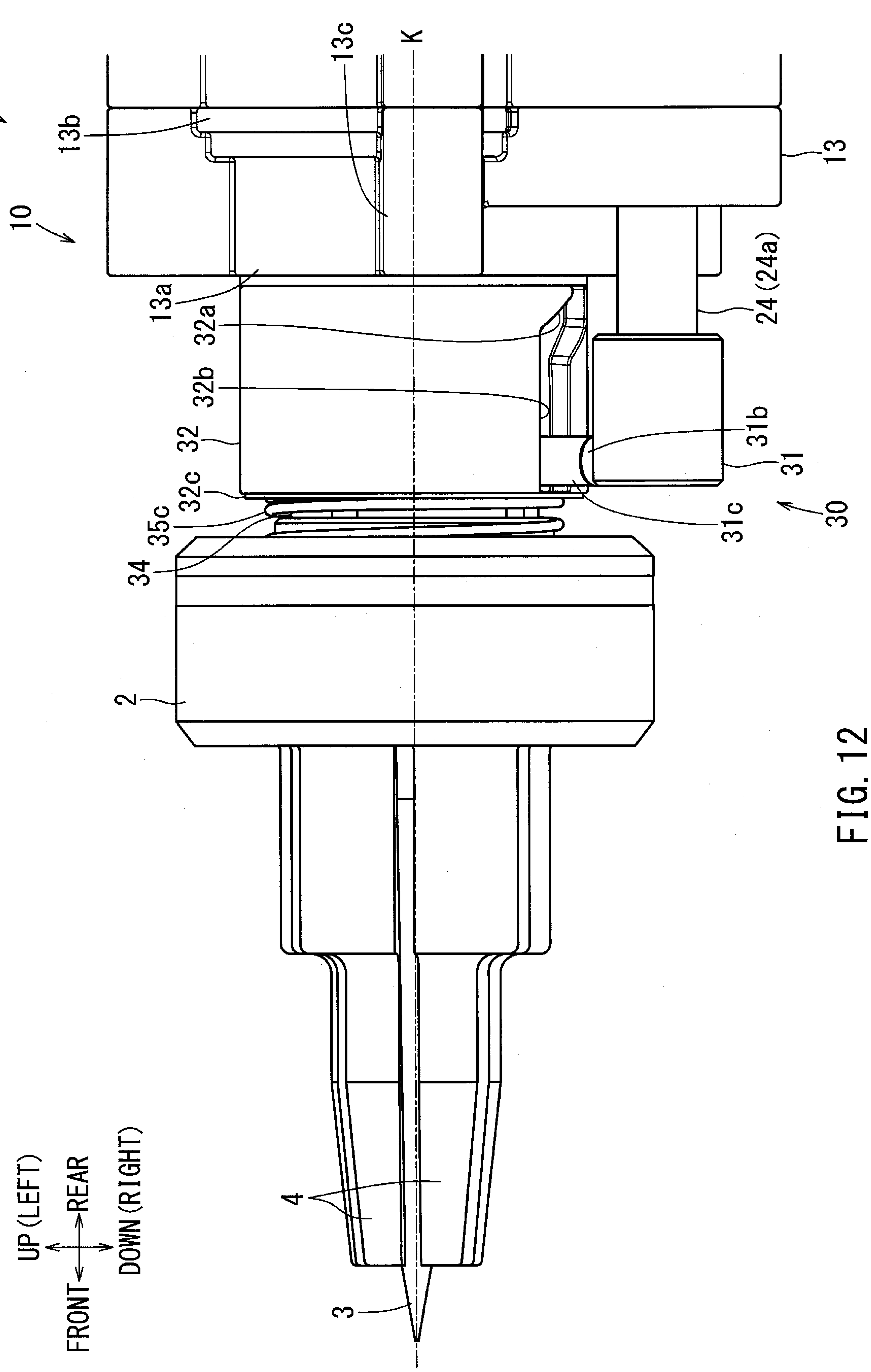

1
10
13b
13c
K
13
13a
32a
32b
32
24 (24a)
31b
31
32c
35c
34
31c
30
2
4
3
UP (LEFT)
REAR
DOWN (RIGHT)
FRONT

FIG. 12

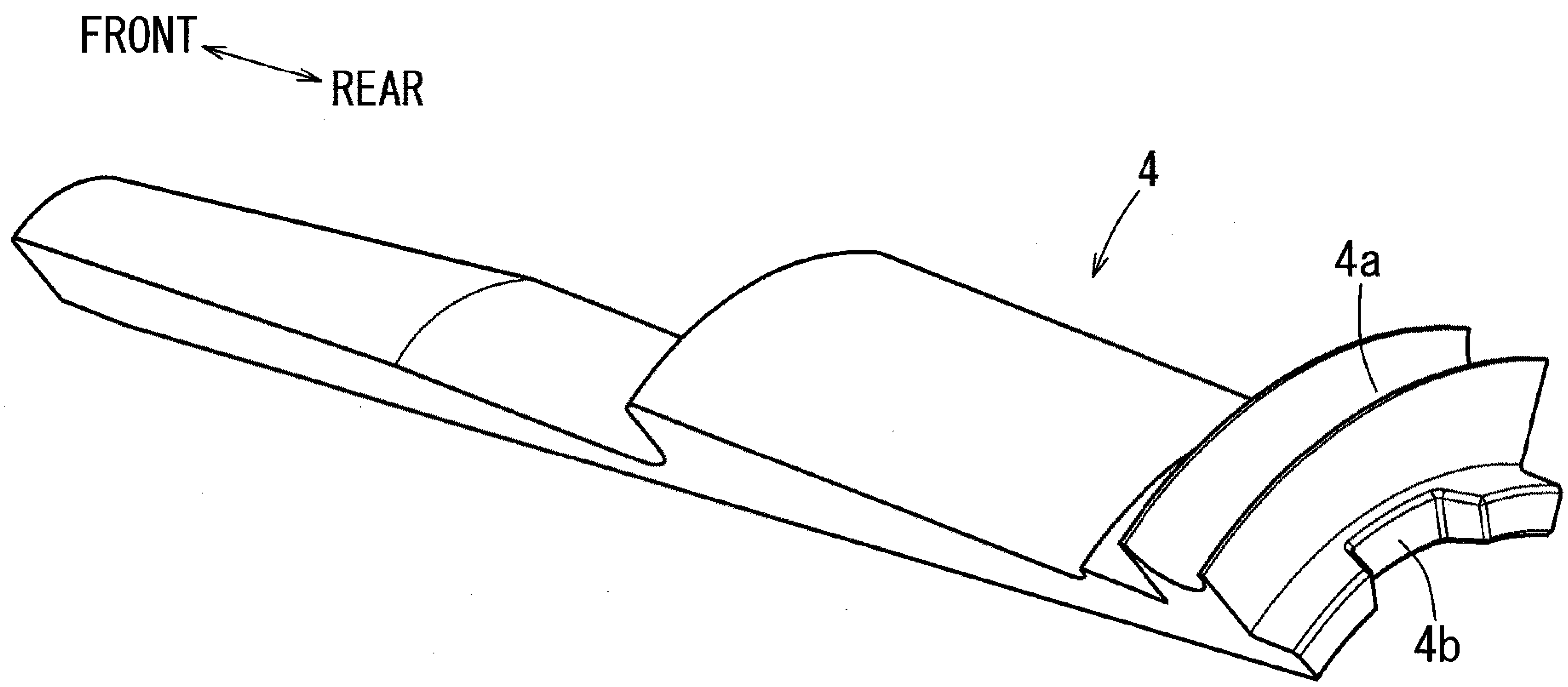


FIG. 13

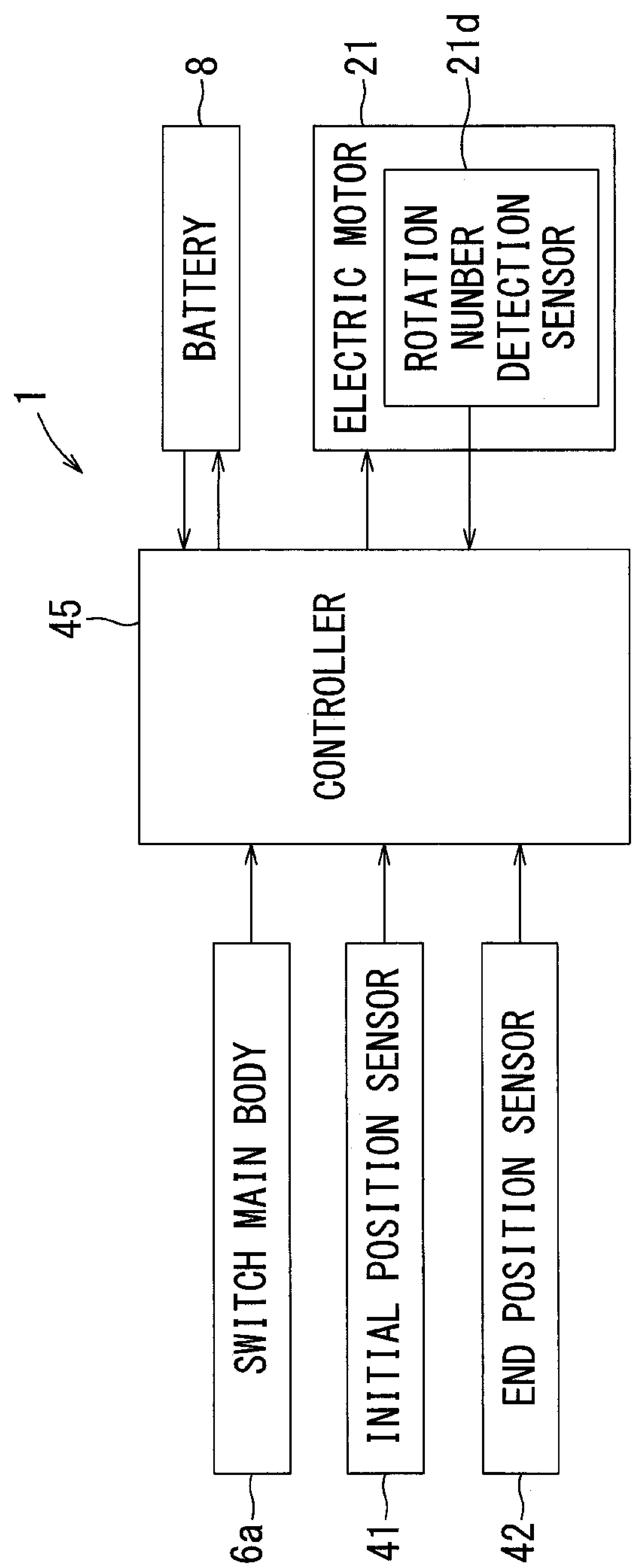
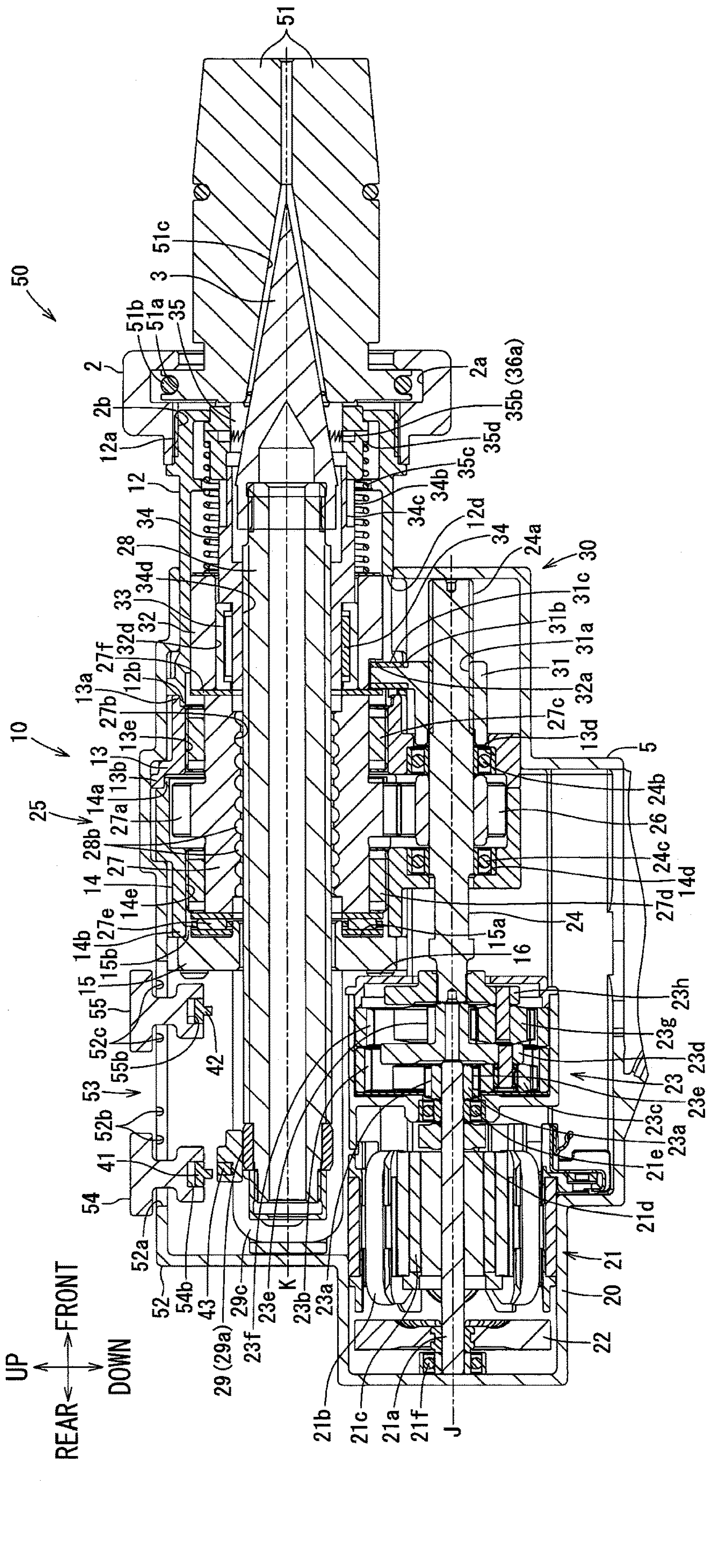
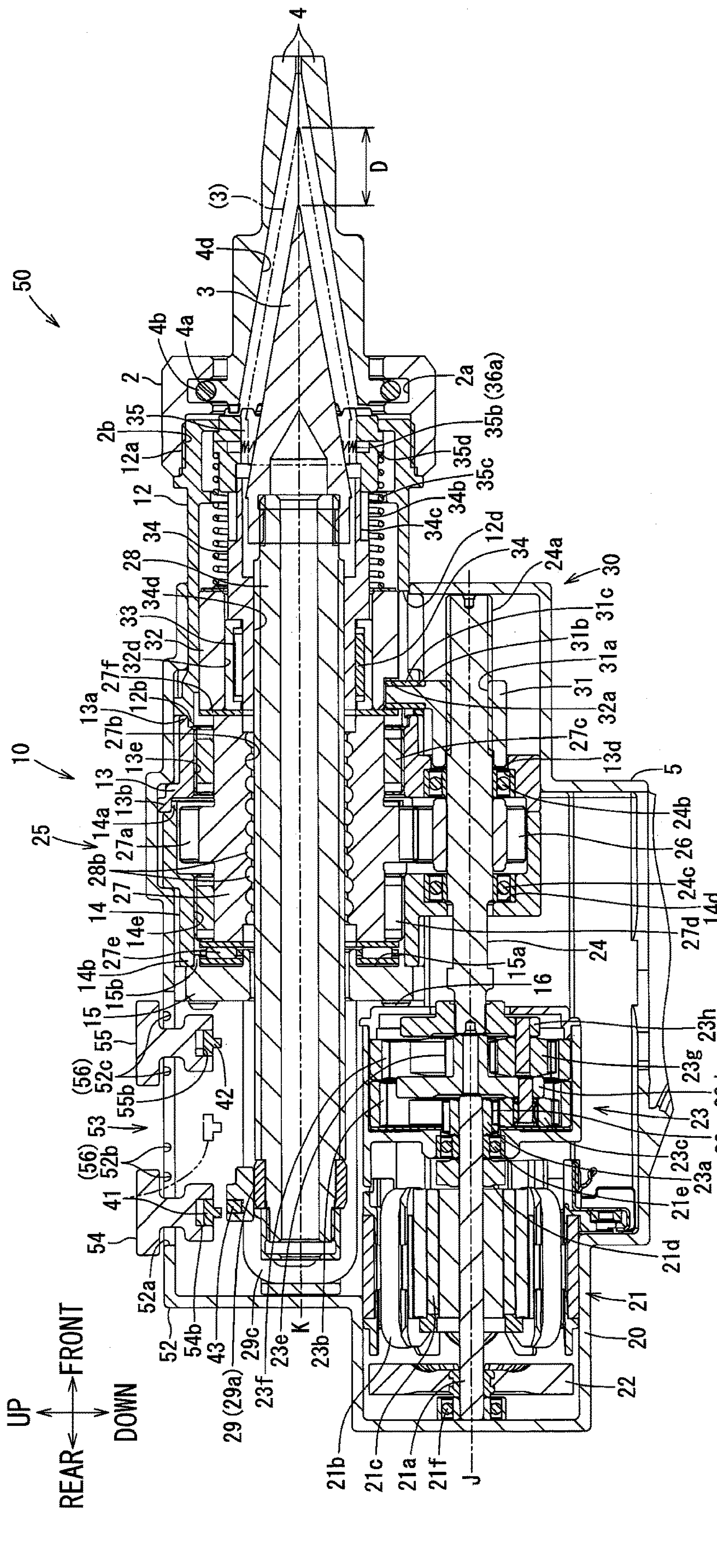

1
8
BATTERY
21
ELECTRIC MOTOR
21d
ROTATION NUNBER DETECTION SENSOR
45
CONTROLLER
SWITCH MAIN BODY
6a
INITIAL POSITION SENSOR
41
END POSITION SENSOR
42

FIG. 14



UP
FRONT
REAR
DOWN
50
51
51c
3
35
51a
51b
2
2a
2b
12a
12
35b (36a)
35d
35c
34b
34c
12d
34
28
34d
33
32
32d
27f
12b
13a
27b
13e
13
13b
14a
27a
28b
25
10
27
14
14e
27e
14b
15b
15
55
52c
55b
42
53
52b
41
54
52a
52
54b
43
29c
29 (29a)
23f
23e
K
23b
23a
21b
21c
21a
21f
J
22
20
21
21d
21e
23c
23e
23d
23
23g
23h
16
15a
24
14d
27d
24c
26
24b
5
13d
27c
32a
31
31a
31b
31c
30
24a

FIG. 15



UP
DOWN
REAR
FRONT
50
10
25
30
4
D
(3)
4d
3
4b
4a
2
2a
35b (36a)
2b
35
12a
35d
35c
12
34b
34c
34
28
34d
33
32
32d
27f
13a
12b
27b
13e
13
13b
14a
27a
28b
27
14
14e
14b
27e
15b
15
55
(56)
52c
55b
42
53
(56)
52b
41
54
52a
52
54b
43
29 (29a)
29c
23f
23e
K
23b
12d
24a
31c
31b
31a
31
32a
27c
13d
5
24b
26
24c
14d
27d
24
15a
16
23h
23g
23d
23
23e
23c
23a
21e
21d
21
20
22
21b
21c
21a
21f
J

FIG. 16

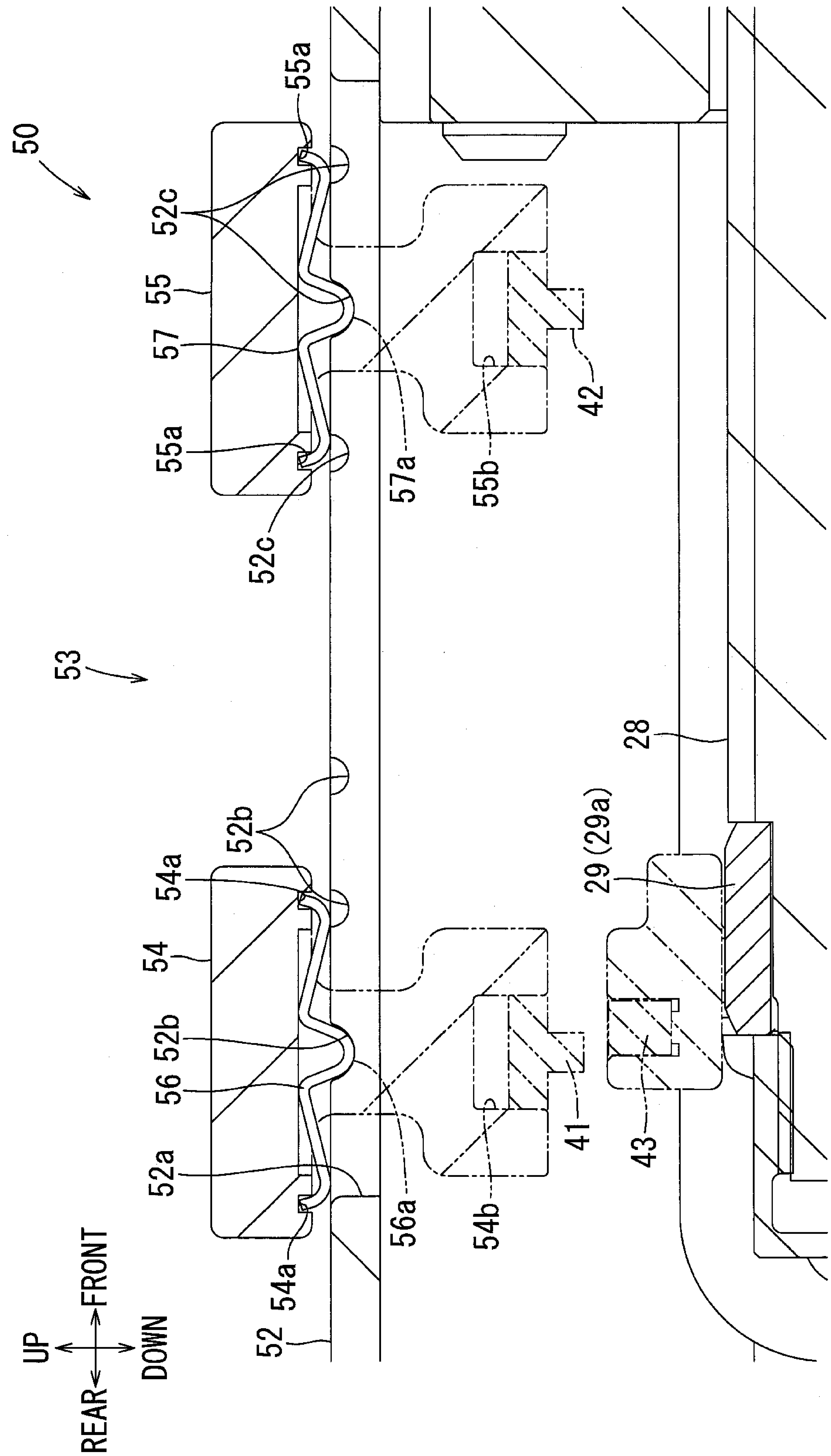

50
53
55a
52c
55
57
55a
57a
55b
42
52c
52b
54a
54
52b
56
52a
54a
56a
54b
41
43
29 (29a)
28
52
UP
FRONT
REAR
DOWN

FIG. 17

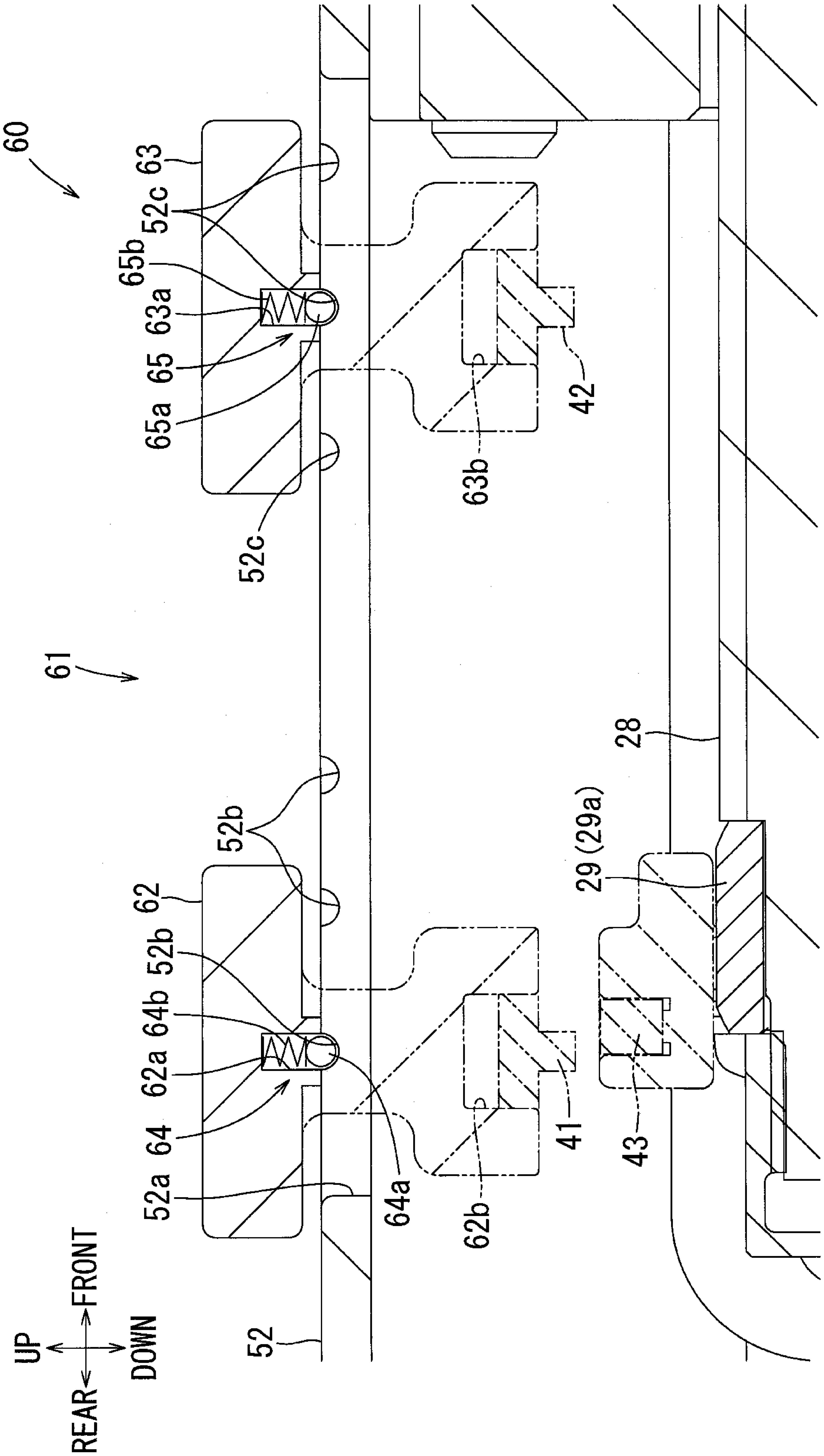

60
63
52c
65b
63a
65
65a
52c
42
63b
61
62
52b
52b
64b
62a
64
52a
64a
62b
41
43
29 (29a)
28
52
UP
DOWN
FRONT
REAR

FIG. 18

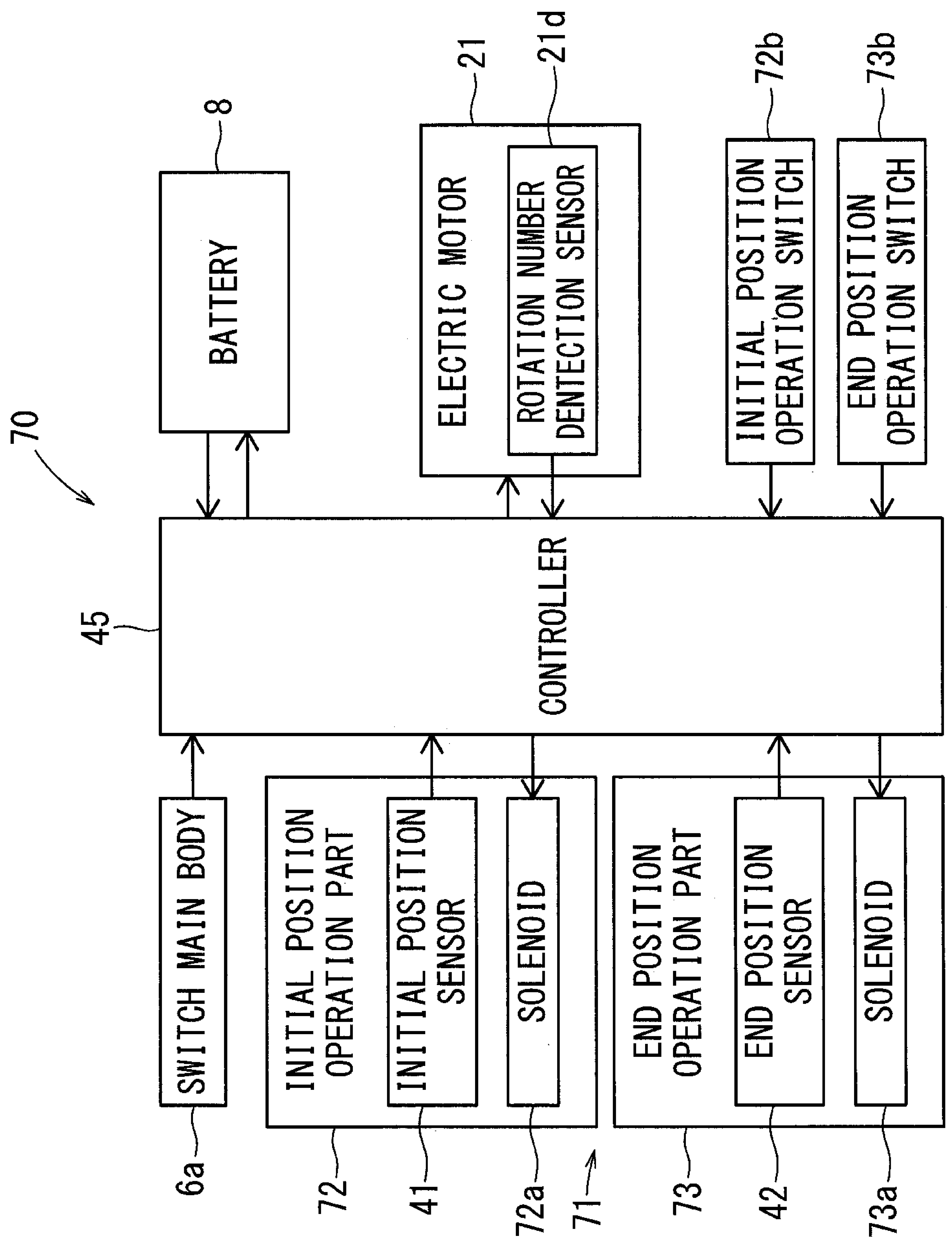

70
45
CONTROLLER
BATTERY
8
ELECTRIC MOTOR
21
ROTATION NUMBER DENTECTION SENSOR
21d
INITIAL POSITION OPERATION SWITCH
72b
END POSITION OPERATION SWITCH
73b
SWITCH MAIN BODY
6a
INITIAL POSITION OPERATION PART
72
INITIAL POSITION SENSOR
41
SOLENOID
72a
71
END POSITION OPERATION PART
73
END POSITION SENSOR
42
SOLENOID
73a

FIG. 19

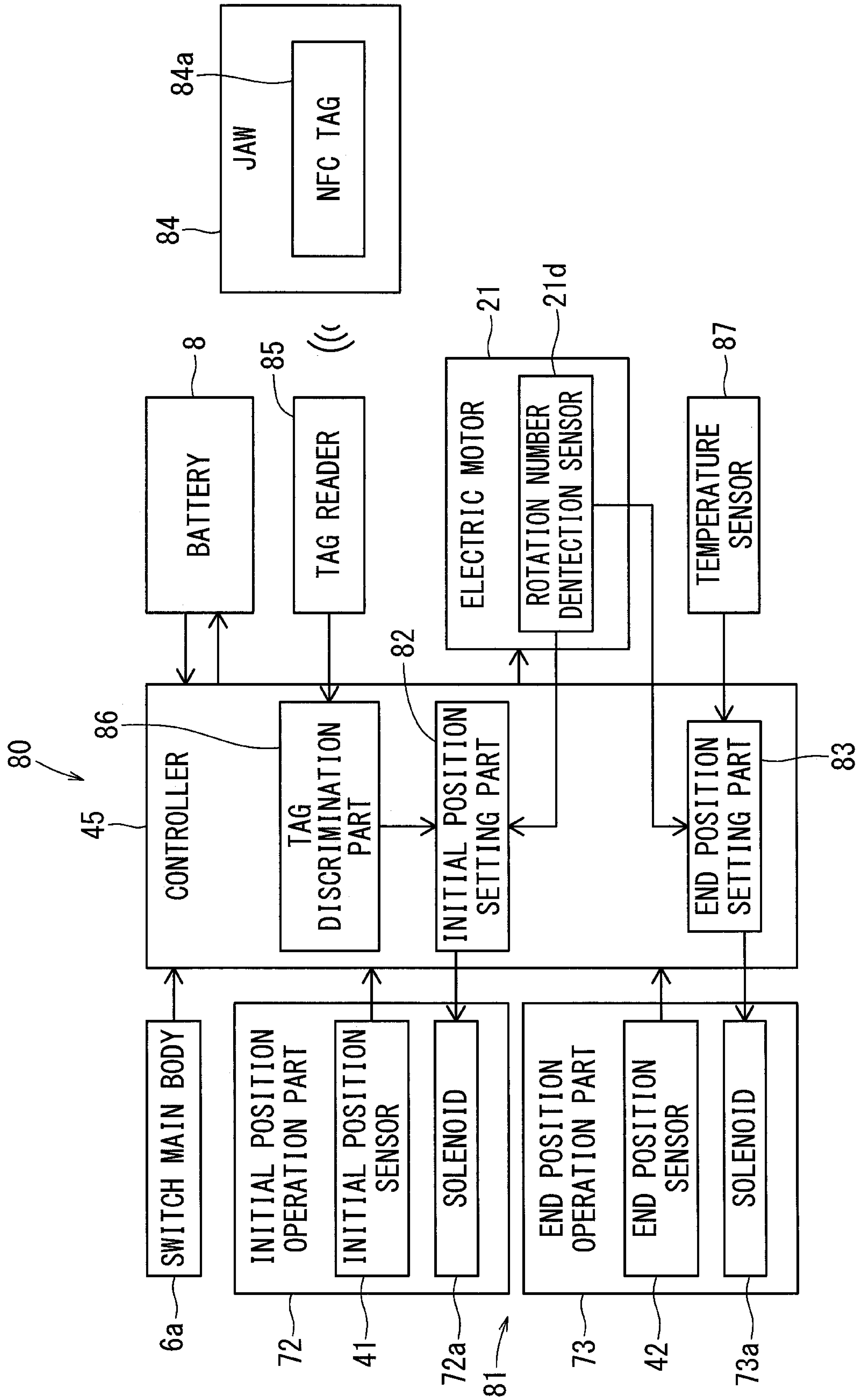

80
45
CONTROLLER
86
TAG DISCRIMINATION PART
82
INITIAL POSITION SETTING PART
END POSITION SETTING PART
83
BATTERY
8
TAG READER
85
JAW
84
NFC TAG
84a
ELECTRIC MOTOR
21
ROTATION NUMBER DENTECTION SENSOR
21d
TEMPERATURE SENSOR
87
SWITCH MAIN BODY
6a
INITIAL POSITION OPERATION PART
72
INITIAL POSITION SENSOR
41
SOLENOID
72a
81
END POSITION OPERATION PART
73
END POSITION SENSOR
42
SOLENOID
73a

FIG. 20

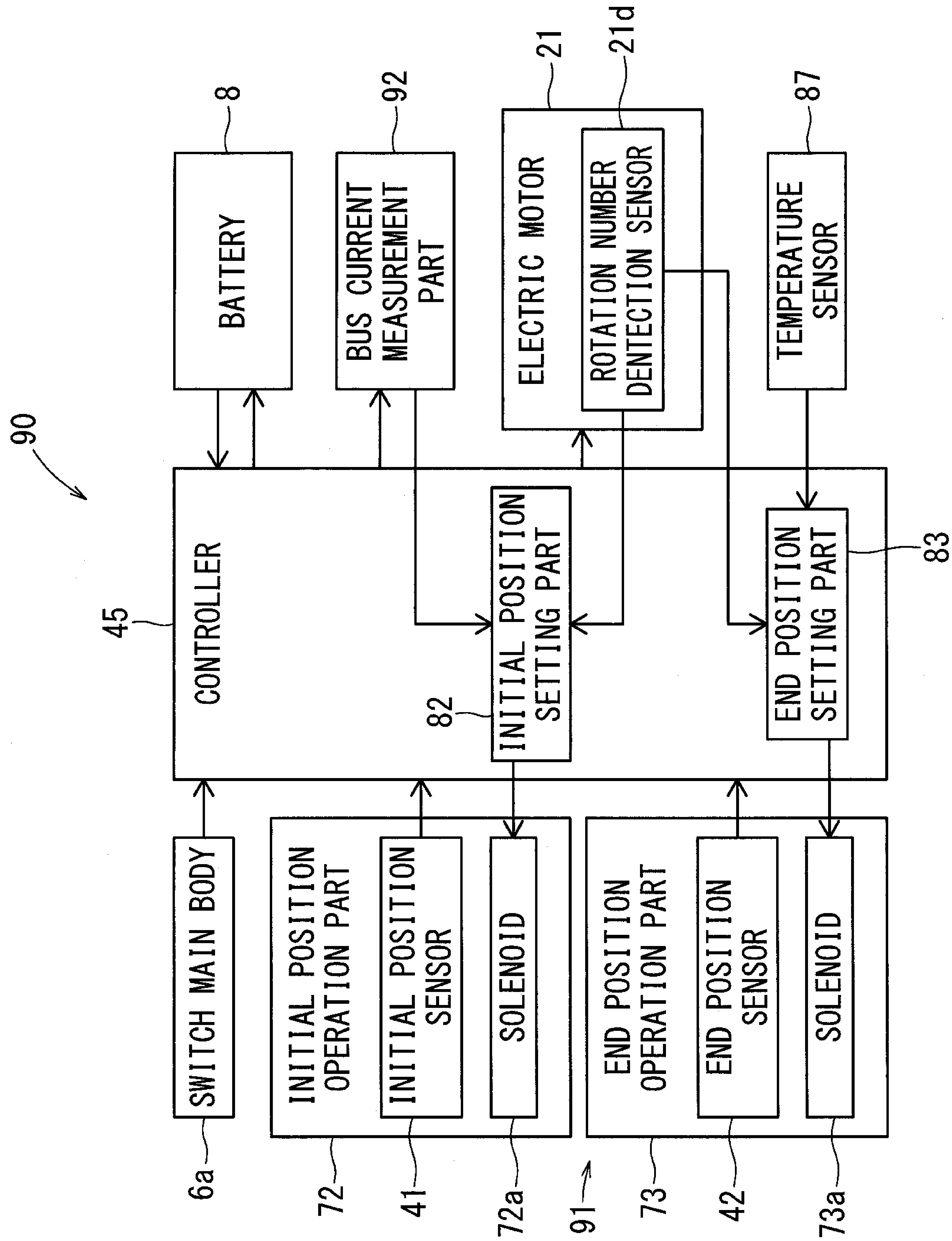

90
BATTERY
8
BUS CURRENT MEASUREMENT PART
92
ELECTRIC MOTOR
21
ROTATION NUMBER DENTECTION SENSOR
21d
TEMPERATURE SENSOR
87
CONTROLLER
45
INITIAL POSITION SETTING PART
82
END POSITION SETTING PART
83
SWITCH MAIN BODY
6a
INITIAL POSITION OPERATION PART
72
INITIAL POSITION SENSOR
41
SOLENOID
72a
91
END POSITION OPERATION PART
73
END POSITION SENSOR
42
SOLENOID
73a

FIG. 21

TUBE EXPANSION TOOL

CROSS-REFERENCE

[0001] This application claims priority to Japanese patent application serial number 2022-005807, filed on Jan. 18, 2022, to Japanese patent application serial number 2022-005813, filed on Jan. 18, 2022, and to Japanese patent application serial number 2022-140599, filed on Sep. 5, 2022, the entire contents of all of which are incorporated herein by reference.

BACKGROUND

[0002] The present invention generally relates to a tube expansion tool that expands, for example, an end portion of a synthetic resin made fluid pipe in order for the fluid pipe to be coupled to a pipe fitting.

[0003] For example, a fluid pipe made of PEX (cross-linked polyethylene) may be coupled to a metal pipe fitting. For this purpose, a tube expansion tool has been used for expanding an inner diameter of an end portion of a PEX tubing. The end portion of the PEX tubing may be expanded by the tube expansion tool to allow the PEX tubing to be coupled to the fitting. The end portion of the PEX tubing may elastically and gradually recover around the fitting to form a tight connection. The PEX tubing may be firmly coupled to the fitting due to this elastic recovery.

[0004] A tube expansion tool that expands a PEX tubing may be driven by an electric motor. The tube expansion tool may include an approximately conical wedge (mandrel) that moves forward/rearward (advances/retreats) with regard to an end portion of the PEX tubing positioned at a front portion of the tool. The tube expansion tool may also include a plurality of jaws circumferentially arranged around the wedge. The plurality of jaws may be opened relative to each other radially outward of the wedge by being pushed by the wedge as the wedge moves forward. When the plurality of jaws are inserted into an opening of an end portion of the PEX tubing and then the jaws are opened radially outward, the end portion of the PEX tubing may be expanded.

[0005] A tool main body of the tube expansion tool may also include an electric motor and a planetary gear reduction mechanism that reduces an output of an electric motor. The tube expansion tool may also include an approximately tubular-shaped grip that extends downward from the tool main body. A user may hold the tube expansion tool by holding the grip. For example, the electric motor, which is relatively heavy in weight, may be arranged in front of the grip. Because of this configuration, the center of gravity of the tool main body may be positioned forward of the center of the tool. As a result, a user may find it difficult to hold the tool main body in a stable manner. Furthermore, the planetary gear reduction mechanism, a total diameter of which is relatively large and a length of which is relatively large in its axial direction, may be arranged between the grip and the electric motor in an up-down direction. Because of this configuration, a length of the tube expansion tool may be large in the up-down direction. As a result, the stability of holding the tube expansion tool may be furthermore decreased.

[0006] A contraction (e.g., elastic recovery) speed of the PEX tubing after it has been expanded may change due to an ambient temperature and/or a temperature of the PEX tubing. For example, when the ambient temperature is high, the PEX tubing may be more elastically contractible (e.g., it may more quickly shrink/recover). That is, a contraction speed may be high. Because of this property, it may be desired that an end portion of the PEX tubing be expanded larger. In contrast, when the ambient temperature is low, the PEX tubing may have increased plasticity. In short, a contraction speed may be slower. Because of this property, when an end portion of the PEX tubing is expanded more (e.g., to compensate for the increased recovery speeds), it may take more time than necessary to couple the PEX tubing to the fitting when the ambient temperature is low. Thus, in this case, it may be desired that an expansion amount of the jaws be small. An expansion amount of the jaws may be larger when an end position (forward end position) of the advancing wedge is shifted forward. In contrast, the expansion amount of the jaws may be smaller when the end position of the advancing wedge is shifted rearward.

SUMMARY

[0007] As described above, there may be room to improve a configuration of an tube expansion tool so that a user can hold it in a more stable manner. It may be required that a user can hold a tube expansion tool in a stable manner, thereby improving operability.

[0008] Furthermore, in order to shift an initial position and an end position of the wedge, it may be required to detect the initial position and/or the end position of the wedge. In addition to this requirement, it may be also required to control a driving of the electric motor according to the desired shift in position(s). However, a conventional tube expansion tool has not adopted a configuration in which the initial position and/or the end position of the wedge can be detected, let alone shifted. Accordingly, a tube expansion tool in which the initial position and/or the end position of the wedge can be shifted and detected may be required.

[0009] According to one feature of the present disclosure, a tube expansion tool that is configured to expand an end portion of a synthetic resin made fluid pipe comprises an electric motor that is housed in a main body housing. The tube expansion tool further comprises a screw shaft in the main body housing that is movable in a direction parallel to an output shaft of the electric motor or along an axis line of the output shaft of the electric motor in a front-rear direction. The tube expansion tool further comprises a female screw member that moves the screw shaft in the front-rear direction by engagement with the screw shaft and rotation around an axis of the screw shaft. The tube expansion tool further comprises a gear that engages the female screw and that transmits a rotation output of the output shaft of the electric motor. The tube expansion tool further comprises a wedge extending forward from the screw shaft. Furthermore, the tube expansion tool further comprises a plurality of jaws that are coupled to the main body housing so as to be opened/closed. When the wedge moves forward integrally with the screw shaft, the plurality of jaws are pushed by the wedge to be opened radially outward relative to each other.

[0010] As described above, the electric motor is arranged such that the output shaft extends parallel to the screw shaft. Because of this configuration, the electric motor is aligned with the screw shaft in the front-rear direction and is located near to the screw shaft. Alternately, the electric motor is arranged such that the output shaft extends so as to be coaxial with the screw shaft. Because of this configuration, the electric motor is arranged close to the screw shaft.

Accordingly, the electric motor, which is heavy in weight, can be positioned close to a center of the main body housing, in which the screw shaft is located. As a result, a good weight balance of the tube expansion tool can be obtained and a user can hold the tube expansion tool in a stable manner. Accordingly, an operability of the tube expansion tool can be improved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. **1** is a perspective view of a tube expansion tool according to an exemplary embodiment of the present disclosure.

[0012] FIG. **2** is a perspective view of a tool main body of the tube expansion tool, from which a main body housing has been removed.

[0013] FIG. **3** is a right side view of the tool main body of the tube expansion tool, from which the main body housing has been removed.

[0014] FIG. **4** is an exploded perspective view of the tool main body.

[0015] FIG. **5** is a lateral cross-sectional view of the tool main body, in which a wedge is located at an initial position.

[0016] FIG. **6** is a lateral cross-sectional view of the tool main body, in which rotation of a jaw has been completed.

[0017] FIG. **7** is a lateral cross-sectional view of the tool main body, in which the wedge is located at an end position.

[0018] FIG. **8** is a cross-sectional view taken along line VIII-VIII of FIG. **5**.

[0019] FIG. **9** is a bottom view of a power conversion ring.

[0020] FIG. **10** is a jaw rotation mechanism viewed from a lower left, in which the wedge is located at the initial position.

[0021] FIG. **11** is the jaw rotation mechanism viewed from the lower left, in which rotation of the jaw has been completed.

[0022] FIG. **12** is the jaw rotation mechanism viewed from the lower left, in which the wedge is located at the end position.

[0023] FIG. **13** is a perspective view of a jaw viewed from a rear side thereof.

[0024] FIG. **14** is a block diagram of electrical components of the tube expansion tool.

[0025] FIG. **15** is a lateral cross-sectional view of a tool main body of a tube expansion tool according to a second embodiment, in which a wedge is located at an initial position.

[0026] FIG. **16** is a lateral cross-sectional view of a tool main body of the tube expansion tool according to the second embodiment, in which a jaw different from that in FIG. **15** is attached to the tool and the wedge is located at the same position as shown in FIG. **15**.

[0027] FIG. **17** is a lateral cross-sectional view of a sensor positioning mechanism.

[0028] FIG. **18** is a lateral cross-sectional view of a sensor positioning mechanism of a tube expansion tool according to a third embodiment.

[0029] FIG. **19** is a block diagram of electrical components of a tube expansion tool according to a fourth embodiment.

[0030] FIG. **20** is a block diagram of electrical components of a tube expansion tool according to a fifth embodiment.

[0031] FIG. **21** is a block diagram of electrical components of a tube expansion tool according to a sixth embodiment.

DETAILED DESCRIPTION

[0032] The detailed description set forth below, when considered with the appended drawings, is intended to be a description of exemplary embodiments of the present invention and is not intended to be restrictive and/or to represent the only embodiments in which the present invention can be practiced. The term "exemplary" used throughout this description means "serving as an example, instance, or illustration," and should not necessarily be construed as preferred or advantageous over other exemplary embodiments. The detailed description includes specific details for the purpose of providing a thorough understanding of the exemplary embodiments of the invention. It will be apparent to those skilled in the art that the exemplary embodiments of the invention may be practiced without these specific details. In some instances, these specific details refer to well-known structures, components, and/or devices that are shown in block diagram form in order to avoid obscuring significant aspects of the exemplary embodiments presented herein.

[0033] According to a feature of the present disclosure, the tube expansion tool further comprises a grip extending downward from the main body housing. The grip is arranged between the electric motor and the plurality of jaws in the front-rear direction. Furthermore, the electric motor is arranged below the screw shaft. Accordingly, the electric motor and the plurality of jaws are arranged so as to have a good weight balance with respect to the grip. As a result, operability of the tube expansion tool can be improved when a user holds the grip.

[0034] According to another feature of the present disclosure, at least a part of the screw shaft overlaps the grip in the front-rear direction. Accordingly, a length of the tube expansion tool in the front-rear direction can be made short. Accordingly, a moment around a center of gravity of the tube expansion tool may be made small, which improves operability of the tube expansion tool.

[0035] According to another feature of the present disclosure, a planetary gear reduction mechanism that reduces a rotation output of the output shaft is arranged between the output shaft of the electric motor and the screw shaft. Accordingly, the planetary gear reduction mechanism is arranged in a compact manner in a rotation power transmission path from the electric motor to the screw shaft. Also, a transmission loss of the rotation power can be suppressed by minimizing the rotation power transmission path from the electric motor to the screw shaft.

[0036] According to another feature of the present disclosure, the tube expansion tool further comprises a rotation drive ring that is linked to a rear portion of the plurality of jaws. Furthermore, the tube expansion tool further comprises a jaw rotation mechanism that rotates the plurality of jaws in a circumferential direction by rotation of the rotation drive ring, which may be caused by the rotation output of the electric motor. Furthermore, the rotation drive ring is arranged in front of the female screw member. Accordingly, the female screw member, the rotation drive ring, and the plurality of jaws are arranged in this order in the front-rear direction, which is the direction in which the screw shaft extends. Because of this configuration, a center of gravity of the tube expansion tool may be positioned close to the screw shaft. As a result, the stability of holding the tube expansion tool can be improved.

[0037] According to another feature of the present disclosure, the tube expansion tool further comprises a cap that supports the plurality of jaws so as to allow the jaws to be opened/closed. The cap is also structured to restrict the plurality of jaws from moving in the front-rear direction. The tube expansion tool further comprises a front side mechanism housing, a first center mechanism housing, and a rear side mechanism housing arranged in this order from a front side to a rear side. These components are positioned within the main body housing. Furthermore, the tube expansion tool further comprises a bolt that connects the front side mechanism housing to the rear side mechanism housing. Furthermore, the front side mechanism housing is made of iron and supports the cap. The rear side mechanism housing is made of iron and supports an end portion of the female screw member. Furthermore, the first center mechanism housing is made of a material that is lighter in weight than iron.

[0038] Because of this configuration, the tube expansion tool has a structure configured by the front side mechanism housing, the first center mechanism housing, and the rear side mechanism housing in a divided manner in the front-rear direction. When the plurality of jaws are opened, the cap and the front side mechanism housing that supports the cap may be strongly pushed forward by the plurality of jaws. The female screw member may be strongly pushed rearward by a reaction force caused by the screw shaft moving forward. Different from the above configuration, for example, in a case where the front side mechanism housing, the first center mechanism housing, and the rear side mechanism housing are combined to form an integral mechanism housing as a single component, when the plurality of jaws is opened, strong pulling forces may be generated at an front end and a rear end of the integral mechanism housing. Because of this, an entirety of the integral mechanism housing may be required to have high strength. However, in the present disclosure, the front mechanism housing, the first center mechanism housing, and the rear mechanism housing are arranged in the front-rear direction in a divided manner. Also, of these components, only the front side mechanism housing and the rear side mechanism housing are made of iron. Because of this configuration, the front side mechanism housing and the rear side mechanism housing, each of which has high strength, can both receive the pulling force in the front-rear direction. Also, the tube expansion tool may be made lighter in weight by the first center mechanism housing being made of a lighter material.

[0039] According to another feature of the present disclosure, the tube expansion tool further comprises a second center mechanism housing positioned between the first center mechanism housing and the rear side mechanism housing. Furthermore, each of the front side mechanism housing, the first center mechanism housing, the second center mechanism housing, and the rear side mechanism housing includes an engagement portion at each end portion thereof, such that adjacent engagement portions are configured to overlap each other in the front-rear direction. Accordingly, the front side mechanism housing and the first center mechanism housing can be precisely positioned relative to each other by overlapping the corresponding engagement portions. Also, the first center mechanism housing and the second center mechanism housing can be precisely positioned relative to each other by overlapping the corresponding engagement portions. Furthermore, the second center mechanism housing and the rear side mechanism housing can be precisely positioned relative to each other by overlapping the corresponding engagement portions. Because of this configuration, assemblability of each mechanism housing can be improved. Also, rattling of the components housed in the main body housing, such as, for example, the female screw member, can be prevented.

[0040] According to another feature of the present disclosure, a spindle that rotates integrally with the gear is arranged in front of the output shaft of the electric motor. Furthermore, the first center mechanism housing and the second center mechanism housing may each support a spindle bearing that rotatably supports the spindle and may also each support a female screw member bearing that rotatably supports the female screw member. Accordingly, the spindle bearings and the female screw member bearings may not substantially receive a direct force in the front-rear direction. Because of this configuration, the spindle and the female screw member can be supported by the first center mechanism housing and the second center mechanism housing, both of which have a weaker strength compared with the front side mechanism housing and the rear side mechanism housing. As a result, the tube expansion tool can be made more light weight, for instance due to having fewer components made of iron.

[0041] According to another feature of the present disclosure, the rear side mechanism housing supports a thrust bearing that contacts a rear end of the female screw member. When the screw shaft moves forward, the female screw member may be pushed rearward by a strong force. The rear side mechanism housing may receive the force by which the female screw member is pushed, via the thrust bearing. Because of this configuration, the female screw member can be precisely rotated around an axis of the screw shaft. As a result, the screw shaft can move precisely in the front-rear direction.

[0042] According to another feature of the present disclosure, a plurality of balls are placed between and engage with the screw shaft and the female screw member. Accordingly, the transmission efficiency of a driving force can be improved by the plurality of balls placed between the screw shaft and the female screw member. As a result, the rotation drive power of the female screw member can be efficiently converted to the movement of the screw shaft in the front-rear direction.

[0043] According to another feature of the present disclosure, the tube expansion tool further comprises a controller that switches between forward and reverse rotations of the output shaft of the electric motor. The tube expansion tool further comprises an initial position sensor and/or an end position sensor that detect(s) the screw shaft at an initial position and/or an end position, respectively, and transmit(s) a corresponding signal to the controller. Furthermore, the screw shaft moves forward and rearward between a rearward initial position and a forward end position by rotation of the female screw member. Furthermore, the initial position sensor, if present, is arranged so as to be movable in the front-rear direction such that an initial position of the screw shaft is movable by moving a position of the initial position sensor. The end position sensor, if present, is arranged so as to be movable in the front-rear direction such that an end position of the screw shaft is movable by moving a position of the end position sensor.

[0044] Because of this configuration, by displacing the end position sensor forward, an end position of the wedge moving forward can be set to a more forward position. Because of this, a pushing force of the wedge to enlarge the plurality of jaws radially outward can be larger at a newly positioned end position. Accordingly, an expansion width of the plurality of jaws opened radially outward relative to each other may be made larger. For example, in a case where a contraction speed of the fluid pipe is high, for example due to a high ambient temperature, an expansion width of the end portion of the fluid pipe can be made large. In contrast, by displacing the end position sensor rearward, an end position of the wedge moving forward can be set to a more rearward position. Because of this, a pushing force of the wedge to enlarge the plurality of jaws radially outward may be smaller at a newly positioned end position. Accordingly, an expansion width of the plurality of jaws **4** opened radially outward relative to each other can be made smaller. For example, in a case where a contraction speed of the fluid pipe is low, for instance due to a low ambient temperature, an expansion width of the end portion of the fluid pipe may be made smaller. In this manner, an expansion width of the jaws can be changed as desired, for instance in accordance with an ambient temperature or a temperature of the fluid pipe.

[0045] Furthermore, because of the above configuration, one may move the initial position sensor forward, thereby allowing an initial position of the wedge to be positioned in a more forward position. Accordingly, a time period from a time when the wedge starts to move from its initial position to a time when the wedge reaches the plurality of jaws can be reduced. As a result, a time taken to open/close the plurality of jaws per cycle can be reduced, which causes an overall operation time to be reduced. Furthermore, by moving the initial position sensor rearward, an initial position of the wedge may be positioned in a more rearward position. Accordingly, for example, when using a plurality of jaws having a thick thickness in a radial direction, an initial position of the wedge can be positioned in a more rearward position, such that the wedge does not interfere with the closing of the plurality of jaws.

[0046] According to another feature of the present disclosure, the initial position sensor and/or the end position sensor include(s) a Hall Effect element, which is positioned in the main body housing. Furthermore, the screw shaft includes a magnet. Accordingly, a structure for detecting the initial position sensor and/or the end position of the screw shaft can be made simple and compact. Accordingly, the main body housing, including the initial position sensor and/or the end position sensor, can be made compact.

[0047] According to another feature of the present disclosure, the initial position sensor and/or the end position sensor include(s) an operation part(s), extending outward of the main body housing. Accordingly, a user can move a position of the initial position sensor and/or a position of the end position sensor by shifting a position of the operation part(s). The user can move the position of the initial position sensor and/or the position of the end position sensor from outside of the main body housing using their finger. Because of this configuration, the initial position sensor and/or the end position sensor can be easily moved to a target position (s).

[0048] According to another feature of the present disclosure, the tube expansion tool further comprises a grip extending downward from the main body housing. Furthermore, the operation part(s) project(s) upward from an upper surface of the main body housing. Accordingly, the operation part(s) can be arranged on an upper side of the main body housing, such that the user can more easily view the operation part(s).

[0049] According to another feature of the present disclosure, the tube expansion tool further comprises a jaw rotation mechanism that rotates the plurality of jaws in a circumferential direction by a rotation output of the electric motor. Furthermore, the controller can supply a current to the electric motor based on a first upper limit value and a second upper limit value. The first upper limit value is defined as an upper limit of a current flowing to the electric motor in a rotation zone in which the plurality of jaws are rotated. Also, the second upper limit is defined as an upper limit of a current flowing to the electric motor in an expansion zone in which the plurality of jaws are opened radially outward relative to each other. That is, an upper limit of a current flowing to the electric motor can be changed based on whether the operation is in the rotation zone or the expansion zone. Because of configuration, for example, when the jaws become un-rotatable, the electric motor can be prevented from continuing to be driven. As a result, an excessive force can be prevented from being applied to, for example, the jaws, the wedge, and the jaw rotation mechanism.

[0050] According to another feature of the present disclosure, the tube expansion tool further comprises a rotation number detection sensor that detects a number of rotations of the electric motor and transmits a corresponding signal to the controller. Furthermore, the controller defines the rotation zone and the expansion zone based on the corresponding signal from the rotation number detection sensor and detection of the signals relating to the initial position and the end position of the screw shaft. Because of this configuration, when an end position of the screw shaft is changed by moving a position of the end position sensor, the rotation zone and the expansion zone can be re-defined. As a result, a rotation operation and an expansion operation of the jaws can be controlled such that the fluid pipe can be expanded to a desired expansion width, for instance according to a contraction speed of the fluid pipe.

[0051] According to another feature of the present disclosure, the first upper limit value is set lower than the second upper limit value. Accordingly, an upper limit of a current flowing to the electric motor can be set low in the rotation zone, in which it is desired that a small load force is applied to the jaws and the jaw rotation mechanism. As a result, the electric motor can be prevented from being excessively driven in the rotation zone. Also, a load force applied to the jaws and the jaw rotation mechanism may be minimized.

[0052] According to another feature of the present disclosure, the rotation zone is a zone in which the wedge moves forward prior to entering the expansion zone. Accordingly, the plurality of jaws can expand radially outward relative to each other after having rotated in the circumferential direction of the wedge. By clear separation of the rotation operation and the expansion operation of the jaws, an unnecessary and accidental load force can be prevented from being applied to the jaws and the jaw rotation mechanism.

[0053] According to another feature of the present disclosure, the rotation zone is a zone in which the wedge moves rearward after having exited the expansion zone. Accordingly, the plurality of jaws can rotate in the circumferential direction of the wedge after the jaws are closed radially inward relative to each other. In this case, because the rotation operation and the expansion operation of the jaws are clearly separated, an accidental load force can be prevented from being applied to the jaws and the jaw rotation mechanism.

[0054] According to another feature of the present disclosure, a plurality of balls are placed between the screw shaft and the female screw member. Accordingly, the transmission efficiency of a driving force may be improved by the plurality of balls placed between the screw shaft and the female screw member. As a result, the rotation drive power of the female screw member can be efficiently converted to the movement of the screw shaft in the front-rear direction.

[0055] According to another feature of the present disclosure, a second plurality of jaws, each of which has a different thickness in the radial direction than the plurality of jaws, are configured to be attached to the tube expansion tool. Accordingly, fluid pipes having various different nominal diameters can be expanded using the same tube expansion tool.

[0056] According to another feature of the present disclosure, the tube expansion tool further comprises one or more sensor positioning mechanism by which the initial position sensor and/or the end position sensor is/are configured to be releasably positioned at a plurality of desired positions in the front-rear direction. Accordingly, the initial position sensor can be positioned such that an initial position of the wedge may be positioned at a desired position selected from predetermined positions. Also, the end position sensor may be positioned such that an end position of the wedge can be positioned at a desired position selected from predetermined positions. Accordingly, a user may not need to fine-adjust an initial position and/or an end position of the wedge, which improves usability of the tube expansion tool. Also, the initial position sensor and/or the end position sensor that is/are once positioned can be prevented from inadvertently being moved.

[0057] Next, one embodiment of the present disclosure will be described with reference to FIGS. **1** to **14**. As shown in FIG. **1**, a tube expansion tool **1** of the present disclosure may include a tool main body **10** that is housed in an approximately tubular-shaped main body housing **11**. The tube expansion tool **1** may also include a grip **5** that extends downward from a middle portion of the tool main body **10** in a front-rear direction. In FIG. **1**, a user who holds the tube expansion tool **1** may be situated on a rear side of the tube expansion tool **1**. In the following explanation, the rear side of the tube expansion tool **1** may be also referred to as a user side, and a side opposite to the user side may be referred to as a front side. Also, a left/right side and an upper/lower side may be based on a user's position.

[0058] As shown in FIGS. **1** and **4**, a ring-shaped cap **2** may be attached to a front portion of the main body housing **11** that is located forward of the grip **5**. An approximately conical wedge **3** extending in a front-rear direction may be arranged inside of an inner circumferential surface of the cap **2**. The wedge **3** may be attached to a front end of a cylindrical-shaped screw shaft **28**. The screw shaft **28** may extend in the front-rear direction in a center of the main body housing **11**. The wedge **3** may be movable in the front-rear direction integrally with the screw shaft **28**. A plurality of jaws **4** may be arranged extending in the front-rear direction. The plurality of jaws **4** may be radially outward of the wedge **3** and radially inward of the cap **2**. The plurality of jaws **4** may be arranged in a circumferential direction of the wedge **3** at equal intervals. For example, six jaws **4** may be arranged in the circumferential direction of the wedge **3** at an equal angular interval of 60 degrees. The plurality of jaws **4** may be opened/closed in a radial direction between a closed state and an open state. In the closed state, the plurality of jaws **4** may contact each other in the circumferential direction and cover the wedge **3**. In the open state, the plurality of jaws **4** may be opened relative to each other radially outward and may expose a part of an end portion of the wedge **3**.

[0059] As shown in FIG. **1**, a trigger-type switch lever **6** may be disposed at a front surface of the grip **5**. A user may pull the switch lever **6** while holding the grip **5**. A switch main body **6***a*, which may turn on and off the tool **1** in conjunction with the pulling operation of the switch lever **6**, may be disposed within the grip **5**. The switch main body **6***a* may be in an off state when the switch lever **6** is not pulled, and may be in an on state when the switch lever **6** is pulled. An approximately rectangular box-shaped housing **7** that extends in the front-rear direction and in a left-right direction with respect to the grip **5** may be disposed at a lower end of the grip **5**. The housing **7** may house a controller **45**. The controller **45** may include a shallow rectangular box-shaped case and a resin-encapsulated control board housed in the case. The controller **45** may be housed in the housing **7** such that a width thereof (a shortest side of the case) extends in the up-down direction. The controller **45** may mainly control the driving of an electric motor **21**, which will be discussed later in detail.

[0060] As shown in FIG. **1**, a battery attachment portion **7***a* may be provided at a lower surface of the housing **7**. A rectangular box-shaped battery **8** may be removably attached to the battery attachment portion **7***a*. The battery **8** may be removed from the battery attachment portion **7***a* by sliding the battery **8** in a forward direction with respect to the battery attachment portion **7***a*. In contrast, the battery **8** may be attached to the battery attachment portion **7***a* by sliding the battery **8** in a rearward direction from a front side of the battery attachment portion **7***a*. The battery **8** removed from the battery attachment portion **7***a* may be repeatedly recharged for use by a dedicated charger. The battery **8** may be used for other electric tools. The battery **8** may serve as a power source for the electric motor **21**.

[0061] As shown in FIG. **4**, the main body housing **11** may include a front side mechanism housing **12**, a first center mechanism housing **13**, a second center mechanism housing **14**, and a rear side mechanism housing **15** in this order in the front-rear direction. The front side mechanism housing **12**, the first center mechanism housing **13**, and the second center mechanism housing **14** may be respectively formed to have substantially a cylindrical shape having an insertion hole at the center thereof that penetrates in the front-rear direction. The rear side mechanism housing **15** may be formed to have a plate shape having an insertion hole in the same manner as the other housings. A thickness direction of the rear side mechanism housing **15** may be aligned in the front-rear direction. The front side mechanism housing **12**, the first center mechanism housing **13**, the second center mechanism housing **14**, and the rear side mechanism housing **15** may cooperate to form a mechanism housing that houses a spindle **24** and a female screw member **27**, both of which will be discussed later in detail. The front side mechanism housing **12** and the rear side mechanism housing **15** may be made of iron or other suitably strong material. The first center mechanism housing **13** and the second center mechanism housing **14** may be made of aluminum or other suitably light material. In other words, the first center mechanism housing **13** and the second center mechanism housing **14** may be made of a material having a density less than that of iron.

[0062] As shown in FIGS. **2** and **4**, a male screw **12***a* may be formed on a front outer circumferential surface of the front side mechanism housing **12**. A female screw **2***b* that engages the male screw **12***a* may be formed on an inner circumferential surface of the cap **2**. By engaging the male screw **12***a* with the female screw **2***b*, the cap **2** may be coupled to a front portion of the front side mechanism housing **12**. A rectangular extension portion **12***c* that extends outward in a radial direction and has an approximately rectangular-shaped plate shape may be formed at a rear portion of the front side mechanism housing **12**. A through hole **12***e* may penetrate the rectangular extension portion **12***c* in the front-rear direction at each of the four corners of the rectangular extension portion **12***c*.

[0063] As shown in FIGS. **2** and **4**, the first center mechanism housing **13**, the second center mechanism housing **14**, and the rear side mechanism housing **15** may each include four boss portions **13***c*, **14***c*, **15***c*, each of which is positioned radially outward. Each of the boss portions **13***c*, **14***c*, **15***c* may be formed in an approximately tubular shape extending in the front-rear direction. The boss portions **13***c*, **14***c* of the first center mechanism housing **13** and the second center mechanism housing **14** may each include central through holes **13***f*, **14***f*, which penetrate in the front-rear direction. Each of the boss portions **15***c* of the rear side mechanism housing **15** may include a screw hole **15***d* that extends in the front-rear direction at the center thereof.

[0064] As shown in FIGS. **2** and **4**, when the rectangular extension portion **12***c* and the boss portions **13***c*, **14***c*, **15***c* are aligned in the front-rear direction, the corresponding through holes **12***e*, **13***f*, **14***f* may communicate with the screw holes **15***d* in the front-rear direction. Four bolts **15***d* may be inserted through the through holes **12***e*, **13***f*, **14***f* in the front-rear direction from the front side and be screw-connected to the screw holes **15***d*. Because of this configuration, the front side mechanism housing **12** and the rear side mechanism housing **15** may be linked to one another by the bolts **16**, and such that the first center mechanism housing **13** and the second center mechanism housing **14** are held between the front side mechanism housing **12** and the rear side mechanism housing **15** in the front-rear direction.

[0065] As shown in FIGS. **3-5**, a rear end of the front side mechanism housing **12** and a front end of the first center mechanism housing **13** may include an approximately cylindrical-shaped engagement portion **12***b* and engagement portion **13***a*, respectively. An outer circumferential surface of the engagement portion **12***b* of the front side mechanism housing **12** may have approximately the same diameter as an inner circumferential surface of the engagement portion **13***a* of the first center mechanism housing **13**. The engagement portion **12***b* of the front side mechanism housing **12** may overlap the engagement portion **13***a* of the first center mechanism housing **13** in the front-rear direction, and the outer circumferential surface of the engagement portion **12***b* of the front side mechanism housing **12** may be tightly fitted with the inner circumferential surface of the engagement portion **13***a* of the first center mechanism housing **13** by a spigot-joint engagement.

[0066] As shown in FIGS. **3-5**, a rear end of the first center mechanism housing **13** and a front end of the second center mechanism housing **14** may include an approximately cylindrical-shaped engagement portion **13***b* and engagement portion **14***a*, respectively. An inner circumferential surface of the engagement portion **13***b* of the first center mechanism housing **13** may have approximately the same diameter as an outer circumferential surface of the engagement portion **14***a* of the second center mechanism housing **14**. The engagement portion **13***b* of the first center mechanism housing **13** may overlap the engagement portion **14***a* of the second center mechanism housing **14** in the front-rear direction, and the inner circumferential surface of the engagement portion **13***b* of the first center mechanism housing **13** may be tightly fitted with the outer circumferential surface of the engagement portion **14***a* of the second center mechanism housing **14** by a spigot-joint engagement.

[0067] As shown in FIGS. **3-5**, a rear end of the second center mechanism housing **14** may include an approximately cylindrical-shaped engagement portion **14***b*. A front surface of the rear side mechanism housing **15** may include an approximately cylindrical-shaped engagement portion **15***b* projecting forward. An inner circumferential surface of the engagement portion **14***b* of the second center mechanism housing **14** may have approximately the same diameter as an outer circumferential surface of the engagement portion **15***b* of the rear side mechanism housing **15**. The engagement portion **14***b* of the second center mechanism housing **14** may overlap the engagement portion **15***b* of the rear side mechanism housing **15** in the front-rear direction, and the inner circumferential surface of the engagement portion **14***b* of the second center mechanism housing **14** may be tightly fitted with the outer circumferential surface of the engagement portion **15***b* of the rear side mechanism housing **15** by a spigot-joint engagement.

[0068] As shown in FIGS. **1** and **5**, an approximately tubular-shaped motor housing **20** that houses the electric motor **21** may be provided at a rear portion of the main body housing **11**. The motor housing **11** may be positioned below the screw shaft **28** and on an upper rear side of the grip **5**. The electric motor **21** may be, for example, a DC blushless motor. An output shaft **21***a* of the electric motor **21** may extend along a motor shaft axis line J in the front-rear direction, which is parallel to a direction in which the screw shaft **28** extends. The output shaft **21***a* may be supported by bearings **21***e*, **21***f* attached to the motor housing **20** so as to be rotatable around the motor shaft axis line J.

[0069] As shown in FIG. **5**, a stator **21***b* of the electric motor **21** may be unrotatably supported on an inner circumferential surface of the motor housing **20**. A rotor **21***c* of the electric motor **21** may be attached to the output shaft **21***a* so as to be integrally rotatable with the output shaft **21***a* and on an inner circumferential side of the stator **21***b*. A rotation number detection sensor **21***d* may be disposed in front of the rotor **21***c*. The rotation number detection sensor **21***d* may be used to detect the number of rotations of the output shaft **21***a* by detecting a rotation angle of the rotor **21***c*. (The controller

45 may determine the number of rotations based on the number of times the rotor **21***c* rotates at a certain angular position.) A fan **22** for introducing cooling air within the motor housing **20** may be attached to the output shaft **21***a* between the rotor **21***c* and the rear bearing **21***f* in the front-rear direction. When the fan **22** rotates integrally with the output shaft **21***a*, cooling air may flow from the front side toward the rear side of the housing **20**.

[0070] As shown in FIG. **5**, a planetary gear reduction mechanism **23** for reducing an output speed of the output shaft **21***a* may be positioned in front of the electric motor **21**. The planetary gear reduction mechanism **23** may have an approximately tubular shape and be disposed around the motor shaft axis line J. The planetary gear reduction mechanism **23** may have approximately the same diameter as the electric motor **21**. A first sun gear **23***a* may be arranged integrally with a front end of the output shaft **21***a*. The first sun gear **23***a* may be positioned at a rear end of the planetary gear reduction mechanism **23**. A first internal gear **23***b* may be arranged radially outside of the first sun gear **23***a*. The first internal gear **23***b* may be ring-shaped around the motor shaft axis line J. A plurality of first planetary gears **23***c* may be engageably arranged between the first sun gear **23***a* and the first internal gear **23***b*. The first planetary gears **23***c* may engage a first carrier **23***d* in front of the first sun gear **23***a*. A rotation power of the output shaft **21***a* may be reduced and transferred to the first carrier **23***d* via the first sun gear **23***a* and the first planetary gears **23***c*.

[0071] As shown in FIG. **5**, the first carrier **23***d* may be formed integrally with a second sun gear **23***e* and also may be rotatable integrally with the second sun gear **23***d* around the motor shaft axis line J. A second internal gear **23***f* may be arranged radially outside of the second sun gear **23***e*. The second internal gear **23***f* may be ring-shaped around the motor shaft axis line J. A plurality of second planetary gears **23***g* may be engageably arranged between the second sun gear **23***e* and the second internal gear **23***f*. The second planetary gears **23***g* may engage a second carrier **23***h* in front of the second sun gear **23***e*. The second carrier **23***h* may be formed integrally with the spindle **24** and may be rotatable around the motor shaft axis line J. Because of this configuration, a rotation power of the first carrier **23***d* may be reduced and transferred to the spindle **24** via the second sun gear **23***e*, the second planetary gears **23***g*, and the second carrier **23***h*. As a result, a rotation power of the output shaft **21***a* may be reduced and transferred to the spindle **24** via the planetary gear reduction mechanism **23**.

[0072] As shown in FIG. **5**, the spindle **24** may be supported by spindle bearings **24***b*, **24***c* so as to be rotatable around the motor shaft axis line J. The front spindle bearing **24***b* may be press-fit to a recessed portion **13***d* formed at a lower portion of the first center mechanism housing **13**. The rear spindle bearing **24***c* may be press-fit to a recessed portion **14***d* formed at a lower portion of the second center mechanism housing **14**. The spindle bearings **24***b*, **24***c* may be housed in a space formed by the first center mechanism housing **13** cooperating with the second center mechanism housing **14**. The spindle **24** may include a gear **26** that is formed integrally with the spindle **24**. The gear **26** may be configured to transmit a rotation power to the screw shaft **28**. The gear **26** may be arranged between the spindle bearings **24***b*, **24***c*. A male screw (thread) **24***a* may be formed on an outer circumferential surface of the spindle **24** in front of the front side spindle bearing **24**.

[0073] As shown in FIGS. **4** and **5**, the tool main body **10** may include a feed screw mechanism **25**, which may be also referred to as a ball screw mechanism. The feed screw mechanism **25** may include the screw shaft **28**, the female screw member **27**, and the gear **26**. The screw shaft **28** may be arranged along a screw shaft axis line K that extends in the front-rear direction and at a center of the main body housing **11**. The screw shaft **28** may be movable in the front-rear direction along the screw shaft axis line K. The screw shaft **28** may be arranged such that at least a part of the screw shaft **28** overlaps a portion of the grip **5** in the front-rear direction within a movable range of the screw shaft **28** from a rear end position to a front end position. When the screw shaft **28** is disposed at the end position in the movable range, the screw shaft **28** may overlap the output shaft **21***a* in the front-rear direction. The female screw member **27** may be formed in an approximately cylindrical shape, and may engage the screw shaft **28** and the gear **26**. A female screw **27***b* may be formed on an inner circumferential surface of the female screw member **27**. The female screw **27***b* may engage a male screw **28***a* of the screw shaft **28** via a plurality of balls **28***b* between the male screw **28***a* and the female screw **27***b*. The female screw member **27** may include a gear **27***a* that protrudes radially outward and engages the gear **26**. A rotation of the spindle **24** may be transmitted to the female screw member **27** due to the engagement of the gear **27***a* of the female screw member **27** with the gear **26** of the spindle **24**.

[0074] As shown in FIGS. **4** and **5**, the female screw member **27** may be rotatably supported around the screw shaft axis line K by female screw member bearings **27***c*, **27***d* in the front-rear direction. The female screw member bearing **27***c* on the front side of the gear **27***a* may be press-fitted to an inner circumferential surface **13***e* of the first center mechanism housing **13**. The female screw member bearing **27***d* on the rear side of the gear **27***a* may be press-fitted to an inner circumferential surface **14***e* of the second center mechanism housing **14**. The female screw member bearings **27***c*, **27***d* may be housed in a space formed by the first center mechanism housing **13** cooperating with the second center mechanism housing **14**. A thrust bearing **27***e* for receiving a thrust load that pushes the female screw member **27** in a rearward direction may be arranged between a rear surface of the female screw member **27** and a front surface **15***a* of the rear side mechanism housing **15**. A washer **27***f* may be arranged between a front surface of the female screw member **27** and a rear surface of the power conversion ring **32**. The power conversion ring **32** will be discussed later in detail.

[0075] As shown in FIGS. **2** and **3**, a screw shaft guide **29** may be provided at a rear portion of the screw shaft **28**. The screw shaft guide **29** may guide a movement of the screw shaft **28** in the front-rear direction with respect to the main body housing **11**. The screw shaft guide **29** may include a support member **29***a* that is coupled to the screw shaft **28** and that extends in a left-right direction. The screw shaft guide **29** may also include a roller **29***b* that is provided on both left and right ends of the support member **29***a*. A pair of rails **29***c* that are each formed in a loop shape and extend in the front-rear direction may be provided on both left and right sides of the main body housing **11**. Each roller **29***b* may engage the corresponding rail **29***c* so as to move in the front-rear direction along the rail **29***c*. The screw shaft **28** may be moved in the front-rear direction while being guided by the rollers **29***b*.

[0076] As shown in FIGS. **4** and **5**, the tool main body **10** may include a jaw rotation mechanism **30** that rotates the plurality of jaws **4**. The jaw rotation mechanism **30** may include a linear movement member **31** and a power conversion ring **32**. The linear movement member **31** may be formed in an approximately cylindrical shape having an axis line in the front-rear direction. The linear movement member **31** may include a female screw **31***a* and a cylindrical-shaped protrusion **31***b*. The female screw **31***a* may be formed on an inner circumferential surface of the linear movement member **31**. The cylindrical-shaped protrusion **31***b* may extend in a direction perpendicular to the axis line of the linear movement member **31**. A roller **31***b* may be provided on an outer circumferential surface of the protrusion **31***b*. The roller **31***b* may cover the protrusion **31***b* in the circumferential direction and be rotatable around an axis of the protrusion **31***b*. The female screw **31***a* of the linear movement member **31** may engage the male screw **24***a* of the spindle **24**. A rotation restriction portion **12***d* that restricts a rotation of the linear movement member **31** may be formed at a lower portion of the front side mechanism housing **12**. The rotation restriction portion **12***d* may be formed in a groove shape extending lineally in the front-rear direction and may be formed so as to penetrate the front side mechanism housing **12** in the radial direction.

[0077] As shown in FIGS. **4** and **9**, the power conversion ring **32** may be formed in an approximately cylindrical shape. The power conversion ring **32** may have an insertion hole **32***d* that penetrates in the front-rear direction. Grooves **32***a*, **32***b* may be formed in a recessed shape on an outer circumferential surface of a lower portion of the power conversion ring **32**. One groove **32***a* may extend in a circumferential direction of the power conversion ring **32**. For example, the groove **32***a* may extend in a direction intersecting an axis of the power conversion ring **32** (e.g., the front-rear direction) at an inclined angle of 45 degrees. An inclined direction of the groove **32***a* may be a counterclockwise direction when viewed from a front side of the power conversion ring **32**. The other groove **32***b* may extend in a direction parallel to the axis direction of the power conversion ring **32**. The protrusion **31***b* to which the roller **31***c* is attached may be inserted into these grooves **32***a*, **32***b*. A front end of the first groove **32***a* may be connected to a rear end of the second groove **32***b*, such that the protrusion **31***b* can be moved smoothly between the first groove **32***a* and the second groove **32***b*.

[0078] As shown in FIGS. **5-8**, the power conversion ring **32** may be housed in the front side mechanism housing **12**. The linear movement member **31** may engage the male screw **24***a* of the spindle **24** at a position generally located below the front side mechanism housing **12**. The protrusion **31***b* may extend upward so as to pass through the rotation restriction portion **12***d* and may be inserted into one of the grooves **32***a*, **32***b*. The roller **31***c* may contact both a wall surface of one of the grooves **32***a*, **32***b* and a wall surface of the rotation restriction portion **12***d*. The linear movement member **31** may be restricted from rotating around an axis of the spindle **24** due to the engagement of the protrusion **31***b* with the rotation restriction portion **12***d*.

[0079] As shown in FIGS. **10-12**, when the spindle **24** rotates around its axis, the linear movement member **31** may move in the front-rear direction due to the engagement of the male screw **24***a* of the spindle **24** with the female screw **31***a* of the linear movement member **31** and due to the rotation restriction of the linear movement member **31** around the axis of the spindle **24**. When the linear movement member **31** is disposed at the rear end of its movable range, the protrusion **31***b* may be disposed at a rear end of the groove **32***a*. As the linear movement member **31** moves forward from the rear end of its movable range, the protrusion **31***b* may move forward within the groove **32***a*. Because the linear movement member **31** is restricted from rotating, the protrusion **31***b* may not be significantly moved in the left-right direction. Because of this configuration, the protrusion **31***b* moving forward may push against the wall surface of the groove **32***a*. Accordingly, the power conversion ring **32** may rotate in a clockwise direction around the screw shaft axis line K when viewed from the front side of the power conversion ring **32**. When the linear movement member **31** moves further forward, the protrusion **31***b* may enter the second groove **32***b* from the first groove **32***a*. Because the second groove **32***b* is not configured to be tilted in the front-rear direction, the protrusion **31***b* may not substantially push against the wall surface of the groove **32***b*. Because of this configuration, the power conversion ring **32** may not rotate at this time.

[0080] As shown in FIGS. **10-12**, when the linear movement member **31** moves rearward from a front end of its movable range, the protrusion **31***b* may firstly move within the second groove **32***b*. In this case, because the protrusion **31***b* does not push against the wall surface of the groove **32***b*, the power conversion ring **32** may not rotate at this time. In contrast, when the protrusion **31***b* moves rearward within the first groove **32***a*, the protrusion **31***b* may push the wall of the first groove **32***a* to cause the power conversion ring **32** to rotate counterclockwise when viewed from the front side of the power conversion ring **32**.

[0081] As shown in FIGS. **4** and **5**, a cylindrical-shaped one way clutch **33** and an approximately cylindrical-shaped first rotation drive ring **34** may be arranged radially inward of the power conversion ring **32**. The one way clutch **33** may be mounted on an inner circumferential surface of the power conversion ring **32**. The first rotation drive ring **34** may be arranged radially inward of the one way clutch **33** and radially outward of the screw shaft **28**. The one way clutch **33** may allow for rotation of the power conversion ring **32** only in a clockwise direction when viewed from the front. Accordingly, when rotating in this direction, rotation of the power conversion ring **32** may be transmitted to the first rotation drive ring **34**. In contrast, a counterclockwise rotation of the power conversion ring **32** may not be transferred to the first rotation drive ring **34** through the one way clutch **33**.

[0082] As shown in FIGS. **4** and **5**, the first rotation drive ring **34** may have an approximately cylindrical shape. The first rotation drive ring **34** may have a through hole **34***d* passing through its center in the front-rear direction. The screw shaft **28** may be inserted into the insertion hole **34***d* so as to be moveable in the front-rear direction. The first rotation drive ring **34** may include a small diameter portion **34***a* and a large diameter portion **34***b*, both of which have a cylindrical shape around the screw shaft axis line K. The small diameter portion **34***a* may be arranged behind the large diameter portion **34***b*. The small diameter portion **34***a* may be press-fitted to an inner circumferential surface of the one way clutch **33**. A plurality of recess grooves **34***c* extending in the front-rear direction may be formed on an outer circumferential surface of the large diameter portion **34***b*. The plurality of recess grooves **34***c* may be arranged at equal intervals in the circumferential direction. For example, the plurality of recess grooves **34***c* may be arranged at 90 degrees.

[0083] As shown in FIGS. **4** and **5**, a second rotation drive ring **35** that engages the first rotation drive ring **34** may be arranged in front of the first rotation drive ring **34**. The second rotation drive ring **35** may have an approximately cylindrical shape. The second rotation drive ring **35** may have a through hole **35***e* passing through its center in the front-rear direction. The screw shaft **28** and the first rotation drive ring **34** may be inserted into the through hole **35***e*. A plurality of engaging protrusions **35***a* extending radially inward may be provided on an inner circumferential surface of the second rotation drive ring **35**. The plurality of engaging protrusions **35***a* may engage the plurality of recess grooves **34***c* when the first rotation drive ring **34** is inserted into the through hole **35***e*. Because of this configuration, the second rotation drive ring **35** may be rotatable around the screw shaft axis line K and may rotate integrally with the first rotation drive ring **34**. Furthermore, the second rotation drive ring **35** may be configured to be slidable with respect to the first rotation drive ring **34** in the front-rear direction, which will be discussed later.

[0084] As shown in FIGS. **4** and **5**, a spring receiving portion **35***d* extending radially outward may be formed at a front portion of the outer circumferential surface of the second rotation drive ring **35**. A washer **32***c* may be arranged in front of the front surface of the power conversion ring **32**. A compression spring **35***c* may be placed between the spring receiving portion **35***d* and the washer **32***c*. The second rotation drive ring **35** may be spring-biased in a forward direction by the compression spring **35***c*. A plurality of engagement teeth **35***b* in a shape of recesses and protrusions alternately arranged in a circumferential direction may be formed on a front surface of the second rotation drive ring **35**.

[0085] As shown in FIGS. **4** and **5**, a third rotation drive ring **36** may be arranged in front of the second rotation drive ring **35**. The third rotation drive ring **36** may engage the second rotation drive ring and the plurality of jaws **4**. The third rotation drive ring **36** may have an approximately cylindrical shape. The third rotation drive ring **36** may have a through hole **36***c* at its center passing through in the front-rear direction. The screw shaft **28** may be inserted into the through hole **36***c*. A plurality of engagement teeth **36***a* in a shape of recesses and protrusions alternately arranged in a circumferential direction may be formed on a rear surface of the third rotation drive ring **36**. The engagement teeth **36***a* of the third rotation drive ring **36** may engage the engagement teeth **35***b* of the second rotation drive ring **35**. The third rotation drive ring **36** may be rotatable around the screw shaft axis line K and may integrally rotate with the second rotation drive ring **35** due to the engagement teeth **35***b* of the second rotation drive ring **35** engaging with the engagement teeth **36***a* of the third rotation drive ring **36**. A plurality of engagement protrusion **36***b* extending in the forward direction may be formed on a front end surface of the third rotation drive ring **36**. Each of the plurality of engagement protrusion **36***b* may engage a corresponding engagement recess **4***b* that is formed on a rear end surface of the corresponding jaw **4** (refer to FIG. **13**). Because of this configuration, the plurality of jaws **4** may be rotatable around the screw shaft axis line K and may rotate integrally with the third rotation drive ring **36**.

[0086] For example, there may be a situation where the jaws **4** are stuck to an inner circumferential surface of a fluid pipe. In this situation, the second rotation drive ring **35** may be moved rearward against the biasing force of the compression spring **35***c*. In other words, the second rotation drive ring **35** may be moved apart from the third rotation drive ring **36**. Because of this configuration, the engagement teeth **35** of the second rotation drive ring **35** may disengage from the engagement teeth **36***a* of the third rotation drive ring **36**. Furthermore, a rotation power transmission path for rotating the plurality of jaws **4** around the screw shaft axis line K may be shut off between the second rotation drive ring **35** and the third rotation drive ring **36**. Accordingly, an excessive rotation power may be prevented from being applied to the jaws **4** when they are stuck to the fluid pipe. As a result, components that transmit rotation power, such as the linear movement member **31**, the power conversion ring **32**, and the first, second, and third rotation drive rings **34**, **35**, **36**, may be prevented from being damaged.

[0087] As shown in FIGS. **5-7** and **13**, a ring holding groove **4***a*, which may have an arc-shaped cross section, may be formed on an outer circumferential surface of a rear portion of each jaw **4**. Each of the ring holding groove **4***a* may be combined to form an annular groove in an integrally continuous manner. The plurality of jaws **4** may be combined in a circumferential direction by an elastically extendible ring **4***c* that is inserted into the ring holding grooves **4***a*. A jaw support groove **2***a* that extends radially outward and in the circumferential direction may be formed on an inner circumferential surface of the cap **2**. The jaw support groove **2***a* may allow a radial movement of the ring **4***c* and may restrict a front-rear movement of the ring **4***c*. The plurality of jaws **4** may open/close in a radial direction around the ring **4***c* that is supported by the jaw support groove **2***a*.

[0088] As shown in FIGS. **5-7**, when the wedge **3** moves forward, the plurality of jaws **4** may open radially outward relative to each other and may push the cap **2** forward and radially outward. When the wedge **3** moves forward, the front side mechanism housing **12**, which is integrally connected to the cap **2**, may receive a strong and forward pulling force. When the screw shaft **28**, which is integrally connected to the wedge **3**, moves forward, the female screw member **27** may be pushed rearward due to a reaction force of the forward movement of the screw shaft **28**. The rear side mechanism housing **15** may receive the reaction force via the thrust bearing **27***e*. Because of this configuration, when the wedge **3** and the screw shaft **28** move forward, strong pulling forces that are opposite to each other in the front-rear direction may be generated between the front side mechanism housing **12** and the rear side mechanism housing **15**.

[0089] As shown in FIGS. **5-7**, the first center mechanism housing **13** and the second center mechanism housing **14**, which may be separated from each other in the front-rear direction, may be placed between the front side mechanism housing **12** and the rear side mechanism housing **15**. Because of this configuration, a forward force that the front side mechanism housing **12** receives may not be transmitted to the rear side mechanism housing **15**. Also, a rearward force that the rear side mechanism housing **15** receives may not be transmitted to the front side mechanism housing **12**.

Furthermore, the front side mechanism housing **12** and the rear side mechanism housing **15** may be made of iron. Because of this configuration, the front side mechanism housing **12** and the rear side mechanism housing **15** may have rigidity against pulling forces opposite to each other in the front-rear direction.

[0090] As shown in FIGS. **5-7**, the first center mechanism housing **13** may house and support the spindle bearing **24***b* and female screw member bearing **27***c*. The second center mechanism housing **14** may house and support the other spindle bearing **24***c* and the other female screw member bearing **27***d*. The spindle **24**, which is rotatably supported by the spindle bearings **24***b*, **24***c*, may receive a reaction force generated by a front-rear movement of the linear movement member **31**. However, this reaction force may be very small in comparison with a force that the female screw member **27** receives. Because of this, the spindle bearings **24***b*, **24***c* may not receive a substantial force in the front-rear direction. The thrust bearing **27***e* may receive a rearward force as it is pushed by the female screw member **27**, which is rotatably supported by the female screw member bearings **27***c*, **27***d*. Because of this, the female screw member bearings **27***c*, **27***d* may not receive a substantial force in the front-rear direction. Furthermore, the first center mechanism housing **13** and the second center mechanism housing **14** may be separated in the front-rear direction with regard to the front side mechanism housing **12** and the rear side mechanism housing **15**. Accordingly, when portions of the tube expansion tool **1** move in the front-rear direction, the first center mechanism housing **13** and the second center mechanism housing **14** may not substantially receive a force in the front-rear direction. As a result, the first center mechanism housing **13** and the second center mechanism housing **14** can be made of a lightweight material, such as die cast aluminum.

[0091] Referring to FIGS. **5-7**, **10-12**, an embodiment of the feed screw mechanism **25** and the jaw rotation mechanism **30** will be explained below. The output shaft **21***a* of the electric motor **21** may rotate. A rotation speed of the output shaft **21***a* may be reduced by the planetary gear reduction mechanism **23** and may then be transmitted to the spindle **24**. When the spindle **24** rotates, the female screw member **27** may rotate due to the engagement between the gear **26** of the spindle **24** and the gear **27***a* of the female screw member **27**. Furthermore, the linear movement member **31** may move in the front-rear direction due to the engagement between the male screw **24***a* of the spindle **27** and the female screw **31***a* of the linear movement member **31** and due to the rotation restriction of the linear movement member **31** by the rotation restriction portion **12***d*. When the female screw member **27** rotates, the screw shaft **28** may move in the front-rear direction due to the engagement between the female screw **27***b* of the spindle **27** and the male screw **28***a* of the screw shaft **28**. When the screw shaft **28** moves forward, the wedge **3**, which is mounted to the front end of the screw shaft **28**, may push the plurality of jaws **4** and the ring **4***c* so as to move them radially outward toward an open position. In contrast, when the screw shaft **28** moves rearward, a pushing force of the wedge **3** may be eliminated to cause the ring **4***c* to shrink, thereby returning the plurality of jaws **4** to a closed position radially inward.

[0092] When the linear movement member **31** moves forward such that the protrusion **31***b* moves forward along and within the groove **32***a*, the power conversion ring **32** may rotate clockwise when viewed from the front side of the power conversion ring **32**. A rotation of the power conversion ring **32** may be transmitted to the first rotation drive ring **34** via the one way clutch **33**. The first rotation drive ring **34**, the second rotation drive ring **35**, and the third rotation drive ring **36** may rotate clockwise when viewed from the front side of the rings **34**, **35**, **36**. Because of this configuration, the plurality of jaws **4**, which are supported by the third rotation drive ring **36**, may also rotate clockwise when viewed from the front side of the jaws **4**. In contrast, when the protrusion **31***b* moves forward along within the second groove **32***b*, the power conversion ring **32** may not rotate. In this case, the first rotation drive ring **34**, the second rotation drive ring **35**, the third rotation drive ring **36**, and the plurality of jaws **4** may not rotate at this time.

[0093] When the linear movement member **31** moves rearward such that the protrusion **31***b* moves rearward along and within the second groove **32***b*, the power conversion ring **32** may not rotate. Thus, the first rotation drive ring **34**, the second rotation drive ring **35**, the third rotation drive ring **36**, and the plurality of jaws **4** may not rotate at this time. When the protrusion **31***b* moves rearward along and within the first groove **32***a*, the power conversion ring **32** may rotate counterclockwise when viewed from the front side of the power conversion ring **32**. Viewed from the front side, the one way clutch **33** may be configured to transmit only its clockwise rotation to the first rotation drive ring **34**. Because of this configuration, the first rotation drive ring **34**, the second rotation drive ring **35**, the third rotation drive ring **36**, and the plurality of jaws **4** may not rotate at this time.

[0094] Forward and reverse rotations of the electric motor **21** can be controlled by the controller **45** (refer to FIG. **1**). When the electric motor **21** rotates in a forward direction, the plurality of jaws **4** may open radially outward relative to each other by being pushed by the wedge **3** moving forward. Also, when the electric motor **21** rotates in the forward direction, the plurality of jaws **4** may rotate clockwise when viewed from the front side owing to the jaw rotation mechanism **30**. When the electric motor **21** rotates in a reverse direction, the plurality of jaws **4** may close radially inward relative to each other according to the rearward movement of the wedge **3**. Also, when the electric motor **21** rotates in the reverse direction, the plurality of jaws **4** may not rotate owing to a rotation restriction of the one way clutch **33**.

[0095] A rotation timing of the plurality of jaws **4** owing to the jaw rotation mechanism **30** and an open/close timing of the plurality of jaws **4** owing to the front-rear movement of the wedge **3** caused by the feed screw mechanism **25** may be modified according to a design change of various mechanisms. For example, the operating timings can be changed by modifying the shapes of the groove **32***a*, **32***b* formed in the power conversion ring **32** or by modifying a movable range of the screw shaft **28** in the front-rear direction. In the disclosed embodiment, the plurality of jaws **4** may be configured to open/close just after a rotation of the plurality of jaws **4** has been completed.

[0096] As shown in FIGS. **3** and **5**, an end position sensor **42** may be arranged above and on a rear side of the female screw member **27**. The end position sensor **42** may detect that the screw shaft **28** has moved to an end position, which is located at a foremost end of its movable range. Furthermore, an initial position sensor **41** may be arranged behind the end position sensor **42**. The initial position sensor **41**

may detect that the screw shaft **28** has moved to an initial position, which is located at a rearmost end of its movable range. A sensor, such as, for example, a Hall Effect sensor, which detects a magnetic field, may be used for both the initial position sensor **41** and the end position sensor **42**. The initial position sensor **41** may be fixed to the main body housing **11** above the screw shaft **28**. The end position sensor **42** may be positioned above the screw shaft **28** and may be supported by the main body housing **11** so as to be movable in the front-rear direction.

[0097] As shown in FIGS. **1** and **5**, a position adjustment mechanism **44** may be provided at an upper portion of the main body housing **11**. The end position sensor **41** can be moved in the front-rear direction by using the position adjustment mechanism **44**. A groove hole **11***a* may be formed on an upper surface of the main body housing **11**. The groove hole **11***a* may pass through the main body housing **11** in an up-down direction and may extend linearly in the front-rear direction. The position adjustment mechanism **44** may include an operation part **44***a* that passes through the groove hole **11***a* and is exposed from the upper surface of the main body housing **11**. The end position sensor **42** may be supported by a lower end of the operation part **44***a*, which may be inside of the main body housing **11**. The end position sensor **42** may be integrally slidable with the operation part **44***a* when the operation part **44***a* slides along the groove hole **11***a* in the front-rear direction. A position of the end position sensor **42** in the front-rear direction can be changed when a user's finger slide operates the operation part **44***a*.

[0098] As shown in FIGS. **3** and **5**, a magnet **43** may be attached to an upper rear side of the screw shaft **28**. The initial position sensor **41** may be positioned such that when the screw shaft **28**, and accordingly the wedge **3**, is positioned at its initial position, the initial position sensor **41** overlaps the magnet **43** in the front-rear direction. The end position sensor **42** may be positioned such that when the screw shaft **28**, and accordingly the wedge **3**, is positioned at its end position, the end position sensor **42** overlaps the magnet **43** in the front-rear direction.

[0099] As described above, an tube expansion tool **1**, which is configured to expand an end portion of a synthetic resin made fluid tube, may include an electric motor **21** that is housed in a main body housing **11**, an embodiment of which is shown in FIGS. **5**-**7**. The tube expansion tool **1** may include a screw shaft **28** housed in the main body housing **11**, such that the screw shaft **28** is movable in a front-rear direction such that it moves approximately parallel to an output shaft **21***a* of the electric motor **21**. In alternative embodiments, the screw shaft **28** may be movable along axis line of the output shaft **21***a* in the front-rear direction. The tube expansion tool **1** may include a female screw member **27** that moves the screw shaft **28** in the front-rear direction due to engagement with the screw shaft **28** and due to its rotation around an axis of the screw shaft **28**. Furthermore, the tube expansion tool **1** may include a gear **26** that engages the female screw member **27** and that transmits a rotation power of the output shaft **21***a* of the electric motor **21** to the female screw member **27**. The tube expansion tool **1** may include a wedge **3** that extends forward from the screw shaft **28**. The tube expansion tool **1** may include a plurality of jaws **4** that are coupled to the main body housing **11** so as to be opened/closed when the wedge **3** moves integrally with the screw shaft **28**. For instance, the plurality of jaws **4** may be pushed by the wedge **3** to be opened radially outward relative to each other when the wedge **3** moves forward.

[0100] As described above, the electric motor **21** may be arranged such that the output shaft **21** extends parallel to the screw shaft **28**. Because of this configuration, the electric motor **21** may be arranged nearer to the screw shaft **28** in the front-rear direction and nearer to the screw shaft **28**. Alternately, the electric motor **21** may be arranged such that the output shaft **21***a* extends coaxial to the screw shaft **28**. Because of this alternate configuration, the electric motor **21** may be arranged closer to the screw shaft **28**. Accordingly, the electric motor **21**, which is typically heavy in weight, may be arranged to be closer to a center of the main body housing **11**, in which the screw shaft **28** is located. As a result, a good weight balance of the tube expansion tool **1** may be obtained and a user can hold the tube expansion tool **1** in a stable manner. Accordingly, an operability of the tube expansion tool **1** can be improved.

[0101] As shown in FIG. **5**, the tube expansion tool **1** may include the grip **5** extending downward from the main body housing **11**. The majority of the grip **5** may be arranged between the electric motor **21** and the plurality of jaws **4** in the front-rear direction. The majority of the electric motor **21** may be arranged below the screw shaft **28**. Accordingly, the electric motor **21** and the plurality of jaws **4** may be arranged so as to have a good weight balance with respect to the grip **5**. As a result, operability of the tube expansion tool **1** can be improved when a user holds the grip **5**.

[0102] As shown in FIG. **5**, at least a part of the screw shaft **28** may overlap the grip **5** in the front-rear direction. Accordingly, a length of the tube expansion tool **1** in the front-rear direction can be made short. Thus, a moment around a center of gravity of the tube expansion tool **1** may be small, which improves operability of the tube expansion tool **1**.

[0103] As shown in FIG. **5**, a portion of a planetary gear reduction mechanism **23**, which is configured to reduce a rotation output of the output shaft **21***a*, may be arranged between the output shaft **21***a* of the electric motor **21** and the screw shaft **28** (e.g., in the up-down direction). Accordingly, the planetary gear reduction mechanism **23** may be arranged in a compact manner. Additionally, a rotation power transmission path from the electric motor **21** to the screw shaft **28** may also be reduced. Also, a transmission loss of the rotation power may be suppressed by minimizing the rotation power transmission path from the electric motor **21** to the screw shaft **28**.

[0104] As shown in FIGS. **4** and **5**, the tube expansion tool **1** may include rotation drive rings **34**, **35**, **36** linked to a rear portion of the plurality of jaws **4**. The tube expansion tool **1** may include a jaw rotation mechanism **30** that rotates the plurality of jaws **4** in the circumferential direction by rotation of the rotation drive rings **34**, **35**, **36**, the rotation of which is caused by the rotation output of the electric motor **21**. The rotation drive rings **34**, **35**, **36** may be arranged in front of the female screw member **27**. Accordingly, the female screw member **27**, the rotation drive rings **34**, **35**, **36**, and the plurality of jaws **4** may be arranged in this order in the front-rear direction, which is a direction in which the screw shaft **28** extends. Because of this configuration, a center of gravity of the tube expansion tool **1** may be positioned closer to the screw shaft **28**. As a result, the stability of holding the tube expansion tool **1** can be improved.

[0105] As shown in FIGS. **4** and **5**, the tube expansion tool **1** may include a cap **2** that supports the plurality of jaws **4** when they are to be opened/closed. The cap **2** may also be configured such that it restricts the plurality of jaws **4** from moving in the font-rear direction. The tube expansion tool **1** may include a front side mechanism housing **12**, a first center mechanism housing **13**, and a rear side mechanism housing **15**, which are arranged in this order from the front side to the rear side and are arranged within the main body housing **11**. The tube expansion tool **1** may include bolts **16** that connect the front side mechanism housing **12** to the rear side mechanism housing **15**. The front side mechanism housing **12** may be made of iron and support the cap **2**. The rear side mechanism housing **15** may be made of iron and support an end portion of the female screw member **27**. Also, the first center mechanism housing **13** may be made of a material that is lighter than iron in weight.

[0106] As described above, the tube expansion tool **1** may have a structure configured by the front side mechanism housing **12**, the first center mechanism housing **13**, and the rear side mechanism housing **15** being positioned in a divided manner in the front-rear direction. When the plurality of jaws **4** are opened, the cap **2** and the front side mechanism housing **12**, which supports the cap **2**, may be strongly pushed forward by the plurality of jaws **4**. The female screw member **27** may be strongly pushed rearward by a reaction force caused by the screw shaft **28** moving forward. Different from the above configuration, for example in a case where the front side mechanism housing **12**, the first center mechanism housing **13**, and the rear side mechanism housing **15** are combined to form a single integral mechanism housing, when the plurality of jaws **4** is opened, strong pulling forces may be generated at a front end and a rear end of such an integral mechanism housing. Because of this, the entirety of the integral mechanism housing may be required to have high strength. However, in the present disclosure, the front mechanism housing **12**, the first center mechanism housing **13**, and the rear mechanism housing **15** may be arranged in the front-rear direction in a divided manner. Also, the front side mechanism housing **12** and the rear side mechanism housing **15** may be made of iron. Because of this configuration, the front side mechanism housing **12** and the rear side mechanism housing **15**, each of which has high strength, can respectively receive the pulling force in the front-rear direction. Also, the tube expansion tool **1** may be made more light weight by making the first center mechanism housing **13** of a light material.

[0107] As shown in FIGS. **2** and **5**, the tube expansion tool **1** may include a second center mechanism housing **14** between the first center mechanism housing **13** and the rear side mechanism housing **15**. The front side mechanism housing **12** may include an engagement portion **12*b*** at a rear end thereof, the first center mechanism housing **13** may include engagement portions **13*a*, 13*b*** at a front and rear end thereof, the second center mechanism housing **14** may include engagement portions **14*a*, 14*b*** at a front and rear end thereof, and the rear side mechanism housing **15** may include an engagement portion **15** at a front end thereof. Each of the engagement portions may be configured to overlap a corresponding adjacent engagement portion. Accordingly, the front side mechanism housing **12** and the first center mechanism housing **13** may be precisely positioned relative to each other by overlapping the engagement portion **12*b*** of the front side mechanism housing **12** with the engagement portion **13*a*** of the first center mechanism housing **13**. Also, the first center mechanism housing **13** and the second center mechanism housing **14** may be precisely positioned relative to each other by overlapping the engagement portion **13*b*** of the first center mechanism housing **13** with the engagement portion **14*a*** of the second center mechanism housing **14**. The second center mechanism housing **14** and the rear side mechanism housing **15** may be precisely positioned relative to each other by overlapping the engagement portion **14*b*** of the second center mechanism housing **14** with the engagement portion **15*b*** of the rear side mechanism housing **15**. Because of this configuration, assemblability of each mechanism housing can be improved. Also, rattling of the components, such as, for example, the female screw member **27**, which are housed in the main body housing **11**, can be prevented.

[0108] As shown in FIG. **5**, the spindle **24**, which is configured to rotate integrally with the gear **26**, may be arranged in front of the output shaft **21*a*** of the electric motor **21**. The first center mechanism housing **13** and the second center mechanism housing **14** may support the spindle bearings **24*b*, 24*c*,** which rotatably support the spindle **24**. Also, the first center mechanism housing **13** and the second center mechanism housing **14** may support the female screw member bearings **27*c*, 27*d*,** which rotatably support the female screw member **27**. Accordingly, the spindle bearings **24*b*, 24*c*** and the female screw member bearings **27*c*, 27*d*** may not substantially receive a force in the front-rear direction. Because of this configuration, the spindle **24** and the female screw member **27** can be supported by the first center mechanism housing **13** and the second center mechanism housing **14**, both of which can have a weaker strength compared with the front side mechanism housing **12** and the rear side mechanism housing **15**. As a result, the tube expansion tool **1** can be made more light weight, for instance by having fewer components made of iron.

[0109] As shown in FIG. **5**, the rear side mechanism housing **15** may support a thrust bearing **27*e*** that is configured to make contact with a rear end of the female screw member **27**. When the screw shaft **28** moves forward, the female screw member **27** may be pushed rearward by a strong force. The rear side mechanism housing **15** may receive the force by which the female screw member **27** is pushed via the thrust bearing **27*e***. Because of this configuration, the female screw member **27** can be precisely rotated around an axis of the screw shaft **28**. As a result, the screw shaft **28** may move more precisely in the front-rear direction.

[0110] As shown in FIG. **5**, a plurality of balls **28*b*** may be placed between and engage with the screw shaft **28** and the female screw member **27**. Accordingly, a transmission efficiency of a driving force may be improved by the plurality of balls **28*b*** placed between the screw shaft **28** and the female screw member **27**. As a result, a rotation drive power of the female screw member **27** may be efficiently converted to movement of the screw shaft **28** in the front-rear direction.

[0111] When the end position sensor **43** is displaced forward, an end position of the wedge **3** may be positioned to a more forward position. As a result, a more rearward portion of an outer circumferential surface of an approximately conical wedge **3**, which has a larger diameter, may push the plurality of jaws **4** radially outward. Therefore, the plurality of jaws **4** may be pushed to have a larger diameter at the newly positioned end position. A force that pushes the plurality of jaws **4** radially outward may be large because the conical wedge **3** has be inserted further through the plurality of jaws **4**. Accordingly, an expansion width of the plurality of jaws **4** extending radially outward relative to each other may be made large. For example, in a case where a contraction speed of an expanded fluid pipe is high owing to a high ambient temperature or a high pipe temperature, an expansion width of an end portion of the fluid pipe may be made large by displacing the end position sensor **42** in a forward position.

[0112] In contrast, when the end position sensor **42** is displaced rearward, an end position of the wedge **3** may be positioned at a more rearward position. As a result, a more frontward portion of an outer circumferential surface of an approximately conical wedge **3** may push the plurality of jaws **4**. Thus a portion of the wedge **3** with a relatively smaller diameter may push the plurality of jaws **4** when the wedge **3** is at the newly positioned end position. Accordingly, a force that pushes the plurality of jaws **4** radially outward may be small because the wedge **3** is inserted less into the plurality of jaws **4**. Accordingly, an expansion width of the plurality of jaws **4** extending radially outward relative to each other may be made small. For example, in a case where a contraction speed of an expanded fluid pipe is low owing to a low ambient temperature or a low pipe temperature, an expansion width of an end portion of the fluid pipe may be made small by displacing the end position sensor **42** in a rearward position.

[0113] When the plurality of jaws **4** shown in FIGS. **5**-**7** are opened radially outward relative to each other, the plurality of jaws **4** may receive a large load force from the fluid pipe when expanding an end portion of the fluid pipe. On the other hand, when the plurality of jaws **4** are rotated within the fluid pipe in a circumferential direction, the plurality of jaws **4** may receive a small load force, compared to a case where the end portion of the fluid pipe is expanded radially outward. Because of this configuration, a required output power of the electric motor **21** when the plurality of jaws **4** are to be opened radially outward relative to each other may be larger than that when the plurality of jaws **4** are to be rotated. In some embodiments, it may be assumed that an upper limit value of a current flowing to the electric motor **21** is always constant. However, the plurality of jaws **4** sometimes may not be able to be rotated because the jaws **4** are stuck to an inner circumferential surface of the fluid pipe. In this case, an increasing current may be applied to the electric motor **21** until the current reaches the upper limit. Because of this possibility, there may be a risk that jaws **4** are damaged owing to an excessive force applied to un-rotatable jaws **4** or that the fluid pipe is damaged owing to the jaws **4** rotating with an excessive force while they are still binding with the fluid pipe.

[0114] In the present disclosure, in a rotation zone, which is a portion of the operation in which the jaws **4** are to be rotated, a first upper limit value of a current flowing to the electric motor **21** may be set in order to prevent an excessive force from being applied to the jaws **4**. Also, in an expansion zone, which is a portion of the operation in which the jaws **4** are to be opened radially outward relative to each other, a second upper limit value of a current flowing to the electric motor **21** may be set. The first upper limit value may be set lower than the second upper limit value. For example, the first upper limit value may be set to less than 70%, less than 50%, or less than 30% of the second upper limit value. Because of this settings, when the jaws **4** become un-rotatable when operating in the rotation zone, driving of the electric motor **21** may be stopped at the first upper limit value, which is lower than the second upper limit value. As a result, an excessive force may be prevented from being applied to the un-rotatable jaws **4**. The controller **45** (refer to FIG. **1**) may detect when the operation is in the rotation zone and the expansion zone, based on a rotation number of the electric motor **21** and/or the position of the wedge **3** in the front-rear direction.

[0115] Referring to FIG. **14**, when the controller **45** receives an on signal from the switch main body **6***a,* the controller **45** may start the electric motor **21** by supplying power to the electric motor **21** from the battery **8**. The controller **45** may detect a number of rotations of the electric motor **21** by receiving a phase detection signal of the rotor **21***c* from the rotation detection sensor **21***d* provided at the electric motor **21**. The initial position sensor **41** may transmit a detection signal of the initial position of the screw shaft **28** to the controller **45** when it detects the magnet **43** (refer to FIG. **5**). Similarly, the end position sensor **42** may transmit a detection signal of the end position of the screw shaft **28** to the controller **45** when it detects the magnet **43**.

[0116] By the controller **45** shown in FIG. **14**, a rotation zone may be set to be a time zone between a time when the controller **45** receives a detection signal of the initial position sensor **41** and a time when the controller **45** detects that the motor **21** has rotated a predetermined number of rotations. A predetermined rotation number of the electric motor **21** may be determined and stored for use by the controller **45**. The predetermined rotation number of the electric motor **21** may be based on, for example, the shapes of the groove **32***a,* **32***b* of the power conversion ring **32** (refer to FIG. **9**), a feeding amount of the screw shaft **28**, the linear movement member **31** per one rotation of the spindle **24** (refer to FIGS. **5**-**7**), etc. The controller **45** may control a forward/reverse rotation and a rotation speed of the electric motor **21**. As a result, a movement direction and a movement speed of the wedge **3**, as well as a rotation direction and a rotation speed of the jaws **4**, may be changed.

[0117] As described above, a tube expansion tool **1** configured to expand an end portion of a synthetic resin made fluid tube may include a controller **45** (refer to FIG. **1**) that switches between forward and reverse rotations of an output shaft **21***a* of an electric motor **21**, as shown in FIG. **5**. The tube expansion tool **1** may include a female screw member **27** that is rotated by the electric motor **21**. The tube expansion tool **1** may include a screw shaft **28** that engages the female screw member **27** and that moves forward and rearward between a rearward initial position and a forward end position due to rotation of the female screw member **27**. The tube expansion tool **1** may include a wedge **3** that extends forward from the screw shaft **28**. The tube expansion tool **1** may include a plurality of jaws **4** that are opened radially outward by being pushed by the wedge **3** when the wedge **3** and the screw shaft **28** move forward. The tube expansion tool **1** may include an end position sensor **42** that detects the screw shaft **28** at the forward end position and that transmits a corresponding signal to the controller **45**. The end position sensor **42** may be arranged so as to be movable in a front-rear direction. An end position of the screw shaft **28** may be adjustable by displacing a position of the end position sensor **42**.

[0118] By displacing the end position sensor **42** forward, an end position of the forward moving wedge **3** may be set to a more forward position. Because of this, a pushing force of the wedge **3** to enlarge the plurality of jaws **4** radially outward may be larger because of the insertion depth of the wedge **3** at a newly positioned end position. Accordingly, an expansion width of the plurality of jaws **4** opened radially outward relative to each other may be made large. For example, in a case where a contraction speed of the fluid pipe is high at a high ambient temperature, an expansion width of the end portion of the fluid pipe may be made large. In contrast, by displacing the end position sensor **42** rearward, an end position of the wedge **3** moving forward may be set to a more rearward position. Because of this, a pushing force of the wedge **3** to enlarge the plurality of jaws **4** radially outward may be smaller because the wedge **3** is inserted less at a newly positioned end position. Accordingly, an expansion width of the plurality of jaws **4** opened radially outward relative to each other may be made small. For example, in a case where a contraction speed of the fluid pipe is low at a low ambient temperature, an expansion width of the end portion of the fluid pipe may be made small. In this manner, an expansion width of the jaws **4** may be changed according to an ambient temperature, a temperature of the fluid pipe, or other parameter.

[0119] As shown in FIGS. **3** and **5**, the tube expansion tool **1** may include an initial position sensor **41** that detects whether the screw shaft **28** is at the initial position. By detecting the initial position and the end position of the screw shaft **28**, a position of the screw shaft **28**, as well as a position of the wedge **3**, may be precisely detected in the front-rear direction.

[0120] As shown in FIG. **5**, the end position sensor **42** may include a Hall Effect sensor provided in the main body housing **11**. The screw shaft **28** may include a magnet **43**. Accordingly, a structure for detecting the end position of the screw shaft **28** may be made simple and compact. Accordingly, a main body housing **11** including an end position sensor **42** may be made compact.

[0121] As shown in FIGS. **1** and **5**, the end position sensor **42** may include an operation part **44***a* extending outward of the main body housing **11**. Accordingly, a user can displace a position of the end position sensor **42** by shifting a position of the operation part **44***a* from outside of the main body housing **11** using their finger. Because of this configuration, an end position sensor **42** can be easily moved to a target position.

[0122] As shown in FIG. **1**, the tube expansion tool **1** may include a grip **5** extending downward from the main body housing **11**. The operation part **44***a* may project upward from an upper surface of the main body housing **11**. Accordingly, the operation part **44***a* can be arranged on an upper side of the main body housing **11** such that the user can easily view the operation part **44***a*.

[0123] As shown in FIG. **5**, the tube expansion tool **1** may include the jaw rotation mechanism **30** that rotates the plurality of jaws **4** in a circumferential direction due to the rotation output of the electric motor **21**. The controller **45** (shown in FIG. **1**) may supply a current to the electric motor **21** based on the first upper limit value or the second upper limit value. The first upper limit value may be set as an upper limit of a current flowing to the electric motor **21** when the operation is in a rotation zone, in which the jaws **4** are to be rotated. The second upper limit value may be set as an upper limit of a current flowing to the electric motor **21** when the operation is in an expansion zone, in which the jaws **4** are to be opened radially outward relative to each other. That is, an upper limit of a current flowing to the electric motor **21** may be changed depending on the intended operation state, for instance the current may be changed depending on whether the operation is in the rotation zone and the expansion zone. Because of this configuration, for example, when the jaws **4** become un-rotatable or it becomes undesirable to rotate the jaws **4**, the electric motor **21** may be prevented from continuing to be driven during certain portions of the operation. As a result, an excessive force may be prevented from being applied to, for example, the jaws **4**, the wedge **3**, the fluid pipe, and/or the jaw rotation mechanism **30**.

[0124] As shown in FIG. **14**, the tube expansion tool **1** may include the rotation number detection sensor **21**, which may be configured to detect a number of rotations of the electric motor **21** and transmit a corresponding signal to the controller **45**. The controller **45** may define the rotation zone and the expansion zone based on the corresponding signal from the rotation number detection sensor **21***d* and detection signals relating to a position of the screw shaft **28**, e.g., the end position and/or the initial position of the screw shaft **28**. Because of this configuration, when an end position of the screw shaft **28** is changed, for instance by moving a position of the end position sensor **42**, the rotation zone and the expansion zone can be re-defined. As a result, a rotation operation and an expansion operation of the jaws **4** can be preferably controlled such that, for example, the fluid pipe can be expanded to a desired expansion width according to a contraction speed of the fluid pipe.

[0125] The first upper limit value of the current flowing to the electric motor **21**, an example of which is shown in FIG. **5**, may be set lower than the second upper limit value. Accordingly, an upper limit of a current flowing to the electric motor **21** may be set lower when the operation is in the rotation zone, which is a portion of the operation in which is desirable that a smaller load force is applied to the jaws **4** and the jaw rotation mechanism **30**. As a result, the electric motor **21** can be prevented from being excessively driven when the operation is in the rotation zone. Also, a load force applied to the jaws **4** and the jaw rotation mechanism **30** may be minimized.

[0126] As shown in FIGS. **5-7**, the rotation zone may be a zone in which the wedge **3** moves forward and in this example is set to be prior to when the operation enters the expansion zone. Accordingly, the plurality of jaws **4** may expand radially outward relative to each other after they have rotated in the circumferential direction of the wedge **3**. By clearly separating the rotation operation and the expansion operation of the jaws **4**, an unnecessary and accidental load force can be prevented from being applied to the jaws **4** and the jaw rotation mechanism **30**.

[0127] Alternatively, referring to FIGS. **5-7**, the rotation zone may be a zone in which the wedge **3** moves rearward and after the operation has exited the expansion zone. Accordingly, the plurality of jaws **4** may rotate in the circumferential direction of the wedge **3** after the jaws **4** have closed radially inward relative to each other. In this case, because the rotation operation and the expansion operation of the jaws **4** are clearly separated, an accidental load force can be prevented from being applied to the jaws **4** and the jaw rotation mechanism **30**.

[0128] As shown in FIG. **5**, a plurality of balls **28***b* may be placed between and engage with the screw shaft **28** and the female screw member **27**. Accordingly, the transmission efficiency of a driving force may be improved by the plurality of balls **28***b* placed between the screw shaft **28** and the female screw member **27**. As a result, the rotation drive power of the female screw member **27** may be efficiently converted to the movement of the screw shaft **28** in the front-rear direction.

[0129] Next, another embodiment according to the present disclosure will be explained with reference to FIGS. **15-17**. As shown in FIG. **15**, a tube expansion tool **50** according to a second embodiment may include a sensor positioning mechanism (which is an embodiment of a position adjustment mechanism) **53**, instead of the configuration of the position adjustment mechanism **44** of the tube expansion tool **1** according to the first embodiment shown in FIG. **5**. The sensor positioning mechanism **53** of the second embodiment may include an initial position operation part **54**, which may be used for shifting a position of the initial position sensor **41** in the front-rear direction. Also, the sensor positioning mechanism **53** may include an end position operation part **55**, which may be used for shifting a position of the end position sensor **42** the front-rear direction. In the following explanation, components that more substantially differ from those of the tube expansion tool **1** of the first embodiment will be explained in detail.

[0130] As shown in FIGS. **15** and **16**, instead of the plurality of jaws **4** of the first embodiment, a second plurality of jaws **51** may instead be attached to a front portion of the tube expansion tool **50**. The first plurality of jaws **4** can be used when expanding a fluid pipe having, for example, a 0.5, 0.75, or 1 inch nominal diameter. In contrast, the second plurality of jaws **51** may be used when expanding a fluid pipe having, for example, a 1.5 inch nominal diameter. When a fluid pipe is expanded by either set of the plurality of jaws **4**, **51**, the plurality of jaws **4**, **51** may receive a force to push them radially outward from the wedge **3**, thereby allowing them to expand the fluid pipe. Accordingly, a reaction force radially inward from the fluid pipe, which is derived from expansion of the fluid pipe, will also be received. Because of this, a bending force may be applied to each set of the plurality of jaws **4**, **51**. As a size of the fluid pipe becomes larger, a bending force may become larger. Accordingly, a thickness of each of the plurality of jaws **51** in a radial direction may be made large in order to improve its durability against the bending force.

[0131] As shown in FIG. **15**, a ring holding groove **51***a* having an arc shape in cross section may be formed on an outer circumferential surface of a rear portion of each of the second plurality of jaws **51**. Each of the ring holding grooves **51***a* may be combined to form an annular groove in an integrally continuous manner. The plurality of jaws **51** may be combined in a circumferential direction by an elastically extendible ring **51***b* that is inserted into the ring holding groove **51***a*. The ring **51***b* may be allowed to move in a radial direction and be restricted from moving in the front-rear direction, for instance by the jaw support groove **2***a* formed on the inner circumferential surface of the cap **2**. The plurality of jaws **51** may open/close in a radial direction of the ring **51***b* as they are supported by the jaw support groove **2***a*.

[0132] Referring to FIGS. **15** and **16**, the cap **2** linked to the first plurality of jaws **4** may be removed from the male screw **12***a* of the front side mechanism housing **12**, and then the cap **2** linked to the second plurality of jaws **51** may engage the male screw **12***a* of the front side mechanism housing **12**. In this manner, the first plurality of jaws **4** can be replaced with the second plurality of jaws **51**.

[0133] Referring to FIG. **15**, there may be a situation where an initial position of the wedge **3** is fixed to a position in which the wedge **3** is near to an inner circumferential wall **51***c* of the second plurality jaws **51**. However, as shown in FIG. **16**, when the first plurality of jaws **4** are attached to the tool **50** to replace the second plurality of jaws **51**, a distance D may be generated between the wedge **3** and the inner circumferential wall **4***d* of the first plurality of jaws **4**. In this case, while the wedge **3** moves within the distance D from the initial position, the wedge **3** may not contact the plurality of jaws **4**, which results in the plurality of jaws **4** not opening radially outward during such time. Because of this, a time taken to open/close the plurality of jaws **4** per cycle may be long, for instance in proportion to the distance D. In the tube expansion tool **50** of the present disclosure however, an initial position of the wedge **3** and the screw shaft **38** can be changed by shifting the initial position sensor **44** in the front-rear direction. As shown by an imaginary line of FIG. **16**, an initial position of the wedge **3** can be change to a position in which the wedge **3** is nearer to an inner circumferential wall of the jaws **4**.

[0134] As shown in FIG. **17**, the initial position operation part **54** may be slidable along an groove hole **52***a* of a main body housing **52** in the front-rear direction. A sensor holding portion **54***b* that holds the initial position sensor **41** may be provided below the initial position operation part **54**. An upper portion of the initial position operation part **54** may be formed in an approximately rectangular plate shape positioned above an upper side of the groove hole **52***a* and may generally extend along the groove hole **52***a* in a left-right direction. A spring holding groove **54***a* may be formed on each of a front side and a rear side of a lower surface of the upper portion of the initial position operation part **54**. Each end of a leaf spring **56** may be inserted into a corresponding spring holding groove **54***a* such that the leaf spring **56** may be prevented from falling off. The leaf spring **56** may be formed in an approximately M shape and may include an engagement portion **56***a* projecting downward from a center of the leaf spring **56**. A lower portion of the engagement portion **56***a* may have an arc shape. The engagement portion **56***a* of the leaf spring **56** may be movable in the up-down direction by the elasticity of the leaf spring **56** retained by the initial position operation part **54**.

[0135] As shown in FIG. **17**, the end position operation part **55** may be slidable along the groove hole **52***a* of the main body housing **52** in the front-rear direction. The end position operation part **55** may have approximately the same shape as the initial position operation part **54**. A sensor holding portion **55***b* that holds the end position sensor **42** may be provided below the end position operation part **55**. A spring holding groove **55***a* may be formed on each of a front side and a rear side of a lower surface of an upper portion of the end position operation part **55**. Each end of a leaf spring **57** may be inserted into a pair of the spring holding groove **55***a* such that the leaf spring **57** is prevented from falling off. The leaf spring **57** may have approximately the same shape as the other leaf spring **56** and may include an engagement portion **57***a* projecting downward from a center of the leaf spring **57**. A lower portion of this engagement portion **57***a* may have an arc shape. The engagement portion **57***a* of the leaf spring **57** may be movable in the up-down direction by the elasticity of the leaf spring **57** retained by the end position operation part **55**.

[0136] As shown in FIG. **17**, a plurality of engagement recesses **52***b*, **52***c* may be formed beside the groove hole **52***a* of the main body housing **52**. The engagement recesses **52***b*, **52***c* may be formed in a recessed and hemispherical shape projecting downward from an upper surface and toward a lower surface of the main body housing **52**. The plurality of engagement recesses **52***b* corresponding to the initial position operation part **54** may be arranged at predetermined intervals in the front-rear direction nearer a rear portion of the groove hole **52***a*. Similarly, the plurality of engagement recesses **52***c* corresponding to the end position operation part **55** may be arranged at predetermined intervals in the front-rear direction nearer a front portion of the groove hole **52***a*.

[0137] As shown in FIG. **17**, when the engagement portion **56***a* moves to the a position corresponding to one of the plurality of the engagement recesses **52***b* in the front-rear direction, the engagement portion **56***a* may move downward to elastically engage the one of the plurality of the engagement recesses **52***b*. In this manner, the initial position operation part **54** can be positioned at a desired position in the front-rear direction. When a force more than a predetermined force is applied to the initial position operation part **54** in the front-rear direction, the engagement portion **56***a* may disengage from the engagement recess **52***b*, which may allow the initial position operation part **54** to be slid in the front-rear direction. In this manner, the initial position operation part **54** can be movably positioned at any one of the desired position in the front-rear direction, with a click feeling occurring at certain positions. For example, when the first plurality of jaws **4**, each of which has a thinner thickness in a radial direction, is attached to a front portion of the tube expansion tool **50**, the initial position operation part **54** may be moved to a forward position. In contrast, when the second plurality of jaws **51**, each of which has a thicker thickness in a radial direction, is attached to a front portion of the tube expansion tool **50**, the initial position operation part **54** may be moved to a rearward position.

[0138] As shown in FIG. **17**, similarly to the above engagement portion **56***a*, when the engagement portion **57***a* corresponding to the end position operation part **55** moves to a position corresponding to one of the plurality of the corresponding engagement recesses **52***c* in the front-rear direction, the engagement portion **57***a* may move downward to elastically engage the one of the plurality of the engagement recesses **52***c*. In this manner, the end position operation part **55** can be positioned at a desired position in the front-rear direction. When a sufficient force is applied to the end position operation part **55** in the front-rear direction, the engagement portion **57***a* may disengage from the engagement recess **52***c*, which may allow the end position operation part **55** to be slidable in the front-rear direction. In this manner, the end position operation part **55** can be movably positioned at any one of the desired position in the front-rear direction, with a click feeling occurring at certain positions. For example, when a contraction speed of the fluid pipe is high at a high ambient temperature, the end position operation part **55** may be moved to a forward position. In contrast, when a contraction speed of the fluid pipe is low at a low ambient temperature, the end position operation part **55** may be moved to a rearward position.

[0139] As described above, the tube expansion tool **50** that is configured to expand an end portion of a synthetic resin made fluid tube may include a controller **45** (refer to FIG. **1**) that switches the rotation of an output shaft **21***a* of the electric motor **21** between a forward and reverse direction, as shown in FIG. **16**. The tube expansion tool **50** may include a female screw member **27** that is rotated by the electric motor **21**. The tube expansion tool **50** may include a screw shaft **28** that engages with the female screw member **27** and moves forward and rearward between a rearward initial position and a forward end position due to rotation of the male screw member **27**. The tube expansion tool **50** may include a wedge **3** that extends forward from the screw shaft **28**. The tube expansion tool **50** may include a plurality of jaws **4** that are opened radially outward by being pushed by the wedge **3** when the wedge **3** and the screw shaft **28** move forward. The tube expansion tool **50** may include an end position sensor **42** that detects whether the screw shaft **28** at the end position and transmits a corresponding signal to the controller **45**. The tube expansion tool **50** may also include an initial position sensor **41** that detects whether the screw shaft **28** at the initial position and transmits a corresponding signal to the controller **45**. The end position sensor **42** and the initial position sensor **41** may be arranged so as to be movable in the front-rear direction. An end position and an initial position of the screw shaft **28** may be movable by displacing a position of the end position sensor **42** and a position of the initial position sensor **41**, respectively.

[0140] Because of the above configuration, by moving the initial position sensor **41** forward, an initial position of the wedge **3** may be positioned in a more forward position. Accordingly, a time period from a time when the wedge **3** starts from the initial position to a time when the wedge **3** reaches the plurality of jaws **4** may be reduced. As a result, a time taken to open/close the plurality of jaws **4** per cycle may be reduced, which in turn causes an overall operation time to be reduced. Furthermore, by moving the initial position sensor **41** rearward, an initial position of the wedge **3** may be positioned in a more rearward position. Accordingly, for example, when the second plurality of jaws **51**, each of which has a thicker thickness in a radial direction, are used, an initial position of the wedge **3** may be positioned in a more rearward position such that the wedge **3** does not interfere with the plurality of jaws **51**.

[0141] As shown in FIGS. **15** and **16**, the initial position sensor **41** and the end position sensor **42** may include an initial position operation part **54** and an end position operation part **55**, respectively, both of which extend outward of the main body housing **11**. Because of this configuration, a user may shift the initial position sensor **41** and the end position sensor **42** by operating the initial position operation part **54** and the end position operation part **55**, respectively, from outside of the main body housing **11**. Thus, the user may easily shift either or both of the initial position sensor **41** and the end position sensor **42** to a desired position.

[0142] As shown in FIGS. **15** and **16**, the second plurality of jaws **51**, each of which has a different thickness than the thickness of each of the first plurality of jaws **4** in a radial direction, can be attached to the tube expansion tool **50** instead of the first plurality of jaws **4**. Accordingly, various kinds of fluid pipes having different nominal diameters can be expanded using the same tube expansion tool **50**.

[0143] As shown in FIG. **17**, the tube expansion tool **50** may include a sensor positioning mechanism **53** by which the initial position sensor **41** and/or the end position sensor **42** can be releasably positioned at a plurality of desired positions in the front-rear direction. Accordingly, the initial position sensor **41** can be positioned such that an initial position of the wedge **3** can be positioned at a desired position, with an additional indication that the initial position sensor **41** is at one of a number of selected predetermined positions. Also, the end position sensor **42** can be positioned such that an end position of the wedge **3** can be positioned at a desired position, with an additional indication that the end position sensor **42** is at one of a number of selected predetermined positions. Accordingly, a user may not need to fine-adjust an initial position and/or an end position of the wedge **3**, which improves usability of the tube expansion tool **50**. Also, once the initial position sensor **41** and/or the end position sensor **42** is at the desired positioned, it/they may be prevented from inadvertently moving.

[0144] Next, another embodiment according to the present disclosure will be explained below with reference to FIG. **18**. A tube expansion tool **60** according to a third embodiment may include a sensor positioning mechanism (which is an embodiment of a position adjustment mechanism) **61**, instead of the sensor positioning mechanism **53** of the tube expansion tool **50** according to the second embodiment shown in FIG. **16**. The sensor positioning mechanism **61** of the third embodiment may include an initial position operation part **62** used for shifting a position of the initial position sensor **41** in the front-rear direction. Also, the sensor positioning mechanism **61** may include an end position operation part **63** used for shifting a position of the end position sensor **42** in the front-rear direction. In the following explanation, components that substantially differ from those of the tube expansion tools **1**, **50** according to the first and second embodiment will be explained in detail.

[0145] As shown in FIG. **18**, the initial position operation part **62** may be slidable along an groove hole **52***a* of a main body housing **52** in the front-rear direction. A sensor holding portion **62***b* that holds the initial position sensor **41** may be provided at a lower portion the initial position operation part **62**. An upper portion of the initial position operation part **62** may be formed in an approximately rectangular plate shape and may be positioned above an upper side of the groove hole **52***a*. The upper portion of the initial operation position part **62** may generally extend from the groove hole **52***a* in a left-right direction. A ball holding groove **62***a* extending upward in a groove hole shape may be formed on a lower surface of the upper portion of the initial position operation part **62**. A ball plunger **64** may be housed in the ball housing groove **62***a* such that the ball plunger **64** does not easily fall out. The ball plunger **64** may include a ball **64***a* that is retained so as to be projectable from a lower end of the ball housing groove **62***a*. Also, the ball housing groove **62***a* may include a compression spring **64***b* that biases the ball **64***a* downward.

[0146] As shown in FIG. **18**, the end position operation part **63** may be slidable along the groove hole **52***a* of the main body housing **52** in the front-rear direction. The end position operation part **63** may be formed in approximately the same shape as the initial position operation part **62**. A sensor holding portion **63***b* that holds the end position sensor **42** may be provided at a lower portion of the end position operation part **63**. A ball holding groove **63***a* extending upward in a groove hole shape may be formed on a lower surface of the upper portion of the end position operation part **63**. A ball plunger **65** may be housed in the ball housing groove **63***a* such that the ball plunger **65** may not easily fall out. The ball plunger **65** may include a ball **65***a* that is retained so as to be projectable from a lower end of the ball housing groove **63***a*. Also, the ball housing groove **63***a* may include a compression spring **65***b* that biases the ball **65***a* downward.

[0147] As shown in FIG. **18**, when the ball **64***a* of the ball plunger **64** moves to a position corresponding to one of the plurality of the engagement recesses **52***b* in the front-rear direction, the ball **64***a* may move downward to elastically engage the one of the plurality of the engagement recesses **52***b*. In this manner, the initial position operation part **62** can be positioned at a desired position in the front-rear direction. When a force more than a predetermined force is applied to the initial position operation part **62** in the front-rear direction, the ball **64***a* may disengage from the engagement recess **52***b*, which allows the initial position operation part **62** to be slidable in the front-rear direction. In this manner, the initial position operation part **62** can be movably positioned at any desired position in the front-rear direction, with certain positions providing a click feeling. For example, the initial position operation part **62** may be moved based on a kind of the plurality of jaws (e.g., based on their thickness in a radial direction and/or their size) attached to the tube expansion tool **60**.

[0148] As shown in FIG. **18**, when the ball **65***a* of the ball plunger **65** moves to a position corresponding to one of the plurality of the engagement recesses **52***c* in the front-rear direction, the ball **65***a* may move downward to elastically engage the one of the plurality of the engagement recesses **52***c*. In this manner, the end position operation part **63** can be positioned at a desired position in the front-rear direction. When a force more than a predetermined force is applied to the end position operation part **63** in the front-rear direction, the ball **65***a* may disengage from the engagement recess **52***c*, which allows the end position operation part **63** to be slidable in the front-rear direction. In this manner, the end position operation part **63** can be movably positioned at any desired position in the front-rear direction, with certain positions providing a click feeling. For example, the end position operation part **63** may be moved based on an ambient temperature.

[0149] Next, another embodiment according to the present disclosure will be explained below with reference to FIG. **19**. A tube expansion tool **70** according to a fourth embodiment may include a sensor positioning mechanism (which is an embodiment of a position adjustment mechanism) **71** that automatically moves the initial position sensor **41** and/or the end position sensor **42** in the front-rear direction. The sensor positioning mechanism **71** may include an initial position operation part **72** that holds the initial position sensor **41** so as to be movable in the front-rear direction and may also include an end position operation part **73** that holds the end position sensor **42** so as to be movable in the front-rear direction. In the following explanation, some components that substantially differ from those of the tube expansion tool **1** according to the first embodiment will be explained in detail.

[0150] As shown in FIG. **19**, the initial position operation part **72** may include a solenoid **72***a*. The solenoid **72***a* may be actuated by operating an initial position operation switch **72***b*. When the solenoid **72***a* is activated, the initial position sensor **41** and the initial position operation part **72** may move forward or rearward. The solenoid **72***a* may be activated for a predetermined time period, for instance for a period of time that would allow the initial position sensor **41** to be moved to a predetermined position. After that, the solenoid **72** may be deactivated. The initial position operation switch **72***b* may be, for example, a push button, a toggle switch, or a dial switch. The initial position operation switch **72***b* may be arranged on the grip **5** (refer to FIG. **1**), although it could be positioned elsewhere. Information relating to a plurality of positions to which the initial position sensor **41** could be moved may be previously stored in a memory of the controller **45** based on, for example, the kinds of jaws expected to be attached to the tube expansion tool **70**.

[0151] As shown in FIG. **19**, the end position operation part **73** may include a solenoid **73***a*. The solenoid **73***a* may be actuated by operating an end position operation switch **73***b*. When the solenoid **73***a* is activated, the end position sensor **42** and the end position operation part **73** may move forward or rearward. The solenoid **73***a* may be activated for a predetermined time period, for instance for a period of time that would allow the end position sensor **42** to be moved to a predetermined position. After that, the solenoid **73** may be deactivated. The end position operation switch **73***b* may be structured in substantially a similar manner as the initial position operation switch **72***b* and may be arranged beside the initial position operation switch **72***b*. Information relating to a plurality of positions to which the end position sensor **42** could be moved may be previously stored in the memory of the controller **45** based on, for example, an expected contraction speed of the fluid pipe at several different ambient temperatures.

[0152] Next, another embodiment according to the present disclosure will be explained below with reference to FIG. **20**. A tube expansion tool **80** according to a fifth embodiment may include a sensor positioning mechanism (which is an embodiment of a position adjustment mechanism) **81** that automatically moves the initial position sensor **41** and/or the end position sensor **42** in the front-rear direction. The sensor positioning mechanism **81** may include an initial position operation part **72** that holds the initial position sensor **41** so that the initial position sensor **41** is movable in the front-rear direction. The sensor positioning mechanism **81** may also include an end position operation part **73** that holds the end position sensor **42** so that the end position sensor **42** is movable in the front-rear direction. In the following explanation, some components that more substantially differ from those in the tube expansion tools **1**, **70** according to the first and fourth embodiments will be explained in detail.

[0153] As shown in FIG. **20**, the tube expansion tool **80** may include a tag reader **85**. The tag reader **85** may be provided in, for example, a front portion of the tool main body (refer to FIG. **1**), a portion to which the cap **2** holding a plurality of jaws **84** can be attached. A NFC (Near Field Communication) tag **84***a* may be attached to the plurality of jaws **84** or the cap **2** (refer to FIG. **1**). The tag reader **85** can read information stored in the NFC tag **84***a* via wireless communication.

[0154] As shown in FIG. **20**, the controller **45** may include an initial position setting part **82**, an end position setting part **83**, and a tag discrimination part **86**. The tag discrimination part **86** may determine features of jaws **84** from the information obtained by the tag reader **85**, which was stored on the NFC tag **84***a*. The initial position setting part **82** may set an initial position (refer to FIG. **5**) of the wedge **3** and the screw shaft **28**, based on the kind of jaws that the tag discrimination part **86** has determined are present and may also determine the number of rotations (e.g., based on the rotation angle) of the electric motor **21** that the rotation number detection sensor **21***d* should detect. The solenoid **72***a* of the initial position operation part **72** may move the initial position sensor **41** to the initial position that has been set by the initial position setting part **82**.

[0155] As shown in FIG. **20**, the tube expansion tool **80** may include a temperature sensor **87** that detects an ambient temperature. The end position setting part **83** may set an end position of the wedge **3** and the screw shaft **28**, based on the detected temperature detected by the temperature sensor **87** and may also set the number of rotations (e.g., based on the rotation angle) of the electric motor **21** that the rotation number detection sensor **21***d* should detect. The solenoid **73***a* of the end position operation part **73** may move the end position sensor **42** to the end position that has been set by the end position setting part **82**.

[0156] Next, another embodiment according to the present disclosure will be explained below with reference to FIG. **21**. A tube expansion tool **90** according to a sixth embodiment may include a sensor positioning mechanism (which is an embodiment of a position adjustment mechanism) **91** that automatically moves the initial position sensor **41** and/or the end position sensor **42** in the front-rear direction. The tube expansion tool **90** may include a bus current measurement part **92**, instead of the tag reader **85** and the tag discrimination part **86** according to the fifth embodiment shown in FIG. **20**. The bus current measurement part **92** may monitor a bus current (e.g., a drive current) that is supplied to the electric motor **21**.

[0157] As shown in FIG. **21**, a certain kind of jaws may be attached to the tube expansion tool **90** at first, and then the switch main body **6***a* may be turned on to drive the electric motor **21**. The bus current measurement part **92** may measure a bus current. The initial position setting part **82** may determine what kind of jaws is attached to the tube expansion tool **90** based on, for example, a maximum value of the bus current and a total bus current power of the bus current, both of which may be monitored by the bus current measurement part **92**. For example, when the plurality of jaws are opened radially outward, the bus current may increase. And when the plurality of jaws are opened to a maximum, a bus current may be at its maximum. In contrast, when the plurality of jaws are closed radially inward, a bus current may decrease. The initial position setting part **82** may determine the kind of jaws (e.g., relating to their thickness in a radial direction and/or size), based on variation characteristics of the bus current. For example, a length of time it takes from when the electric motor **21** has started being operated (for instance with the screw shaft **28** being positioned in the rearmost initial position) to when the bus current has increased to a certain level, or the rate of the increase indicating that the wedge **3** is pressing against the jaws, may be determined. This variation characteristic of the bus current could be different based on the kind of jaws attached. For example, the length of time would be shorter for the configuration shown in FIG. **15** compared to that shown in FIG. **16**. Other methods may also be used. For example, the maximum bus current for one operation cycle may be measured, the measurement of which could indicate the kind of jaws being used. Also, the initial position setting part **82** may set an initial position of the wedge **3** and the screw shaft **28** (refer to FIG. **5**) based on the determined kind of jaws. The solenoid **72***a* may move the initial position sensor **41** to the initial position set by the initial position setting part **82**. As long as it is determined that the same kind of the plurality of jaws are being used, an initial position of the wedge **3** and the screw shaft **28** may be maintained at the position to which the initial position sensor **41** had moved according to the above procedure.

[0158] The embodiments discussed above may be modified in various ways. In the above embodiment, the tube expansion tool **1** may include six jaws **4**. Instead of this, the tube expansion tool **1** may include, for example, five or less jaws **4**, or may include seven or more jaws **4**. In the above exemplified embodiment, the electric motor **21** may be arranged below the screw shaft **28** and on a rear upper side of the grip **5**. However, instead of this configuration, the electric motor **21** may be arranged above the screw shaft **28** and on the rear upper side of the grip **5**. Alternatively, the electric motor **21** may be located entirely within the grip **5**.

[0159] In the above exemplified embodiments, the first center mechanism housing **13** and the second center mechanism housing **14** may be arranged in the front-rear direction between the front side mechanism housing **12** and the rear side mechanism housing **15**. However, instead of this configuration, for example, only one center mechanism housing may be present or more than three center mechanism housings may be arranged between the front side mechanism housing **12** and the rear side mechanism housing **15**. In the above exemplified embodiments, the first center mechanism housing **13** and the second center mechanism housing **14** are made of die cast aluminum. However, instead of this, the first center mechanism housing **13** and the second center mechanism housing **14** may be made of another lightweight material, such as die cast magnesium.

[0160] In the above exemplified embodiments, the linear movement member **31** may include a protrusion **31***b* projecting radially outward from a side surface of the linear movement member **31**, and the power conversion ring **32** may include grooves **32***a*, **32***b* that engage the protrusion **31***b* on the outer circumferential surface of the power conversion ring **32**. However, instead of this configuration, for example, a groove may be provided on a side surface of the linear movement member **31**, and the power conversion ring **32** may include a protrusion projecting radially outward from an outer circumferential surface of the power conversion ring **32**.

[0161] In the above exemplified embodiments, the tube expansion tool **1** may include an operation part **44***a* that a user can use to move the end position sensor **42**. However, instead of this configuration, there may be provided a movement mechanism that automatically moves the end position sensor **42** based on an ambient temperature detected by a temperature sensor. Also, a motor or a solenoid may be used as the movement mechanism. Furthermore, in the above exemplified embodiment, the main body housing **11** may support the initial position sensor **41** and the end position sensor **42**, and the magnet **43** may be attached to the screw shaft **28**. However, instead of this configuration, the main body housing **11** may support magnets at positions corresponding to desired initial and end positions, and the screw shaft may include a Hall Effect sensor for detecting the position of the screw shaft **28**.

[0162] In the above exemplified embodiments, the expansion zone of the jaws **4** may be defined as a portion of the operation after the rotation zone. However, instead of this configuration, the rotation zone may be defined as a portion of the operation after the expansion zone. Furthermore, in the above exemplified embodiments, when the controller **45** detects a predetermined number of rotations of the electric motor **21** that has been previously stored in the memory of the controller **45**, the rotation zone of the jaws **4** may be determined to have finished. However, instead of this configuration, a sensor (e.g., a Hall Effect sensor) that detects a position that indicates that the rotation zone of the jaws **4** has finished may be arranged between the initial position sensor **41** and the end position sensor **42**.

[0163] In the above exemplified embodiments, the feed screw mechanism **25** may move the wedge **3** in the front-rear direction. However, instead of this configuration, for example, a cam that is rotated by rotation of the electric motor **21** may move the wedge **3**, and a rotation zone and an expansion zone may be defined by detecting an initial angle and a rotation angle of the cam and/or a number of rotations of the electric motor **21**.

[0164] In the above exemplified embodiments, the feed screw mechanism **25** may include the plurality of balls **28***b* placed between the screw shaft **28** and the female screw member **27**. However, instead of this configuration, for example, a feed screw mechanism may be configured such that the screw shaft **28** directly engages the female screw member **27**, without placing the balls **28** therebetween.

[0165] Relating to the engagement recesses **52***b*, **52***c* that respectively position the initial position operation part **54** and the end position operation part **55**, the number of the recesses **52***b*, **52***c* and the positions of the recesses **52***b*, **52***c* in the front-rear direction may be changed as needed without being limited by the disclosure of the specific embodiments. Also, in the above exemplified embodiments, the engagement portion **56***a* of the leaf spring **56** and the ball **64***a* of the ball plunger **64** may move in the up-down direction. However, instead of this configuration, for example, an engagement portion of the leaf spring and a ball of the ball plunger may move in the left-right direction with regard to a side wall of the groove hole **52***a* formed in the main body housing **52**.

[0166] In the above exemplified embodiments, a solenoid **72***a* that moves the initial position sensor **41** in the front-rear direction may be used. However, instead of the solenoid **72***a*, for example, an electric motor may be used. Also, instead of the solenoid **73***a* that moves the end position sensor **42** in the front-rear direction, for example, an electric motor may be used.

[0167] Furthermore, the sensor positioning mechanism **53**, in which the leaf springs **56**, **67** are used and the sensor positioning mechanism **61** in which the ball plungers **64**, **65** are used, may be applied to any of the tube expansion tools **70**, **80**, **90** in which the initial position sensor **41** and the end position sensor **42** are automatically moved in the front-rear direction.

[0168] Furthermore, instead of the monitoring of the bus current in the tube expansion tool **90**, a total number of rotations of the electric motor **21** from a time when the wedge **3** moves from an initial position until a time when the plurality of jaws starts to open radially outward may be detected by the rotation number detection sensor **21***d*. A movement amount of the screw shaft **28** may be calculated by using the total rotation number of the electric motor **21**. A zone in which the wedge **3** does not serve to expand the plurality of jaws radially outward may be determined from the movement amount of the screw shaft **28**. As a result, an initial position sensor **41** may be shifted and an initial position of the wedge **3** may be newly set such that a zone in which the wedge **3** does not serve to expand the jaws may be reduced. Alternately, an upper /lower limit of the motor current based on the type of jaws attached to the PEX expansion tool can be adjusted. By adjusting a maximum current of the motor, a thinner walled pipe may not be damaged or expansion power of the tool may not be unnecessary limited when working with the thicker walled pipes.

What is claimed is:

1. A tube expansion tool for expanding an end portion of a synthetic resin made fluid pipe, comprising:
- an electric motor housed in a main body housing;
- a screw shaft positioned in the main body housing and configured to be movable in a front-rear direction, which is a direction coaxial with or parallel to an output shaft of the electric motor;
- a female screw member configured to move the screw shaft in the front-rear direction by engaging with the screw shaft and rotating around an axis of the screw shaft;
- a gear engaged with the female screw member, the gear being configured to transmit a rotation output of the output shaft of the electric motor to the female screw member;
- a wedge extending forward from the screw shaft; and
- a plurality of jaws coupled to the main body housing so as to be openable/closable, wherein when the wedge moves forward integrally with the screw shaft, the wedge pushes the plurality of jaws so that each jaw of the plurality of jaws opens radially outward relative to each other.

2. The tube expansion tool according to claim **1**, further comprising:
- a grip extending downward from the main body housing, wherein:
- a majority of the grip is arranged between the electric motor and the plurality of jaws in the front-rear direction; and
- the electric motor is arranged below the screw shaft.

3. The tube expansion tool according to claim **2**, wherein at least a part of the screw shaft overlaps the grip in the front-rear direction.

4. The tube expansion tool according to claim **1**, wherein a portion of a planetary gear reduction mechanism, which is configured to reduce the rotation output of the output shaft, is arranged between the output shaft of the electric motor and the screw shaft.

5. The tube expansion tool according to claim **1**, further comprising:
- a rotation drive ring linked to a rear portion of the plurality of jaws; and
- a jaw rotation mechanism configured to rotate the plurality of jaws in a circumferential direction due to rotation of the rotation drive ring, which is caused by the rotation output of the electric motor, wherein:
- the rotation drive ring is positioned in front of the female screw member.

6. The tube expansion tool according to claim **1**, further comprising:
- a cap that supports the plurality of jaws so that the plurality of jaws can be opened/closed and so that the plurality of jaws are restricted from moving in the front-rear direction;
- a front side mechanism housing, a first center mechanism housing, and a rear side mechanism housing that are arranged in this order from a front side to a rear side, each of the front side mechanism housing, the first center mechanism housing, and the rear side mechanism housing being positioned within the main body housing; and
- a bolt that connects the front side mechanism housing to the rear side mechanism housing, wherein:
- the front side mechanism housing is made of a material containing iron and is configured to support the cap;
- the rear side mechanism housing is made of a material containing iron and is configured to support an end portion of the female screw member; and
- the first center mechanism housing is made of a material that is lighter in weight than iron.

7. The tube expansion tool according to claim **6**, further comprising:
- a second center mechanism housing positioned between the first center mechanism housing and the rear side mechanism housing, wherein:
- each of the front side mechanism housing, the first center mechanism housing, the second center mechanism housing, and the rear side mechanism housing includes an engagement portion at each end portion thereof, the engagement portions being positioned such that adjacent end portions are configured to overlap each other in the front-rear direction.

8. The tube expansion tool according to claim **7**, further comprising:
- a spindle configured to rotate integrally with the gear, the spindle being arranged in front of the output shaft of the electric motor, wherein:
- the first center mechanism housing and the second center mechanism housing each supports a spindle bearing, which are configured to rotatably support the spindle; and
- the first center mechanism housing and the second center mechanism housing each supports a female screw member bearing, which are configured to rotatably support the female screw member.

9. The tube expansion tool according to claim **6**, wherein the rear side mechanism housing supports a thrust bearing that contacts a rear end of the female screw member.

10. The tube expansion tool according to claim **1**, wherein a plurality of balls are placed between and engage with the screw shaft and the female screw member.

11. The tube expansion tool according to claim **7**, wherein the first center mechanism and the second center mechanism are made of a material having a density less than that of iron.

12. A tube expansion tool for expanding an end portion of a synthetic resin made fluid pipe, comprising:
- an electric motor housed in a main body housing;
- a screw shaft positioned in the main body housing and configured to be movable in a front-rear direction;
- a female screw member configured to move the screw shaft in the front-rear direction by engaging with the screw shaft and rotating around an axis of the screw shaft;

a gear engaged with the female screw member, the gear being configured to transmit a rotation output of the output shaft of the electric motor to the female screw member;

a spindle configured to rotate integrally with the gear, the spindle extending in a direction parallel to the screw shaft;

a wedge extending forward from the screw shaft; and

a plurality of jaws coupled to the main body housing so as to be openable/closable, wherein when the wedge moves forward integrally with the screw shaft, the wedge pushes the plurality of jaws so that each jaw of the plurality of jaws opens radially outward relative to each other.

13. The tube expansion tool according to claim **12**, wherein at least a portion of the electric motor is positioned rearward of a rearmost portion of the screw shaft in the front-rear direction.

14. The tube extension tool according to claim **12**, further comprising:

a grip extending downward from the main body housing, wherein:

at least a part of the screw shaft overlaps the grip in the front-rear direction.

15. The tube expansion tool according to claim **14**, wherein the electric motor overlaps at least a portion of the grip in the front-rear direction..

16. The tube expansion tool according to claim **12**, further comprising:

a rotation drive ring linked to a rear portion of the plurality of jaws; and

a jaw rotation mechanism configured to rotate the plurality of jaws in a circumferential direction due to rotation of the rotation drive ring, which is caused by the rotation output of the electric motor, wherein:

the rotation drive ring is positioned in front of the female screw member in the front-rear direction.

17. The tube expansion tool according to claim **16**, further comprising:

a power conversion ring with a first groove and a second groove, both of which are formed in a recessed shape, the power conversion ring being disposed behind the rotation drive ring in the front-rear direction; wherein:

the first groove extend in a direction parallel to an axis direction of the power conversion ring; and

the second groove extends in a direction non-parallel to the axis direction of the power conversion ring.

18. The tube expansion tool according to claim **17**, further comprising:

a linear movement member configured to be movably linked to the spindle, wherein:

the linear movement member includes a protrusion extending in a direction perpendicular to an axis line of the linear movement member; and

the protrusion extends so as to be inserted into one of the first and second grooves.

19. The tube expansion tool according to claim **14**, further comprising:

a screw shaft guide positioned within the main body housing, the screw shaft guide being configured to guide the screw shaft in the front-rear direction, wherein:

the screw shaft guide overlaps the grip in the front-rear direction.

20. The tube expansion tool according to claim **19**, wherein a center axis of the grip, which extends through a center of the grip, traverses the screw shaft guide in a direction perpendicular to the front-rear direction.

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