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(54) **ELECTRIC NEEDLE SCALER**

(71) Applicant: **Makita Corporation,** Anjo-shi (JP)

(72) Inventors: **Tomohiro SAEKI,** Anjo-shi (JP); **Masanori Furusawa,** Anjo-shi (JP); **Kei Watanabe,** Anjo-shi (JP); **Yuji Sakakibara,** Anjo-shi (JP)

(73) Assignee: **Makita Corporation**, Anjo-shi (JP)

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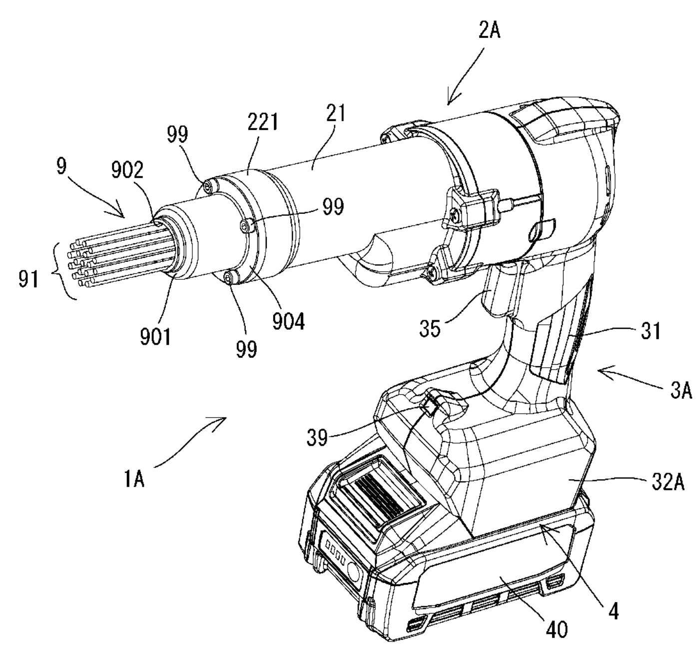
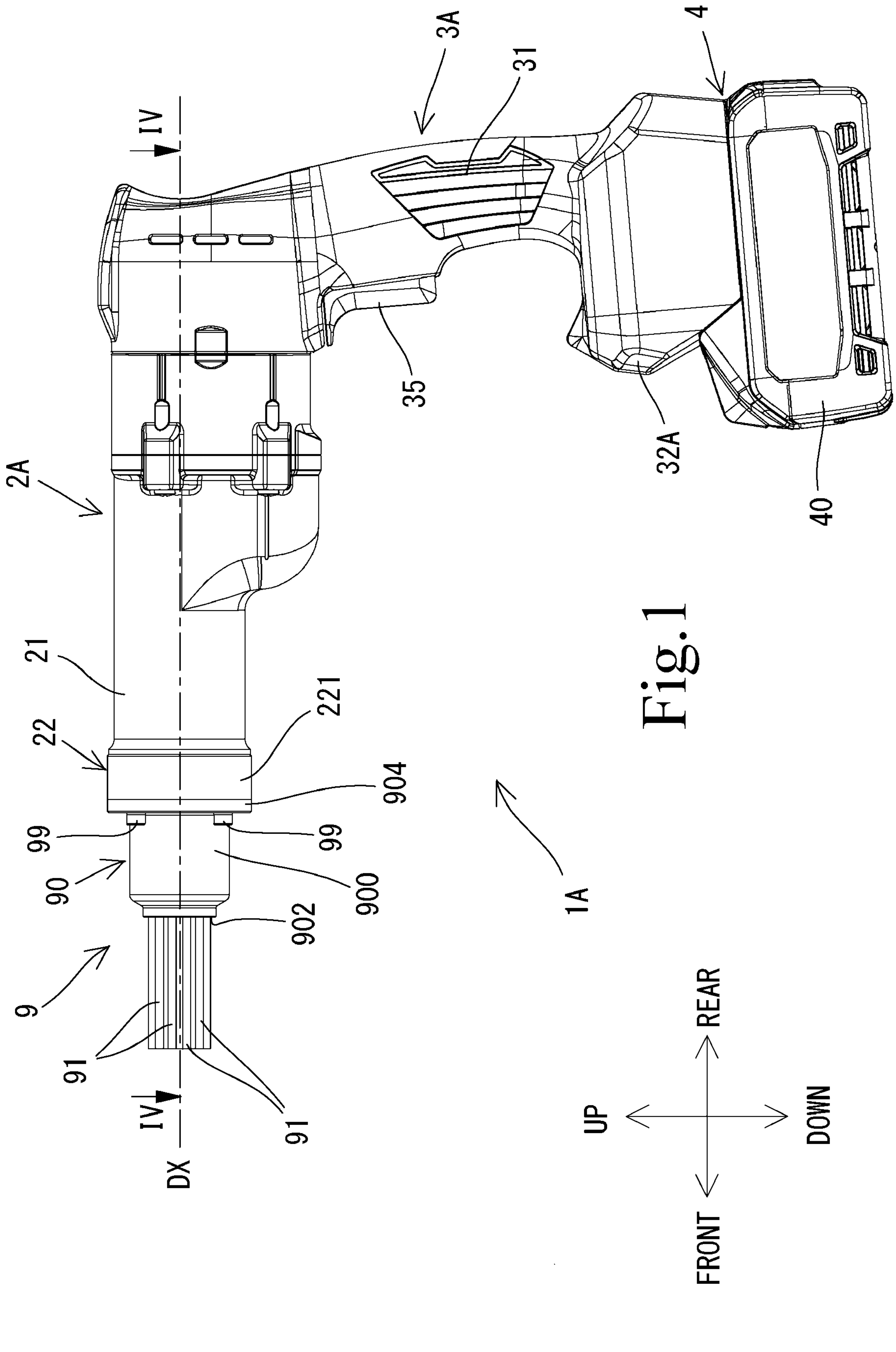
(57) **ABSTRACT**

A needle scaler includes: a tool body, at least part of which extends along a driving axis that defines a front-rear direction of the needle scaler; an electric motor that is housed in the tool body; a battery mounting part that is configured to removably receive a battery; a power transmitting mechanism that is housed in the tool body; and a scaling mechanism that is supported by a front end part of the tool body. The scaling mechanism includes needles. The needles protrude forward to be exposed out of the tool body and are supported to be movable in respective axial directions of the needles. The power transmitting mechanism includes a power transmitting part. The power transmitting part is operably connected to the output shaft of the motor and reciprocates along the driving axis by utilizing rotation of the output shaft and transmit axial force to the needles.

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91
IV
DX
REAR
UP
DOWN
FRONT

Fig.1

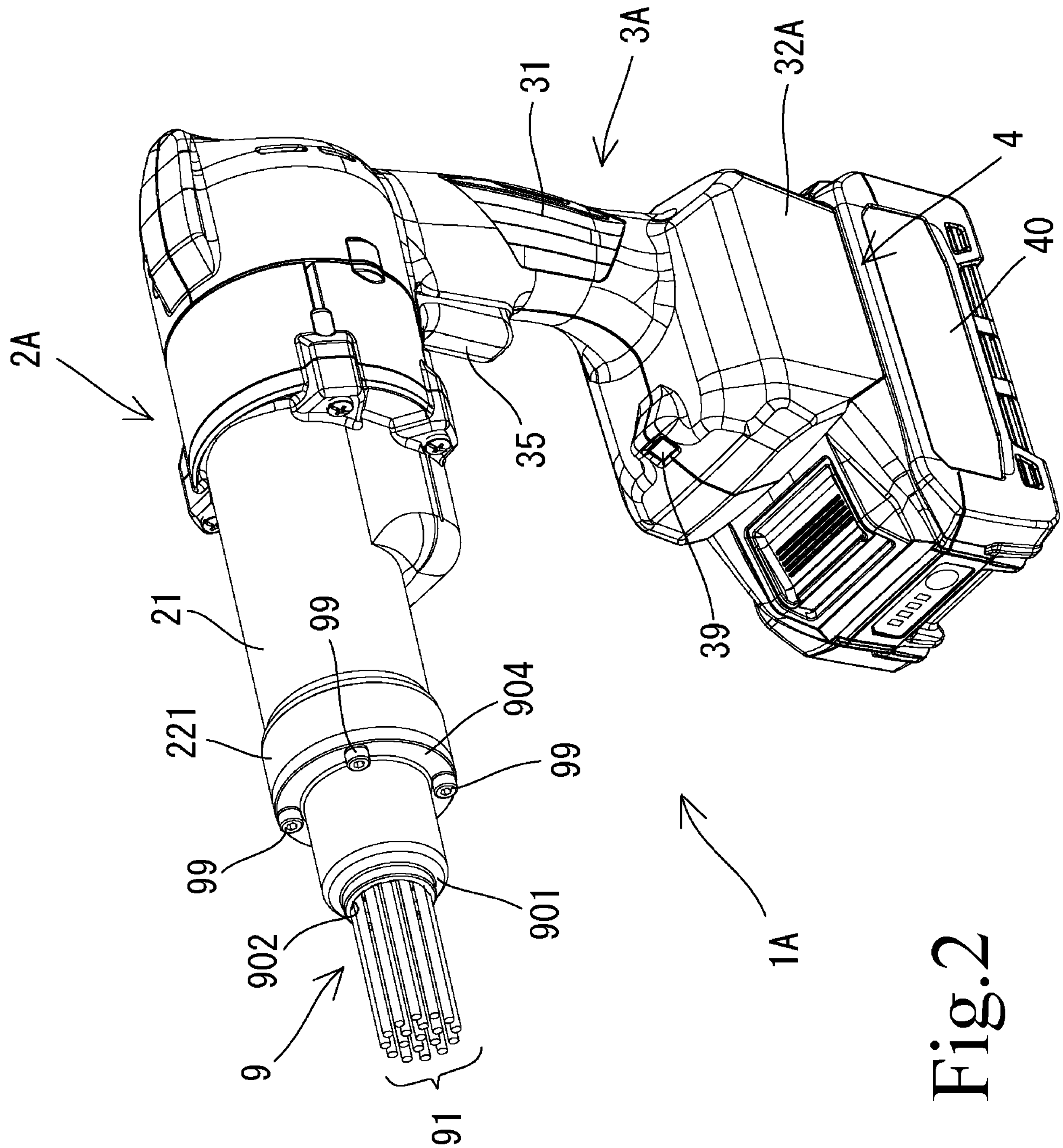
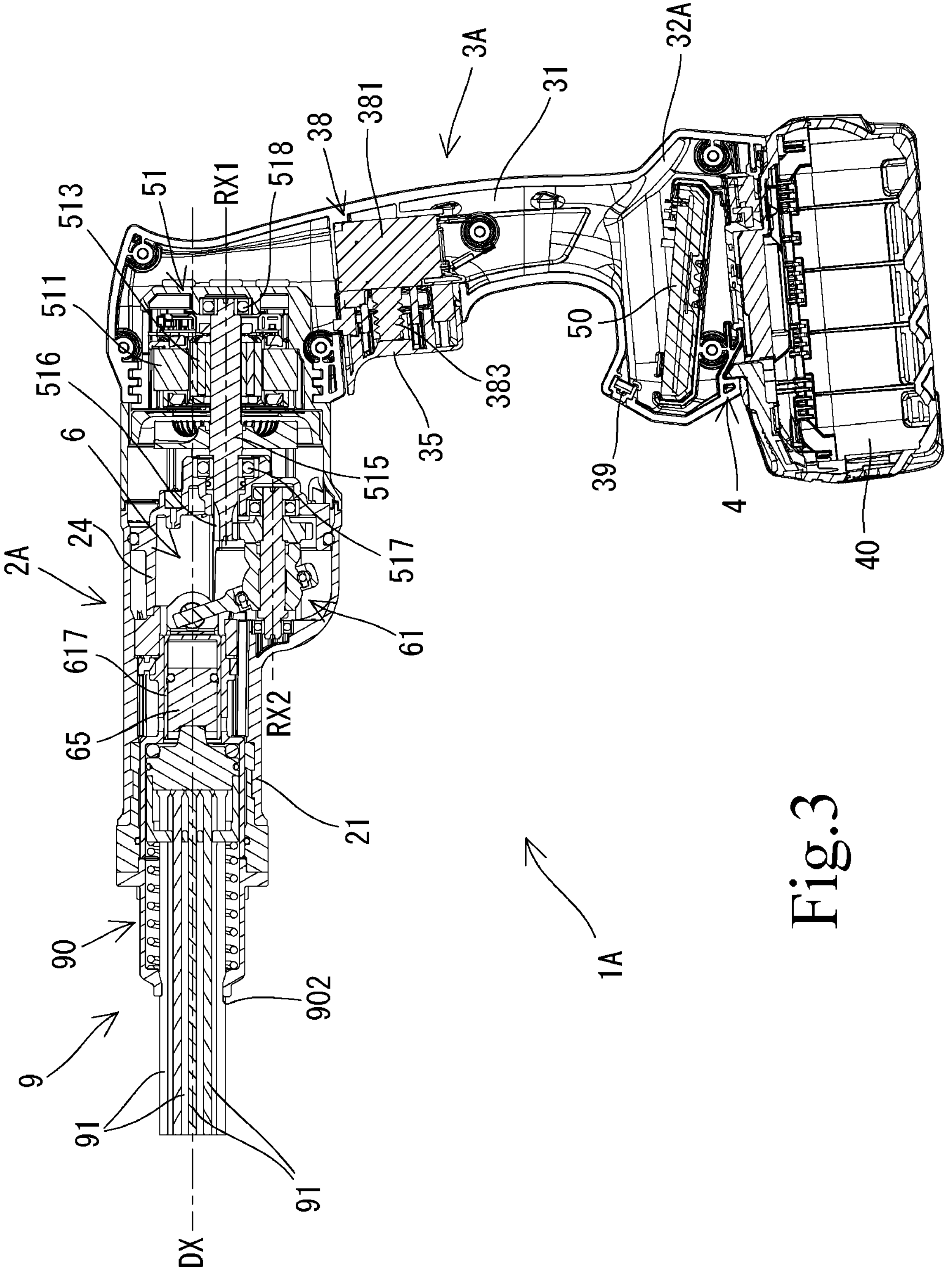


Fig.2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39
4
40
90
902
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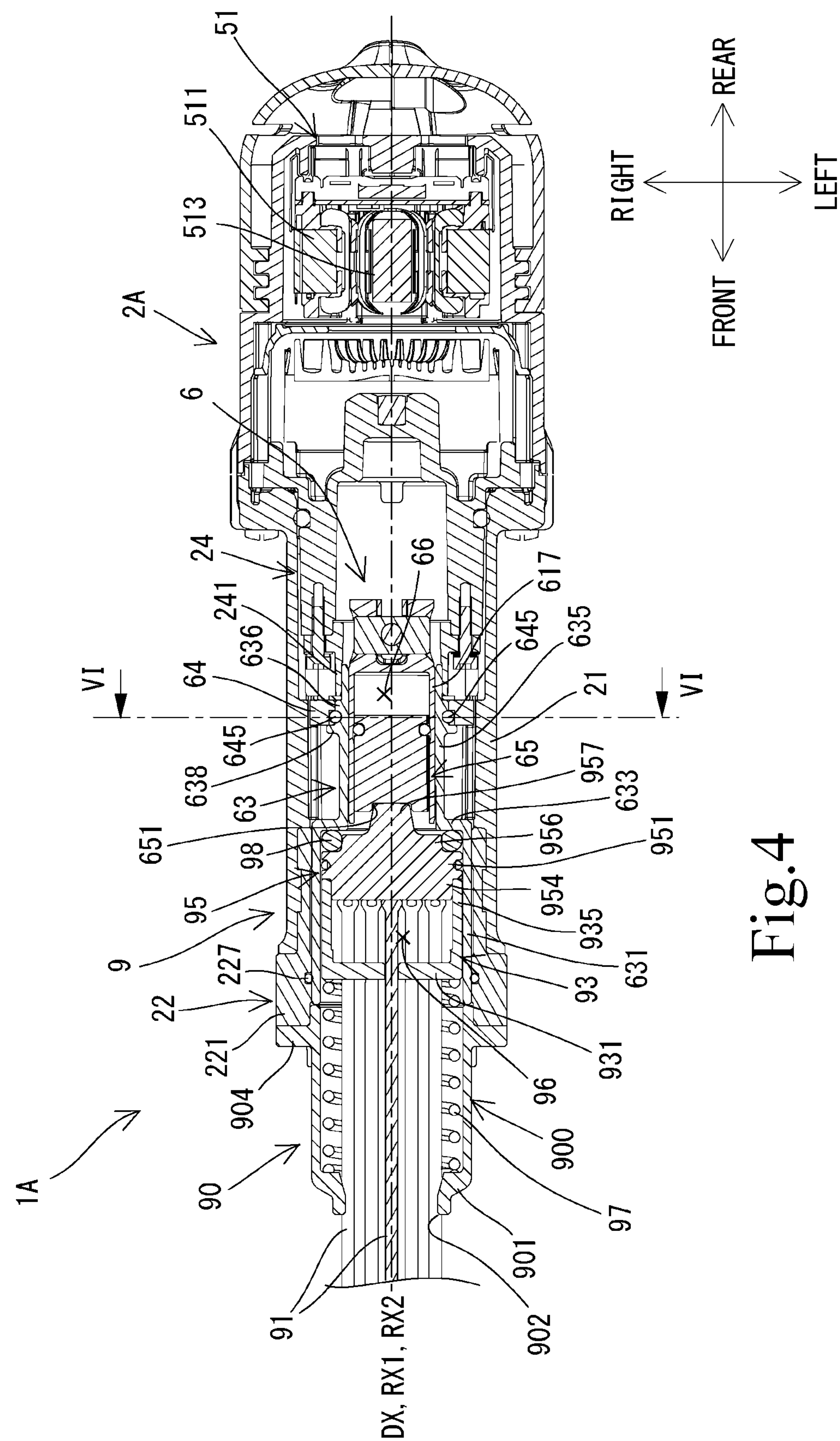
91
91
DX
1A

Fig.3



REAR
RIGHT
LEFT
FRONT
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511
513
2A
6
66
24
241
617
636
645
635
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VI
VI
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645
638
65
957
63
633
651
98
956
951
95
954
935
9
631
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904
1A
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901
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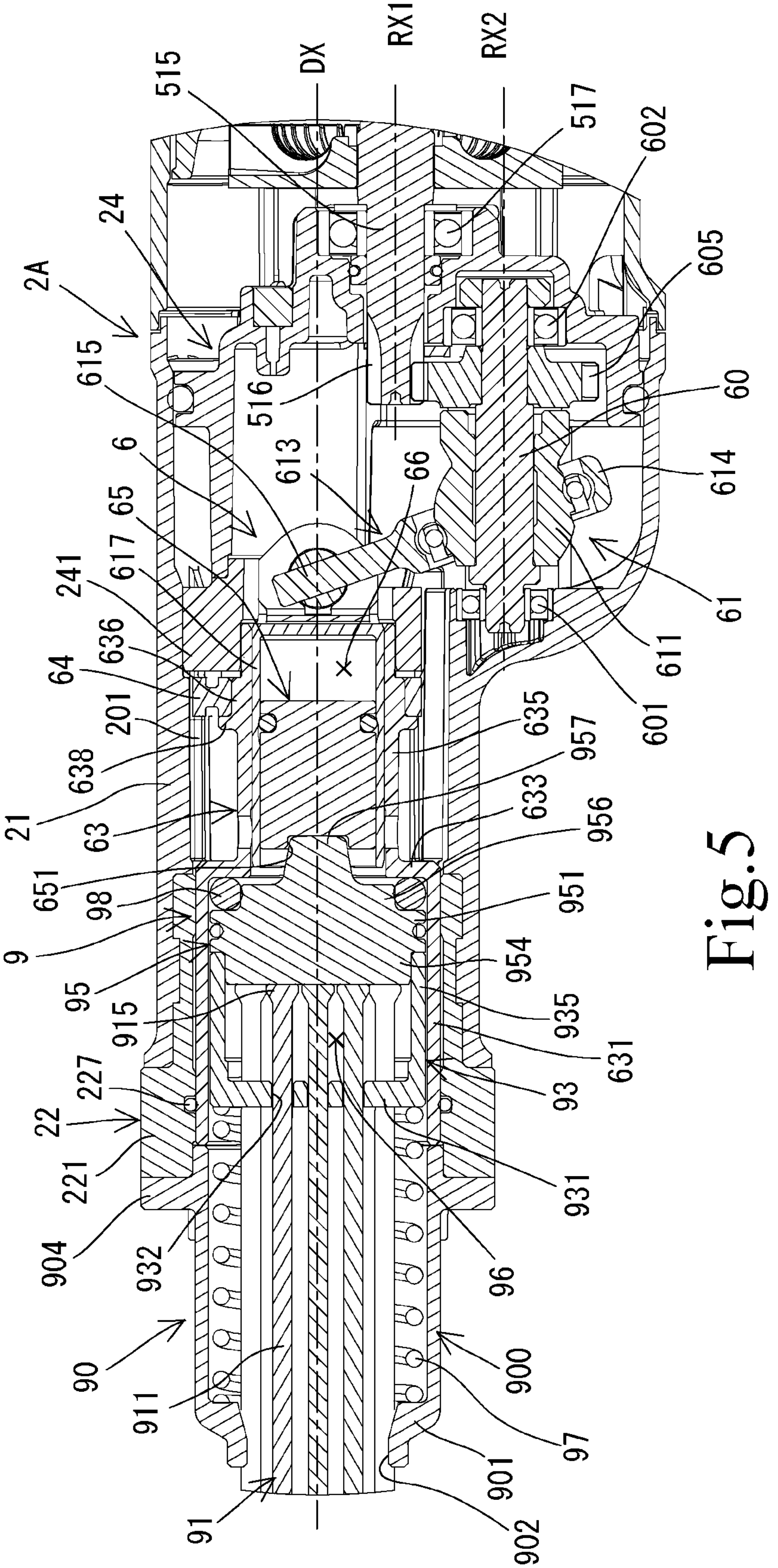
902
DX, RX1, RX2

Fig.4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201
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951
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954
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935
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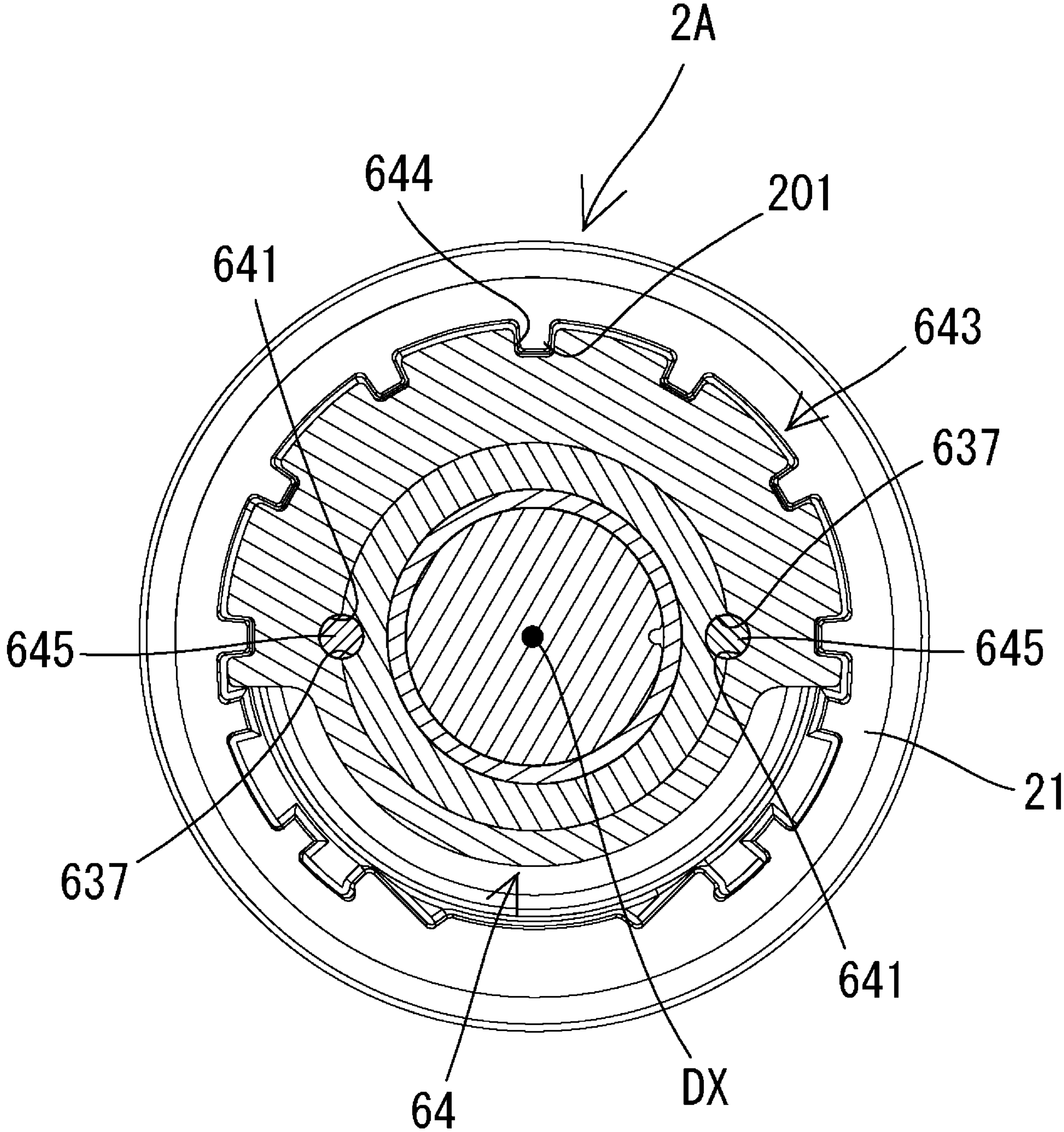
Fig.5



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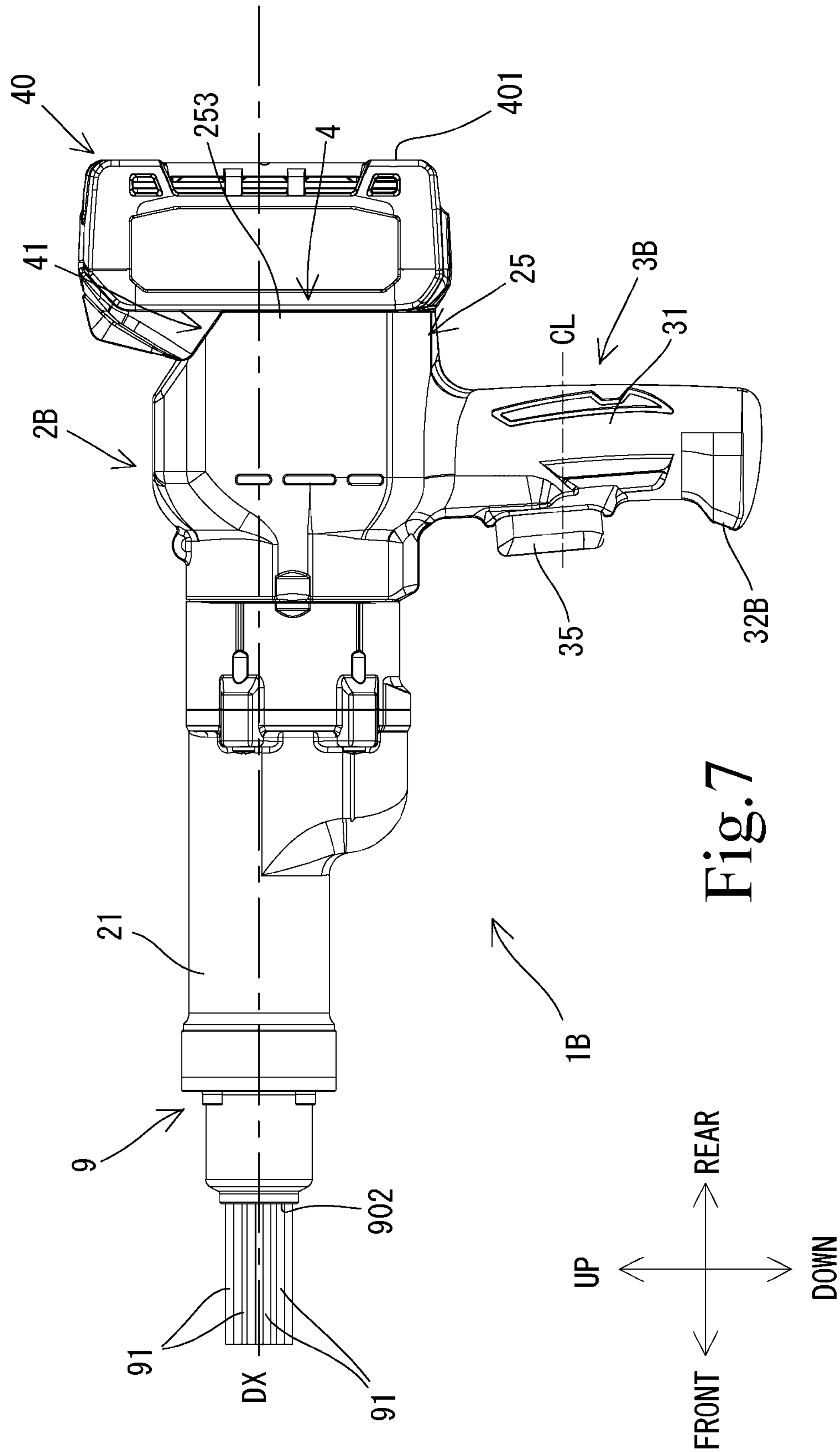
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32B
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902
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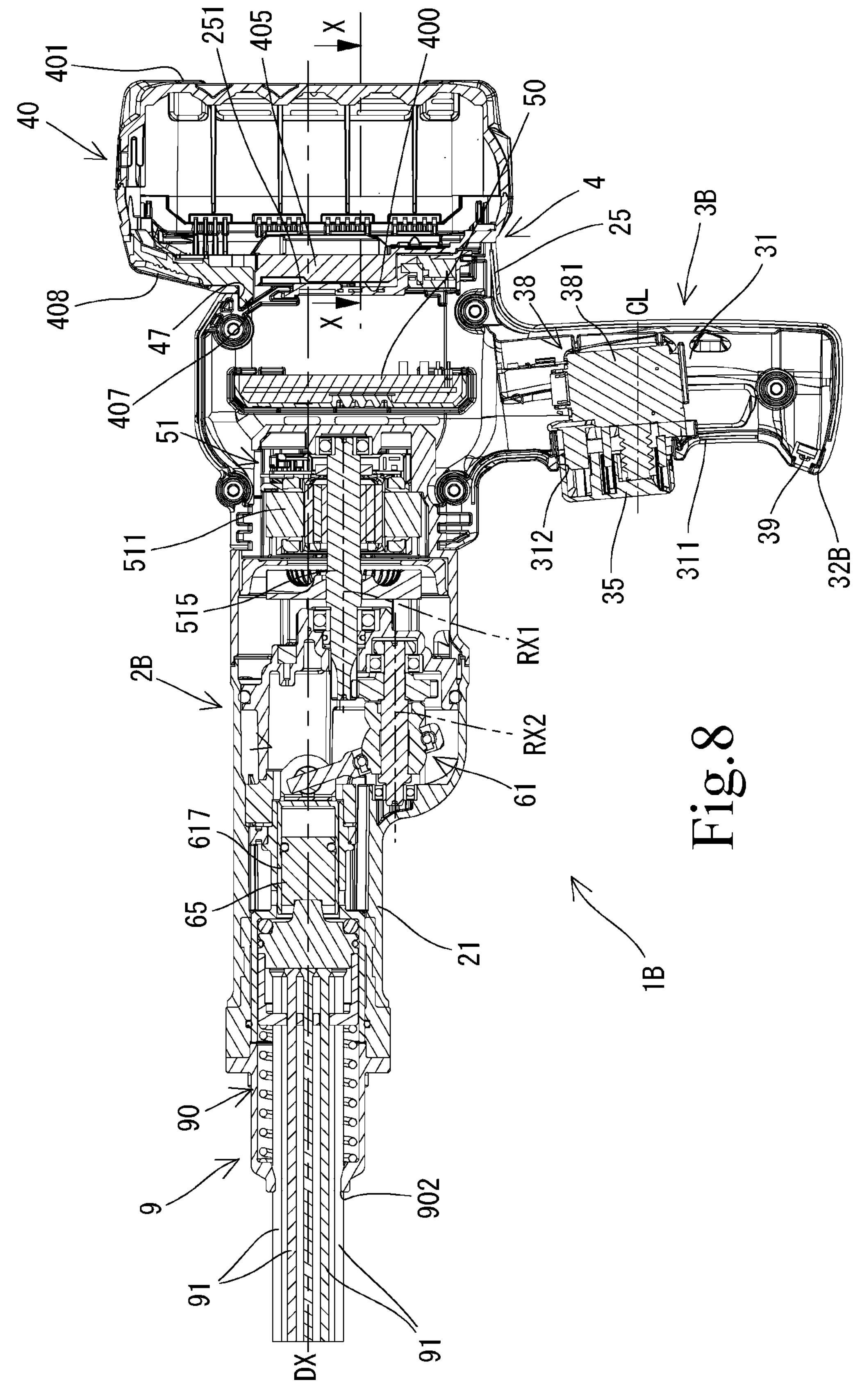
DX
91
UP
REAR
DOWN
FRONT

Fig. 7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312
35
311
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32B
RX1
2B
RX2
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617
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1B
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9
902
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DX
91

Fig.8

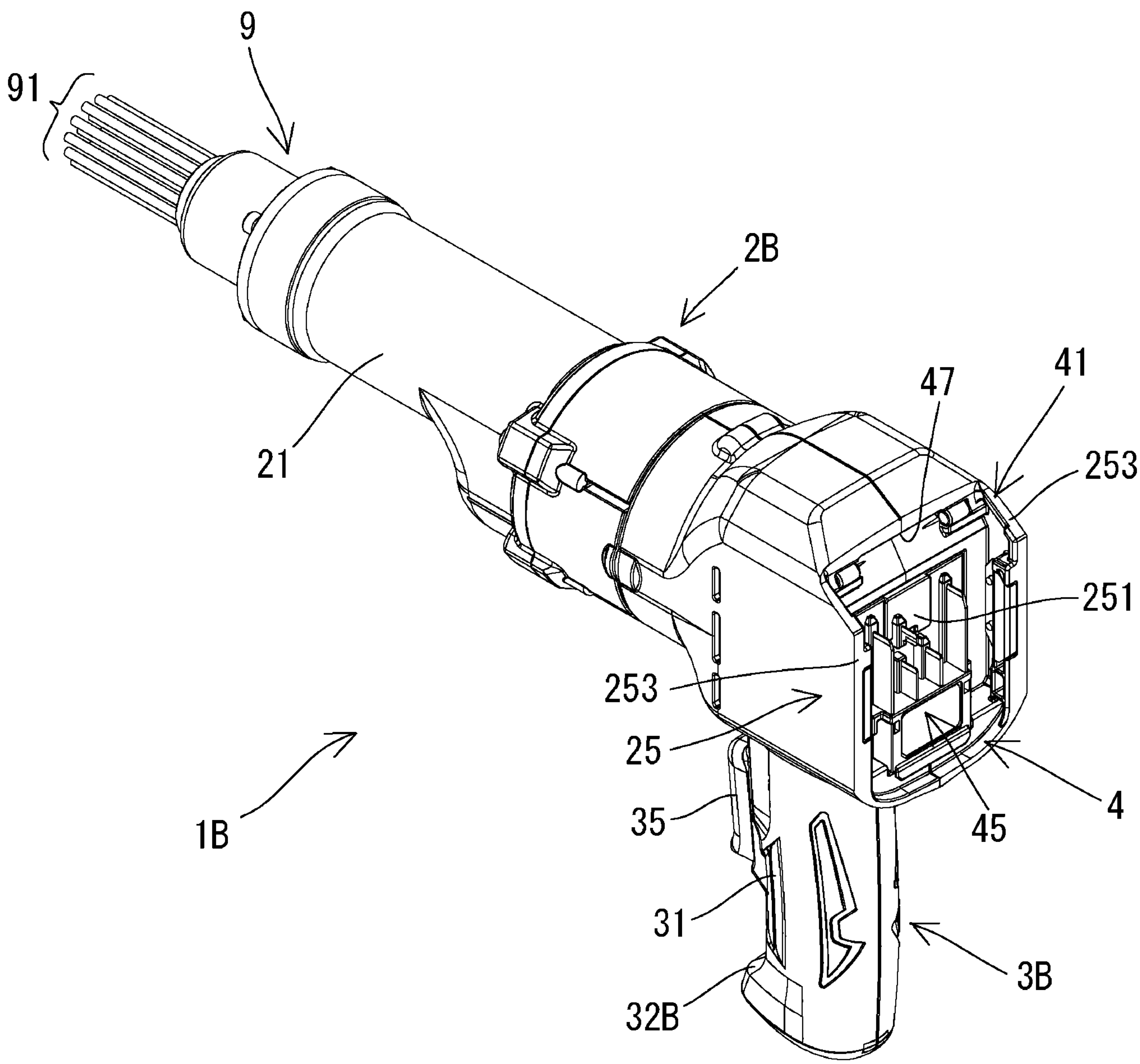


Fig.9

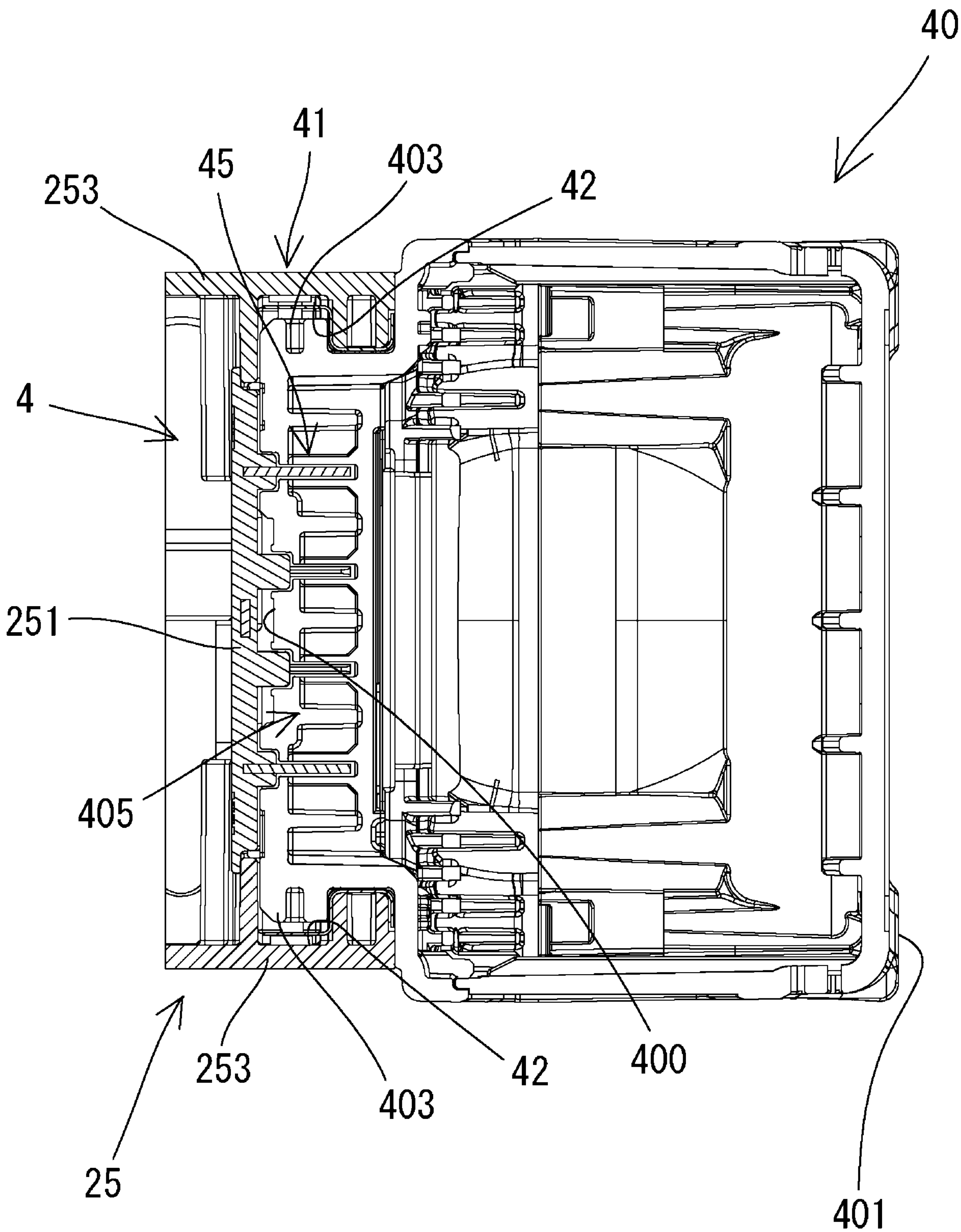
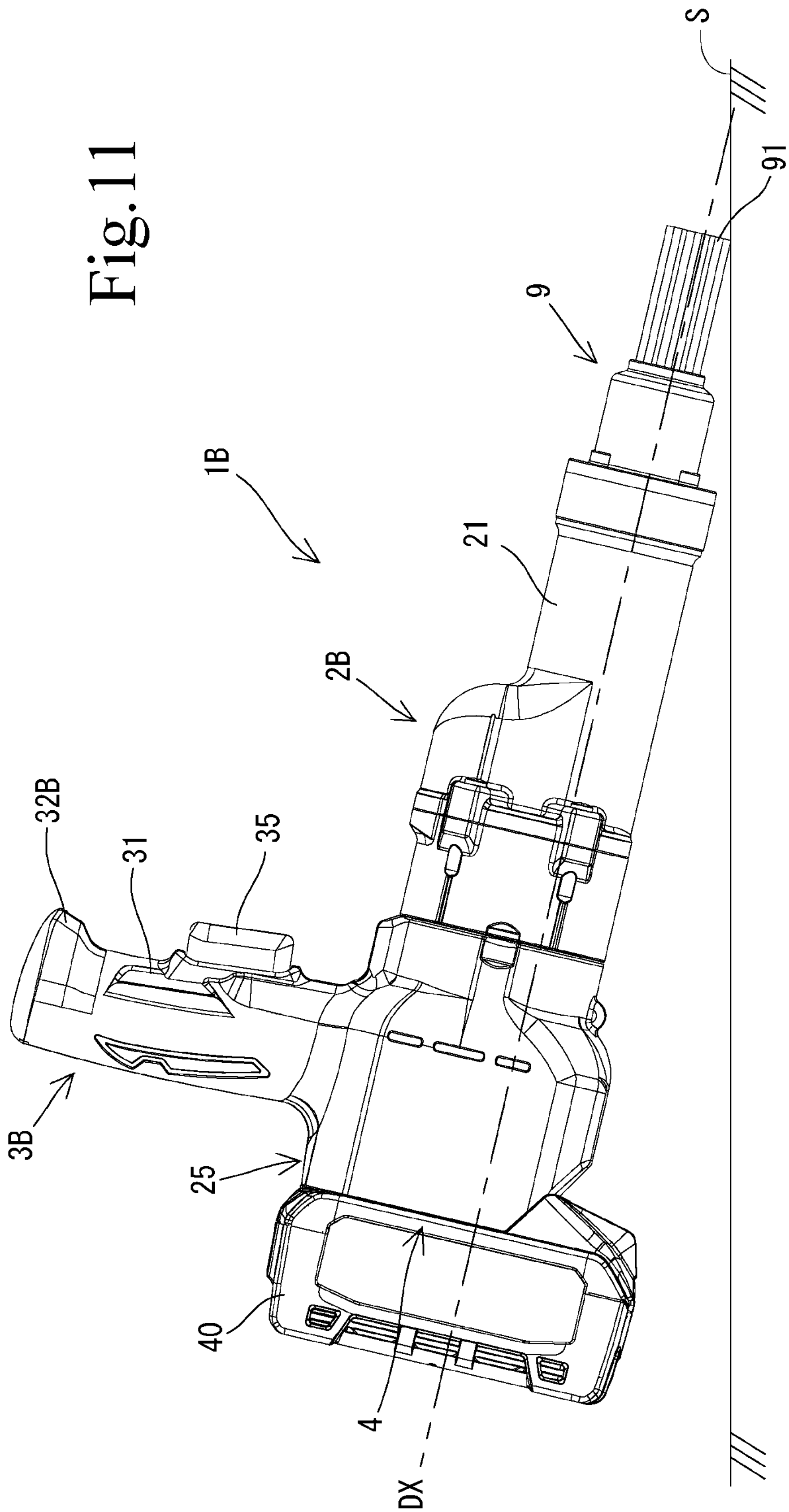
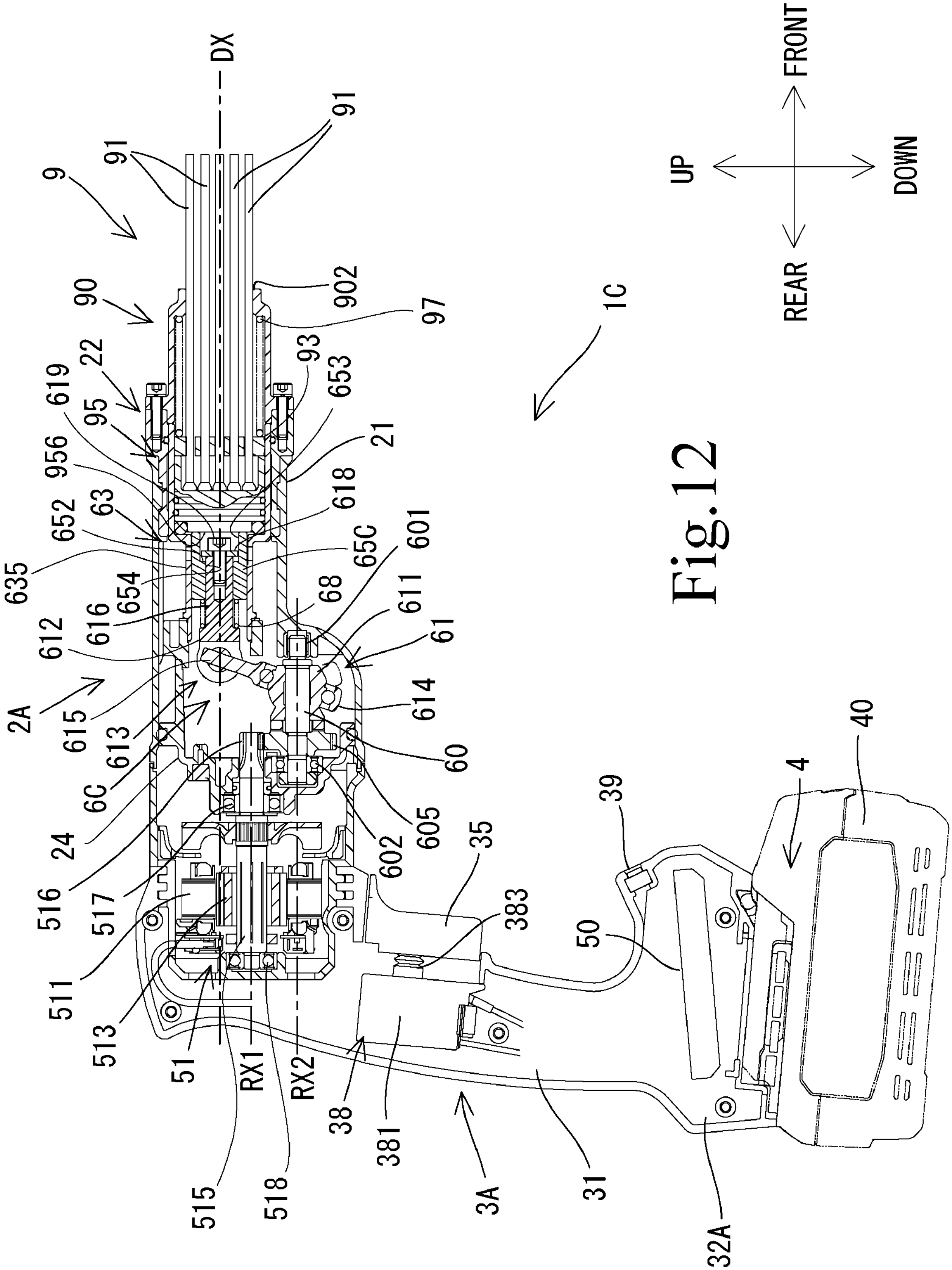


Fig.10

Fig.11

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618
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654
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616
68
612
611
61
2A
615
614
613
6C
60
24
605
602
516
35
517
39
4
40
511
383
50
513
51
RX1
RX2
515
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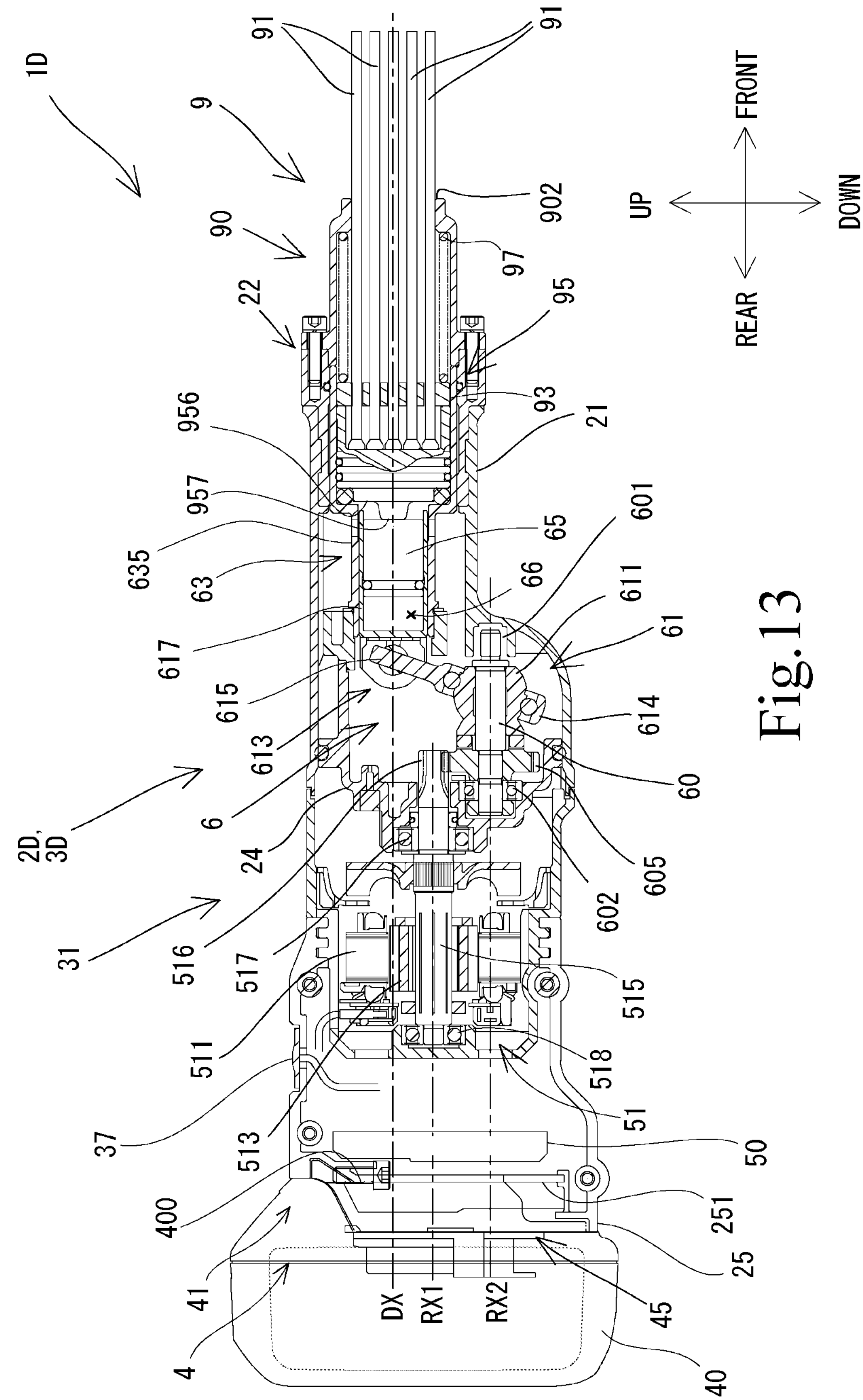
381
3A
31
32A
1C
UP
DOWN
FRONT
REAR

Fig.12



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518
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513
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DX
RX1
RX2
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4
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FRONT
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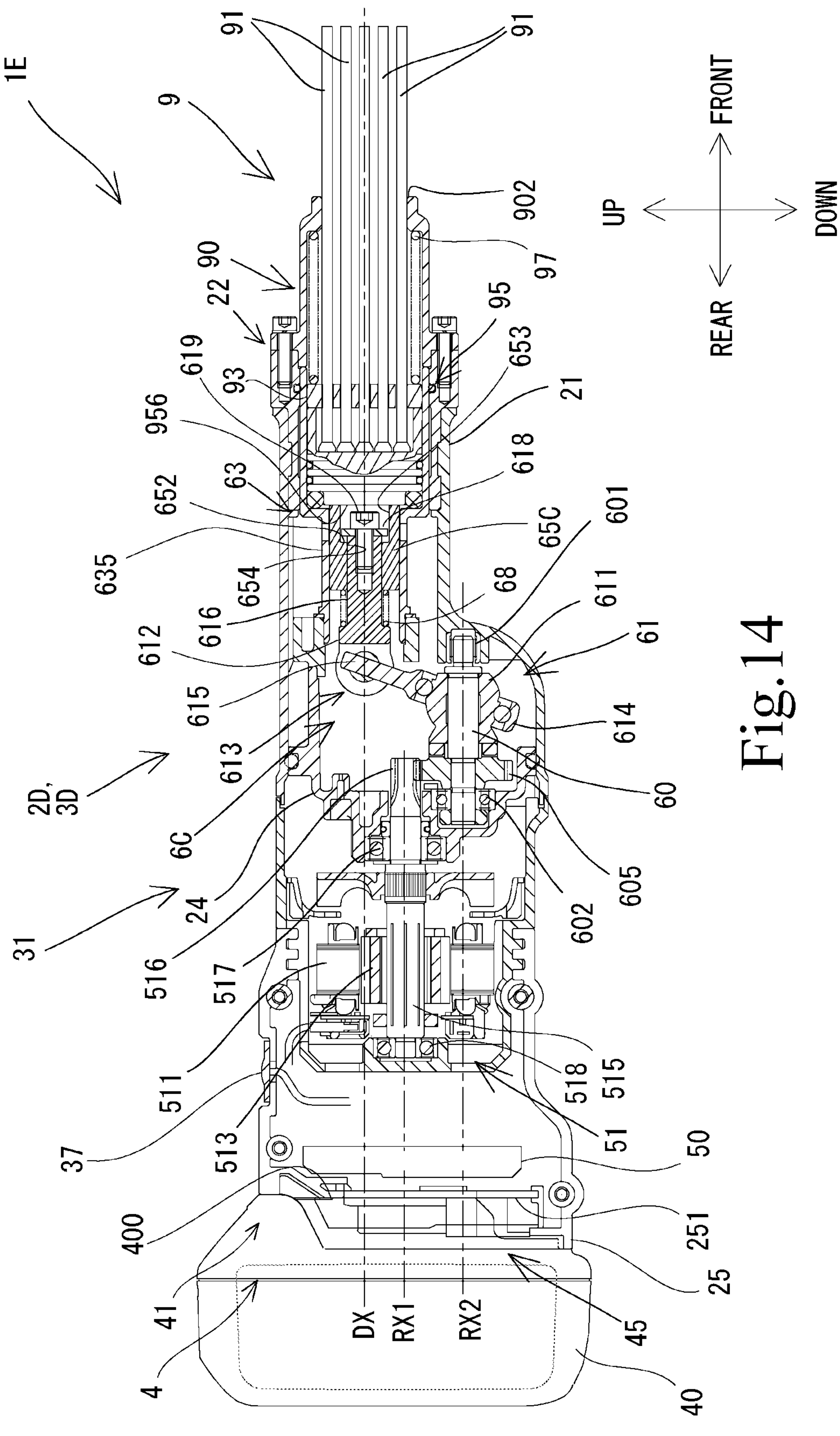
DOWN
REAR

Fig.13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DX
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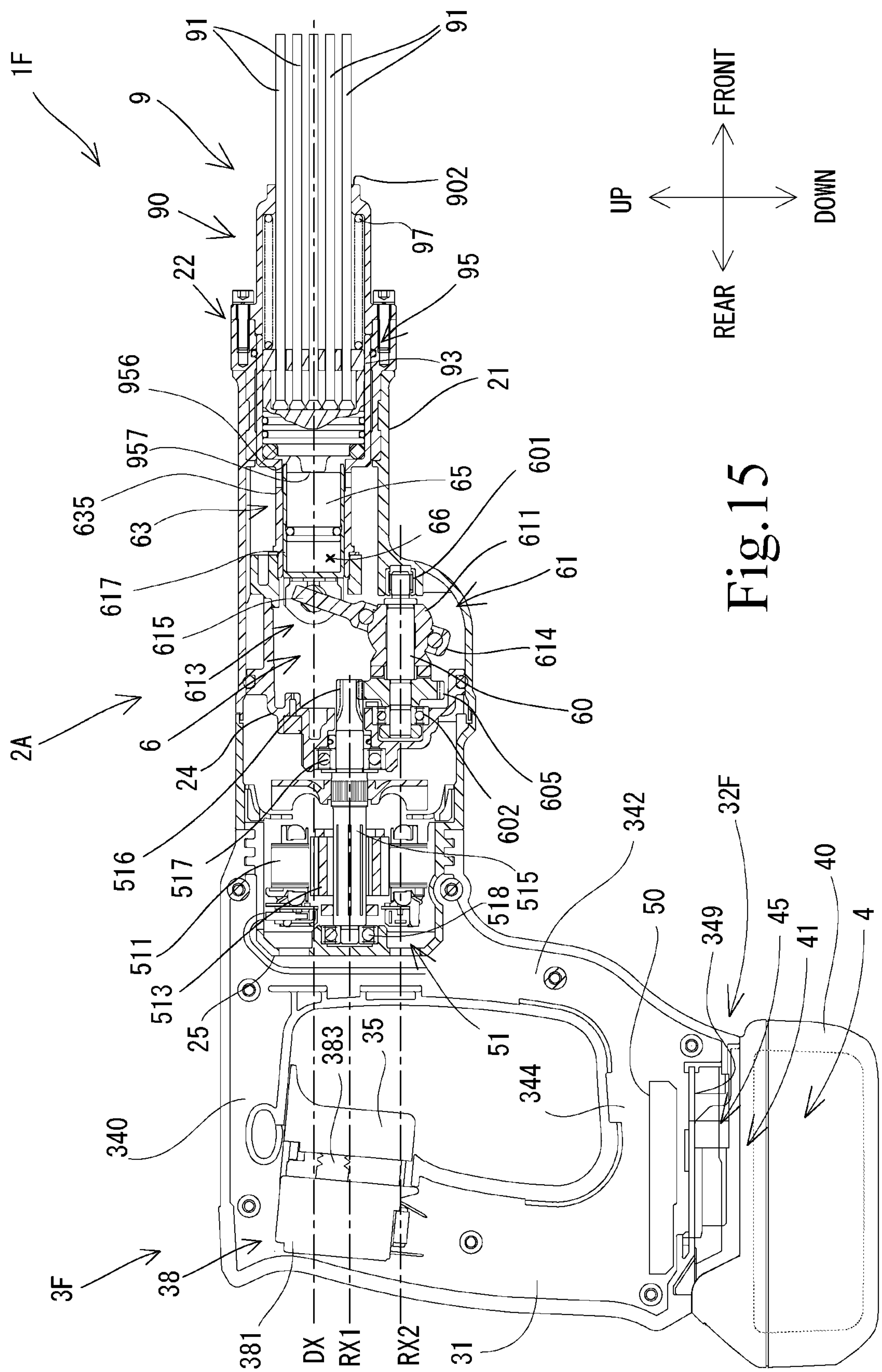
REAR

Fig.14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41
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FRONT
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UP
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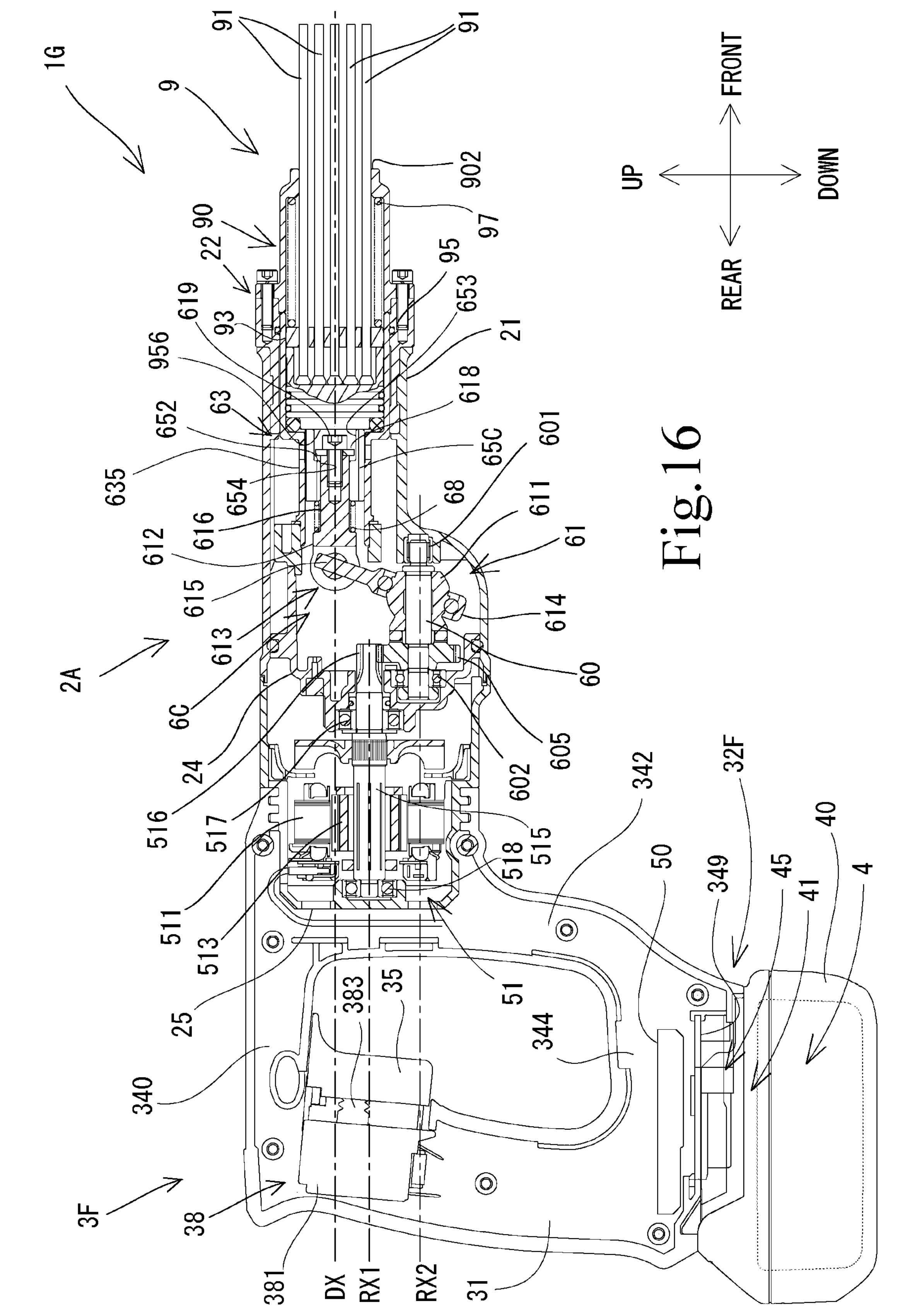
Fig.15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DX
RX1
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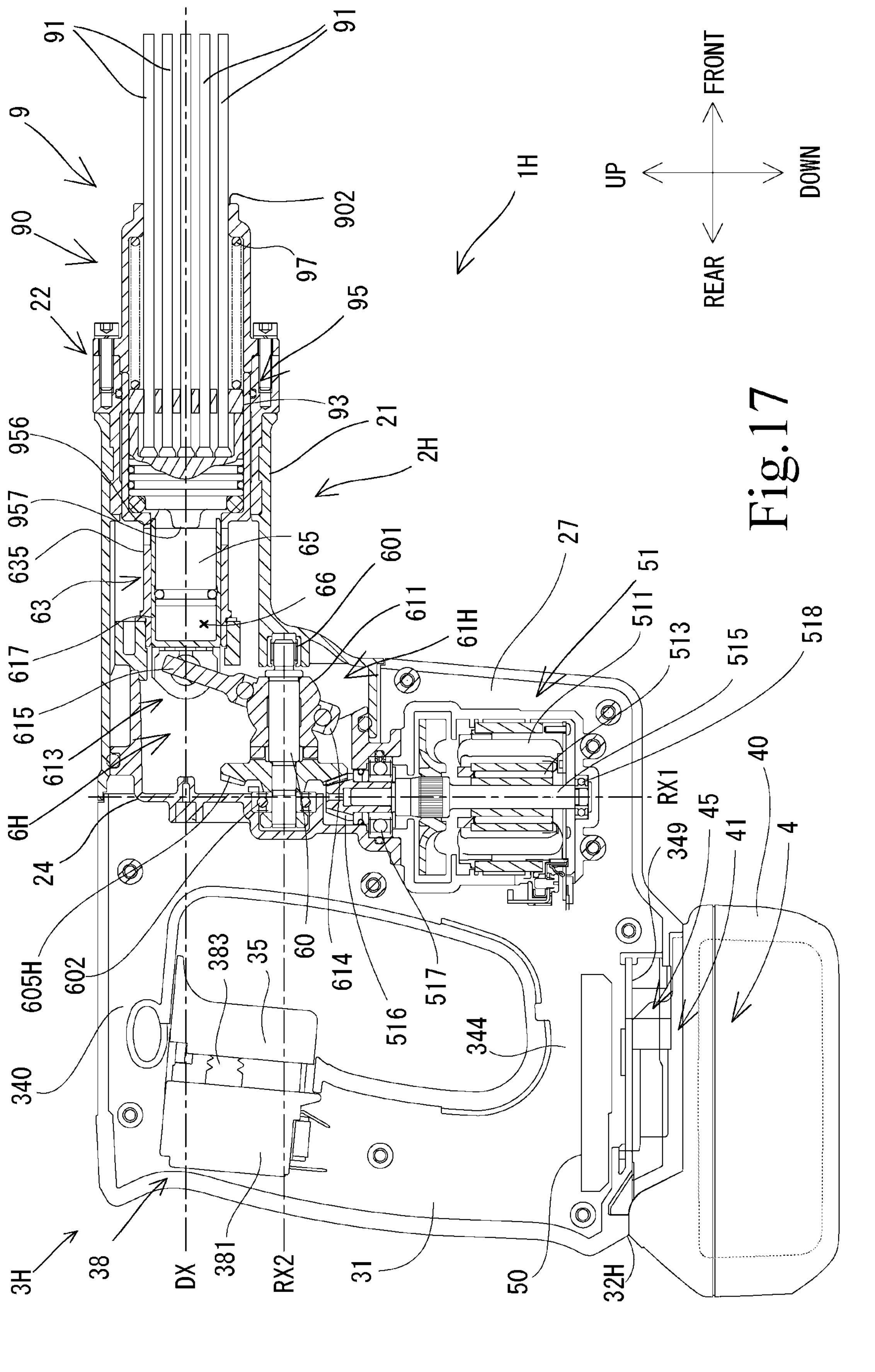
Fig.16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6H
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61H
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RX1
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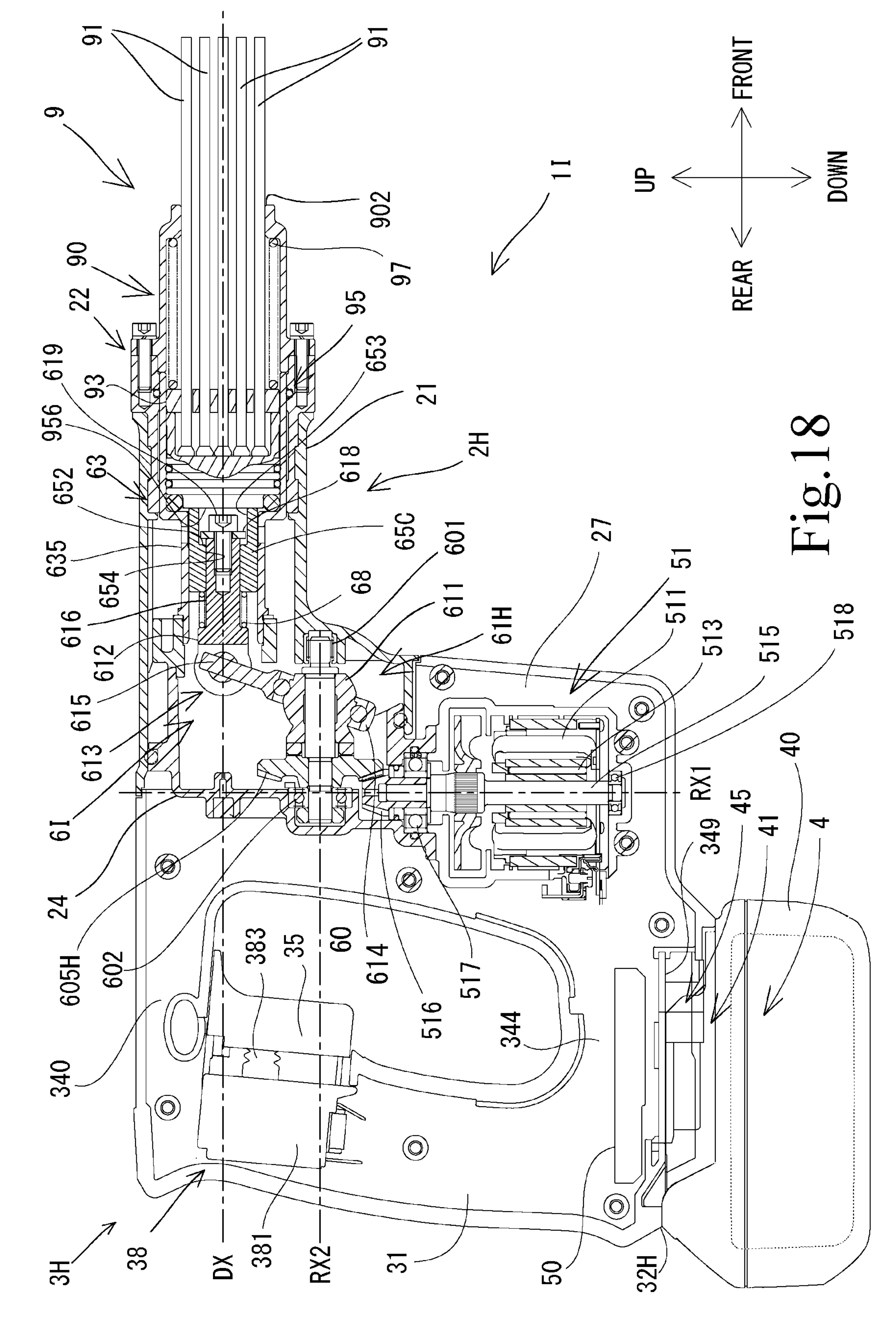
32H

Fig.17


FRONT
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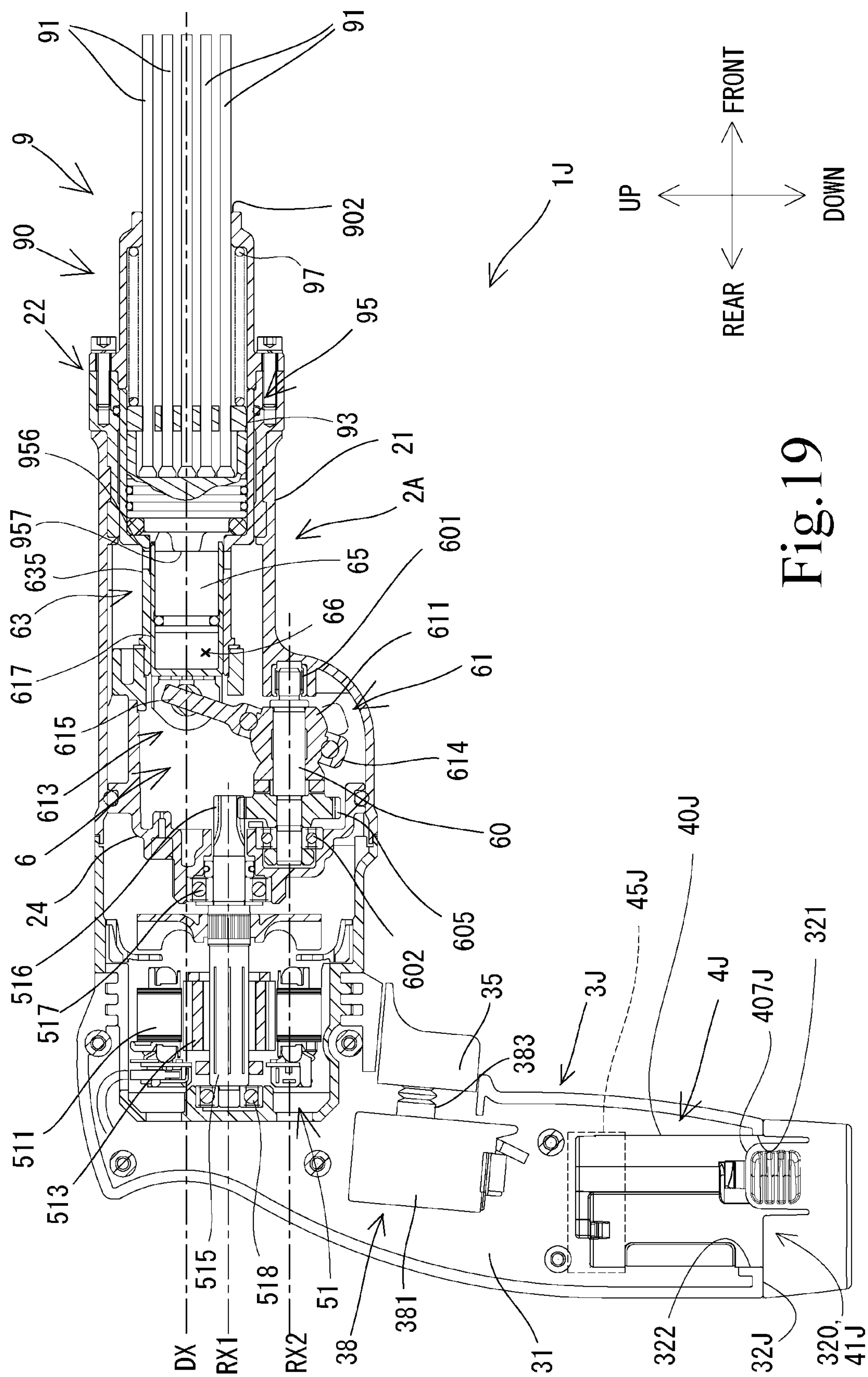
32H

Fig.18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3J
45J
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4J
407J
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513
515
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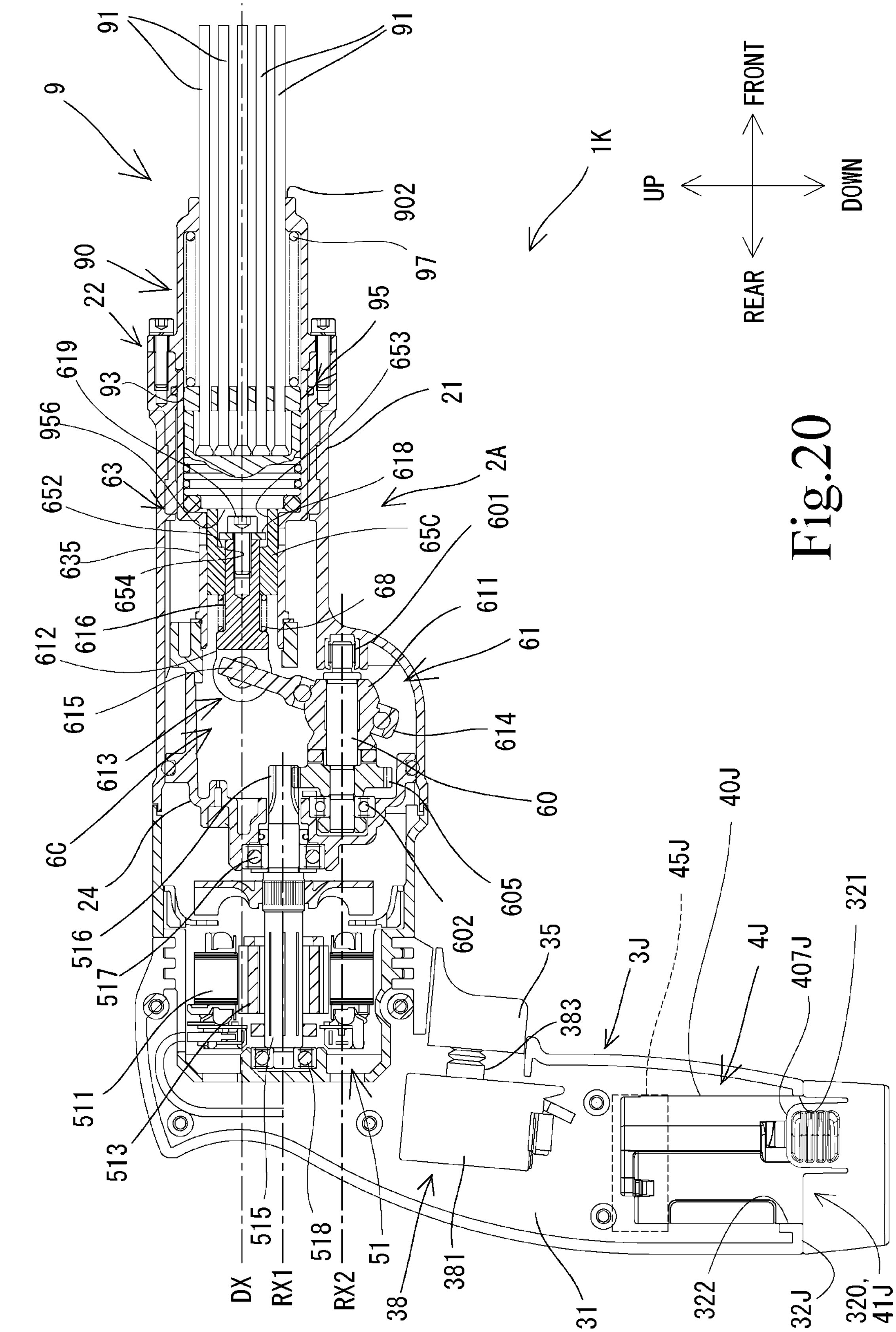
32J
320,
41J
DX
RX1
RX2
1J
UP
DOWN
FRONT
REAR

Fig.19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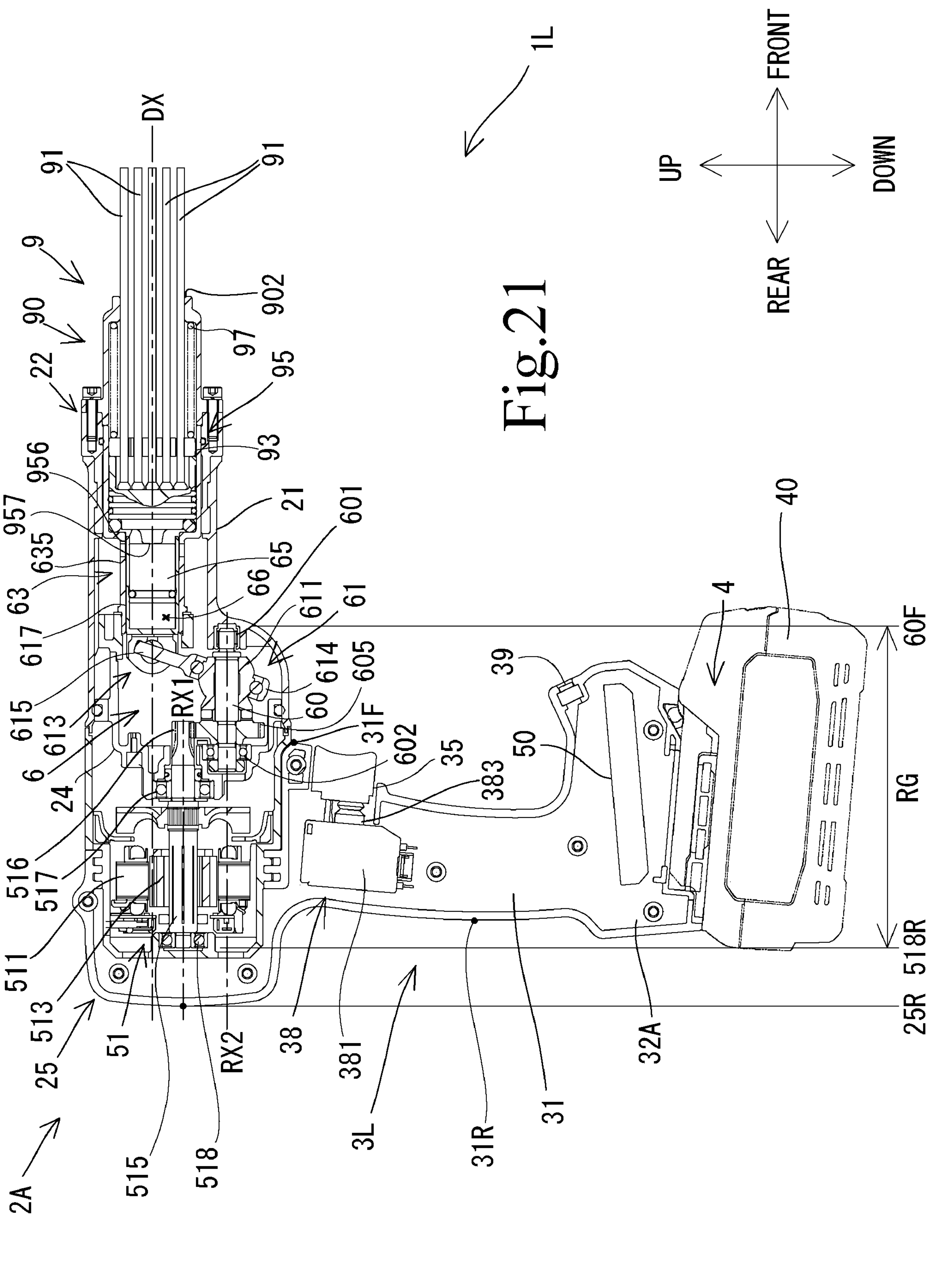
FRONT
REAR

Fig.20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51
25
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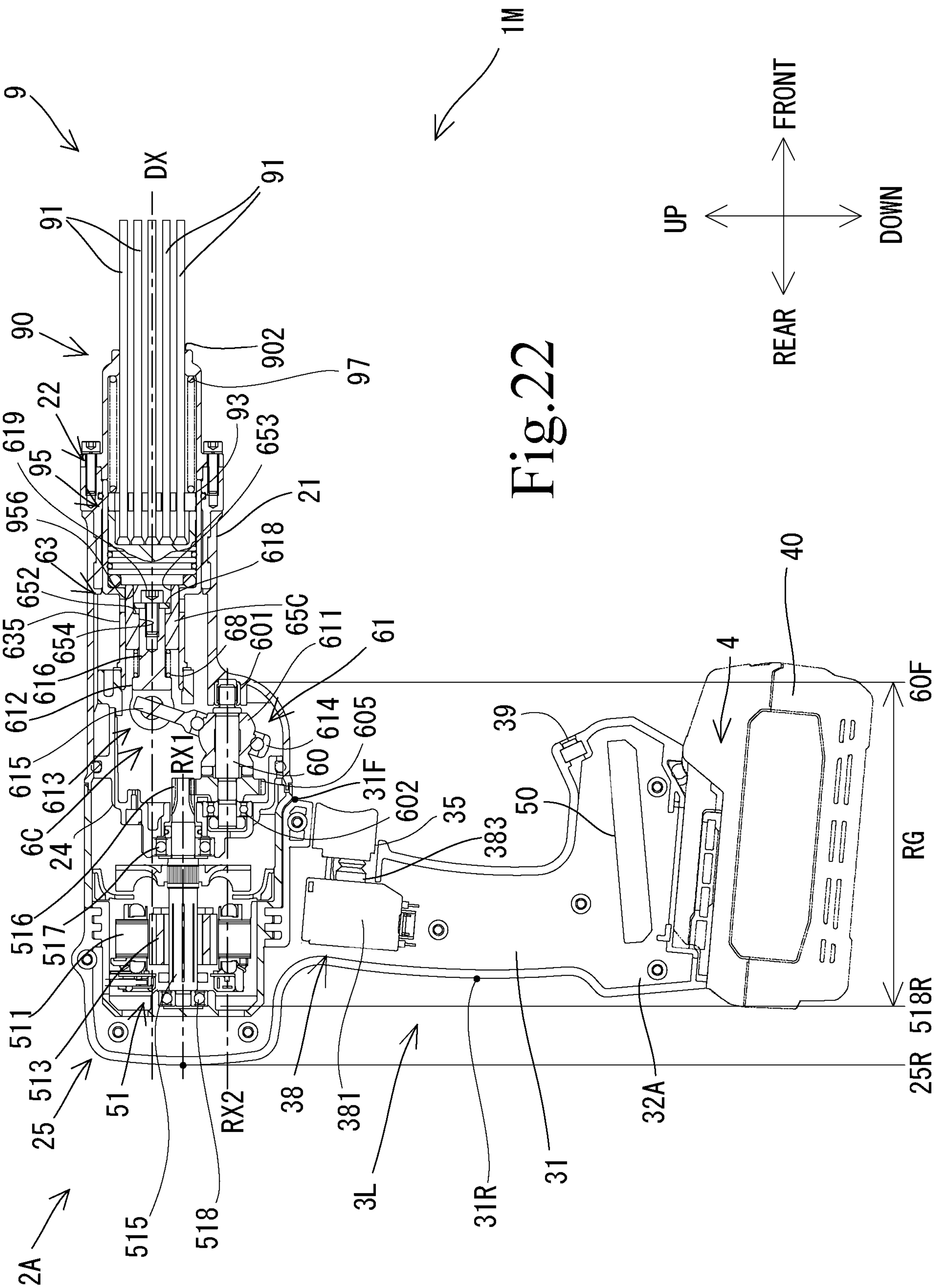
2A
UP
FRONT
DOWN
REAR

Fig.21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511
513
51
25
515
518
RX2
38
381
3L
31R
31
32A
518R
25R
2A
FRONT
UP
DOWN
REAR

Fig.22

ELECTRIC NEEDLE SCALER

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority to Japanese Patent Application No. 2024-196581, filed on November 11, 2024; Japanese Patent Application No. 2024-204740, filed on November 25, 2024; and Japanese Patent Application No. 2025-157501, filed on September 22, 2025. The contents of the foregoing applications are hereby fully incorporated herein by reference.

TECHNICAL FIELD

[0002] The present disclosure relates to an electric needle scaler.

BACKGROUND

[0003] A needle scaler (also referred to as a needle gun scaler or a needle gun) is a tool for removing foreign matters from a surface of a workpiece. The needle scaler has a number of needles (also referred to as pins) that are each axially movably supported by a support. The needle scaler is configured to remove foreign matters from a surface of a workpiece by applying hammering force to the needles and hitting the workpiece with tips of the needles. For example, a needle scaler disclosed in Japanese Utility Model Application Publication No. S63-34865 is configured to strike an anvil with a hammer that is reciprocated by an electric motor so as to apply hammering force to the needles via the anvil.

SUMMARY

[0004] The needle scaler is desired to be further improved in durability and convenience.

[0005] It is accordingly a non-limiting object of the present disclosure to provide a technique that contributes to improvement of the durability and convenience of an electric needle scaler.

[0006] According to one non-limiting aspect of the present disclosure, an electric needle scaler is provided that has a tool body, a motor, a battery mounting part, a power transmitting mechanism and a scaling mechanism.

[0007] At least part of the tool body extends along a driving axis that defines a front-rear direction of the needle scaler. The motor is an electric motor and is housed in the tool body. The motor includes an output shaft that is rotatable around a first rotational axis. The battery mounting part is configured to removably receive a battery. The power transmitting mechanism is housed in the tool body. The scaling mechanism includes needles. The needles protrude forward to be exposed out of the tool body and are supported to be movable in respective axial directions of the needles. The power transmitting mechanism includes a power transmitting part. The power transmitting part is operably connected to the output shaft of the motor and reciprocates along the driving axis by utilizing rotation of the output shaft and transmit force to the needles in the respective axial directions.

[0008] The needle scaler according to this aspect has the battery mounting part to which a battery can be mounted. Therefore, the needle scaler is provided with excellent operability and portability and thus with excellent convenience, compared with a needle scaler that can be connected to an external commercial power source.

[0009] According to another non-limiting aspect of the present disclosure, an electric needle scaler is provided that has a tool body, a motor, a hammering mechanism and a scaling mechanism.

[0010] The tool body extends along a driving axis that defines a front-rear direction of the needle scaler. The motor is an electric motor and is housed in the tool body. The motor includes an output shaft that is rotatable around a first rotational axis. The hammering mechanism is housed in the tool body. The scaling mechanism is supported by a front end part of the tool body and includes needles. The needles protrude forward to be exposed out of the tool body and are supported to be movable in respective axial directions of the needles. The hammering mechanism includes a piston and a striker. The piston is operably connected to the output shaft of the motor and configured to reciprocate along the driving axis along with rotation of the output shaft. The striker is configured to reciprocate along the driving axis by pressure fluctuations caused in an air chamber by reciprocation of the piston and apply hammering force to the needles.

[0011] The needle scaler according to this aspect has the hammering mechanism that is driven by power of the electric motor. The hammering mechanism reciprocates the striker by the action of air spring, or specifically by pressure fluctuations caused in the air chamber by reciprocation of the piston, and applies hammering force to the needles of the scaling mechanism. Therefore, the needle scaler is provided with excellent durability, compared with a structure in which the piston and the striker are connected by a mechanical spring (such as a compression coil spring) in order to apply the hammering force.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. **1** is a left side view of a needle scaler according to a first embodiment.

[0013] FIG. **2** is a front perspective view of the needle scaler.

[0014] FIG. **3** is a sectional view of the needle scaler.

[0015] FIG. **4** is a sectional view taken along line IV-IV in FIG. **1**.

[0016] FIG. **5** is a partial, enlarged view of FIG. **3**.

[0017] FIG. **6** is a sectional view taken along line VI-VI in FIG. **4**.

[0018] FIG. **7** is a left side view of a needle scaler according to a second embodiment.

[0019] FIG. **8** is a sectional view of the needle scaler.

[0020] FIG. **9** is a rear perspective view of the needle scaler with a battery removed therefrom.

[0021] FIG. **10** is a sectional view taken along line X-X in FIG. **8**.

[0022] FIG. **11** is an explanatory view for showing a using manner of the needle scaler.

[0023] FIG. 12 is an explanatory view showing a needle scaler according to a third embodiment.

[0024] FIG. 13 is an explanatory view showing a needle scaler according to a fourth embodiment.

[0025] FIG. 14 is an explanatory view showing a needle scaler according to a fifth embodiment.

[0026] FIG. 15 is an explanatory view showing a needle scaler according to a sixth embodiment.

[0027] FIG. 16 is an explanatory view showing a needle scaler according to a seventh embodiment.

[0028] FIG. 17 is an explanatory view showing a needle scaler according to an eighth embodiment.

[0029] FIG. 18 is an explanatory view showing a needle scaler according to a ninth embodiment.

[0030] FIG. 19 is an explanatory view showing a needle scaler according to a tenth embodiment.

[0031] FIG. 20 is an explanatory view showing a needle scaler according to an eleventh embodiment.

[0032] FIG. 21 is an explanatory view showing a needle scaler according to a twelfth embodiment.

[0033] FIG. 22 is an explanatory view showing a needle scaler according to a thirteenth embodiment.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0034] In one non-limiting embodiment according to the present disclosure, the power transmitting mechanism may include a reciprocating member and a striker as the power transmitting part. The reciprocating member is operably connected to the output shaft of the motor and reciprocates along the driving axis along with rotation of the output shaft. The striker applies hammering force to the needles by reciprocation of the reciprocating member.

[0035] According to this embodiment, strong hammering force can be applied to the needles by the power transmitting mechanism using the striker.

[0036] In addition or in the alternative to the preceding embodiments, the power transmitting mechanism may include an intermediate shaft and an oscillating member. The intermediate shaft may be operably connected to the output shaft and configured to rotate around a second rotational axis parallel to the first rotational axis along with rotation of the output shaft. The oscillating member may be arranged on the intermediate shaft and configured to oscillate in the front-rear direction along with rotation of the intermediate shaft. The reciprocating member may be operably connected to the oscillating member and configured to linearly reciprocate along the driving axis along with oscillation of the oscillating member.

[0037] According to this embodiment, the motion converting mechanism that converts rotary motion of the output shaft of the motor into linear motion of the reciprocating member is reduced in size, compared with a structure using a crank-piston mechanism.

[0038] In addition or in the alternative to the preceding embodiments, the reciprocating member may comprise a piston that forms an air chamber between the reciprocating member and the striker. The striker may reciprocate along the driving axis by pressure fluctuations caused in the air chamber by reciprocation of the piston.

[0039] According to this embodiment, the power transmitting mechanism reciprocates the striker by the action of air spring, or specifically by pressure fluctuations caused in the air chamber by reciprocation of the piston, and applies hammering force to the needles of the scaling mechanism. Therefore, the needle scaler is provided with excellent durability, compared with a structure in which the piston and the striker are connected by a mechanical spring in order to apply the hammering force.

[0040] In addition or in the alternative to the preceding embodiments, the piston may comprise a bottomed cylindrical piston cylinder. The striker may be slidable along the driving axis within the piston cylinder. The air chamber may be defined between a bottom of the piston cylinder and the striker.

[0041] According to this embodiment, the hammering mechanism is reduced in size, compared with a structure in which a cylindrical piston is arranged within a cylinder formed separately from the piston.

[0042] In addition or in the alternative to the preceding embodiments, the power transmitting mechanism may further include an elastic member that elastically connects the reciprocating member and the striker. The striker may reciprocate along the driving axis by an elastic force of the elastic member that is generated by reciprocation of the reciprocating member.

[0043] According to this embodiment, the power transmitting mechanism is realized with a relatively simple structure and the needle scaler is improved in productivity. Further, the hammering force of the striker can be adjusted by a simple way of adjusting the elastic force of the elastic member.

[0044] In addition or in the alternative to the preceding embodiments, the needle scaler may further include a sleeve that is arranged within the front end part of the tool body and holds the scaling mechanism. The front end part of the tool body may be made of synthetic resin. The sleeve may be made of metal and integrally formed with the front end part of the tool body. The scaling mechanism having the needles that move in the axial direction is easy to generate heat.

[0045] According to this embodiment, the tool body having the holding part (sleeve) that holds the scaling mechanism is provided with excellent durability, and the number of parts in assembling is reduced.

[0046] In addition or in the alternative to the preceding embodiments, the scaling mechanism may include a needle housing, a support and an anvil. The needle housing may have a front end having an opening through which the needles are inserted, and may be fixed to the tool body. The support may support the needles to be movable in the respective axial directions. The anvil may be arranged between the power transmitting part and the support in the front-rear direction. The anvil may be configured to apply the axial force to the needles by being struck by the power transmitting part. The support may have a bottomed cylindrical shape and include a bottom and a cylindrical peripheral wall. The bottom may have holes through which the needles are respectively inserted. The peripheral wall may extend rearward from an outer peripheral edge of the bottom and may be configured to slide in the front-rear direction along the driving axis within the needle housing. The anvil may include a large-diameter part and a small-diameter part. The large-diameter part may be configured to slide in the front-rear direction along the driving axis within the needle housing. The small-diameter part may protrude forward from the large-diameter part and have a smaller outer diameter than the large-diameter part. A rear end part of the peripheral wall of the support is configured to be fitted onto the small-diameter part of the anvil.

[0047] According to this embodiment, the anvil and the support substantially integrally slide within the needle housing, so that the anvil is restrained from tilting relative to the needle housing while the whole length of the anvil in the axial direction is reduced.

[0048] In addition or in the alternative to the preceding embodiments, one end part of each of the needles in the axial direction may be movable within a space that is defined between the bottom of the support and the anvil in the front-rear direction and surrounded by the peripheral wall of the support.

[0049] According to this embodiment, the space in which the needles can move in the axial direction is appropriately secured by the support and the anvil.

[0050] In addition or in the alternative to the preceding embodiments, the scaling mechanism may include a needle housing, a support, an anvil and an elastic element. The needle housing may have a front end having an opening through which the needles are inserted, and may be fixed to the tool body. The support may support the needles to be movable in the respective axial directions. The support may be configured to slide in the front-rear direction along the driving axis within the needle housing. The anvil may be arranged between the power transmitting part and the support in the front-rear direction and configured to slide in the front-rear direction along the driving axis within the needle housing. The anvil may be configured to apply hammering force to the needles by being struck by the power transmitting part. The elastic element may be disposed between the anvil and a rear end part of the needle housing in the front-rear direction.

[0051] According to this embodiment, the elastic element alleviates impact of collision when the needles are bounced back rearward and collide with the anvil.

[0052] In addition or in the alternative to the preceding embodiments, the needle scaler may further comprise a handle and an operation member. The handle may be connected to the tool body and include a grip part extending in a first direction crossing the driving axis. The operation member may be provided on a front side of the grip part and configured to be manually operated by a user to instruct start of the motor. The grip part may have a first end that is closer to the tool body and a second end that is farther from the tool body, in the first direction. The operation member may be arranged in a region of the grip part that includes at least a center position of the grip part that is substantially equidistant from the first and second ends in the first direction.

[0053] According to this embodiment, the operation member is arranged in a region including a center position in the first direction (or the longitudinal direction of the grip part). Thus, the operation member can be easily operated with one or more fingers of a user, whether the user holds the grip part in an orientation with a thumb on a first end side (on the end of the tool body side) of the grip part, or in an orientation with the thumb on a second end side (opposite side from the tool body) of the grip part. Further, the needle scaler can be used in various attitudes, but the orientation in which the grip part is held does not substantially affect the operability of the operation member, so that the needle scaler exhibits superior operability in various attitudes.

[0054] In addition or in the alternative to the preceding embodiments, the needle scaler may further comprise a lighting device that is arranged to illuminate an area forward of the needles.

[0055] According to this embodiment, workability in a dark place is improved.

[0056] Representative, non-limiting embodiments of the present disclosure are now specifically described with reference to the drawings.

<First Embodiment>

[0057] A needle scaler **1**A according to a first embodiment of the present disclosure is now described with reference to FIGS. **1** to **6**.

[0058] The needle scaler **1**A is a relatively small portable power tool, which is also referred to as a needle gun scaler or a needle gun. The needle scaler **1**A is configured to move elongate needles **91** in an axial direction to remove foreign matters (such as rust and paint) from a surface (hereinafter referred to as a working surface) of a workpiece with tips of the needles. The needles **91** can be replaced with other needles **91**, but cannot be replaced with a tool accessory (such as a tool bit for crushing or chipping and a scraper for peeling) of a different kind from the needles **91**. In other words, the needle scaler **1**A of this embodiment is dedicated for operation using the needles **91**.

[0059] First, the structure of the needle scaler **1**A is described in brief.

[0060] As shown in FIGS. **1** to **3**, an outer shell of the needle scaler **1**A is defined by a tool body **2**A extending along a driving axis DX and an elongate handle **3**A protruding from the tool body **2**A in a direction crossing the driving axis DX.

[0061] The tool body **2**A houses a scaling mechanism **9** including the needles **91**, an electric motor **51**, and a hammering mechanism **6** that is operably connected to the motor **51** and applies hammering force to the scaling mechanism **9** when the motor **51** is driven. The scaling mechanism **9** is supported by one end part of the tool body **2**A in the extending direction of the driving axis DX. The hammering mechanism **6** is configured to convert rotational power of the motor **51** into linear motion and apply hammering force to the scaling mechanism **9** by utilizing the action of air spring and thus move the needles **91** in the axial direction.

[0062] The handle **3**A is a so-called pistol grip and is connected to the tool body **2**A in a cantilever manner. Specifically, one end of the handle **3**A in a longitudinal direction is connected as a base end to the tool body **2**A, and the other end is a free end. In this embodiment, the handle **3**A extends in a direction substantially orthogonal to the driving axis DX, from an end part of the tool body **2**A on the opposite side from the scaling mechanism **9** in the extending direction of the driving axis DX. The handle **3**A includes a grip part **31** configured to be held by a user, and a trigger **35** that is operated by a user to start the motor **51**. When the trigger **35** is depressed, the motor **51** is driven, and the hammering mechanism **6** and thus the scaling mechanism **9** are operated.

[0063] The structure of the needle scaler **1**A is now described in detail. In the following description, for convenience sake, the extending direction of the driving axis DX is defined as a front-rear direction of the needle scaler **1**A. In the front-rear direction, the side of the scaling mechanism **9** is defined as the front side of the needle scaler **1**A, and the opposite side (on which the handle **3**A is connected) is defined as the rear side of the needle scaler **1**A. A direction orthogonal to the driving axis DX and corresponding to the extending direction of the handle **3**A is defined as an up-down direction of the needle scaler **1**A. The up-down direction of the needle scaler **1**A is not synonymous with a vertical direction. In the up-down direction, the side of the base end of the handle **3**A is defined as an upper side of the needle scaler **1**A, and the opposite side (the side of the free end) is defined as a lower side of the needle scaler **1**A. A direction orthogonal to the front-rear direction and the up-down direction of the needle scaler **1**A is defined as a left-right direction of the needle scaler **1**A.

[0064] The structure of the tool body **2**A is now described.

[0065] As shown in FIGS. **3** and **4**, the tool body **2**A is a hollow body extending along the driving axis DX. The tool body **2**A of this embodiment is made of synthetic resin. A front part of the tool body **2**A is also referred to as a barrel part **21**, and has a circular cylindrical shape having a smaller diameter than a rear part of the tool body **2**A extending rearward from the barrel part **21**. The barrel part **21** extends along the driving axis DX. A user can use an auxiliary handle (not shown) that can be removably attached to the barrel part **21**, as necessary. Alternatively, a user can hold the handle **3** with one hand and auxiliary hold the barrel part **21** with the other hand. The barrel part **21** houses part of the scaling mechanism **9** and part of the hammering mechanism **6**. The rear part of the tool body **2**A extending rearward from the barrel part **21** houses the motor **51** and part of the hammering mechanism **6**.

[0066] A metal support **24** is fitted into the tool body **2**A and supported to be substantially immovable relative to the tool body **2**A. The support **24** partitions an inside space of the tool body **2**A into a space in which the motor **51** is housed behind the support **24** and a space in which the hammering mechanism **6** is disposed in front of the support **24**. Lubricant is filled in the space in front of the support **24**. It can be said that the tool body **2**A is an outer housing and the support **24** is an inner housing fixed within the outer housing.

[0067] Elements (mechanisms) disposed within the tool body **2**A are now described.

[0068] First, the motor **51** is described. As shown in FIG. **3**, the motor **51** is disposed within the rear end part of the tool body **2**A. The motor **51** has a stator **511**, a rotor **513** and an output shaft **515** that integrally rotates with the rotor **513**. In this embodiment, the motor **51** is a brushless DC motor, but in other embodiments, the motor **51** may be a brush motor.

[0069] The output shaft **515** is rotatably supported at front and rear end parts by bearings **517**, **518**, respectively, and extends in the front-rear direction. The front bearing **517** is supported by the support **24**. The front end part of the output shaft **515** protrudes into the space in front of the support **24**, and a pinion **516** is formed in this part. The rear bearing **518** is supported by the tool body **2**A. A rotational axis RX1 of the output shaft **515** extends in parallel to the driving axis DX below the driving axis DX.

[0070] The hammering mechanism **6** is now described. As shown in FIGS. **3** to **5**, the hammering mechanism **6** is arranged in front of the motor **51** (specifically, substantially in a central part in the front-rear direction) within the tool body **2**A. The hammering mechanism **6** includes an intermediate shaft **60**, a motion converting mechanism **61** and a striker **65**.

[0071] As shown in FIG. **5**, the intermediate shaft **60** is rotatably supported at front and rear end parts by bearings **601**, **602**, respectively, and extends within a central part of the tool body **2**A in the front-rear direction. The front bearing **601** is supported by the tool body **2**A. The rear bearing **602** is supported by the support **24**. A rotational axis RX2 of the intermediate shaft **60** extends in parallel to the driving axis DX and the rotational axis RX1 of the output shaft **515** below the rotational axis RX1. With this arrangement, the distance (so-called center height) between the driving axis DX and an upper surface of the tool body **2**A can be made significantly shorter than the distance between the driving axis DX and a lower surface of the tool body **2**A. In this embodiment, the driving axis DX and the rotational axes RX1, RX2 are arranged on a plane that substantially divides the tool body **2**A into two halves in the left-right direction.

[0072] The intermediate shaft **60** is operably connected to the output shaft **515** of the motor **51**. More specifically, a gear **605** is fixedly fitted onto a rear end part of the intermediate shaft **60** and engaged with the pinion **516** formed on the front end part of the output shaft **515**. Thus, the intermediate shaft **60** is rotated along with rotation of the output shaft **515**.

[0073] The motion converting mechanism **61** includes a rotary body **611** that is arranged on the intermediate shaft **60**, an oscillating member **613** that is operably connected to the rotary body **611**, and a piston cylinder **617** that is operably connected to the oscillating member **613**.

[0074] The rotary body **611** is fitted onto the intermediate shaft **60** in front of the gear **605** so as to be integrally rotated with the intermediate shaft **60**. The oscillating member **613** includes a ring part **614** that is fitted onto the rotary body **611**, and an arm part **615** extending from the ring part **614**. The rotary body **611** and the oscillating member **613** are configured such that the arm part **615** is oscillated in the front-rear direction along with rotation of the intermediate shaft **60** and the rotary body **611**. In this embodiment, the rotary body **611** and the oscillating member **613** are connected via rolling elements and integrally formed as an assembly that is called a swash bearing, a wobble bearing or a wobble plate. The rotary body **611** and the oscillating member **613** can however be appropriately changed in structure, provided that rotation of the intermediate shaft **60** can be converted into linear motion in the front-rear direction and transmitted to the piston cylinder **617**. For example, the rotary body **611** may be integrally formed with the intermediate shaft **60**.

[0075] The piston cylinder **617** is a circular bottomed cylindrical member. The piston cylinder **617** is arranged with an opening facing forward within a rear half part of a cylinder **63**. The cylinder **63** of this embodiment is a cylindrical stepped member and has a front half part having a larger inner diameter and a larger outer diameter than the rear half part of the cylinder **63**. The front and rear half parts of the cylinder **63** are hereinafter referred to as a large-diameter part **631** and a small-diameter part **635**, respectively. A part connecting a rear end of the large-diameter part **631** and a front end of the small-diameter part **635** is referred to as a shoulder part **633**. The cylinder **63** is fixedly held within the tool body 2A. The mechanism for holding the cylinder **63** will be described in detail below.

[0076] The piston cylinder **617** is configured to slide within the small-diameter part **635** of the cylinder **63** in the front-rear direction along the driving axis DX. Thus, the small-diameter part **635** of the cylinder **63** is configured as a sliding guide for the piston cylinder **617**. A rear end part of the piston cylinder **617** is operably connected to the arm part **615** of the oscillating member **613**. Thus, the piston cylinder **617** is reciprocally slid in the front-rear direction along with oscillation of the arm part **615**.

[0077] The striker **65** is a striking element that is configured to apply hammering force to the needles **91** by striking an anvil **95** (described below) of the scaling mechanism **9** along with reciprocation of the piston cylinder **617**. The striker **65** is a cylindrical member and is arranged within the piston cylinder **617** so as to be slidable along the driving axis DX. A space between the bottom of the piston cylinder **617** and the striker **65** defines an air chamber **66** that functions as an air spring. The striker **65** is reciprocally slid within the piston cylinder **617** by pressure fluctuations caused in the air chamber **66** by the reciprocation of the piston cylinder **617**. A recess **651** having a circular section is formed in a central part of a front end surface of the striker **65**.

[0078] The holding mechanism for the cylinder **63** is now described.

[0079] As shown in FIGS. **4** and **5**, the cylinder **63** is supported within the tool body **2A** so as to be substantially immovable in the front-rear direction relative to the tool body 2A. More specifically, the rear end part of the small-diameter part **635** of the cylinder **63** is fitted onto a cylindrical part **241** formed on an upper front end part of the support **24**. A small flange **636** is formed on a rear part of the small-diameter part **635** and protrudes radially outward. A front end of the cylindrical part **241** of the support **24** abuts on the small flange **636** via a washer and prevents further rearward movement of the cylinder **63**.

[0080] The large-diameter part **631** of the cylinder **63** is fitted into a cylindrical sleeve **22** fixed to the barrel part **21**. A front part of the sleeve **22** is configured as a flange **221** and has a larger diameter than the other part of the sleeve **22**. The flange **221** of the sleeve **22** is arranged in front of a front end of the barrel part **21**, and a part (small-diameter part) extending rearward of the flange **221** is arranged within the barrel part **21**. In this embodiment, the sleeve **22** is made of metal and integrally formed with the barrel part **21** made of synthetic resin. Thus, the sleeve **22** and the barrel part **21** are formed as a single member that cannot be substantially separated from each other. The sleeve **22** may therefore be considered as part of the tool body **2**A.

[0081] Although the details will be described later below, the large-diameter part **631** of the cylinder **63** is part of a needle housing **90** of the scaling mechanism **9**. When the scaling mechanism **9** is driven, a support **93** and an anvil **95** slide within the large-diameter part **631**, so that the large-diameter part **631** generates heat. Thus, the durability of the tool body **2**A is enhanced by providing the metal sleeve **22** for holding the large-diameter part **631** like in this embodiment. Further, the number of parts in assembling is reduced by integrally forming the sleeve **22** with the tool body **2**A. In other embodiments, however, the sleeve **22** may be separately formed from the tool body **2**A and then fixed within the tool body **2**A. Alternatively, the sleeve **22** may be omitted.

[0082] Although the details will be described later below, a cylindrical member **900**, which is another part of the needle housing **90**, is fixed to the sleeve **22** with a screw **99** (see FIG. **2**) from the front. A rear end of the cylindrical member **900** abuts on a front end of the large-diameter part **631** and prevents further forward movement of the cylinder **63**.

[0083] An annular groove is formed in an inner peripheral surface of a front end part of the sleeve **22**, and an annular elastic element (O-ring) **227** for sealing is fitted in the groove. The elastic element **227** seals a gap between an inner peripheral surface of the sleeve **22** and the large-diameter part **631** of the cylinder **63** and thus reduces the possibility of leakage of lubricants from the tool body **2**A to the outside.

[0084] As shown in FIGS. **4** and **6**, the cylinder **63** and the tool body **2**A are unrotatably connected to each other via a rotation stopper ring **64**. The rotation stopper ring **64** is a ring-like (annular) member and is fitted onto a rear end part (specifically, the small flange **636** of the small-diameter part **635**) of the cylinder **63**.

[0085] Two recesses **641** are formed in an inner peripheral surface of the rotation stopper ring **64** and arranged opposite to each other across the driving axis DX. The recesses **641** have a semispherical section and extend from a front end to a central part of the rotation stopper ring **64** in the font-rear direction. Two semispherical recesses **637** are formed corresponding to the recesses **641** of the rotation stopper ring **64** in an outer peripheral surface of the small flange **636** of the small-diameter part **635**. The cylinder **63** and the rotation stopper ring **64** are connected so as not to be rotatable around the driving axis DX relative to each other, via balls **645** respectively disposed in the recesses **637**, **641**. A large flange **638** having a larger diameter than the small flange **636** of the cylinder **63** is disposed in front of the small flange **636**. The rotation stopper ring **64** is held between the large flange **638** and the washer disposed in front of the cylindrical part **241** of the support **24**.

[0086] A projection **643** is formed on about a half of an outer periphery of the rotation stopper ring **64** and protrudes radially outward in a circular arc shape. Grooves **644** are formed in an outer peripheral surface of the projection **643** and arranged apart from each other. The grooves **644** have a rectangular section and extend from a front end to a rear end of the rotation stopper ring **64**. Projections **201** are formed corresponding to the grooves **644** in an inner peripheral surface of an upper half part of a rear part of the barrel part **21**. The projections **201** have a rectangular section and extend in the font-rear direction. The tool body **2**A and the rotation stopper ring **64** are connected so as not to be rotatable around the driving axis DX relative to each other, by engagement between the projections **201** and the grooves **644**.

[0087] As described above, the needle scaler **1**A is dedicated for operation using the needles **91**. In such a dedicated tool, the needles **91** may just be movable in the axial direction (substantially in the front-rear direction) relative to the tool body **2**A, and from the viewpoint of working efficiency, it is rather preferred that the scaling mechanism **9** is configured not to be rotated. Therefore, in this embodiment, the cylinder **63** is supported to be substantially unrotatable relative to the tool body **2**A via the rotation stopper ring **64**. In other embodiments, however, the rotation stopper ring **64** may be omitted.

[0088] The scaling mechanism **9** is now described. As shown in FIGS. **4** and **5**, the scaling mechanism **9** is supported in a front half part of the barrel part **21** of the tool bod **2**A. The scaling mechanism **9** of this embodiment includes the needle housing **90**, the support **93**, the needles **91** supported by the support **93**, and the anvil **95** that transmits the hammering force to the needles **91**.

[0089] The needle housing **90** has a cylindrical shape, and is supported coaxially with the cylinder **63** by the front half part of the barrel part **21**. The needle housing **90** houses the support **93**, the anvil **95** and part of the needles **91**. In this embodiment, the needle housing **90** includes the large-diameter part **631** and the shoulder part **633** of the cylinder **63** and the cylindrical member **900** separate from the cylinder **63**.

[0090] A front end of the cylindrical member **900** has an annular wall **901** protruding radially inward. An inner periphery of the wall **901** defines a front end opening **902** of the needle housing **90**. A flange **904** is formed on a rear end part of the cylindrical member **900** and protrudes radially outward. The cylindrical member **900** is fixed to the sleeve **22** and thus the tool body **2**A by the screw **99** being inserted through a hole of the flange **904** and screwed into a screw hole of the flange **221** of the sleeve **22** (see FIG. **2**). The needles **91** can be replaced by removing the screw **99** and the cylindrical member **900**.

[0091] The large-diameter part **631** of the cylinder **63** and the cylindrical member **900** have substantially the same inner diameter, and are arranged such that the rear end of the cylindrical member **900** abuts on the front end of the large-diameter part **631** of the cylinder **63**. With this arrangement, the large-diameter part **631** and the shoulder part **633** of the cylinder **63** form a rear half part of the needle housing **90**, and the cylindrical member **900** forms a front half part of the needle housing **90**.

[0092] Each of the needles **91** includes an elongate cylindrical (round rod-like) body **911** and a head **915** formed on one end of the body **911** in the axial direction. In this embodiment, the head **915** has a truncated conical shape having a diameter decreasing toward the other end of the body **911** in the axial direction (a tip of the needle **91**).

[0093] The support **93** supports the needles **91** to be movable in the axial direction of the needles **91**. The support **93** is arranged within the needle housing **90** so as to be slidable in the front-rear direction along the driving axis DX. More specifically, the support **93** is a bottomed cylindrical member having a slightly smaller outer diameter than the needle housing **90**, and includes a circular bottom **931** and a cylindrical peripheral wall **935** extending in the axial direction of the support **93** from a peripheral edge of the bottom **931**. The support **93** is arranged coaxially with the needle housing **90** within the needle housing **90** in such a direction that the peripheral wall **935** extends rearward from the bottom **931**.

[0094] The bottom **931** has holes **932** formed through the bottom **931** in the front-rear direction. Each of the holes **932** has a rear end part that is configured to come into surface contact with part of the head **915** of the needle **91** when the needle **91** moves forward. The other part (other than the rear end part) of the hole **932** has a diameter large enough to allow the body **911** of the needle **91** to slide therethrough.

[0095] The needle **91** is inserted through the hole **932** from behind the bottom **931**, with the head **915** on the rear side. Although slightly tilted, the needle **91** moves substantially in the front-rear direction of the needle scaler **1**A, while the body **911** slides within the hole **932**. The needle **91** can slide up to a position where the head **915** abuts on the rear end part of the hole **932**, relative to the support **93** in the axial direction of the needle **91**. Part of the needle **91** including the tip (front end) of the needle **91** always protrudes forward of the needle housing **90** from the front end opening **902** of the needle housing **90**.

[0096] The anvil **95** is arranged between the striker **65** of the hammering mechanism **6** and the support **93** in the front-rear direction. The anvil **95** can be slid in the front-rear direction along the driving axis DX within the needle housing **90**. More specifically, the anvil **95** is a cylindrical stepped member as a whole and is arranged coaxially with the needle housing **90** within the needle housing **90**. The anvil **95** includes a large-diameter part **951**, a front small-diameter part **954**, a rear small-diameter part **956** and a rear projection **957**.

[0097] The large-diameter part **951** is a central part of the anvil **95** in the axial direction (the front-rear direction) and has the largest diameter in the anvil **95**. The large-diameter part **951** is configured to slide within the needle housing **90**. The large-diameter part **951** may also be referred to as a sliding part.

[0098] The front small-diameter part **954** protrudes forward from the large-diameter part **951** and has a smaller diameter than the large-diameter part **951**. Thus, the large-diameter part **951** protrudes radially outward of the front small-diameter part **954** in a flange-like form behind the front small-diameter part **954**. The diameter of the front small-diameter part **954** is slightly smaller than the inner diameter of the peripheral wall **935** of the support **93**. Therefore, the rear end part of the peripheral wall **935** of the support **93** can slide in the front-rear direction relative to the front small-diameter part **954** while being fitted onto the front small-diameter part **954**. Thus, the anvil **95** and the support **93** substantially integrally slide within the needle housing **90**, so that the anvil **95** is restrained from tilting relative to the needle housing **90** while the whole length of the anvil **95** in the axial direction is reduced.

[0099] With such structure, a cylindrical space **96** is defined between the bottom **931** of the support **93** and the front small-diameter part **954** radially inside of the peripheral wall **935** and in the front-rear direction. The rear end part of the needle **91** can move in the front-rear direction within the space **96**. A front surface of the front small-diameter part **954** collides with a rear surface of the head **915** and applies hammering force to the needles **91**.

[0100] The rear small-diameter part **956** protrudes rearward from the large-diameter part **951** and has a smaller diameter than the large-diameter part **951**. An annular elastic element (O-ring) **98** is fitted onto the rear small-diameter part **956**. Thus, in the radial direction, the elastic element **98** is disposed between the anvil **95** (specifically, the rear small-diameter part **956**) and the needle housing **90** (specifically, the rear half part). Further, in the front-rear direction, the elastic element **98** is disposed between the anvil **95** (specifically, the large-diameter part **951**) and the rear end part of the needle housing **90** (specifically, the shoulder part **633** of the cylinder **63**).

[0101] The rear projection **957** protrudes rearward from the rear small-diameter part **956**. The diameter of the rear projection **957** is set smaller than the diameter of the recess **651** formed in the front end surface of the striker **65**. Although the details will be described later below, in this embodiment, when the hammering mechanism **6** is driven, the rear projection **957** is directly struck by the striker **65** arranged within the small-diameter part **635** of the cylinder **63**. A rear end surface of the rear projection **957** receives the hammering force from the striker **65**. In other embodiments, the rear projection **957** of the anvil **95** may be omitted, and the front surface of the striker **65** may collide with a rear surface of the rear small-diameter part **956**. Alternatively, a projection may be formed on the striker **65** and protrude forward, and a front surface of the projection may collide with the anvil **95**.

[0102] Further, the scaling mechanism **9** of this embodiment includes a biasing member **97** that is disposed between the front end wall **901** of the needle housing **90** and the support **93** in the front-rear direction. The biasing member **97** of this embodiment is a compression coil spring. The biasing member **97** biases the support **93** rearward relative to the needle housing **90** and thus the tool body **2**A. As described above, the rear end part of the peripheral wall **935** of the support **93** is fitted onto the front small-diameter part **954**. The rear end of the peripheral wall **935** abuts on the front end surface of the large-diameter part **951** of the anvil **95** by the biasing force of the biasing member **97**, and the anvil **95** is also biased rearward relative to the needle housing **90**.

[0103] The handle **3**A and elements (mechanisms) disposed therein are now described.

[0104] As shown in FIGS. **1** to **3**, the handle **3**A is an elongate hollow body protruding downward from the rear end part of the tool body **2**A. The handle **3**A includes a grip part **31** configured to be held by a user. The grip part **31** has a diameter suitable for a user to hold, and has a length slightly longer than the average width of a hand of an adult male. In this embodiment, the whole handle **3**A except for a lower end part **32** forms the grip part **31**.

[0105] The trigger **35** is arranged on the front side of the grip part **31**. The trigger **35** is a manual operation member that is configured to be depressed by a user to start the motor **51**. In this embodiment, the trigger **35** is supported by an upper end part of the grip part **31** so as to be linearly slidable substantially in the front-rear direction (the extending direction of the driving axis DX).

[0106] A switch **38** is arranged just behind the trigger **35** within the grip part **31**. The switch **38** is configured to be turned on and off according to the depressing operation of the trigger **35**. The switch **38** of this embodiment has a switch body **381** and a plunger **383** biased forward and protruding forward from the switch body **381**. A protruding end of the plunger **383** is held in contact with the trigger **35**. The switch **38** is configured to be normally kept off, and turned on when the plunger **383** is pushed into the switch body **381**. The switch **38** is electrically connected to a controller **50** (described below).

[0107] In an initial state in which the trigger **35** is biased forward by the plunger **383** and not subjected to rearward external force, the trigger **35** is held in a frontmost position. When the trigger **35** is located in the frontmost position, the switch **38** is in an off state. When the trigger **35** is depressed and slid rearward to a prescribed position while pushing in the plunger **383**, the switch **38** is tuned on.

[0108] A lower end part **32**A of the handle **3**A has a rectangular box-like shape larger than the diameter of the grip part **31**. A lighting unit **39** is arranged on the front side of the lower end part **32**A. The lighting unit **39** includes a light source (such an LED) and is supported by the lower end part **32**A to illuminate a working area of the needles **91** (i.e. an area in front of the barrel part **21**). Specifically, the lighting unit **39** is arranged to illuminate diagonally forward and upward through an opening formed in the lower end part **32**A.

[0109] The controller **50** is disposed within the lower end part **32**A. The controller **50** includes at least one processor (such as a CPU) or processing circuit and controls operation of the needle scaler **1**A. In this embodiment, the controller **50** controls driving of the motor **51** and driving of the lighting unit **39**. More specifically, the controller **50** drives the motor **51** and lights the lighting unit **39** while the switch **38** is in an on state.

[**0110**] A battery mounting part **4** to which a battery **40** as a power source can be mounted is provided in the lower end part **32**A of the handle **3**A. The battery **40** is mounted to the battery mounting part **4** and most of the battery **40** is exposed below the lower end part **32**A of the handle **3**A. The structure of the battery **40** is well known and therefore not shown and described in detail in this embodiment. In other embodiments, the power source of the needle scaler **1**A may be an external AC power source instead of the battery **40**.

[**0111**] Operation of the needle scaler **1**A is now described.

[**0112**] A user holds the grip part **31** and places the tips of the needles **91** in the vicinity of the working surface. When the user depresses the trigger **35**, the motor **51** is driven and the hammering mechanism **6** is operated to apply hammering force to the scaling mechanism **9**. Specifically, the air pressure inside the air chamber **66** fluctuates along with reciprocation of the piston cylinder **617**, so that the striker **65** is slid in the front-rear direction within the piston cylinder **617**. More specifically, when the piston cylinder **617** is moved forward, air of the air chamber **66** is compressed, so that the internal pressure increases. Then the striker **65** moves forward at high speed by the action of the air spring and collides with the anvil **95**.

[**0113**] The anvil **95** transmits the kinetic energy of the striker **65** to the support **93** that abuts on the front end surface of the large-diameter part **951** of the anvil **95**. The anvil **95** and the support **93** move forward against the biasing force of the biasing member **97**. The front surface of the anvil **95** strikes the heads **915** of the needles **91**, so that hammering force is applied to the needles **91**. The needles **91** move in the axial direction, and the tips of the needles **91** collide with a workpiece and thereby remove foreign matters from a working surface of the workpiece. When the needles **91** are bounced back rearward by reaction of the collision with the workpiece, the needles **91** collide with the anvil **95**. At this time, the elastic element **98** disposed between the rear surface of the large-diameter part **951** of the anvil **95** and the rear end part of the needle housing **90** (the shoulder part **633**) alleviates the impact of the collision.

[**0114**] As described above, the needle scaler **1**A of this embodiment has the hammering mechanism **6** that is driven by power of the electric motor **51**. The hammering mechanism **6** reciprocates the striker **65** by the action of air spring, or specifically by pressure fluctuations caused in the air chamber **66** by reciprocation of the piston, and applies hammering force to the needles **91** of the scaling mechanism **9**. Therefore, the needle scaler **1**A of this embodiment is provided with excellent durability, compared with a structure in which the piston and the striker are connected by a mechanical spring (such as a compression coil spring) to apply the hammering force.

<Second Embodiment>

[**0115**] A needle scaler **1**B according to a second embodiment of the present disclosure is now described with reference to FIGS. **7** to **11**. The needle scaler **1**B is different from the needle scaler **1**A of the first embodiment mainly in the structures of a tool body **2**B and a handle **3**B, but otherwise it has substantially the same structure as the needle scaler **1**A. Therefore, in the following description, components or structures substantially identical to those of the first embodiment are given like reference numerals, and are not described or only simply described. The structures different from the first embodiment are now mainly described.

[**0116**] As shown in FIGS. **7** and **8**, the needle scaler **1**B of this embodiment has a tool body **2**B that extends along the driving axis DX and houses the motor **51**, the hammering mechanism **6** and the scaling mechanism **9**. In this embodiment, a handle **3**B is connected to a rear end part **25** of the tool body **2**B in a cantilever manner and extends from a lower end of the rear end part **25** in a direction substantially orthogonal to the driving axis DX.

[**0117**] The tool body **2**B and elements (mechanisms) disposed therein are first described. The tool body **2**B of this embodiment is different from the tool body **2**A of the first embodiment mainly in that the battery mounting part **4** is provided in the rear end part **25** and the controller **50** is housed in the rear end part **25**.

[**0118**] As shown in FIGS. **8** and **9**, the rear end part **25** of the tool body **2**B has a rectangular box-like shape. Side wall parts **253** of the rear end part **25** protrude rearward of a rear wall part **251** of the tool body **2**B. In this embodiment, the rear wall part **251** is a generally rectangular wall having a rear surface substantially orthogonal to the driving axis DX. In other embodiments, however, the rear wall part **251** may be inclined to the driving axis DX. The battery mounting part **4** to which the battery **40** can be mounted is provided in the lower end part **25**.

[**0119**] The detailed structures of the battery **40** and the battery mounting part **4** of this embodiment are now described.

[**0120**] The battery **40** is a rechargeable battery (also referred to as battery pack) and can be mounted to plural kinds of power tools including the needle scaler **1**B. As shown in FIGS. **8** and **10**, the battery **40** has a generally rectangular parallelepiped (hexahedral) shape. A pair of guide rails **403** and a connector part **405** having terminals are provided on one surface (hereinafter referred to as a mounting surface **400**) of the battery **40**. The guide rails **403** protrude from the mounting surface **400** and extend parallel to each other in a longitudinal direction of the battery **40**. The connector part **405** is arranged between the guide rails **403**. A direction in which the guide rails **403** face each other defines a width direction of the battery **40**. A direction substantially orthogonal to the mounting surface **400** defines a height direction of the battery **40**.

[**0121**] As shown in FIGS. **8** to **10**, the battery mounting part **4** includes an engagement part **41** that can be physically engaged with the battery **40**, and a connector part **45** that can be electrically connected to the battery **40**. The engagement part **41** includes a pair of guide grooves **42** respectively formed in the side wall parts **253**. The guide grooves **42** are long linear grooves respectively formed in inner surfaces of the side wall parts **253**. The guide grooves **42** extend downward in the up-down direction in parallel to each other from an upper end of the side wall parts **253**. The guide grooves **42** are configured to be slidingly engaged with the guide rails **403** of the battery **40**. The connector part **45** is arranged on the rear wall part **251** (between the guide grooves **42**). The connector part **45** includes terminals that can be respectively electrically connected to the terminals of the battery **40**.

[0122] In order to mount the battery **40** to the battery mounting part **4**, the guide rails **403** of the battery **40** are fitted into the guide grooves **42** of the battery mounting part **4** from above, while the battery **40** is held with the guide rails **403** extending in the up-down direction of the needle scaler **1**B. Specifically, in this embodiment, a direction of mounting the battery **40** to the battery mounting part **4** substantially corresponds to the downward direction of the needle scaler **1**B. When the battery **40** is slid downward to a prescribed mounting position, the connector part **405** (the terminals) of the battery **40** is electrically connected to the connector part **45** (the terminals) and mounting of the battery **28** is completed.

[0123] A recessed part **47** is formed in an upper end part of the battery mounting part **4** (above the connector part **45**) and configured to be engaged with a locking member **407** (see FIG. **8**) provided on the mounting surface **400** of the battery **40**. When the battery **40** is placed at the mounting position, the locking member **407** is engaged with the recessed part **47** and restricts movement of the battery **40** in the up-down direction relative to the battery mounting part **4**.

[0124] When the battery **40** is mounted to the battery mounting part **4**, the rear wall part **251** faces the mounting surface **400** of the battery **40**. In this embodiment, the driving axis DX passes through the battery mounting part **4** (specifically, the rear wall part **251**) and the battery **40**. Thus, the driving axis DX passes through the battery mounting part **4** (specifically, the rear wall part **251**) and the battery **40**, when the needle scaler **1**B is viewed from a direction orthogonal to the driving axis DX and a longitudinal axis of the handle **3**B (the grip part **31**) (specifically, from the left or right). Further, the driving axis DX also passes through the battery mounting part **4** and the battery **40**, when the needle scaler **1**B is viewed from the longitudinal direction of the handle **3**B (specifically, from above or below). In this embodiment, the driving axis DX passes through the centers of the battery mounting part **4** and the battery **40** in the left-right direction.

[0125] In order to remove the battery **40** from the battery mounting part **4**, a release button **408** (see FIG. **8**), which is provided adjacent to the locking member **407** on the battery **40**, is depressed to disengage the locking member **407** from the recessed part **47**. Subsequently, the battery **40** is lifted upward and removed while the guide rails **403** are slid in the guide grooves **42**. Specifically, in this embodiment, a direction of removing the battery **40** from the battery mounting part **4** is defined as the upward direction of the needle scaler **1**B.

[0126] In this embodiment, the guide grooves **42** of the battery mounting part **4** extend in the up-down direction, and thus the longitudinal direction of the battery **40** placed in the mounting position substantially corresponds to the up-down direction of the needle scaler **1**B. Therefore, the whole length of the tool body **2**B with the battery **40** mounted thereon in the front-rear direction is reduced, compared with a structure in which the guide grooves **42** extend in the front-rear direction in parallel to the driving axis DX. Further, the guide grooves **42** are arranged in symmetry to a plane including the driving axis DX and the longitudinal axis of the handle **3**B, and the mounted battery **40** also has a substantially symmetrical shape to the plane. Thus, the tool body **2**B with the battery **40** mounted thereto is well-balanced in the left-right direction.

[0127] Further, the guide grooves **42** are configured to receive the battery **40** from above. Thus, the battery **40** placed in the mounting position relatively greatly protrudes upward from the battery mounting part **4**, but little protrudes downward from the battery mounting part **4**. Various kinds of batteries **40** different in size (particularly, length and height) can be mounted to the battery mounting part **4**. The amount of upward protrusion of the batteries **40** from the battery mounting part **4** is different according to the kind of the batteries **40**, but any battery **40** little protrudes downward from the battery mounting part **4**.

[0128] As shown in FIG. **8**, the arrangement of the motor **51**, the hammering mechanism **6** and the scaling mechanism **9** in the tool body **2**B is the same as in the first embodiment. In this embodiment, however, the controller **50** is not arranged within the handle **3**B, but within the rear end part **25** of the tool body **2**B. More specifically, the controller **50** is arranged between the motor **51** and the battery mounting part **4** in the front-rear direction. The driving axis DX passes through the motor **51** and the controller **50** as well as through the battery mounting part **4**.

[0129] The handle **3**B and elements (mechanisms) disposed therein are now described.

[0130] As shown in FIGS. **7** and **8**, the handle **3**B of this embodiment is different from the handle **3**A of the first embodiment mainly in the structure of a lower end part **32**B and in that the trigger **35** is arranged in a central region of the grip part **31** in the longitudinal direction.

[0131] The handle **3**B is an elongate hollow body including a grip part **31**. The whole handle **3**B except for the lower end part **32**B forms the grip part **31**.

[0132] The handle **3**B of this embodiment extends downward from a lower end of a part of the tool body **2**B that is located slightly forward of the battery mounting part **4** in the front-rear direction. Thus, the handle **3**B is arranged on the same side as the rotational axis RX**1** of the output shaft **515** and the rotational axis RX**2** of the intermediate shaft **60** relative to the driving axis DX in the up-down direction. Further, in this embodiment, the handle **3**B is arranged rearward of the stator **511** of the motor **51** and the hammering mechanism **6** and forward of the battery mounting part **4** in the front-rear direction. The controller **50** is arranged in a region just above the grip part **31** within the tool body **2**B.

[**0133**] As described above, in this embodiment, the battery **40** mounted to the battery mounting part **4** little protrudes downward from the battery mounting part **4**. An area just below the battery **40** and just behind the grip part **31** is secured as a space area (where nothing exists) for a hand of the user to hold the grip part **31**.

[**0134**] The lower end part **32**B of the handle **3**B does not have a rectangular box-like shape like in the first embodiment, but only protrudes slightly forward from the grip part **31**. The lighting unit **39** is arranged in this protruding part. The lighting unit **39** is supported by the lower end part **32**B to illuminate a working area of the needles **91**.

[**0135**] The trigger **35** is arranged on the front side of the grip part **31**. In this embodiment, the trigger **35** is arranged in a region including the center position CL of the grip part **31** in the longitudinal direction (substantially in the up-down direction of the needle scaler **1**B). The center position CL is a position substantially equidistant from both ends (i.e. an upper end close to the tool body **2**B, which is also the base end of the handle **3**B, and a lower end close to the free end of the handle **3**B) of a front surface of the grip part **31** in the longitudinal direction of the grip part **31**. More specifically, the trigger **35** is arranged in a central region of the grip part **31** in the longitudinal direction and away from the upper and lower ends of the front surface of the grip part **31**. This central region is a region including the center position CL of the grip part **31** in the longitudinal direction.

[**0136**] The trigger **35** of this embodiment is supported by the grip part **31** so as to be linearly slidable substantially in the front-rear direction (the extending direction of the driving axis DX). More specifically, an opening **312** is formed in the front wall part **311** that defines the front surface of the grip part **31**. The trigger **35** is arranged to partially protrude from the front wall part **311** through the opening **312**. A switch **38** is arranged just behind the trigger **35** within the grip part **31**. The trigger **35** can be moved in the front-rear direction while sliding on plate-like guides, which protrude rearward from the front wall part **311** on the upper and lower sides of the opening **312**, respectively, and sliding on a plate-like guide formed on the switch **38**.

[**0137**] As described above, the needle scaler **1**B of this embodiment has the handle **3**B that protrudes in a direction crossing the driving axis DX from the tool body **2**B extending along the driving axis DX. The trigger **35** is configured to be depressed to instruct start of the motor **51** and arranged in a region including the center position CL of the grip part **31** in the longitudinal direction. Thus, the trigger **35** can be easily depressed with one or more fingers of a user, whether the user holds the grip part **31** in an orientation with a thumb on the upper end side (the tool body **2**B side) of the grip part **31** (hereinafter referred to as a normal orientation), or in an orientation with the thumb on the lower end side (the lower end part **32**B side) of the grip part **31** (hereinafter referred to as a reverse orientation).

[**0138**] In the needle scaler **1**A of the first embodiment, the trigger **35** is arranged in the upper end part of the grip part **31**. This arrangement is suitable for a user to hold the grip part **31** in the normal orientation and depress the trigger **35** with a forefinger. When holding the grip part **31** in the reverse orientation, however, the user needs to depress the trigger **35** with a little finger, so that it is difficult to apply a sufficient depressing force to the trigger **35**. In the needle scaler **1**B of this embodiment, the user can apply substantially equal depressing force to the trigger **35** whether the grip part **31** is held in the normal orientation or in the reverse orientation.

[**0139**] Further, the trigger **35** is arranged away from the upper and lower ends of the grip part **31** and supported to be slidable in the front-rear direction. Thus, with a simple structure, the trigger **35** is provided that can be easily operated by a user holding the grip part **31** whether in the normal orientation or in the reverse orientation.

[**0140**] Although not described in detail and shown, in another embodiment, an elongate switch lever may be provided in place of the trigger **35**. The switch lever is rotatably supported at one end part by a lower end part or an upper end part of the grip part **31** and configured to extend to a position beyond the center position CL of the grip part **31** (or to have a length longer than half the length of the grip part **31** in the longitudinal direction). Such a switch lever also realizes the operation member that can be easily depressed with one or more fingers of a user, whether in the normal orientation or in the reverse orientation.

[**0141**] The needle scaler **1**B can be used in various attitudes. Specifically, the side on which the handle **3**B is placed relative to the driving axis DX in the vertical direction, and the angle of the driving axis DX relative to a working surface of a workpiece can be changed according to the kind of machining and the position and angle of the working surface. In the needle scaler **1**B of this embodiment, as described above, the orientation in which the grip part **31** is held does not substantially affect the operability of the trigger **35**. Thus, the needle scaler **1**B exhibits superior operability in various attitudes as described in the following non-limiting examples.

[**0142**] For example, in an operation of crushing a wall surface in front of a user, the user can hold the grip part **31** in the normal orientation, or hold the needle scaler **1**B in an attitude (hereinafter referred to as a normal attitude) in which the handle **3**B is placed below the driving axis DX in the vertical direction and protrudes downward (or obliquely downward). Alternatively, the user can hold the grip part **31** in the reverse orientation, or hold the needle scaler **1**B in an attitude (hereinafter referred to as an inverted attitude) in which the handle **3**B is placed above the driving axis DX in the vertical direction and protrudes upward (or obliquely upward).

[**0143**] In an operation of removing foreign matters from a working surface, as shown in FIG. **11**, it is preferable that an angle formed between a working surface S and the driving axis DX is made as small as possible. Accordingly, the user can easily perform the operation by holding the needle scaler **1**B in the inverted attitude and holding the grip part **31** in the reverse orientation.

[**0144**] Further, in the needle scaler **1**B of this embodiment, the battery mounting part **4** is arranged in the rear end part **25** of the tool body **2**B such that the driving axis

DX passes through the battery mounting part **4** and the battery **40**. With this arrangement, compared with the needle scaler **1**A of the first embodiment in which the battery **40** is mounted to the lower end of the handle **3**A, the needle scaler **1**B is improved in operability and/or workability when used in various attitudes, as described in the following.

[0145] Firstly, when using the needle scaler **1**B while holding the grip part **31** in the reverse orientation, a user can obtain similar operability and sense of use to those obtained when using the needle scaler **1**B while holding the grip part **31** in the normal orientation. Specifically, when the needle scaler **1**A of the first embodiment is used in the inverted attitude, a relatively heavy battery **40** is located above the driving axis DX in the vertical direction, so that user's operation is not easily performed with stability. The needle scaler **1**B of this embodiment can however be stably operated even in the inverted attitude. In this embodiment, the grip part **31** extends in a direction substantially orthogonal to the driving axis DX. This arrangement also helps realize similar operability and sense of use in the reverse orientation to those in the normal orientation.

[0146] Secondly, when the needle scaler **1**B is used in the attitude with the handle **3**B protruding in a direction toward a working surface of the workpiece, the angle formed between the driving axis DX and the working surface of the workpiece can be made smaller than that of the needle scaler **1**A of the first embodiment. Therefore, the attitude with the handle **3**B protruding in a direction toward the surface of the workpiece can be applied to a greater variety of operations.

[0147] Thirdly, in the needle scaler **1**B with the battery **40** mounted to the battery mounting part **4**, in the front-rear direction, the motor **51** and the hammering mechanism **6** are arranged forward of the grip part **31**, while the heavy battery **40** is arranged rearward of the grip part **31**. With this arrangement, superior operability is realized when the needle scaler **1**B is used in the attitude with the driving axis DX extending in a substantially horizontal direction.

[0148] The battery **40** has a rectangular parallelepiped shape, so that, among outer surfaces of the battery **40** mounted to the battery mounting part **4**, the mounting surface **400** and the opposite surface **401** are substantially orthogonal to the driving axis DX (see FIG. **8**). In this embodiment, the driving axis DX, the rotational axis RX**1** of the motor **51** and the rotational axis RX**2** of the intermediate shaft **60** all pass through the battery mounting part **4** (specifically, the rear wall part **251**) and the surface **401** of the battery **40**. Thus, the needle scaler **1**B is stably supported when the surface **401** of the battery **40** mounted to the battery mounting part **4** is placed on a substantially horizontal plane (such as an upper surface of a workbench and a floor surface).

[0149] As for the other effects obtained by provision of substantially the same elements or structures as in the needle scaler **1**A of the first embodiment, the needle scaler **1**B also has the same effects as those described in the first embodiment.

<Third Embodiment>

[0150] As shown in FIG. **12**, a needle scaler **1**C according to a third embodiment of the present disclosure is different from the needle scaler **1**A of the first embodiment in that a hammering mechanism **6**C is provided in place of the hammering mechanism **6**, but otherwise it has substantially the same structure as the first embodiment. In the needle scaler **1**C, like in the needle scaler **1**A of the first embodiment, the battery mounting part **4** to which the battery **40** as a power source can be mounted is provided in the lower end part **32**A of the handle **3**A.

[0151] As shown in FIG. **12**, the hammering mechanism **6**C is of a so-called mechanical spring type that applies hammering force to the needles **91** by utilizing a mechanical spring. The other structure of the hammering mechanism **6**C is substantially the same as the hammering mechanism **6**.

[0152] The hammering mechanism **6**C is configured to convert rotational power of the motor **51** into linear motion and apply axial hammering force to the scaling mechanism **9** by utilizing an elastic force of an elastic element and thus move the needles **91** in the axial direction. The hammering mechanism **6**C has a rod **616**, a compression coil spring **68** and a striker **65**C.

[0153] The rod **616** is a metal member having a columnar shape such as a cylinder and a polygonal column. The rod **616** is disposed within the small-diameter part **635** of the cylinder **63**. The rod **616** is reciprocated in the front-rear direction within the small-diameter part **635** along with oscillation of the arm part **615**. A spring receiver **612** is formed on a rear end of the rod **616** and protrudes radially outward. A bolt **619** is fastened to the center of a front end of the rod **616**, and a washer **618** is fixed on the front end of the rod **616** by the bolt **619**.

[0154] The striker **65**C is a striking element that is configured to apply hammering force to the needles **91** by striking the anvil **95** of the scaling mechanism **9** along with reciprocation of the rod **616**. The striker **65**C is different in shape from the striker **65** of the first embodiment, but otherwise it has substantially the same structure.

[0155] The striker **65**C has a generally cylindrical shape having a stepped through hole **654** inside. The striker **65**C is arranged within the small-diameter part **635** of the cylinder **63** so as to be slidable along the driving axis DX. Thus, the small-diameter part **635** of the cylinder **63** is configured as a sliding guide for the striker **65**C.

[0156] A recess **653** having a circular section is formed in a central part of a front end surface of the striker **65**C. The striker **65**C is arranged with the open side facing forward and configured to slide on the radial outside of the rod **616**. The recess **653** in the front end part of the striker **65**C has a bottom **652** having a smaller diameter than a front end of the recess **653**. The rod **616** is inserted into the through hole **654** formed through the bottom **652**, and the striker **65**C is configured to slide on the radial outside of the rod **616** in the front-rear direction relative to the rod **616**.

[0157] The washer **618** has a larger outer diameter than the outer diameter of the front end of the rod **616**. When the striker **65**C moves forward, the washer **618** abuts on the bottom **652** of the striker **65**C and thus restricts further forward movement of the striker **65**C. In the position where the washer **618** restricts movement of the striker **65**C, the washer **618** and the bolt **619** are received in the recess **653** of the striker **65**C, and the front end of the striker **65**C is located forward of the washer **618** and the front end of the bolt **619**.

[0158] The compression coil spring **68** is inserted onto the rod **616** and arranged on the radial outside of the rod **616**. The compression coil spring **68** elastically connects the rod **616** and the striker **65**C. Specifically, the rear side of the compression coil spring **68** is supported by the spring receiver **612** of the rod **616** and biases the striker **65**C forward. The hammering mechanism **6**C may have an arbitrary elastic element such as a plate spring and a disc spring in place of the compression coil spring **68**. Further, the hammering mechanism **6**C may have a spring that is not limited to a metal spring, but is formed of an arbitrary elastic material, including an elastomer and a polymeric material, such as urethane rubber.

[0159] The hammering mechanism **6**C is operated by driving of the motor **51** and applies hammering force to the scaling mechanism **9**. The striker **65**C receives the elastic force of the compression coil spring **68** along with reciprocation of the rod **616** and slides in the front-rear direction within the cylinder **63**. More specifically, when the rod **616** is moved forward, the compression coil spring **68** is compressed and the striker **65**C moves forward by the biasing force of the compression coil spring **68**. The front end of the striker **65**C then collides with the rear surface of the rear small-diameter part **956** of the anvil **95** and applies hammering force to the needles **91**. The compression coil spring **68** elastically absorbs the impact of the collision between the striker **65**C and the anvil **95**.

[0160] As described above, the needle scaler **1**C of this embodiment has the mechanical-spring type hammering mechanism **6**C. The hammering mechanism **6**C reciprocates the striker **65**C by the elastic force of the compression coil spring **68** that is generated by reciprocation of the rod **616** and applies hammering force to the needles **91** of the scaling mechanism **9**. Thus, the hammering mechanism **6**C is realized with a relatively simple structure and the needle scaler **1**C is improved in productivity. Further, the hammering force of the striker **65**C can be adjusted by a simple way of adjusting the elastic force of the compression coil spring **68**.

[0161] The needle scaler **1**C of this embodiment has the battery mounting part **4** to which the battery **40** can be mounted. Therefore, the mechanical-spring type needle scaler **1**C is provided with excellent operability and portability, compared with a mechanical-spring type needle scaler **1**C that can be connected to an external commercial power source.

<Fourth Embodiment>

[0162] As shown in FIG. **13**, a needle scaler **1**D according to a fourth embodiment of the present disclosure is different from the needle scaler **1**A of the first embodiment in that a tool body **2**D and a handle **3**D are provided in place of the tool body **2**A and the handle **3**A, respectively, and in that a touch switch **37** is provided in place of the trigger **35** and the switch **38**, but otherwise it has substantially the same structure as the needle scaler **1**A.

[0163] As shown in FIG. **13**, the needle scaler **1**D of this embodiment has the tool body **2**D extending along the driving axis DX. The tool body **2**D houses the motor **51**, the hammering mechanism **6** and the scaling mechanism **9** that are arranged in the axial direction. In this embodiment, the tool body **2**D also serves as the handle **3**D. Thus, the needle scaler **1**D has a so-called straight type handle **3**D. Specifically, a rear part of the tool body **2**D that extends rearward of the barrel part **21** serves as the grip part **31**. Thus, the longitudinal direction of the handle **3**D is substantially parallel to the driving axis DX. For example, a user can hold a rear half part of the tool body **2**D with one hand and auxiliary hold the barrel part **21** with the other hand. By integrating the handle **3**D with the tool body **2**D, the needle scaler **1**D is reduced in size in the up-down direction, so that the needle scaler **1**D is improved in portability and in workability in a narrow place.

[0164] As shown in FIG. **13**, the touch switch **37**, for example, of a capacitance type is provided on an upper end part of the handle **3**D. The touch switch **37** receives a touch operation of the user and outputs an ON signal to the controller **50**. The touch switch **37** is also referred to as a touch sensor and a touch key. When receiving the ON signal, the controller **50** supplies electric power to the motor **51** and drives the motor **51**. When the touch switch **37** is not operated, the touch switch **37** stops outputting the ON signal to the controller **50**, and the motor **51** stops. The arrangement position of the touch switch **37** is not limited to the upper side of the tool body **2**D, but the touch switch **37** may be arranged in an arbitrary position such as on the left or right side or the lower side of the tool body **2**D.

[0165] In place of the touch switch **37**, however, the needle scaler **1**D may have a push switch that receives a pushing-down operation of the user and outputs an ON signal to the controller **50**, or a push-down type mechanical switch such as a tactile switch. Alternatively, in place of the touch switch **37**, the needle scaler **1**D may have various kinds of operation parts such as a slide switch or a switch lever that is turned on and off by sliding operation in one direction, and a trigger switch or a paddle switch that is turned on and off by depressing operation.

[0166] As shown in FIG. **13**, the battery **40** and the battery mounting part **4** have substantially the same structures as in the second embodiment. Specifically, the battery mounting part **4** is provided in the rear end part **25** of the tool body **2**D. The direction of mounting the battery **40** to the battery mounting part **4** substantially corresponds to the downward direction of the needle scaler **1**D. When the battery **40** is mounted to the battery mounting part **4**, the rear wall part **251** of the tool body **2**D faces the mounting surface **400** of the battery **40**.

[0167] In this embodiment, the driving axis DX passes through the battery mounting part **4** (specifically, the rear wall part **251**) and the battery **40**. Thus, the driving axis DX passes through the battery mounting part **4** (specifically, the rear wall part **251**) and the battery **40**, when the needle scaler **1**D is viewed from the left-right direction. Further, the driving axis DX also passes through the battery mounting part **4** and the battery **40**, when the needle scaler **1**D is viewed from the up-down direction. The driving axis DX passes through the centers of the battery mounting part **4** and the battery **40** in the left-right direction.

[**0168**] The direction of mounting the battery **40** to the battery mounting part **4** may substantially correspond to the front-rear direction of the needle scaler **1**D. For example, the guide grooves **42** may extend in the front-rear direction in parallel to the driving axis DX. With this structure, the needle scaler **1**D is reduced in size in the up-down direction. In this case, the driving axis DX may or may not pass through the battery mounting part **4** and the battery **40**.

[**0169**] As shown in FIG. **13**, the arrangement of the controller **50** within the tool body **2**D is the same as in the second embodiment. Thus, the controller **50** is arranged within the rear end part **25** of the tool body **2**D and extends in the up-down direction. More specifically, the controller **50** is arranged between the motor **51** and the battery mounting part **4** in the front-rear direction. The driving axis DX passes through the motor **51** and the controller **50** as well as through the battery mounting part **4**. It can also be said that the controller **50** is arranged within a rear end part of the handle **3**D extending in the front-rear direction.

[**0170**] The controller **50** may however be arranged to extend in the front-rear direction within the tool body **2**D. For example, where the guide grooves **42** of the battery mounting part **4** extend in the front-rear direction in parallel to the driving axis DX, the controller **50** and the battery mounting part **4** can be rationally arranged in the tool body **2**D by arranging the controller **50** in parallel to the battery mounting part **4**.

<Fifth Embodiment>

[**0171**] As shown in FIG. **14**, a needle scaler **1**E according to a fifth embodiment of the present disclosure is a modification of the needle scaler **1**D of the fourth embodiment. The needle scaler **1**E is different from the needle scaler **1**D of the fourth embodiment in the structure of the hammering mechanism **6**C, but otherwise it has substantially the same structure as the needle scaler **1**D of the fourth embodiment. The hammering mechanism **6**C is of a so-called mechanical spring type described in the third embodiment above. Thus, as shown in FIG. **14**, the needle scaler **1**E may be provided with a combination of the straight type handle **3**D integrally formed with the tool body **2**D and the mechanical spring type hammering mechanism **6**C.

<Sixth Embodiment>

[**0172**] As shown in FIG. **15**, a needle scaler **1**F according to a sixth embodiment of the present disclosure is different from the needle scaler **1**A of the first embodiment in that a handle **3**F is provided in place of the handle **3**A, but otherwise it has substantially the same structure as the first embodiment.

[**0173**] The handle **3**F is connected to the rear end part **25** of the tool body **2**A. The handle **3**F is annularly formed, having a generally D-shape when the needle scaler **1**F is viewed from the left-right direction. The handle **3**F is also referred to as a D-shaped handle. The handle **3**F includes a grip part **31**, an upper extending part **340**, a front extending part **342** and a lower extending part **344**.

[**0174**] The grip part **31** extends in the up-down direction. A trigger **35** having the same structure as the trigger **35** of the first embodiment is provided on the front side of the upper end part of the grip part **31**. The arrangement of the trigger **35** is different from that of the first embodiment. Specifically, in this embodiment, the trigger **35** is arranged in a position where the driving axis DX passes through the grip part **31** and the trigger **35** when the needle scaler **1**F is viewed from the left-right direction. Further, the driving axis DX also passes through the grip part **31** and the trigger **35** when the needle scaler **1**F is viewed from the up-down direction. With this arrangement, a user can easily perform the operation of pressing the needles **91** onto a workpiece in the axial direction (the front-rear direction) corresponding to the extending direction of the driving axis DX, while holding the handle **3**F and operating the trigger **35**.

[**0175**] The upper extending part **340** extends rearward from the upper side of the rear end part **25** of the tool body **2**A and is connected to the upper end part of the grip part **31**. The lower extending part **344** extends forward from the lower end part of the grip part **31**.

[**0176**] The controller **50** is housed in the lower extending part **344** and extends in the front-rear direction. The arrangement and structure of the controller **50** is substantially the same as the controller **50** of the first embodiment. Specifically, the controller **50** is arranged in a position where a line orthogonal to the driving axis DX passes through the controller **50** and the grip part **31** when the needle scaler **1**F is viewed from the left-right direction. The controller **50** may be arranged other than in the lower extending part **344** and may be arranged to extend in the up-down direction.

[**0177**] The battery mounting part **4** is provided extending in the front-rear direction in a lower end part of the lower extending part **344**, or a lower end part **32**F of the handle **3**F. The arrangement and structure of the battery mounting part **4** is substantially the same as the battery mounting part **4** of the first embodiment. Specifically, the battery mounting part **4** is arranged in a position where a line orthogonal to the driving axis DX passes through the battery mounting part **4** and the handle **3**F when the needle scaler **1**F is viewed from the left-right direction. The battery mounting part **4** may be arranged other than in the lower end part **32**F of the handle **3**F such as on a rear end of the grip part **31** and may be arranged to extend in the up-down direction.

[**0178**] As shown in FIG. **15**, the front extending part **342** connects the lower extending part **344** and the rear end part **25** of the tool body **2**A. More specifically, the front extending part **342** extends substantially upward from a front end part of the lower extending part **344** and is connected to the lower side of the rear end part **25** of the tool body **2**A.

[0179] In the needle scaler **1**F of this embodiment, the handle **3**F is formed in an annular form, which improves the strength of the handle **3**F, compared, for example, with a cantilever handle like the handle **3**A of the first embodiment. Further, when operating the needle scaler **1**F in the inverted attitude, a user can improve the workability in the operation in the inverted attitude by holding the grip part **31** with one hand and auxiliary holding the front extending part **342** with the other hand. In the operation in the inverted attitude, by auxiliary holding the front extending part **342**, the user can more easily place an upper end of the tool body **2**A close to a working surface than when holding the barrel part **21** and thus improve the workability in the operation in the inverted attitude.

<Seventh Embodiment>

[0180] As shown in FIG. **16**, a needle scaler **1**G according to a seventh embodiment of the present disclosure is a modification of the needle scaler **1**F of the sixth embodiment. The needle scaler **1**G is different from the needle scaler **1**F of the sixth embodiment in the structure of the hammering mechanism **6**C, but otherwise it has substantially the same structure as the needle scaler **1**F of the sixth embodiment. The hammering mechanism **6**C is of a so-called mechanical spring type described in the third embodiment above. Thus, as shown in FIG. **16**, the needle scaler **1**G may be provided with a combination of the so-called D-shaped handle **3**F connected to the rear end part **25** of the tool body **2**A and the mechanical spring type hammering mechanism **6**C.

<Eighth Embodiment>

[0181] As shown in FIG. **17**, a needle scaler **1**H according to an eighth embodiment of the present disclosure is different from the needle scaler **1**A of the first embodiment in that a handle **3**H, a tool body **2**H and a hammering mechanism **6**H are provided in place of the handle **3**A, the tool body **2**A and the hammering mechanism **6**, respectively, but otherwise it has substantially the same structure as the needle scaler **1**A of the first embodiment.

[0182] The tool body **2**A of the first embodiment extends along the driving axis DX, but the tool body **2**H is generally L-shaped. Specifically, the tool body **2**H has a barrel part **21** and a body extending part **27**. The barrel part **21** has substantially the same structure as the barrel part **21** of the first embodiment and is a hollow body extending along the driving axis DX. The barrel part **21** houses part of the scaling mechanism **9** and part of the hammering mechanism **6**H.

[0183] The body extending part **27** is connected to a rear end of the barrel part **21**. The body extending part **27** extends substantially downward from the rear end of the barrel part **21**. The body extending part **27** houses the motor **51** and part of the hammering mechanism **6**H. The motor **51** is arranged just below a motion convert converting mechanism **61**H. Specifically, the motor **51** is arranged below the driving axis DX and the rotational axis RX**2** when the needle scaler **1**H is viewed from the left-right direction. With this arrangement of the motor **51** below the driving axis DX and the rotational axis RX**2**, the needle scaler **1**H is reduced in length in the front-rear direction. In this embodiment, the rotational axis RX**1** of the output shaft **515** of the motor **51** extends in the up-down direction orthogonally to the driving axis DX and the rotational axis RX**2**.

[0184] The hammering mechanism **6**H is different from the hammering mechanism **6** of the first embodiment in that the motion convert converting mechanism **61**H has a gear **605**H in place of the gear **605**, but otherwise it has substantially the same structure as the hammering mechanism **6** of the first embodiment. The gear **605**H is arranged with gear teeth facing rearward and engaged with the pinion **516** formed on the extending end of the output shaft **515** extending in the up-down direction. Thus, the hammering mechanism **6**H is configured to convert rotational power of the rotational axis RX**1** of the output shaft **515** extending in the up-down direction into linear motion in the front-rear direction and apply hammering force to the scaling mechanism **9**.

[0185] The rotational axis RX**1** of the output shaft **515** of the motor **51** may cross not orthogonally but obliquely at a prescribed angle to the driving axis DX and the rotational axis RX**2**. For example, the arrangement of the motor **51** is changed such that an upper end part of the motor **51** (an upper end of the output shaft **515**) is located at substantially the same position as that shown in FIG. **17** and a lower end part of the motor **51** is located forward of the position shown in FIG. **17**. In this case, the rotational axis RX**1** is inclined forward toward the lower side. With this structure, the lower end part of the motor **51** is shifted forward, so that the handle **3**H can be shifted forward toward the tool body **2**H. Therefore, the needle scaler **1**H is reduced in length in the front-rear direction and thus reduced in size. In this case, it is preferable that the angle of the gear teeth of the gear **605**H is changed to correspond to the pinion **516** of the inclined output shaft **515**.

[0186] The handle **3**H connects the grip part **31** and the tool body **2**H and forms an annular part together with the grip part **31** and the tool body **2**H. The handle **3**H includes the grip part **31**, an upper extending part **340** and a lower extending part **344**.

[0187] The grip part **31** extends in the up-down direction. A trigger **35** having the same structure as the trigger **35** of the sixth embodiment is provided on the front side of the upper end part of the grip part **31**. Specifically, in this embodiment, the trigger **35** is arranged in a position where the driving axis DX passes through the grip part **31** and the trigger **35** when the needle scaler **1**H is viewed from the left-right direction. Further, the driving axis DX also passes through the grip part **31** and the trigger **35** when the needle scaler **1**H is viewed from the up-down direction. With this arrangement, a user can easily perform the operation of pressing the needles **91** onto a workpiece in the axial direction (the front-rear direction) corresponding to the extending direction of the driving axis DX, while holding the handle **3**H and operating the trigger **35**.

[0188] The upper extending part **340** extends rearward from an upper rear end of the tool body **2**H or the rear end of the barrel part **21**, and is connected to the upper end part of the grip part **31**. The lower extending part **344** extends forward from the lower end part of the grip part **31** and is connected to the body extending part **27**.

[0189] The controller **50** is housed in the lower extending part **344** and extends in the front-rear direction. The arrangement and structure of the controller **50** is substantially the same as the controller **50** of the first embodiment. Specifically, the controller **50** is arranged in a position where a line orthogonal to the driving axis DX passes through the controller **50** and the grip part **31** when the needle scaler **1**H is viewed from the left-right direction. The controller **50** may be arranged other than in the lower extending part **344** and may be arranged to extend in the up-down direction.

[0190] The battery mounting part **4** is provided extending in the front-rear direction in a lower end part of the lower extending part **344**, or a lower end part **32**H of the handle **3**H. The arrangement and structure of the battery mounting part **4** is substantially the same as the battery mounting part **4** of the first embodiment. Specifically, the battery mounting part **4** is arranged in a position where a line orthogonal to the driving axis DX passes through the battery mounting part **4** and the handle **3**H when the needle scaler **1**H is viewed from the left-right direction. The controller **50** may be arranged other than in the lower end part **32**H of the handle **3**H such as on the rear end of the grip part **31** and may be arranged to extend in the up-down direction.

[0191] In the needle scaler **1**H of this embodiment, by arranging the motor **51** below the driving axis DX and the rotational axis RX2, the length of the needle scaler **1**H in the front-rear direction is reduced and thus the workability of the needle scaler **1**H is improved. Further, by forming the handle **3**H in an annular form, the handle **3**H is improved in strength, compared, for example, with a cantilever handle like the handle **3**A of the first embodiment. Further, when operating the needle scaler **1**H in the inverted attitude, a user can improve the workability in the operation in the inverted attitude by holding the grip part **31** with one hand and auxiliary holding the body extending part **27** with the other hand. In the operation in the inverted attitude, by auxiliary holding the body extending part **27** , the user can more easily place an upper end of the tool body **2**H close to a working surface than when holding the barrel part **21** and thus improve the workability in the operation in the inverted attitude.

<Ninth Embodiment>

[0192] As shown in FIG. **18**, a needle scaler **1**I according to a ninth embodiment of the present disclosure is a modification of the needle scaler **1**H of the eighth embodiment. The needle scaler **1**I is different from the needle scaler **1**H of the eighth embodiment in the structure of a hammering mechanism **6**I, but otherwise it has substantially the same structure as the needle scaler **1**H of the eighth embodiment. The hammering mechanism **6**I has the motion convert converting mechanism **61**H including the gear **605**H of the eighth embodiment, in place of the motion convert converting mechanism **61** of the hammering mechanism **6**C of the third embodiment. Specifically, the needle scaler **1**I may be provided with a combination of the handle **3**H, the tool body **2**H and the mechanical spring type hammering mechanism **6**I.

<Tenth Embodiment>

[0193] As shown in FIG. **19**, a needle scaler **1**J according to a tenth embodiment of the present disclosure is different from the needle scaler **1**A of the first embodiment in that a handle **3**J and a battery mounting part **4**J are provided in place of the handle **3**A and the battery mounting part **4**, respectively, but otherwise it has substantially the same structure as the first embodiment. The needle scaler **1**J is configured such that a battery **40**J that is different from the battery **40** of the first embodiment and is also referred to as a so-called stick type battery can be mounted thereto.

[0194] Unlike the battery **40** having a generally rectangular parallelepiped shape in the first embodiment, the battery **40**J has a rod-like shape extending in one direction. The battery **40**J has a smaller battery capacity (Ah) than the battery **40**. The battery **40**J has a smaller size than the battery **40** and is configured such that most of the battery **40**J can be inserted into the handle **3**J. The battery **40**J has a locking member **407**J.

[0195] The handle **3**J is similar to the handle **3**A of the first embodiment in that it is a so-called pistol grip and is connected to the tool body **2**A in a cantilever manner. The handle **3**J is different from the handle **3**A of the first embodiment in that it has a lower end part **32**J different in shape from the lower end part **32**A and in that the handle **3**J has the battery mounting part **4**J in place of the battery mounting part **4**.

[0196] The lower end part **32**J of the handle **3**J is a free end and has substantially the same outer diameter as the outer diameter of the grip part **31**. A battery insertion part **320** is formed in the lower end part **32**J. The battery insertion part **320** is configured to receive part of the battery **40**J. The battery insertion part **320** includes an opening **321** formed in the lower end part **32**J of the handle **3**J, and a guide wall **322** connected to the opening **321** and extending into the inside of the handle **3**J. The battery **40**J is inserted from the opening **321** and the guide wall **322** defines the inserting direction of the battery **40**J. An engagement part (not shown) is formed on the battery insertion part **320** and configured to be engaged with the locking member **407**J of the battery **40**J.

[0197] The battery mounting part **4**J includes an engagement part **41**J that can be physically engaged with the battery **40**J, and a connector part **45**J that can be electrically connected to the battery **40**J. The engagement part **41**J includes the battery insertion part **320** formed in the lower end part **32**J of the handle **3**J.

[0198] The connector part **45**J is arranged in the inside of the handle **3**J. In this embodiment, the connector part **45**J is arranged just below the switch **38**. The connector part **45**J includes terminals that can be electrically connected to terminals of the battery **40**J.

[0199] When the battery **40**J is mounted to the battery mounting part **4**J, the battery **40**J is inserted into the opening **321** of the battery insertion part **320** from below the handle **3J**. Thus, in this embodiment, the direction of mounting the battery **40J** to the battery mounting part **4J** substantially corresponds to the upward direction of the needle scaler **1J**. When the battery **40J** is guided by the guide wall **322** and moved upward to a prescribed mounting position, the locking member **407J** is engaged with the engagement part of the battery insertion part **320**, so that the battery **40J** is restricted from moving relative to the battery mounting part **4J** in the up-down direction. The connector part **405** (terminals) of the battery **40J** is then electrically connected to the connector part **45J** (terminals) and mounting of the battery **40J** is completed. The mounted battery **40J** extends in the up-down direction of the needle scaler **1J**. The mounted battery **40J** can be removed from the battery mounting part **4J** by manually operating the locking member **407J** to disengage the locking member **407J** from the engagement part (not shown).

[0200] As described above, the needle scaler **1J** of this embodiment is configured such that the stick type battery **40J** can be removably mounted thereto. Therefore, the needle scaler **1J** is reduced in weight and size, compared with the needle scaler **1A** of the first embodiment, so that the needle scaler **1J** is improved in operability and portability.

<Eleventh Embodiment>

[0201] As shown in FIG. **20**, a needle scaler **1K** according to an eleventh embodiment of the present disclosure is a modification of the needle scaler **1J** of the tenth embodiment. The needle scaler **1K** is different from the needle scaler **1J** of the tenth embodiment in that a hammering mechanism **6C** is provided in place of the hammering mechanism **6**, but otherwise it has substantially the same structure as the needle scaler **1J** of the tenth embodiment. The hammering mechanism **6C** is of a so-called mechanical spring type described in the third embodiment. Thus, as shown in FIG. **20**, the needle scaler **1K** may be provided with a combination of the handle **3J** and the battery mounting part **4J** to which the stick type battery **40J** can be removably mounted, and the mechanical spring type hammering mechanism **6C**. The needle scalers of the third to ninth embodiments may be configured such that the stick type battery **40J** can be removably mounted thereto, and the battery mounting part **4J** of this embodiment may be provided in place of the battery mounting part **4**.

<Twelfth Embodiment>

[0202] As shown in FIG. **21**, a needle scaler **1L** according to a twelfth embodiment of the present disclosure is different from the needle scaler **1A** of the first embodiment in that a handle **3L** is provided in place of the handle **3A**, but otherwise it has substantially the same structure as the first embodiment.

[0203] The handle **3L** is similar to the handle **3A** of the first embodiment in that it is connected to the tool body **2A** in a cantilever manner, but different in the arrangement relative to the tool body **2A**. In the other points, the handle **3L** has substantially the same structure as the handle **3A**.

[0204] As shown in FIG. **21**, in this embodiment, the handle **3L** is arranged forward of a connecting position (shown in FIG. **3**) between the tool body **2A** and the handle **3A**. The handle **3L** and the tool body **2A** form a generally T-shape, so that the handle **3L** is also referred to as a T-shaped handle.

[0205] The motor **51** and the motion convert converting mechanism **61** are arranged in a rear part of the tool body **2A**. In the needle scaler **1L**, among the elements disposed in the tool body **2A**, the loads on the motor **51** and the motion convert converting mechanism **61** tend to be large compared with the loads on the other elements. Thus, the center of gravity of the needle scaler **1L** is located slightly rearward of the center of the tool body **2A** in the extending direction of the driving axis DX.

[0206] As shown in FIG. **21**, the handle **3L** is connected to the tool body **2A** at a position slightly rearward of the center of the tool body **2A** so as to be connected at a position close to the center of gravity of the needle scaler **1L**. Specifically, a base end of the handle **3L** is connected to the tool body **2A** within a range RG from an arrangement position **518R** of the rear bearing **518** of the motor **51** to an arrangement position **60F** of the front bearing **601** of the intermediate shaft **60** of the motion convert converting mechanism **61** in the front-rear direction. Therefore, the needle scaler **1L** can be operated in a well-balanced manner by using the handle **3L**. In other embodiments, the handle **3L** may be connected within a range from the rear end **25R** of the tool body **2A** to the position **60F**.

[0207] In this embodiment, the grip part **31** of the handle **3L** is connected to the tool body **2A** just below the motor **51** and extends in a direction substantially orthogonal to the driving axis DX. Further, the whole grip part **31** is arranged within the range RG. In other words, a rear end **31R** of the grip part **31** is arranged forward of the position **518R**, and a front end **31F** of the grip part **31** is arranged rearward of the position **60F**. Therefore, the needle scaler **1L** can be operated in a well-balanced manner by using the handle **3L**. The "front end **31F** of the grip part **31**" can include a front end of a member such as the trigger **35** that is provided in the grip part **31**. The front end **31F** of the grip part **31** may be a front end within a range from the trigger **35** to the lower end part **32A** in the grip part **31**. As shown in FIG. **21**, in other embodiments, the rear end **31R** of the grip part **31** may be arranged forward of the rear end **25R** of the tool body **2A**.

[0208] In the needle scaler **1L** of this embodiment, the grip part **31** of the handle **3L** is connected to the tool body **2A** just below the motor **51** and extends in a direction substantially orthogonal to the driving axis DX. The handle **3L** is connected to the tool body **2A** at a position close to the center of gravity of the tool body **2A**, so that the needle scaler **1L** is easily well-balanced in the front-rear direction. Thus, the needle scaler **1L** is improved in workability.

[0209] Further, by arranging the grip part **31** just below the tool body **2A**, the whole length of the needle scaler **1L** in the front-rear direction is shortened compared with the needle scaler **1A** of the first embodiment. Therefore, the needle scaler **1L** is reduced in size and thus improved in convenience.

<Thirteenth Embodiment>

[0210] As shown in FIG. **22**, a needle scaler **1M** according to a thirteenth embodiment of the present disclosure is a modification of the needle scaler **1L** of the twelfth embodiment. The needle scaler **1M** is different from the needle scaler **1L** of the twelfth embodiment in that a hammering mechanism **6C** is provided in place of the hammering mechanism **6**, but otherwise it has substantially the same structure as the needle scaler **1L**. The hammering mechanism **6C** is of a so-called mechanical spring type described in the third embodiment above. Thus, as shown in FIG. **22**, the needle scaler **1M** may be provided with a combination of the handle **3L**, which is connected to the tool body **2A** just below the motor **51** and extends in a direction substantially orthogonal to the driving axis DX, and the mechanical spring type hammering mechanism **6C**.

[0211] As shown in FIG. **22**, the base end of the handle **3L** is connected to the tool body **2A** within the range RG. The handle **3L** may be connected within a range from the rear end **25R** of the tool body **2A** to the position **60F** of the front end of the intermediate shaft **60**, or within a range from the position **518R** to the position **60F**. The rear end **31R** of the grip part **31** is arranged forward of the position **518R**, and the front end **31F** of the grip part **31** is arranged rearward of the position **60F**.

[0212] Correspondences between the features of the above-described embodiments and the features of the present disclosure or invention are as follows. However, the features of the above-described embodiments are merely exemplary and do not limit the features of the present disclosure or invention.

[0213] The needle scalers **1A**, **1B**, **1C**, **1D**, **1E**, **1F**, **1G**, **1H**, **1I**, **1J**, **1K**, **1L**, **1M** are examples of the "needle scaler". The tool body **2A**, **2B**, **2D**, **2H** are examples of the "tool body". The motor **51** is an example of the "motor". The hammering mechanisms **6**, **6C**, **6H**, **6I** are examples of the "power transmitting mechanism" and the "hammering mechanism". The scaling mechanism **9** and the needles **91** are examples of the "scaling mechanism" and the "needles", respectively. The piston cylinder **617** and the strikers **65**, **65C** are examples of the "piston" and the "striker", respectively. The piston cylinder **617**, the strikers **65**, **65C**, the rod **616** and the compression coil spring **68** are examples of the "power transmitting part". The piston cylinder **617** and the rod **616** are examples of the "reciprocating member". The compression coil spring **68** is an example of the "elastic member".

[0214] The battery mounting parts **4**, **4J** are examples of the "battery mounting part". The intermediate shaft **60** and the oscillating member **613** are examples of the "intermediate shaft" and the "oscillating member", respectively. The sleeve **22** is an example of the "sleeve". The needle housing **90**, the support **93** and the anvil **95** are examples of the "needle housing", the "support" and the "anvil", respectively. The bottom **931** and the peripheral wall **935** of the support **93** are examples of the "bottom" and the "peripheral wall" of the "support", respectively. The large-diameter part **951** and the front small-diameter part **954** of the anvil **95** are examples of the "large-diameter part" and the "small-diameter part" of the "anvil", respectively. The elastic element **98** is an example of the "elastic element". The handle **3B** and the grip part **31** are examples of the "handle" and the "grip part", respectively. The trigger **35** is an example of the "operation member". The lighting unit **39** is an example of the "lighting device".

[0215] The needle scaler according to the present disclosure is not limited to the needle scalers **1A**, **1B**, **1C**, **1D**, **1E**, **1F**, **1G**, **1H**, **1I**, **1J**, **1K**, **1L**, **1M** of the above-described embodiments. For example, the following non-limiting modifications may be made. At least one of these modifications can be adopted in combination with at least one of the features of the needle scalers **1A**, **1B**, **1C**, **1D**, **1E**, **1F**, **1G**, **1H**, **1I**, **1J**, **1K**, **1L**, **1M** of the above-described embodiments and the claimed invention.

[0216] The structures of the power transmitting mechanism and the hammering mechanism are not limited to those of the hammering mechanisms of the above-described embodiments. For example, in other embodiments, the power transmitting mechanism and the hammering mechanism may use a crank shaft that is operably connected to the output shaft **515** of the motor **51**, in place of the rotary body **611** and the oscillating member **613** on the intermediate shaft **60**. In this case, a cylindrical piston may be slidably arranged within the cylinder **63** and operably connected to an eccentric pin provided on the crank shaft. It is advantageous that the rotary body **611** and the oscillating member **613** on the intermediate shaft **60** contribute to size reduction of the hammering mechanism **6**.

[0217] Further, for example, in other embodiments, the power transmitting mechanism may be a cam type power transmitting mechanism that converts rotational driving power of the output shaft **515** or the intermediate shaft **60** to axial reciprocating motion. In this case, the power transmitting mechanism may have a driven member that reciprocates in the axial direction, and a cam member that rotates together with the output shaft **515** and the intermediate shaft **60** and converts rotary motion to reciprocating motion of the driven member, in place of the hammering mechanism **6**, **6C**, **6H**, **6I**. The driven member is an example of the "power transmitting part".

[0218] The scaling mechanism of the needle scaler according to the present disclosure may just be configured to appropriately transmit the hammering force of the striker to the needles, and its structure is not limited to that of the scaling mechanism **9** of the above-described embodiments. For example, the needle housing **90** may be a single cylindrical member formed separately from the cylinder **63**, instead of being formed by part of the cylinder **63** and the cylindrical member **900**. The shapes of the support **93** and the anvil **95** may be appropriately changed, provided that the support **93** and the anvil **95** can slide within the needle housing **90**. Further, for example, the support **93** and the anvil **95** need not be able to slide independently from each other within the needle housing **90**, but may be fixed to each other and integrally slide. The biasing member **97** may be a mechanical spring other than a compression coil spring, or an elastic element (such as elastomer) other than a spring. The elastic element **98** may be changed to a mechanical spring (such as a compression coil spring).

[0219] In view of the nature of the present disclosure and the above-described embodiments, the following aspects are provided. At least one of the aspects can be adopted in combination with at least one of the features of the above-described embodiments and modifications and the claimed invention.

[0220] (Aspect A1) The scaling mechanism includes:

[0221] a needle housing that has a front end having an opening through which the needles are inserted;

[0222] a support that supports the needles to be movable in the respective axial directions within the needle housing; and

[0223] an anvil that is arranged between the striker and the support in the front-rear direction and can slide in the front-rear direction along the driving axis within the needle housing; and

[0224] the striker is configured to directly strike the anvil.

[0225] (Aspect A2) The support can slide in the front-rear direction along the driving axis within the needle housing.

[0226] (Aspect A3) The scaling mechanism includes a biasing member that is disposed between the support and the needle housing in the front-rear direction and biases the support and the anvil rearward relative to the needle housing.

[0227] (Aspect A4) The operation member is arranged away from the first and second ends of the grip part in the first direction.

[0228] (Aspect A5) The operation member is supported by the grip part so as to be linearly slidable.

[0229] (Aspect A6) The hammering mechanism further includes:

[0230] an intermediate shaft that is operably connected to the output shaft and rotates around a second rotational axis along with rotation of the output shaft; and

[0231] an oscillating member that is arranged on the intermediate shaft and oscillates in the front-rear direction along with rotation of the intermediate shaft;

[0232] the piston is operably connected to the oscillating member and linearly reciprocates along the driving axis along with oscillation of the oscillating member;

[0233] the driving axis, the first rotational axis and the second rotational axis are parallel to each other; and

[0234] the handle protrudes from the tool body in a direction toward the second rotational axis from the driving axis.

[0235] (Aspect A7) The needle scaler further comprises a battery mounting part to which a battery can be removably mounted; and

[0236] the driving axis passes through the battery mounting part when the needle scaler is viewed from a second direction orthogonal to the front-rear direction and the first direction.

[0237] (Aspect A8) The battery mounting part is provided in a rear end part of the tool body; and

[0238] the handle is arranged between the hammering mechanism and the battery mounting part in the front-rear direction.

[0239] (Aspect A9) At least part of the motor is arranged on the opposite side from the battery mounting part relative to the handle in the front-rear direction.

[0240] (Aspect A10) The needle scaler further includes a controller that controls driving of the needle scaler;

[0241] the controller is arranged between the motor and the battery mounting part in the front-rear direction; and

[0242] the driving axis passes through the motor , the controller and the battery mounting part.

[0243] (Aspect A11) A line orthogonal to the driving axis passes through the controller and the handle when the needle scaler is viewed from a second direction orthogonal to the front-rear direction and the first direction.

[0244] (Aspect A12) The battery mounting part includes an engagement part that is configured to be slidingly engaged with the battery in a direction crossing the driving axis.

[0245] (Aspect A13) The engagement part is configured to be slidingly engaged with the battery in the first direction.

[0246] The following aspects B1 to B10 are provided in order to solve a non-limiting object of the present disclosure to provide a technique that contributes to improvement of the durability of an electric needle scaler. The following aspects B1 to B10 can be adopted individually or in combination of at least two of them. Alternatively, at least one of the following aspects B1 to B10 can be adopted in combination with at least one of the needle scalers **1**A, **1**B, **1**C, **1**D, **1**E, **1**F, **1**G, **1**H, **1**I, **1**J, **1**K, **1**L, **1**M of the above-described embodiments, the above-described modifications, the aspects A1 to A13 and the features of the claimed invention.

[0247] (Aspect B1) An electric needle scaler, comprising:

[0248] a tool body that extends along a driving axis that defines a front-rear direction of the needle scaler;

[0249] an electric motor that is housed in the tool body and includes an output shaft that is rotatable around a first rotational axis;

[0250] a hammering mechanism that is housed in the tool body; and

[0251] a scaling mechanism that is supported by a front end part of the tool body and includes needles that protrude forward to be exposed out of the tool body and are supported to be movable in respective axial directions of the needles;

[0252] wherein the hammering mechanism includes: (i) a piston that is operably connected to the output shaft of the motor and reciprocates along the driving axis along with rotation of the output shaft; and (ii) a striker that reciprocates along the driving axis by pressure fluctuations caused in an air chamber by reciprocation of the piston and applies hammering force to the needles.

[0253] The needle scaler according to aspect B1has the hammering mechanism that is driven by power of the electric motor. The hammering mechanism reciprocates the striker by the action of air spring, or specifically by pressure fluctuations caused in the air chamber by reciprocation of the piston, and applies hammering force to the needles of the scaling mechanism. Therefore, the needle scaler is provided with excellent durability, compared with a structure in which the piston and the striker are connected by a mechanical spring (such as a compression coil spring) in order to apply the hammering force.

[0254] (Aspect B2) The needle scaler as defined in aspect B1 may further comprise a battery mounting part that is configured to removably receive a battery.

[0255] According to this aspect, the needle scaler is provided with excellent operability and portability, compared with a needle scaler that can be connected to an external commercial power source. The battery mounting part typically includes an engagement part (such as a guide rail and a guide groove) that can be physically engaged with the battery, and a connector part having terminals that can be electrically connected to the battery.

[0256] (Aspect B3) The needle scaler as defined in aspect B1 or B2, wherein the hammering mechanism may include an intermediate shaft and an oscillating member. The intermediate shaft may be operably connected to the output shaft and configured to rotate around a second rotational axis parallel to the first rotational axis along with rotation of the output shaft. The oscillating member may be arranged on the intermediate shaft and configured to oscillate in the front-rear direction along with rotation of the intermediate shaft. The piston may be operably connected to the oscillating member and configured to linearly reciprocate along the driving axis along with oscillation of the oscillating member.

[0257] According to this aspect, the motion converting mechanism that converts rotary motion of the output shaft of the motor into linear motion of the piston is reduced in size, compared with a structure using a crank-piston mechanism.

[0258] (Aspect B4) The needle scaler as defined in aspect B3, wherein the piston may comprise a bottomed cylindrical piston cylinder. The striker may be slidable along the driving axis within the piston cylinder. The air chamber may be defined between a bottom of the piston cylinder and the striker.

[0259] According to this aspect, the hammering mechanism is reduced in size, compared with a structure in which a cylindrical piston is arranged within a cylinder formed separately from the piston.

[0260] (Aspect B5) The needle scaler as defined in any one of aspects B1 to B4 may further comprise a sleeve that is arranged within the front end part of the tool body and holds the scaling mechanism. The front end part of the tool body may be made of synthetic resin. The sleeve may be made of metal and integrally formed with the front end part of the tool body. The scaling mechanism having the needles that move in the axial direction is easy to generate heat.

[0261] According to this aspect, the tool body having the holding part (sleeve) that holds the scaling mechanism is provided with excellent durability, and the number of parts in assembling is reduced.

[0262] (Aspect B6) The needle scaler as defined in any one of aspects B1 to B5, wherein the scaling mechanism may include a needle housing, a support and an anvil. The needle housing may have a front end having an opening through which the needles are inserted, and may be fixed to the tool body. The support may support the needles to be movable in the respective axial directions. The anvil may be arranged between the striker and the support in the front-rear direction. The anvil may be configured to apply hammering force to the needles by being struck by the striker. The support may have a bottomed cylindrical shape and include a bottom and a cylindrical peripheral wall. The bottom may have holes through which the needles are respectively inserted. The peripheral wall may extend rearward from an outer peripheral edge of the bottom and may be configured to slide in the front-rear direction along the driving axis within the needle housing. The anvil may include a large-diameter part and a small-diameter part. The large-diameter part may be configured to slide in the front-rear direction along the driving axis within the needle housing. The small-diameter part may protrude forward from the large-diameter part and have a smaller outer diameter than the large-diameter part. A rear end part of the peripheral wall of the support is configured to be fitted onto the small-diameter part of the anvil.

[0263] According to this aspect, the anvil and the support substantially integrally slide within the needle housing, so that the anvil is restrained from tilting relative to the needle housing while the whole length of the anvil in the axial direction is reduced.

[0264] (Aspect B7) The needle scaler as defined in aspect B6, wherein one end part of each of the needles in the axial direction can move within a space that is defined between the bottom of the support and the anvil in the front-rear direction and surrounded by the peripheral wall of the support.

[0265] According to this aspect, the space in which the needles can move in the axial direction is appropriately secured by the support and the anvil.

[0266] (Aspect B8) The needle scaler as defined in any one of aspects B1 to B7, wherein the scaling mechanism may include a needle housing, a support, an anvil and an elastic element. The needle housing may have a front end having an opening through which the needles are inserted, and may be fixed to the tool body. The support may support the needles to be movable in the respective axial directions. The support may be configured to slide in the front-rear direction along the driving axis within the needle housing. The anvil may be arranged between the striker and the support in the front-rear direction and configured to slide in the front-rear direction along the driving axis within the needle housing. The anvil may be configured to apply hammering force to the needles by being struck by the striker. The elastic element may be disposed between the anvil and a rear end part of the needle housing in the front-rear direction.

[0267] According to this aspect, the elastic element alleviates impact of collision when the needles are bounced back rearward by reaction and collide with the anvil.

[0268] (Aspect B9) The needle scaler as defined in any one of aspects B1 to B8 may further comprise a handle and an operation member. The handle may be connected to the tool body and include a grip part extending in a first direction crossing the driving axis. The operation member may be provided on a front side of the grip part and configured to be manually operated by a user to instruct start of the motor. The grip part may have a first end that is closer to the tool body and a second end that is farther from the tool body, in the first direction. The operation member may be arranged in a region of the grip part that includes at least a center position of the grip part that is substantially equidistant from the first and second ends in the first direction.

[0269] According to this aspect, the operation member is arranged in a region including a center position in the first direction (or the longitudinal direction of the grip part). Thus, the operation member can be easily operated with one or more fingers of a user, whether the user holds the grip part in an orientation with a thumb on a first end side (on the end of the tool body side) of the grip part, or in an orientation with the thumb on a second end side (opposite side from the tool body) of the grip part. Further, the needle scaler can be used in various attitudes, but the orientation in which the grip part is held does not substantially affect the operability of the operation member, so that the needle scaler exhibits superior operability in various attitudes.

[0270] (Aspect B10) The needle scaler as defined in any one of aspects B1 to B9 may further comprise a lighting device that is arranged to illuminate an area forward of the needles.

[0271] According to this aspect, workability in a dark place is improved.

[0272] Correspondences between the features of aspects B1 to B10 and the features of the present disclosure or invention are as follows. However, the features of the above-described embodiments are merely exemplary and do not limit the features of aspects B1 to B10.

[0273] The needle scalers **1**A, **1**B are examples of the "needle scaler". The tool body **2**A, **2**B are examples of the "tool body". The motor **51** is an example of the "motor". The hammering mechanism **6** is an example of the "hammering mechanism". The scaling mechanism **9** and the needle **91** are examples of the "scaling mechanism" and the "needles", respectively. The piston cylinder **617** and the striker **65** are examples of the "piston" and the "striker", respectively.

[0274] The battery mounting part **4** is an example of the "battery mounting part". The intermediate shaft **60** and the oscillating member **613** are examples of the "intermediate shaft" and the "oscillating member", respectively. The sleeve **22** is an example of the "sleeve". The needle housing **90**, the support **93** and the anvil **95** are examples of the "needle housing", the "support" and the "anvil", respectively. The bottom **931** and the peripheral wall **935** of the support **93** are examples of the "bottom" and the "peripheral wall" of the "support", respectively. The large-diameter part **951** and the front small-diameter part **954** of the anvil **95** are examples of the "large-diameter part" and the "small-diameter part" of the "anvil", respectively. The elastic element **98** is an example of the "elastic element". The handle **3**B and the grip part **31** are examples of the "handle" and the "grip part", respectively. The trigger **35** is an example of the "operation member". The lighting unit **39** is an example of the "lighting device".

DESCRIPTION OF THE REFERENCE NUMERALS

[0275] **1**A, **1**B, **1**C, **1**D, **1**E, **1**F, **1**G, **1**H, **1**I, **1**J, **1**K, **1**L, **1**M: needle scaler, **2**A, **2**B, **2**D, **2**H: tool body, **201**: projection, **21**: barrel part, **22**: sleeve, **221**: flange, **227**: elastic element, **24**: support, **241**: cylindrical part, **25**: rear end part, **25**R: rear end, **251**: rear wall part, **253**: side wall part, **27**: body extending part, **3**A, **3**B, **3**D, **3**F, **3**H, **3**J, **3**L: handle, **31**: grip part, **31**F: front end, **31**R: rear end, **311**: front wall part, **312**: opening, **32**A, **32**B, **32**F, **32**H, **32**J: lower end part, **320**: battery insertion part, **321**: opening, **322**: guide wall, **340**: upper extending part, **342**: front extending part, **344:** lower extending part, **35**: trigger, **37**: touch switch, **38**: switch, **381**: switch body, **383**: plunger, **39**: lighting unit, **4**, **4**J: battery mounting part, **41**, **41**J: engagement part, **42**: guide groove, **45**, **45**J: connector part, **47**: recessed part, **40**: battery, **400**: mounting surface, **401**: surface, **403**: guide rail, **405**: connector part, **407**, **407**J: locking member, **408**: release button, **50**: controller, **51**: motor, **511**: stator, **513**: rotor, **515**: output shaft, **516**: pinion, **517**: bearing, **518**: bearing, **6**, **6**C, **6**H, **6**I: hammering mechanism, **60**: intermediate shaft, **601**: bearing, **602**: bearing, **605**, **605**H: gear, **61**, **61**H: motion converting mechanism, **611**: rotary body, **612**: spring receiver, **613**: oscillating member, **614**: ring part, **615**: arm part, **616**: rod, **617**: piston cylinder, **618**: washer, **619**: bolt, **63**: cylinder, **631**: large-diameter part, **633**: shoulder part, **635**: small-diameter part, **636**: small flange, **637**: recess, **638**: large flange, **64**: rotation stopper ring, **641**: recess, **643**: projection, **644**: groove, **645**: ball, **65**, **65**C: striker, **651**: recess, **652**:bottom, **653**: recess, **654**: through hole, **66**: air chamber, **68**: compression coil spring, **9**: scaling mechanism, **90**: needle housing, **900**: cylindrical member, **901**: wall, **902**: opening, **904**: flange, **91**: needle, **911**: body, **915**: head, **93**: support, **931**: bottom, **932**: hole, **935**: peripheral wall, **95**: anvil, **951**: large-diameter part, **954**: front small-diameter part, **956**: rear small-diameter part, **957**: rear projection, **96:** space, **97**: biasing member, **98**: elastic element, CL: center position, DX: driving axis, RX1: rotational axis, RX2: rotational axis, S: working surface

1. An electric needle scaler, comprising:
   - a tool body, at least part of which extends along a driving axis that defines a front-rear direction of the needle scaler;
   - an electric motor that is housed in the tool body and includes an output shaft that is rotatable around a first rotational axis;
   - a battery mounting part that is configured to removably receive a battery;
   - a power transmitting mechanism that is housed in the tool body; and
   - a scaling mechanism that is supported by a front end part of the tool body and includes needles that protrude forward to be exposed out of the tool body and are supported to be movable in respective axial directions of the needles;

wherein:

   - the power transmitting mechanism includes a power transmitting part that is operably connected to the output shaft of the motor and reciprocates along the driving axis by utilizing rotation of the output shaft and transmit force to the needles in the respective axial directions.

2. The needle scaler as defined in claim 1, wherein the power transmitting mechanism includes: (i) a reciprocating member that is operably connected to the output shaft of the motor and reciprocates along the driving axis along with rotation of the output shaft; and (ii) a striker as the power transmitting part that applies hammering force to the needles by reciprocation of the reciprocating member.

3. The needle scaler as defined in claim 2, wherein:
the power transmitting mechanism includes: (i) an intermediate shaft that is operably connected to the output shaft and rotates around a second rotational axis parallel to the first rotational axis along with rotation of the output shaft; and (ii) an oscillating member that is arranged on the intermediate shaft and oscillates in the front-rear direction along with rotation of the intermediate shaft; and
the reciprocating member is operably connected to the oscillating member and linearly reciprocates along the driving axis along with oscillation of the oscillating member.

4. The needle scaler as defined in claim 3, further comprising:
a handle that is connected to the tool body and includes a grip part extending in a first direction crossing the driving axis;
wherein:
the driving axis, the first rotational axis and the second rotational axis are parallel to each other; and
the handle protrudes from the tool body in a direction toward the second rotational axis from the driving axis.

5. The needle scaler as defined in claim 2, wherein:
the reciprocating member comprises a piston that forms an air chamber between the reciprocating member and the striker; and
the striker reciprocates along the driving axis by pressure fluctuations caused in the air chamber by reciprocation of the piston.

6. The needle scaler as defined in claim 5, wherein:
the piston comprises a bottomed cylindrical piston cylinder;
the striker is slidable along the driving axis within the piston cylinder; and
the air chamber is defined between a bottom of the piston cylinder and the striker.

7. The needle scaler as defined in claim 2, wherein:
the power transmitting mechanism further includes an elastic member that elastically connects the reciprocating member and the striker; and
the striker reciprocates along the driving axis by an elastic force of the elastic member that is generated by reciprocation of the reciprocating member.

8. The needle scaler as defined in claim 1, further comprising:
a sleeve that is arranged within the front end part of the tool body and holds the scaling mechanism,
wherein:
the front end part of the tool body is made of synthetic resin; and
the sleeve is made of metal and integrally formed with the front end part.

9. The needle scaler as defined in claim 1, wherein;
the scaling mechanism includes:
a needle housing that has a front end having an opening through which the needles are inserted, and is fixed to the tool body;
a support that supports the needles to be movable in the respective axial directions; and
an anvil that is arranged between the power transmitting part and the support in the front-rear direction, and configured to apply the axial force to the needles by being struck by the power transmitting part;
wherein:
the support has a bottomed cylindrical shape, and includes: (i) a bottom having holes through which the needles are respectively inserted; and (ii) a peripheral wall that has cylindrical shape and extends rearward from an outer peripheral edge of the bottom and is configured to slide in the front-rear direction along the driving axis within the needle housing;
the anvil includes: (i) a large-diameter part that is configured to slide in the front-rear direction along the driving axis within the needle housing; and (ii) a small-diameter part that protrudes forward from the large-diameter part and has a smaller outer diameter than the large-diameter part; and
a rear end part of the peripheral wall of the support is configured to be fitted onto the small-diameter part of the anvil.

10. The needle scaler as defined in claim 9, wherein one end part of each of the needles in the axial direction is movable within a space that is defined between the bottom of the support and the anvil in the front-rear direction and surrounded by the peripheral wall of the support.

11. The needle scaler as defined in claim 10, wherein:
the support is configured to slide in the front-rear direction along the driving axis within the needle housing;
the anvil is configured to slide in the front-rear direction along the driving axis within the needle housing; and
the needle scaler includes an elastic element that is disposed between the anvil and a rear end part of the needle housing in the front-rear direction.

12. The needle scaler as defined in claim 1, wherein:
the scaling mechanism includes:
a needle housing that has a front end having an opening through which the needles are inserted, and is fixed to the tool body;
a support that supports the needles to be movable in the respective axial directions and is configured to slide in the front-rear direction along

the driving axis within the needle housing; and

an anvil that is arranged between the power transmitting part and the support in the front-rear direction and is configured to slide in the front-rear direction along the driving axis within the needle housing, the anvil being configured to apply the axial force to the needles by being struck by the power transmitting part; and

the needle scaler includes an elastic element that is disposed between the anvil and a rear end part of the needle housing in the front-rear direction.

13. The needle scaler as defined in claim **1**, further comprising:

a handle that is connected to the tool body and includes a grip part extending in a first direction crossing the driving axis; and

an operation member that is provided on a front side of the grip part and configured to be manually operated by a user to instruct start of the motor;

wherein:

the grip part has a first end that is closer to the tool body and a second end that is farther from the tool body, in the first direction; and

the operation member is arranged in a region of the grip part that includes at least a center position of the grip part that is substantially equidistant from the first and second ends in the first direction.

14. The needle scaler as defined in claim **1**, further comprising a lighting device that is arranged to illuminate an area forward of the needles.

15. The needle scaler as defined in claim **1**, further comprising:

a handle that is connected to the tool body and includes a grip part extending in a first direction crossing the driving axis;

wherein a line orthogonal to the driving axis passes through the battery mounting part and the handle when the needle scaler is viewed from a second direction orthogonal to the front-rear direction and the first direction.

16. An electric needle scaler, comprising:

a tool body, at least part of which extends along a driving axis that defines a front-rear direction of the needle scaler;

an electric motor that is housed in the tool body and includes an output shaft that is rotatable around a first rotational axis;

a hammering mechanism that is housed in the tool body; and

a scaling mechanism that is supported by a front end part of the tool body and includes needles that protrude forward to be exposed out of the tool body and are supported to be movable in respective axial directions of the needles;

wherein the hammering mechanism includes: (i) a piston that is operably connected to the output shaft of the motor and reciprocates along the driving axis along with rotation of the output shaft; and (ii) a striker that reciprocates along the driving axis by pressure fluctuations caused in an air chamber by reciprocation of the piston and applies hammering force to the needles.

* * * * *