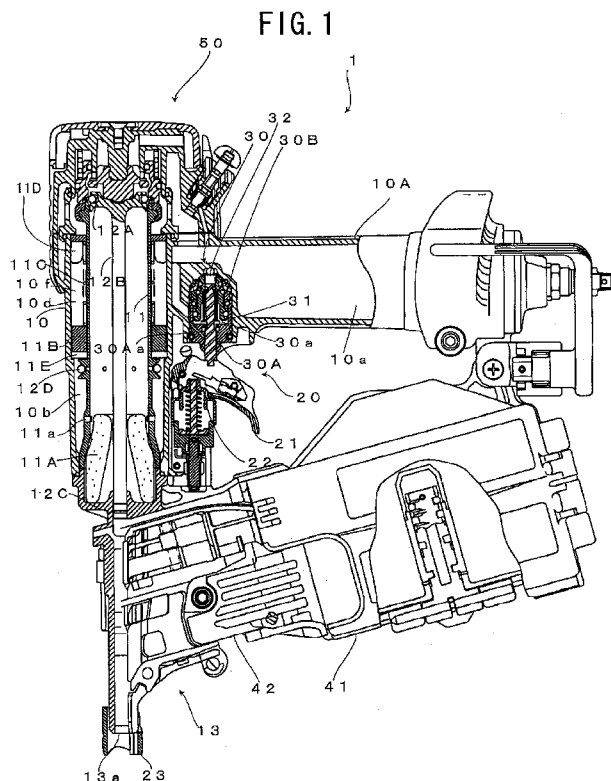




- (51) International Patent Classification: Not classified
- (21) International Application Number: PCT/JP2013/000484
- (22) International Filing Date: 30 January 2013 (30.01.2013)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
2012-018613 31 January 2012 (31.01.2012) JP
2012-063098 21 March 2012 (21.03.2012) JP
- (71) Applicant: HITACHI KOKI CO., LTD. [JP/JP]; 15-1, Konan 2-chome, Minato-ku, Tokyo, 1086020 (JP).
- (72) Inventors: KOMAZAKI, Yoshiichi; c/o Hitachi Koki Co., Ltd., 1060, Takeda, Hitachinaka-shi, Ibaraki, 3128502 (JP). TANJI, Isamu; c/o Hitachi Koki Co., Ltd., 1060, Takeda, Hitachinaka-shi, Ibaraki, 3128502 (JP). NISHIDA, Masashi; c/o Hitachi Koki Co., Ltd., 1060, Takeda, Hitachinaka-shi, Ibaraki, 3128502 (JP).
- (74) Agents: KITAZAWA, Kazuhiro et al.; 6F, First Genesis Bldg., 31-14, Yushima 2-chome, Bunkyo-ku, Tokyo, 1130034 (JP).
- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.
- (84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: DRIVING TOOL



(57) Abstract: A driving tool includes a housing, accumulator chamber, cylinder, piston, and counterweight. The piston divides an inner space formed within the cylinder into a first piston chamber and a second piston chamber. The piston moves in a first direction directed from the second piston chamber to the first piston chamber by the compressed air supplied into the first piston chamber, thereby performing a driving process to generate a driving force. The counterweight opposes the cylinder in a direction perpendicular to an axial direction of cylinder and is capable of moving in a second direction opposite to the first direction.



Published:

- *without international search report and to be republished
upon receipt of that report (Rule 48.2(g))*

Description

Title of Invention: DRIVING TOOL

Technical Field

[0001] The invention relates to a driving tool.

Background Art

[0002] A driving tool is conventionally known that strikes and drives fasteners such as nails and staples. In a driving tool, by pressing a push lever against a workpiece and pulling a trigger at an initial state prior to driving, a plunger of a trigger valve is pushed up against pressure of compressed air, which actuates a main valve allowing communication between an accumulator chamber in which compressed air is stored and a piston upper chamber defined by a cylinder inner surface and a piston. With this operation, the piston is displaced rapidly due to compressed air that has flowed into the piston upper chamber, and gives an impact on a fastener for driving the fastener. With displacement of the piston, compressed air in the piston upper chamber flows into a return air chamber from inside the cylinder, and is used to return the piston to a position at the initial state. This kind of driving tool is described in, for example, Japanese Patent No. 2,658,721.

Disclosure of Invention

Solution to Problem

[0003] In the driving tool described in Japanese Patent No. 2,658,721, a counteraction absorbing member is disposed to face an upper chamber of an impact piston of an impact cylinder, the counteraction absorbing member has a downward effective surface larger than an upward effective area of the piston and facing an upper surface of the impact piston, and is slidable in a movement axis of the impact piston. When the impact piston is driven by compressed air pressure, the counteraction absorbing member having a larger effective surface than the cross-sectional area of the impact piston is driven to the opposite direction to the impact piston with the same compressed air pressure. With this operation, all of reaction force that generates in connection with driving of the impact piston is absorbed by part of reaction force that generates when the counteraction absorbing member is driven in the opposite direction, thereby weakening upward reaction force due to driving of the impact piston.

[0004] In the configuration described in the above-identified literature, however, because the counteraction absorbing member is disposed at an upper part of the impact cylinder, the overall height of the driving tool is large. If the overall height of the driving tool is large, a problem occurs that, during a driving operation of nails or the like, the main body of the driving tool does not fit between columns and hence nails or the like

cannot be driven at desired positions.

[0005] Further, in order to increase power of a driving tool, compressed air need to flow instantaneously into a piston upper chamber having as small volume as possible. In the configuration described in the above-identified literature, because the counteraction absorbing member is larger than the impact piston, the piston upper chamber has a large space. In addition, because energy of compressed air is also used for movement of the counteraction absorbing member, a problem occurs that power of driving nails or the like decreases.

[0006] In view of the foregoing, an object of the invention is to provide a driving tool that can reduce counteraction of a main body at the time of driving, without increasing the overall height and without lowering driving power.

[0007] In order to attain above and other objects, the present invention provides a driving tool including a housing, accumulator chamber, cylinder, piston, and a counterweight. The accumulator chamber is disposed in the housing and configured to accumulate compressed air. The cylinder is disposed in the housing and has a first end and a second end in an axial direction. The piston is disposed in the cylinder and capable of reciprocating in the axial direction. The piston divides an inner space defined within the cylinder into a first piston chamber located near the first end and a second piston chamber located near the second end. The piston moves in a first direction directed from the second piston chamber to the first piston chamber by the compressed air supplied into the first piston chamber, thereby performing a driving process to generate a driving force. The counterweight opposes the cylinder in a direction perpendicular to the axial direction and is capable of moving in a second direction opposite to the first direction.

[0008] With this construction, reaction force by which the piston moves in the first direction from the first end toward the second end of the cylinder acts on the housing and the cylinder to push the housing and the cylinder toward the first end side. On the other hand, however, the counterweight is moved in the opposite direction to the piston, and its reaction force acts on the housing and the cylinder so that the housing and the cylinder can be pushed toward the second end side. Hence, reaction force acting on the housing and the cylinder can be offset and counteraction can be reduced.

[0009] Further, there is a positional relationship that the counterweight opposes the cylinder in a direction perpendicular to the axial direction of the cylinder, which prevents a situation in which the dimension of the driving tool in the axial direction of the cylinder becomes large. Further, if this construction is applied to an air-type driving tool for driving nails, the dead space can be utilized effectively.

[0010] It is preferable that the counterweight is capable of moving within a distance greater than or equal to a half of distance the piston moves during the driving process.

- [0011] With this configuration, because the distance the counterweight can move is long, by moving the counterweight in synchronization with movement of the piston, counteraction can be reduced over the entirety of a driving process.
- [0012] It is preferable that the driving tool further includes a sub-cylinder extending in the axial direction and having one end located near the first end and another end located near the second end. The counterweight includes a sub-piston capable of reciprocating in the axial direction in the sub-cylinder. The sub-piston divides an inner space defined within the sub-cylinder into a first sub-piston chamber located near the one end and a second sub-piston chamber located near the another end.
- [0013] With this construction, the counterweight can be configured that can move in the opposite direction to the moving direction of the piston in the axial direction of the cylinder with a simple configuration.
- [0014] It is preferable that the driving tool further includes a communication passage allowing the second sub-piston chamber and air accumulator chamber to communicate with each other.
- [0015] With this construction, the compressed air flows into the first piston chamber from the air accumulator chamber and concurrently flows into the second sub-piston chamber. Thus, the counterweight can be provided that utilizes compressed air to move in the opposite direction to the moving direction of the piston in the axial direction of the cylinder.
- [0016] It is preferable that the driving tool further includes a switch disposed in the communication passage and configured to switch communication/blocking between the second sub-piston chamber and the first piston chamber.
- [0017] With this construction, reaction force can be utilized without offsetting, as necessary. For example, assume a situation in which nails are driven consecutively. When a nail has been driven and a subsequent nail is to be driven, a driving tool is pushed up by utilizing reaction force, and an operator changes a place to drive a nail at this moment and brings the driving tool down using its own weight or with a light load. In this way, the operator can drive the subsequent nail without using large force, and can drive nails consecutively.
- [0018] It is preferable that the piston is capable of reciprocating between a top dead center and a bottom dead center. The counterweight moves in the second direction with a delay after the piston starts moving toward the bottom dead center.
- [0019] With this construction, the counterweight is provided that, with a delay after the piston starts moving toward the bottom dead center, moves in the opposite direction to the moving direction of the piston in the axial direction of the cylinder. Thus, when a fastener is driven into a workpiece, counteraction due to reaction force acting on the driving tool can be reduced effectively.

- [0020] It is preferable that the driving tool further includes a return air chamber disposed in the housing and configured to store the compressed air supplied in the first piston chamber when the piston moves from the top dead center to the bottom dead center, thereby returning the piston from the bottom dead center to the top dead center. The counterweight is driven in the second direction due to an increase in pressure of compressed air stored in the return air chamber.
- [0021] With this construction, a counterweight can be configured that can move in the opposite direction to the moving direction of the piston in the axial direction of the cylinder with a simple configuration.
- [0022] It is preferable that the counterweight has a ring shape surrounding a circumferential surface of the cylinder.
- [0023] With this construction, because the ring-shaped counterweight is fitted around the cylinder, the counterweight can be arranged by utilizing a space around the cylinder. Hence, a separate counterweight need not to be provided at the outside of the housing, which prevents a situation in which a portion where the counterweight is provided protrudes from the outside of the housing. Thus, the outer shape of the driving tool becomes a simple shape, which prevents a situation in which a portion where the counterweight is provided hinders driving operations. Further, it is possible to prevent the dimension of the driving tool in the axial direction of the cylinder from becoming large. In addition, because this position corresponds to a dead space, the dead space can be utilized effectively.
- [0024] It is preferable that the housing and the cylinder define a sub-cylinder having a substantially cylindrical shape extending in the axial direction. The sub-cylinder surrounds entirety of a circumferential surface of the cylinder and defines a sub-cylinder space therein. The counterweight includes a sub-piston disposed coaxially with the cylinder in the sub-cylinder space. The counterweight is capable of reciprocating in the axial direction within the sub-cylinder space. The sub-piston divides the sub-cylinder space into a first sub-piston chamber located near the one end and a second sub-piston chamber located near the another end. The second sub-piston chamber and the first piston chamber communicate with each other when the piston moves in the first direction. The second sub-piston chamber and the second piston chamber communicate with each other when the piston moves in the second direction.
- [0025] With this construction, the portion of the return air chamber defines the sub-cylinder space, the compressed air that flows into the return air chamber can be utilized to move the sub-piston. Hence, compressed air need not to be used only for moving the sub-piston, and the consumption amount of compressed air can be suppressed. Further, with a simple configuration, a counterweight can be configured that can move in the opposite direction to the moving direction of the piston in the axial direction of the

cylinder.

Advantageous Effects of Invention

[0026] According to a driving tool of the invention, a driving tool can be provided that can reduce counteraction of the main body at the time of driving.

Brief Description of Drawings

[0027] [fig.1]Fig. 1 is a side partial cross-sectional view showing a driving tool according to a first embodiment of the invention.

[fig.2]Fig. 2 is a front cross-sectional view showing the relevant parts in a state where a piston is located at a top dead center in the driving tool according to the first embodiment of the invention.

[fig.3]Fig. 3 is a front cross-sectional view showing the relevant parts in a state where compressed air starts flowing into an upper chamber of the piston in the driving tool according to the first embodiment of the invention.

[fig.4]Fig. 4 is a front cross-sectional view showing the relevant parts in a state where the piston is located at a bottom dead center in the driving tool according to the first embodiment of the invention.

[fig.5]Fig. 5 is a front partial cross-sectional view showing a driving tool according to a second embodiment of the invention.

[fig.6]Fig. 6 is a side partial cross-sectional view showing the driving tool according to the second embodiment of the invention.

[fig.7A]Fig. 7A is a schematic view showing a state in which a sub-piston driving valve is located at a highest position in the driving tool according to the second embodiment of the invention.

[fig.7B]Fig. 7B is a schematic view showing a state in which the sub-piston driving valve is located at a lowest position in the driving tool according to the second embodiment of the invention.

[fig.7C]Fig. 7C is a schematic view showing a sub-piston lower-chamber communication passage of the driving tool according to the second embodiment of the invention.

[fig.8]Fig. 8 is a cross-sectional view showing the relevant parts in a state in which the sub-piston driving valve is fixed in the driving tool according to the second embodiment of the invention.

[fig.9]Fig. 9 is a cross-sectional view showing the relevant parts in a state in which the sub-piston driving valve is movable in the driving tool according to the second embodiment of the invention.

[fig.10]Fig. 10 is a front cross-sectional view showing the relevant parts in a state in which a piston is located at a top dead center in the driving tool according to the

second embodiment of the invention.

[fig.11]Fig. 11 is a front cross-sectional view showing the relevant parts in a state in which compressed air starts flowing into a piston upper chamber in the driving tool according to the second embodiment of the invention.

[fig.12]Fig. 12 is a front cross-sectional view showing the relevant parts in a state in which the piston is located at a bottom dead center in the driving tool according to the second embodiment of the invention.

[fig.13]Fig. 13 is a side partial cross-sectional view showing a first modification of the driving tool according to the second embodiment of the invention.

[fig.14]Fig. 14 is a side partial cross-sectional view showing a second modification of the driving tool according to the second embodiment of the invention.

[fig.15]Fig. 15 is a front partial cross-sectional view showing a third modification of the driving tool according to the second embodiment of the invention.

Mode for Carrying Out the Invention

[0028] A first embodiment of a driving tool according to the invention will be described while referring to Figs. 1 through 4. In the following descriptions, upper and lower sides of Fig. 1 is defined as upper and lower sides of a driving tool 1, respectively, for descriptions purposes. Further, a direction from the right side toward the left side is defined as a front side, and its opposite direction is defined as a rear side. Additionally, a direction from the far side toward the near side with respect to the surface of the drawing sheet is defined as a left side, and its opposite direction is defined as a right side.

[0029] As shown in Fig. 1, the driving tool 1 is a driving tool driven by compressed air, and includes a frame 10 and a handle 10A located at one side of the frame 10 and provided integrally with the frame 10. The frame 10 and the handle 10A serve as a housing. The handle 10A is connected to an air hose (not shown), so that compressed air can be supplied to an accumulator chamber 10a formed in the handle 10A and the frame 10 through the air hose (not shown).

[0030] A cylinder 11 having a cylindrical shape is provided within the frame 10. A piston 12A slidable reciprocatingly upward and downward is provided within the cylinder 11. A driver blade 12B is provided integrally with the piston 12A, so that a nail that is an example of a fastener (not shown) can be driven by an end portion 12C of the driver blade 12B. A check valve 12D is provided at substantially a center portion of the cylinder 11 in the axial direction thereof. A return air chamber 10b for storing compressed air to return the driver blade 12B to the top dead center is defined at outside of a lower portion of the cylinder 11 by part of the frame 10 and part of the cylinder 11. It is so configured that, due to the check valve 12D, compressed air can flow only in one direction from inside the cylinder 11 to the return air chamber 10b.

An air passage 11a allowing constant communication between inside of the cylinder 11 and inside of the return air chamber 10b is formed at a lower portion of the cylinder 11. A piston bumper 11A for absorbing surplus energy of the driver blade 12B subsequent to driving a fastener (not shown) is provided at a lower end of the cylinder 11.

- [0031] The return air chamber 10b is constituted by a space defined by an outer circumferential surface of the cylinder 11 and an inner circumferential surface of the frame 10, and extends from a portion adjacent to the lower end to a portion adjacent to the upper end of the cylinder 11. A portion of the frame 10 and the cylinder 11 defining an upper section of the return air chamber 10b located at the upper side of the check valve 12D constitutes a sub-cylinder. The upper section of the return air chamber 10b constitutes an in-sub-cylinder space 10d. Hence, the in-sub-cylinder space 10d has a ring shape that is long in its axial direction, in other words, has a tubular shape having a predetermined thickness in its radial direction. Specifically, the frame 10 and the cylinder 11 define the sub-cylinder having a substantially cylindrical shape extending in the axial direction. The sub-cylinder surrounds entirety of a circumferential surface of the cylinder 11 and defining the sub-cylinder space 10d therein.
- [0032] The area of a cross-section of the in-sub-cylinder space 10d perpendicular to the axial direction of the in-sub-cylinder space 10d is much smaller than the area of a cross-section of the space within the cylinder 11 perpendicular to the axial direction of the cylinder 11. Thus, the volume of the in-sub-cylinder space 10d can be designed to be small. Hence, an amount of air for driving a sub-piston 11B described later can be made small, and a drop in striking force of the piston 12A can be made minimum.
- [0033] The sub-piston 11B is provided in the in-sub-cylinder space 10d. The sub-piston 11B has a ring shape surrounding a circumferential surface of the cylinder 11 and having a coaxial positional relationship with the in-sub-cylinder space 10d. The sub-piston 11B is slidable in the axial direction of the in-sub-cylinder space 10d relative to the outer circumferential surface of the cylinder 11 and the inner circumferential surface of the frame 10. The sub-piston 11B divides the in-sub-cylinder space 10d into a sub-piston upper chamber 10f and a sub-piston lower chamber 10g (Fig. 3 etc.).
- [0034] A lower end of a spring 11C is in contact with the upper end of the sub-piston 11B, while an upper end of the spring 11C is in contact with a wall portion defining the upper end of the return air chamber 10b. The urging force of the spring 11C is weak to an extent that the urging force does not hinder movement of the sub-piston 11B within the sub-cylinder and that the urging force causes the sub-piston 11B to be located at the lower end (bottom dead center) when the driving tool 1 is not operating and no external force is acting. A rubber-made sub-bumper 11D is provided at a wall portion defining the upper end of the return air chamber 10b. The sub-bumper 11D can be collided by the sub-piston 11B when the sub-piston 11B moves upward and, due to this

collision, can absorb surplus energy of movement of the sub-piston 11B. The weight of the sub-piston 11B is the same as the weight of the piston 12A, and is approximately 80 grams. The sub-piston 11B serves as a counterweight.

[0035] A rubber-made sealing member 11E is fixed to a lower surface of the sub-piston 11B. The sealing member 11E has a ring shape that has a width in the radial direction slightly greater than the thickness of the sub-piston 11B in the radial direction and that has a predetermined thickness in the axial direction. The sealing member 11E is in constant contact with the outer circumferential surface of the cylinder 11 and the inner circumferential surface of the frame 10, thereby sealing the sub-piston upper chamber 10f and the sub-piston lower chamber 10g.

[0036] An operating section 20 is provided at a base portion of the handle 10A. The operating section 20 includes a trigger 21 operated by a finger of an operator, an arm plate 22 mounted rotatably on the trigger 21, and a push lever 23 protruding from the lower end of the frame 10 and extending to vicinity of the arm plate 22 and movable along the lower end portion of the frame 10. A trigger valve section 30 described later is provided at the base portion of the handle 10A opposing the trigger 21.

[0037] When both of a pulling operation of the trigger 21 by a finger of the operator and a pressing operation of the push lever 23 against the workpiece are performed concurrently, a link mechanism consisting of the arm plate 22 and the trigger 21 is configured to push up a plunger 32 of the trigger valve section 30 described later.

[0038] An injecting section 13 for injecting fasteners (not shown) is provided at a lower end portion of the frame 10. The injecting section 13 is connected to a magazine 41 for loading nails (not shown) as an example of fasteners, and to a feeding mechanism 42 that sequentially feeds an injection opening 13a with fasteners (not shown) loaded in the magazine 41.

[0039] As shown in Fig. 1, the trigger valve section 30 includes an outer valve bush 30A, an inner valve bush 30B, a valve piston 31, and the plunger 32. The outer valve bush 30A and the inner valve bush 30B are fixed to the frame 10 as a trigger-valve outer frame section constituting the outer frame of the trigger valve.

[0040] The valve piston 31 is located within the outer valve bush 30A and within the inner valve bush 30B, and is slidable reciprocatingly relative to the outer valve bush 30A and the inner valve bush 30B. Although not shown in the drawing, an upper end portion of the valve piston 31 in the sliding direction thereof faces the accumulator chamber 10a. At the lower side of the valve piston 31, a trigger valve chamber 30a is defined by the lower end portion of the valve piston 31 and the outer valve bush 30A.

[0041] The plunger 32 is disposed in a through-hole formed at an axial center position of the valve piston 31, and is slidable reciprocatingly relative to the valve piston 31 defining the through-hole. A lower end portion of the plunger 32 penetrates through the trigger

valve chamber 30a, and penetrates through a through-hole formed in the valve bush 30A and is capable of contacting the arm plate 22.

[0042] A spring is provided between the valve piston 31 and the plunger 32, and urges the valve piston 31 upward and urges the plunger 32 downward.

[0043] An air passage 30Aa communicated with the accumulator chamber 10a and the trigger valve chamber 30a is provided between the plunger 32 and the valve bush 30A. In addition, a trigger-valve control passage communicated with the trigger valve chamber 30a and the atmosphere is formed between the plunger 32 and the valve piston 31. The air passage 30Aa and the trigger-valve control passage are communicated/blocked in an alternative way by sliding movement of the plunger 32.

[0044] The trigger valve section 30 is connected to a main-valve control passage (not shown) extending from a main valve chamber 10e (Fig. 2) to be described later. Specifically, a main-valve air inlet passage communicated with the main-valve control passage and the accumulator chamber 10a is formed at a position between the valve piston 31 and the inner valve bush 30B and below an opening of the main-valve control passage. Further, a second air passage communicated with the main-valve control passage and the atmosphere is formed at a position between the valve piston 31 and the inner valve bush 30B and above the opening of the main-valve control passage. The main-valve control passage can be communicated with the main-valve air inlet passage and the second air passage constituting a space between the valve piston 31 and the inner valve bush 30B. The main-valve air inlet passage and the second air passage are configured to be communicated/blocked in an alternative way by upward and downward sliding movement of the valve piston 31.

[0045] When the valve piston 31 is located at the top dead center side, the main-valve air inlet passage opens and allows communication between the accumulator chamber 10a and the main-valve control passage, and the second air passage closes and blocks communication between the main-valve control passage and the atmosphere. Further, when the valve piston 31 is located at the bottom dead center side, the main-valve air inlet passage closes and blocks communication between the main-valve control passage and the accumulator chamber 10a, and the second air passage opens and allows communication between the main-valve control passage and the atmosphere.

[0046] When the plunger 32 is located at the bottom dead center side, the trigger-valve control passage closes and blocks communication between the trigger valve chamber 30a and the atmosphere, and the air passage 30Aa opens and allows communication between the accumulator chamber 10a and the trigger valve chamber 30a. Further, when the plunger 32 is located at the top dead center side, the trigger-valve control passage opens and allows communication between the trigger valve chamber 30a and the atmosphere, and the air passage 30Aa closes and blocks communication between

the accumulator chamber 10a and the trigger valve chamber 30a.

[0047] As shown in Fig. 2 etc., a main valve section 50 is provided above the upper end of the cylinder 11. The main valve section 50 includes a main valve 51, a main valve rubber 52A fixedly attached to an upper portion of the cylinder 11, a main valve spring 53 that urges the main valve 51 toward the bottom dead center side, and an exhaust rubber 52B disposed above the cylinder 11 and configured to block an air passage 10c for venting compressed air in a piston upper chamber 11b of the piston 12A by contacting the main valve 51. The air passage 10c is communicated with the atmosphere via a venting hole (not shown) formed in an upper portion of the frame 10.

[0048] The main valve 51 is configured to be accommodated within a main-valve-chamber defining section 10D that is formed by part of the frame 10. A portion of the main-valve-chamber defining section 10D capable of accommodating the main valve 51 constitutes the main valve chamber 10e, and is communicated with the main-valve control passage. An O-ring 51A for constantly blocking communication between the main valve chamber 10e and the air passage 10c is provided at an upper portion of the main valve 51. In addition, an O-ring 51B for constantly blocking communication between the main valve chamber 10e and the accumulator chamber 10a is provided at the main valve 51. The O-rings 51A and 51B keep the main valve chamber 10e in an air-tight state.

[0049] As shown in Figs. 3 and 4, when the main valve 51 is located at the top dead center side, the main valve 51 makes contact with the exhaust rubber 52B to close the air passage 10c so that communication between the piston upper chamber 11b of the piston 12A and the atmosphere is blocked and communication between the piston upper chamber 11b and the accumulator chamber 10a is allowed. Further, as shown in Fig. 2, when the main valve 51 is located at the bottom dead center side, the main valve 51 makes contact with the main valve rubber 52A to block communication between the piston upper chamber 11b of the piston 12A and the accumulator chamber 10a, and the main valve 51 is spaced away from the exhaust rubber 52B to open the air passage 10c so that the piston upper chamber 11b is communicated with the atmosphere.

[0050] Next, a driving operation by the driving tool 1 will be described. First, an air hose (not shown) is connected to the driving tool 1, and compressed air is accumulated in the accumulator chamber 10a. Due to the urging force of the spring, the plunger 32 is located at the bottom dead center. Because the plunger 32 is located at the bottom dead center, the air passage is opened and the accumulator chamber 10a and the trigger valve chamber 30a are communicated with each other. At the same time, because the trigger-valve control passage is closed, communication between the trigger valve chamber 30a and the atmosphere is blocked, and a portion of compressed air in the ac-

cumulator chamber 10a flows into the trigger valve chamber 30a via the air passage to accumulate air at the same pressure as the accumulator chamber 10a.

[0051] At this time, the valve piston 31 is located at the top dead center. Because the valve piston 31 is located at the top dead center, the main-valve air inlet passage opens and the accumulator chamber 10a and the main-valve control passage are communicated with each other. At the same time, because the second air passage is closed, communication between the main-valve control passage and the atmosphere is blocked, and a portion of compressed air in the accumulator chamber 10a flows into the main-valve control passage so that air at the same pressure as the accumulator chamber 10a is accumulated in the main valve chamber 10e. Because a portion of compressed air in the accumulator chamber 10a flows into the main valve chamber 10e, the main valve 51 is located at the bottom dead center due to compressed air and the urging force of the main valve spring 53.

[0052] Because the main valve 51 is located at the bottom dead center, the main valve 51 makes contact with the main valve rubber 52A and is slightly spaced away from the exhaust rubber 52B so that the air passage 10c is opened. Thus, the piston upper chamber 11b of the piston 12A within the cylinder 11 is communicated with the atmosphere, and the piston upper chamber 11b is at atmospheric pressure. Further, because communication between the piston upper chamber 11b and the accumulator chamber 10a is blocked, air in the accumulator chamber 10a does not flow into the piston upper chamber 11b. Hence, the piston 12A is in a stopped state at the top dead center side.

[0053] Next, both of a pulling operation of the trigger 21 and a pressing operation of the push lever 23 against the workpiece are performed to push up the plunger 32 to the top dead center. Because the plunger 32 is located at the top dead center side, the trigger-valve control passage is opened. With this operation, the trigger valve chamber 30a is communicated with the atmosphere, and pressure in the trigger valve chamber 30a becomes atmospheric pressure. Further, the air passage closes to block communication between the accumulator chamber 10a and the trigger valve chamber 30a, so that inflow of compressed air from the accumulator chamber 10a into the trigger valve chamber 30a is stopped. As a result of this, because pressure in the trigger valve chamber 30a becomes atmospheric pressure, a difference is generated between pressure acting on the accumulator chamber 10a side of the valve piston 31 and pressure acting on the trigger valve chamber 30a side of the valve piston 31, which causes the valve piston 31 to move to the bottom dead center.

[0054] Because the valve piston 31 is located at the bottom dead center, the main-valve air inlet passage closes to block communication between the main-valve control passage and the accumulator chamber 10a, and inflow of compressed air from the accumulator

chamber 10a into the main-valve control passage is stopped. Further, the second air passage opens to allow communication between the main-valve control passage and the atmosphere. With this operation, pressure in the main-valve control passage becomes atmospheric pressure, and pressure in the main valve chamber 10e communicated with the main-valve control passage also becomes atmospheric pressure. When pressure in the main valve chamber 10e become substantially atmospheric pressure, the main valve 51 moves to the top dead center side.

[0055] When the main valve 51 starts moving toward the top dead center side, because the accumulator chamber 10a is communicated with the piston upper chamber 11b of the piston 12A, the main valve 51 moves rapidly to the top dead center side and makes contact with the exhaust rubber 52B, thereby blocking communication between the accumulator chamber 10a and the atmosphere and communication between the piston upper chamber 11b of the piston 12A and the atmosphere.

[0056] When the main valve 51 moves from the bottom dead center to the top dead center, compressed air in the accumulator chamber 10a flows into the piston upper chamber 11b of the piston 12A, and the piston 12A moves rapidly to the bottom dead center side and the end portion 12C drives a fastener (not shown). At this time, the driver blade 12B receives reaction force from the fastener (not shown), and pushes the frame 10 and the like upward through compressed air in the piston upper chamber 11b of the piston 12A.

[0057] During moving of the piston 12A toward the bottom dead center side, air in the cylinder 11 below the piston 12A flows into the return air chamber 10b through the air passage 11a. When the piston 12A passes the check valve 12D, compressed air in the piston upper chamber 11b of the piston 12A flows from the piston upper chamber 11b into the return air chamber 10b through the check valve 12D and the air passage 11a. Due to compressed air that has flowed in, the sub-piston 11B moves upward against the urging force of the spring 11C. With this operation, reaction force that generates due to movement of the piston 12A and reaction force that generates due to movement of the sub-piston 11B offset each other.

[0058] A counterweight is provided that, with a delay after the piston starts moving toward the bottom dead center, moves in the opposite direction to the moving direction of the piston in the axial direction of the cylinder. Thus, when a fastener is driven into a workpiece, counteraction due to reaction force acting on the driving tool can be reduced effectively.

[0059] Next, when the main valve 51 moves to the bottom dead center and makes contact with the main valve rubber 52A, thereby blocking communication between the accumulator chamber 10a and the piston upper chamber 11b of the piston 12A, and is spaced away from the exhaust rubber 52B, thereby allowing communication between

the piston upper chamber 11b and the atmosphere. Due to compressed air accumulated in the return air chamber 10b, the lower side of the piston 12A is pushed and the piston 12A moves rapidly to the top dead center side. With this movement, the sub-piston 11B returns to the bottom dead center. Air in the piston upper chamber 11b is discharged to the atmosphere from the venting hole through the air passage 10c.

[0060] Subsequently, the piston 12A is pushed up by compressed air in a piston lower chamber 11c and returns to the top dead center. Due to returning of the piston 12A, compressed air in the piston lower chamber 11c expands and pressure in the piston lower chamber 11c decreases and, because compressed air is discharged through a gap between the driver blade 12B of the piston 12A and the injection opening 13a, pressure in the piston lower chamber 11c further decreases.

[0061] Next, either when the trigger 21 is returned or when a pressing operation of the push lever 23 against the workpiece is stopped, the plunger 32 moves to the bottom dead center side due to pressure of the accumulator chamber 10a acting on the upper end portion and the pressing force of the spring. When the plunger 32 moves to the bottom dead center, the trigger-valve control passage is blocked and compressed air in the accumulator chamber 10a flows into the trigger valve chamber 30a through the air passage.

[0062] When compressed air flows into the trigger valve chamber 30a, the valve piston 31 moves to the top dead center side due to pressing force that generates from a difference between the area of an upper end surface of the valve piston 31 and the area of a lower end surface of the valve piston 31 and due to the urging force of the spring.

[0063] The sub-piston 11B is provided that can move in the opposite direction to the moving direction of the piston in the axial direction of the cylinder 11. Hence, reaction force by which the piston 12A moves downward from one end side toward the other end side of the cylinder 11 acts on the frame 10, the cylinder 11, etc to push the frame 10, the cylinder 11, etc upward. On the other hand, however, the counterweight is moved in the opposite direction to the piston 12A, and its reaction force acts on the frame 10, the cylinder 11, etc so that the frame 10, the cylinder 11, etc can be pushed downward. Hence, reaction force acting on the frame 10, the cylinder 11, etc can be offset and counteraction can be reduced.

[0064] Further, because an annular-shaped (ring-shaped) counterweight is fitted around the cylinder 11, the counterweight can be arranged by utilizing a space around the cylinder 11. Hence, a separate counterweight need not to be provided at the outside of the frame 10 serving as a housing, which prevents a situation in which a portion where the counterweight is provided protrudes from the outside of the frame 10. Thus, the outer shape of the driving tool becomes a simple shape, which prevents a situation in which a portion where the counterweight is provided hinders driving operations.

- [0065] Further, the sub-piston 11B serving as the counterweight is fitted around the cylinder 11, which prevents the dimension of the driving tool in the axial direction of the cylinder 11 from becoming large. In addition, because this position corresponds to a dead space, the dead space can be utilized effectively.
- [0066] Further, a portion of the return air chamber 10b constitutes the in-sub-cylinder space 10d, compressed air that flows into the return air chamber 10b can be utilized to move the sub-piston 11B. Hence, compressed air need not to be used only for moving the sub-piston 11B, and the consumption amount of compressed air can be suppressed. Further, with a simple configuration, a counterweight can be configured that can move in the opposite direction to the moving direction of the piston 12A in the axial direction of the cylinder 11.
- [0067] A driving tool according to a second embodiment of the invention will be described while referring to Figs. 5 through 12 wherein like parts and components are designated by the same reference numerals to avoid duplicating description. In the following descriptions, upper and lower sides of Fig. 5 is defined as upper and lower sides of a driving tool 101, respectively, for descriptions purposes. Further, a direction from the right side toward the left side is defined as a front side, and its opposite direction is defined as a rear side. Additionally, a direction from the far side toward the near side with respect to the surface of the drawing sheet is defined as a left side, and its opposite direction is defined as a right side. The driving tool 101 according to the second embodiment includes a sub-piston 172 serving as a counterweight instead of the sub-piston 11B of the driving tool 1 according to the first embodiment.
- [0068] As shown in Figs. 5 and 6, the driving tool 101 is a driving tool driven by compressed air, and includes a frame 110 and a handle 110A located at one side of the frame 110 and provided integrally with the frame 110. The frame 110 and the handle 110A serve as a housing.
- [0069] The handle 110A is connected to an air hose (not shown), so that compressed air can be supplied to the accumulator chamber 10a formed in the handle 110A and the frame 110 through the air hose (not shown). A branch passage 110Aa is formed in the handle 110A. One end of the branch passage 110Aa opens to an accumulator chamber 110a, and another end of the branch passage 110Aa opens to a main-valve control passage described later. One end of a sub-piston lower-chamber communication passage 110Ab described later opens to a middle of the branch passage 110Aa. A sub-piston driving valve 110AA is provided at a portion of the branch passage 110Aa at which one end of the sub-piston lower-chamber communication passage 110Ab (Figs. 7A-7C) described later opens.
- [0070] As shown in Figs. 7A-7C, the sub-piston driving valve 110AA includes a large diameter section constituting a lower section, a middle diameter section constituting a

middle section, and a small diameter section constituting an upper section. A lower sealing member 110AD, a middle sealing member 110AC, and an upper sealing member 110AB each constituted by an O-ring are provided at the large diameter section, the middle diameter section, and a connection between the middle diameter section and the small diameter section, respectively. The sub-piston driving valve 110AA is movable upward and downward due to pressure of compressed air.

[0071] As shown in Figs. 6 and 7A-7C, the sub-piston lower-chamber communication passage 110Ab is formed at a portion of the branch passage 110Aa at which the sub-piston driving valve 110AA is provided. The sub-piston lower-chamber communication passage 110Ab are communicated with the accumulator chamber 10a formed within the handle 110A and a sub-piston lower chamber 171a (Fig. 11) described later. One end of the sub-piston lower-chamber communication passage 110Ab opens to a portion of the branch passage 110Aa at which the sub-piston driving valve 110AA is provided, and extends from this opening to the sub-piston lower chamber 171a (Fig. 11) within the handle 110A and within the frame 110, and opens to the sub-piston lower chamber 171a. Further, one end opening of an atmosphere communication outlet passage 110Ac in communication with the atmosphere is formed at a portion of the branch passage 110Aa at which the sub-piston driving valve 110AA is provided, the portion being below one end opening of the sub-piston lower-chamber communication passage 110Ab. Note that, for clarity, the sub-piston driving valve 110AA is omitted in Fig. 7C.

[0072] The branch passage 110Aa narrows at its upper end, and can be sealed by the upper sealing member 110AB of the sub-piston driving valve 110AA so that compressed air does not flow from the accumulator chamber 10a to inside the branch passage 110Aa. A portion of the branch passage 110Aa slightly below the upper end has a larger diameter than the upper end, and can be sealed by the middle sealing member 110AC of the sub-piston driving valve 110AA so that compressed air does not flow to above and below the middle sealing member 110AC. A portion of the branch passage 110Aa further below the above-mentioned portion has an even larger diameter, and can be sealed by the lower sealing member 110AD of the sub-piston driving valve 110AA so that compressed air does not flow to above and below the lower sealing member 110AD.

[0073] As shown in Fig. 7A, when the sub-piston driving valve 110AA is located at the highest position, a large portion of one end opening the atmosphere communication outlet passage 110Ac is located between the middle sealing member 110AC and the upper sealing member 110AB, but the remaining portion is located below the middle sealing member 110AC. Hence, when the sub-piston driving valve 110AA is located at the highest position, the atmosphere communication outlet passage 110Ac is com-

municated with the sub-piston lower-chamber communication passage 110Ab and is communicated with the atmosphere. Further, communication between the accumulator chamber 10a and the branch passage 110Aa is blocked. As shown in Fig. 7B, when the sub-piston driving valve 110AA is located at the lowest position, communication is blocked between the atmosphere communication outlet passage 110Ac and the sub-piston lower-chamber communication passage 110Ab, and one end opening of the sub-piston lower-chamber communication passage 110Ab is opened, and pressure in the branch passage 110Aa and the accumulator chamber 10a becomes the same as pressure in the sub-piston lower chamber 171a (Fig. 11 etc.).

[0074] Further, when the valve piston 31 is located at the top dead center side, the main-valve air inlet passage opens so that the accumulator chamber 10a, the main-valve control passage, and a portion of the branch passage 110Aa located at the other end side of the sub-piston driving valve 110AA (hereinafter, referred to as "branch-passage other-end-side portion 110aa" shown in Figs. 8a and 9) are communicated with one another, and the second air passage closes so that communication between the branch-passage other-end-side portion 110aa and the atmosphere and communication between the main-valve control passage and the atmosphere are blocked. Further, when the valve piston 31 is located at the bottom dead center side, the main-valve air inlet passage closes so that communication between the branch-passage other-end-side portion 110aa and the accumulator chamber 10a and communication between the main-valve control passage and the accumulator chamber 110a are blocked, and the second air passage opens so that the branch-passage other-end-side portion 110aa and the main-valve control passage are communicated with the atmosphere.

[0075] As shown in Figs. 8 and 9, a semilunar shaft 176 is provided at the branch passage 110Aa. The semilunar shaft 176 is supported so as to be rotatable relative to the handle 110A with a rotational axis extending in the left-right direction at a positional relationship that its side surface defines the branch passage 110Aa. The semilunar shaft 176 has a shape that is formed by cutting a circular cylinder in a cross-section passing through its axis, and a cross-section along a surface perpendicular to the axis has a semilunar shape. A knob 177 is provided at one end of the semilunar shaft 176 in the axial direction, such that the knob 177 is rotatable together with the semilunar shaft 176 about the center line in a width direction of this cross-section of the semilunar shaft 176.

[0076] When the knob 177 is rotated to become a state shown in Fig. 8, the semilunar shaft 176 makes contact with a lower end of the sub-piston driving valve 110AA, which is a fixed state where the sub-piston driving valve 110AA cannot move upward or downward. When the knob 177 is rotated to become a state shown in Fig. 9, it is in a state where the sub-piston driving valve 110AA can move upward and downward.

- [0077] The sub-piston lower-chamber communication passage 110Ab is provided with the semilunar shaft 176, the knob 177, and the sub-piston driving valve 110AA serving as a switch for switching communication/blocking between the sub-piston lower chamber 171a and a piston upper chamber 112b. Hence, reaction force can be utilized without offsetting, as necessary. For example, assume a situation in which nails are driven consecutively. When a nail has been driven and a subsequent nail is to be driven, a driving tool 101 is pushed up by utilizing reaction force, and an operator changes a place to drive a nail at this moment and brings the driving tool 101 down using its own weight or with a light load. In this way, the operator can drive the subsequent nail without using large force, and can drive nails consecutively.
- [0078] As shown in Fig. 5, a sub-cylinder 171 having a cylindrical shape is provided at the left-side side surface of the frame 110. The axial direction of the sub-cylinder 171 is parallel to the axial direction of the cylinder 111. Thus, there is a positional relationship that the sub-cylinder 171 opposes the cylinder 111 in a direction perpendicular to the axial direction of the cylinder 111. The area of a cross-section of the space within the sub-cylinder 171 perpendicular to the axial direction of the sub-cylinder 171 is much smaller than the area of a cross-section of the space within the cylinder 111 perpendicular to the axial direction of the cylinder 111. Thus, the volume of the sub-cylinder 171 can be designed to be small. Hence, an amount of air for driving a sub-piston 172 described later can be made small, and a drop in striking force of the piston 112A can be made minimum.
- [0079] The sub-piston 172 having substantially a cylindrical shape is provided within the sub-cylinder 171 such that the sub-piston 172 is slidable relative to an inner surface of the sub-cylinder 171. The sub-piston 172 is in contact with a lower end of a spring 173, while an upper end of the spring 173 is in contact with an upper end portion of the sub-cylinder 171. The urging force of the spring 173 is weak to an extent that the urging force does not hinder movement of the sub-piston 172 within the sub-cylinder 171 and that the urging force causes the sub-piston 172 to be located at the lower end when the driving tool 1 is not operating and no external force is acting. The sub-piston 172 serves as a counterweight. The sub-piston 172 divides a space within the sub-cylinder 171 into a sub-piston upper chamber 171b located near the upper end of the sub-cylinder 171 and a sub-piston lower chamber 171a located near the lower end of the sub-cylinder 171.
- [0080] The weight of the sub-piston 172 is approximately the same as the weight of the piston 12A, and is approximately 80 grams. It is preferable that the sub-piston 172 be made of material having higher density than density of the piston 12A. With this configuration, the sub-piston 172 can be downsized. For example, the sub-piston 172 may be made of brass, and the piston 12A may be made of aluminum. Further, there is a po-

sitional relationship that the lower end of the sub-cylinder 171 is aligned with the lower end of the cylinder 11. A stroke of the sub-piston 172 within the sub-cylinder 171, that is, a range in which the sub-piston 172 can move relative to the inner surface of the sub-cylinder 171 is approximately the same as a stroke of the piston 12A within the cylinder 11, that is, a range in which the piston 12A can move relative to the inner surface of the cylinder 11. This stroke is approximately 10 cm. It is preferable that the distance the sub-piston 172 can move be greater than or equal to a half of the distance the piston 12A moves during a driving process. With this configuration, because the distance the sub-piston 172 can move is long, by moving the sub-piston 172 in synchronization with movement of the piston 12A, counteraction can be reduced over the entirety of a driving process.

[0081] Next, a driving operation by the driving tool 1 will be described. First, an air hose (not shown) is connected to the driving tool 1, and compressed air is accumulated in the accumulator chamber 10a. Due to the urging force of the spring, the plunger 32 is located at the bottom dead center. Because the plunger 32 is located at the bottom dead center, the air passage is opened and the accumulator chamber 10a and the trigger valve chamber 30a are communicated with each other. At the same time, because the trigger-valve control passage is closed, communication between the trigger valve chamber 30a and the atmosphere is blocked, and a portion of compressed air in the accumulator chamber 10a flows into the trigger valve chamber 30a via the air passage to accumulate air at the same pressure as the accumulator chamber 10a.

[0082] At this time, the valve piston 31 is located at the top dead center. Because the valve piston 31 is located at the top dead center, the main-valve air inlet passage opens and the accumulator chamber 10a, the main-valve control passage, and the branch-passage other-end-side portion 110aa are communicated with one another. At the same time, because the second air passage is closed, communication between the main-valve control passage and the atmosphere is blocked, and a portion of compressed air in the accumulator chamber 10a flows into the main-valve control passage and into the branch-passage other-end-side portion 110aa, so that air at the same pressure as the accumulator chamber 10a is accumulated in the main valve chamber 10e. Because a portion of compressed air in the accumulator chamber 10a flows into the main valve chamber 10e, the main valve 51 is located at the bottom dead center due to compressed air and the urging force of the main valve spring 53. Further, because a portion of compressed air in the accumulator chamber 10a flows into the branch-passage other-end-side portion 110aa, the sub-piston driving valve 110AA is pushed up to the highest position and closes one end opening of the branch passage 110Aa.

[0083] Because the main valve 51 is located at the bottom dead center, the main valve 51 makes contact with the main valve rubber 52A and is slightly spaced away from the

exhaust rubber 52B so that the air passage 10c is opened. Thus, the piston upper chamber 11b of the piston 12A within the cylinder 11 is communicated with the atmosphere, and the piston upper chamber 11b is at atmospheric pressure. Further, because communication between the piston upper chamber 11b and the accumulator chamber 10a is blocked, air in the accumulator chamber 10a does not flow into the piston upper chamber 11b. Hence, the piston 12A is in a stopped state at the top dead center side.

[0084] Next, both of a pulling operation of the trigger 21 and a pressing operation of the push lever 23 against the workpiece are performed to push up the plunger 32 to the top dead center. Because the plunger 32 is located at the top dead center side, the trigger-valve control passage is opened. With this operation, the trigger valve chamber 30a is communicated with the atmosphere, and pressure in the trigger valve chamber 30a becomes atmospheric pressure. Further, the air passage closes to block communication between the accumulator chamber 10a and the trigger valve chamber 30a, so that inflow of compressed air from the accumulator chamber 10a into the trigger valve chamber 30a is stopped.

[0085] As a result of this, because pressure in the trigger valve chamber 30a becomes atmospheric pressure, a difference is generated between pressure acting on the accumulator chamber 10a side of the valve piston 31 and pressure acting on the trigger valve chamber 30a side of the valve piston 31, which causes the valve piston 31 to move to the bottom dead center.

[0086] Because the valve piston 31 is located at the bottom dead center, the main-valve air inlet passage closes to block communication between the branch-passage other-end-side portion 110aa and the accumulator chamber 10a and communication between the main-valve control passage and the accumulator chamber 10a, and inflow of compressed air from the accumulator chamber 10a into the branch-passage other-end-side portion 110aa and the main-valve control passage is stopped. Further, the second air passage opens to allow communication between the branch-passage other-end-side portion 110aa and the atmosphere and communication between the main-valve control passage and the atmosphere. With this operation, pressure in the branch-passage other-end-side portion 110aa and the main-valve control passage becomes atmospheric pressure, and pressure in the main valve chamber 10e communicated with the main-valve control passage also becomes atmospheric pressure.

[0087] When pressure in the main valve chamber 10e becomes substantially atmospheric pressure, the main valve 51 moves to the top dead center side. Concurrently, as shown in Fig. 9, the sub-piston driving valve 110AA is pushed down by compressed air to open one end opening of the sub-piston lower-chamber communication passage 110Ab, compressed air flows into the sub-piston lower chamber 171a through the sub-

piston lower-chamber communication passage 110Ab.

- [0088] When the main valve 51 starts moving toward the top dead center side, because the accumulator chamber 10a is communicated with the piston upper chamber 11b of the piston 12A, the main valve 51 moves rapidly to the top dead center side and makes contact with the exhaust rubber 52B, thereby blocking communication between the accumulator chamber 10a and the atmosphere and communication between the piston upper chamber 11b of the piston 12A and the atmosphere.
- [0089] When the main valve 51 moves from the bottom dead center to the top dead center, compressed air in the accumulator chamber 10a flows into the piston upper chamber 11b of the piston 12A, and the piston 12A moves rapidly to the bottom dead center side and the end portion 12C drives a fastener (not shown). At this time, the driver blade 12B receives reaction force from the fastener (not shown), and pushes the frame 10 and the like upward through compressed air in the piston upper chamber 11b of the piston 12A. In other words, the piston 12A moves in a first direction (downward) directed from the piston upper chamber 11c to the piston lower chamber 11b by the compressed air supplied into the piston upper chamber 11c, thereby performing a driving process to generate a driving force.
- [0090] Concurrently, however, compressed air that has flowed into the sub-piston lower chamber 171a causes the sub-piston 172 to slide upward by the same amount as sliding amount of the piston 12A against the urging force of the spring 173. With this operation, reaction force that generates due to movement of the piston 12A and driving of a fastener (not shown) and reaction force that generates due to movement of the sub-piston 172 offset each other.
- [0091] Air below the piston 12A within the cylinder 11 flows into the return air chamber 10b through the air passage 11a. When the piston 12A passes by the check valve 12D, compressed air in the piston upper chamber 11b of the piston 12A flows from the piston upper chamber 11b into the return air chamber 10b through the check valve 12D and the air passage 11a.
- [0092] Next, when the main valve 51 moves to the bottom dead center and makes contact with the main valve rubber 52A, thereby blocking communication between the accumulator chamber 10a and the piston upper chamber 11b of the piston 12A, and is spaced away from the exhaust rubber 52B, thereby allowing communication between the piston upper chamber 11b and the atmosphere. Due to compressed air accumulated in the return air chamber 10b, the lower side of the piston 12A is pushed and the piston 12A moves rapidly to the top dead center side. With this movement, the sub-piston 11B returns to the bottom dead center. Air in the piston upper chamber 11b is discharged to the atmosphere from the venting hole through the air passage 10c.
- [0093] Subsequently, the piston 12A is pushed up by compressed air in a piston lower

chamber 11c and returns to the top dead center. Due to returning of the piston 12A, compressed air in the piston lower chamber 11c expands and pressure in the piston lower chamber 11c decreases and, because compressed air is discharged through a gap between the driver blade 12B of the piston 12A and the injection opening 13a, pressure in the piston lower chamber 11c further decreases.

- [0094] Next, either when the trigger 21 is returned or when a pressing operation of the push lever 23 against the workpiece is stopped, the plunger 32 moves to the bottom dead center side due to pressure of the accumulator chamber 10a acting on the upper end portion and the pressing force of the spring. When the plunger 32 moves to the bottom dead center, the trigger-valve control passage is blocked and compressed air in the accumulator chamber 10a flows into the trigger valve chamber 30a through the air passage.
- [0095] When compressed air flows into the trigger valve chamber 30a, the valve piston 31 moves to the top dead center side due to pressing force that generates from a difference between the area of an upper end surface of the valve piston 31 and the area of a lower end surface of the valve piston 31 and due to the urging force of the spring.
- [0096] Further, a sub-piston driving valve 110AA is pushed up by compressed air, and communication between the accumulator chamber 10a and the branch passage 110Aa. Further, the sub-piston lower-chamber communication passage 110Ab is communicated with the atmosphere communication outlet passage 110Ac, and compressed air within the sub-piston lower chamber 171a is discharged to the atmosphere through the atmosphere communication outlet passage 110Ac.
- [0097] The sub-piston 11B is provided that can move in the opposite direction to the moving direction of the piston in the axial direction of the cylinder 11. Hence, reaction force by which the piston 12A moves downward from one end side toward the other end side of the cylinder 11 acts on the frame 110, the cylinder 11, etc to push the frame 110, the cylinder 11, etc upward. On the other hand, however, the counterweight is moved in the opposite direction to the piston 12A, and its reaction force acts on the frame 110, the cylinder 11, etc so that the frame 10, the cylinder 11, etc can be pushed downward. Hence, reaction force acting on the frame 10, the cylinder 11, etc can be offset and counteraction can be reduced.
- [0098] Further, there is a positional relationship that the counterweight opposes the cylinder 11 in a direction perpendicular to the axial direction of the cylinder 11, which prevents a situation in which the dimension of the driving tool in the axial direction of the cylinder 11 becomes large. In addition, because this position corresponds to a dead space, the dead space can be utilized effectively.
- [0099] Further, the counterweight is constituted by the sub-piston 172 that is provided within the sub-cylinder 171 such that the sub-piston 172 can slide reciprocatingly

relative to the sub-cylinder 171 and that divides the space within the sub-cylinder 171 into the sub-piston upper chamber 171b located near one end of the sub-cylinder 171 and the sub-piston lower chamber 171a located near the other end of the sub-cylinder 171. Hence, with a simple configuration, the counterweight can be configured that can move in the opposite direction to the moving direction of the piston 12A in the axial direction of the cylinder 11.

[0100] Further, because the sub-piston lower-chamber communication passage 110Ab is formed to allow the sub-piston lower chamber 171a and the piston upper chamber 11b, compressed air flows into the upper chamber of the piston 12A and concurrently flows into the sub-piston lower chamber 171a. Thus, the counterweight can be provided that utilizes compressed air to move in the opposite direction to the moving direction of the piston 12A in the axial direction of the cylinder 11.

[0101] Further, sliding amount of the sub-piston 172 relative to the sub-cylinder 171 is the same as sliding amount of the piston 12A relative to the cylinder 11. Hence, it can be easily configured that the sub-piston 172 can move in the opposite direction to the moving direction of the piston 12A in the axial direction of the cylinder 11.

[0102] Further, the weight of the counterweight is the same as the weight of the piston 12A. Hence, it can be easily configured that the sub-piston 172 can move in the opposite direction to the moving direction of the piston 12A in the axial direction of the cylinder 11.

[0103] While the driving tool according to the invention have been described in detail with reference to the above aspects thereof, it would be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the scope of the claims.

[0104] For example, the dimensions and weights of the sub-cylinder and the sub-piston 11B are not limited to those in the first embodiment. For example, the area of the lower surface of the sub-piston 11B defining the sub-piston lower chamber 10g may be identical to the area of the upper surface of the piston 12A defining the piston upper chamber 11b.

[0105] With this configuration, pressure receiving areas that receive compressed air are identical, and the sub-piston 11B can easily move in the opposite direction to the moving direction of the piston 12A in the axial direction of the cylinder 11.

[0106] In the first embodiment, it is so configured that the sub-piston 11B is pushed up by compressed air that flows into the return air chamber 10b. However, a configuration of pushing up the sub-piston 11B is not limited to this configuration.

[0107] In the first embodiment, a driving tool driven by compressed air is described. A driving tool may be an electric driving tool including a counterweight that, with a delay after a piston starts moving toward the bottom dead center, moves in the opposite

direction to the moving direction of the piston and including electric data. This type of electric driving tool can also effectively reduce counteraction due to reaction force that generates when a fastener is driven. Further, a power source of moving the counterweight in the opposite direction to the moving direction of the piston may be electric power.

- [0108] In the second embodiment, although the sub-cylinder 171 is provided at the left-side side surface of the frame 110, the position of the sub-cylinder is not limited to this. For example, as shown in Fig. 13, in a driving tool 201, a sub-cylinder 271 may be provided adjacent to a portion of the frame 110 that is connected to the handle 110A. Or, as shown in Fig. 14, in a driving tool 301, a sub-cylinder 371 may be provided at the front side of the frame 110. Further, the number of the sub-cylinder is not limited to one. For example, as shown in Fig. 15, in a driving tool 401, two sub-cylinders 471 may be provided.
- [0109] Further, the invention is not limited to a configuration that the sub-piston 172 constitutes the counterweight. In addition, the shape, the dimensions, or the like of the sub-cylinder 171 and the sub-piston 172 are not limited to those in the above-described embodiments. For example, the area of the lower surface of the sub-piston 172 defining the sub-piston lower chamber 171a may be the same as the area of the upper surface of the piston 12A defining the piston upper chamber 12b. With this configuration, pressure receiving areas that receive compressed air are identical, and the sub-piston 172 can easily move in the opposite direction to the moving direction of the piston 12A in the axial direction of the cylinder 11.
- [0110] In the second embodiment, when a fastener (not shown) is driven, the sub-piston 172 starts moving concurrently with starting of moving of the piston 12A. However, the timing is not limited to this, and the piston 12A and the sub-piston 172 may start moving at different timings.
- [0111] In the second embodiment, the sub-piston 172 has substantially a cylindrical shape. However, the sub-piston 172 is not limited to this shape.
- [0112] In the second embodiment, the semilunar shaft 176 is provided and the sub-piston driving valve 110AA is configured to be fixable. However, the semilunar shaft 176 and the sub-piston driving valve 110AA need not to have these features.

Industrial Applicability

- [0113] The invention is particularly useful in a field of driving tools that need to reduce counteraction when a nail etc. is driven.

Claims

- [Claim 1] A driving tool comprising:
a housing;
an accumulator chamber disposed in the housing and configured to accumulate compressed air;
a cylinder disposed in the housing and having a first end and a second end in an axial direction; and
a piston disposed in the cylinder and capable of reciprocating in the axial direction, the piston dividing an inner space defined within the cylinder into a first piston chamber located near the first end and a second piston chamber located near the second end, the piston moving in a first direction directed from the second piston chamber to the first piston chamber by the compressed air supplied into the first piston chamber, thereby performing a driving process to generate a driving force; characterized by
a counterweight opposing the cylinder in a direction perpendicular to the axial direction and being capable of moving in a second direction opposite to the first direction.
- [Claim 2] The driving tool according to claim 1, wherein the counterweight is capable of moving within a distance greater than or equal to a half of distance the piston moves during the driving process.
- [Claim 3] The driving tool according to claim 1, further comprising a sub-cylinder extending in the axial direction and having one end located near the first end and another end located near the second end; wherein the counterweight comprises a sub-piston capable of reciprocating in the axial direction in the sub-cylinder, the sub-piston dividing an inner space defined within the sub-cylinder into a first sub-piston chamber located near the one end and a second sub-piston chamber located near the another end.
- [Claim 4] The driving tool according to claim 3, further comprising a communication passage allowing the second sub-piston chamber and air accumulator chamber to communicate with each other.
- [Claim 5] The driving tool according to claim 4, further comprising a switch disposed in the communication passage and configured to switch communication/blocking between the second sub-piston chamber and the first piston chamber.
- [Claim 6] The driving tool according to claim 1, wherein the piston is capable of

reciprocating between a top dead center and a bottom dead center;
wherein the counterweight moves in the second direction with a delay
after the piston starts moving toward the bottom dead center.

[Claim 7] The driving tool according to claim 6, further comprising a return air
chamber disposed in the housing and configured to store the
compressed air supplied in the first piston chamber when the piston
moves from the top dead center to the bottom dead center, thereby
returning the piston from the bottom dead center to the top dead center;
wherein the counterweight is driven in the second direction due to an
increase in pressure of compressed air stored in the return air chamber.

[Claim 8] The driving tool according to claim 1, wherein the counterweight has a
ring shape surrounding a circumferential surface of the cylinder.

[Claim 9] The driving tool according to claim 1, wherein the housing and the
cylinder define a sub-cylinder having a substantially cylindrical shape
extending in the axial direction, the sub-cylinder surrounding entirety
of a circumferential surface of the cylinder and defining a sub-cylinder
space therein;

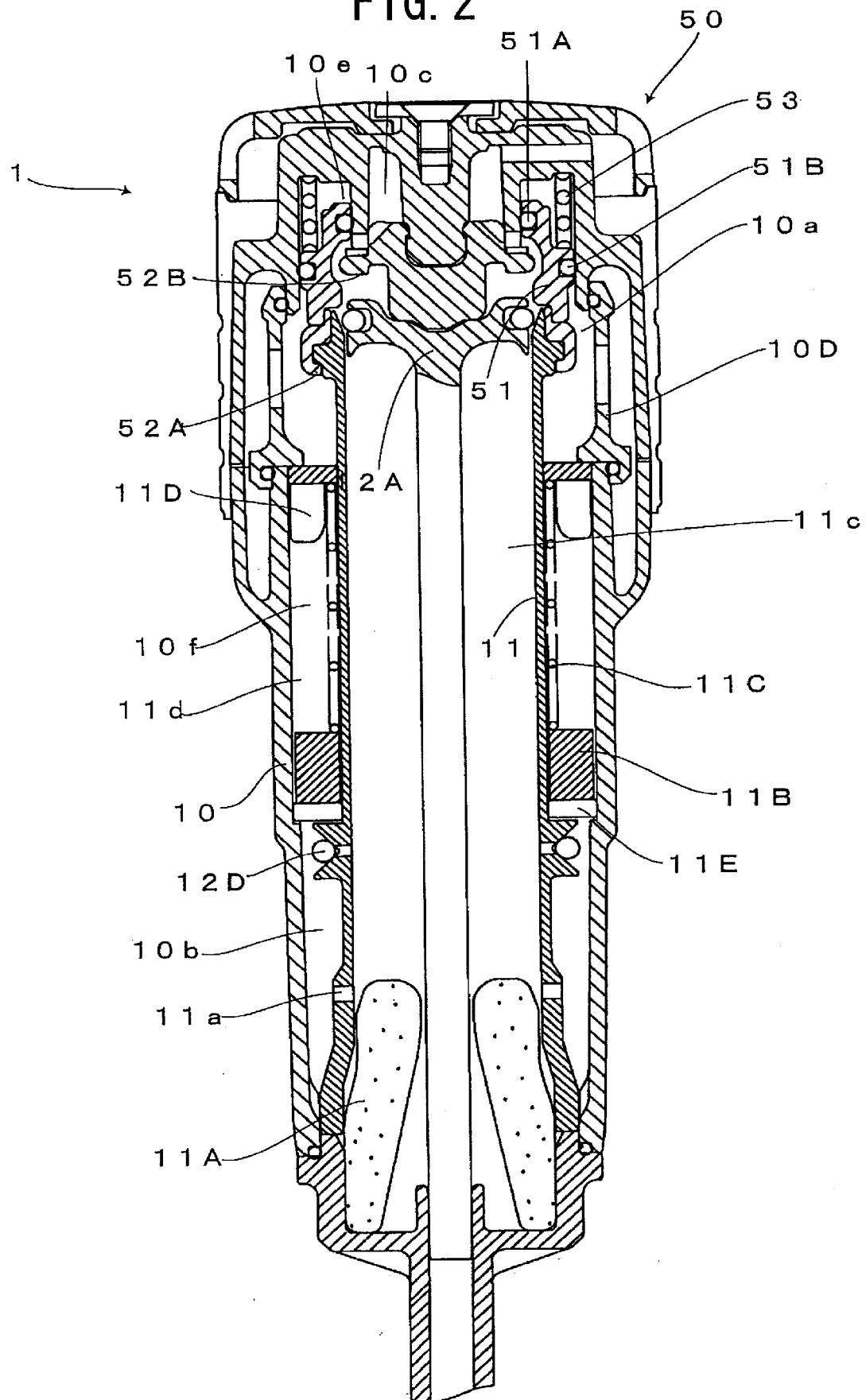
wherein the counterweight comprises a sub-piston disposed coaxially
with the cylinder in the sub-cylinder space, the counterweight being
capable of reciprocating in the axial direction within the sub-cylinder
space, the sub-piston dividing the sub-cylinder space into a first sub-
piston chamber located near the one end and a second sub-piston
chamber located near the another end;

wherein the second sub-piston chamber and the first piston chamber
communicate with each other when the piston moves in the first
direction;

wherein the second sub-piston chamber and the second piston chamber
communicate with each other when the piston moves in the second
direction.

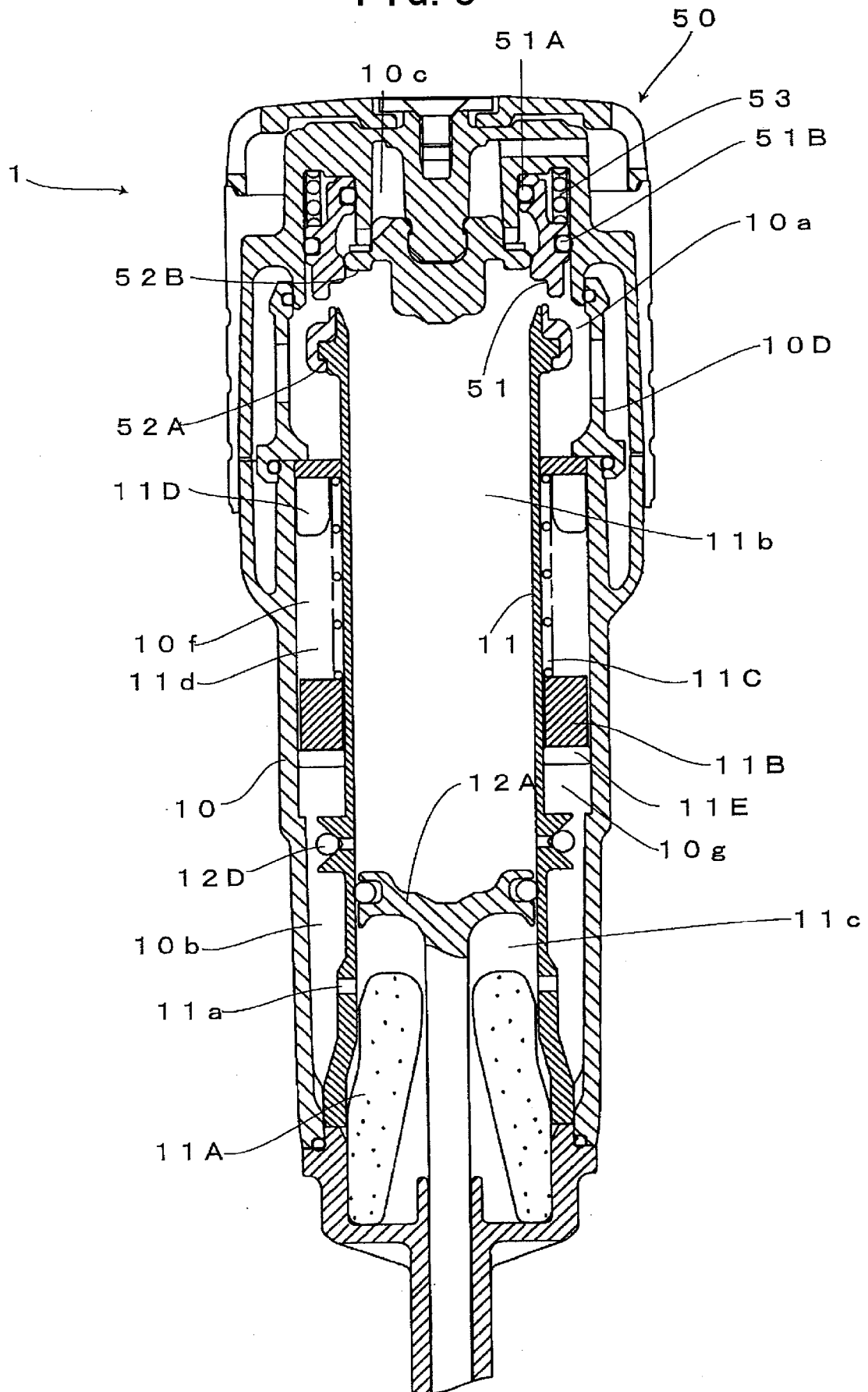
[Fig. 2]

FIG. 2



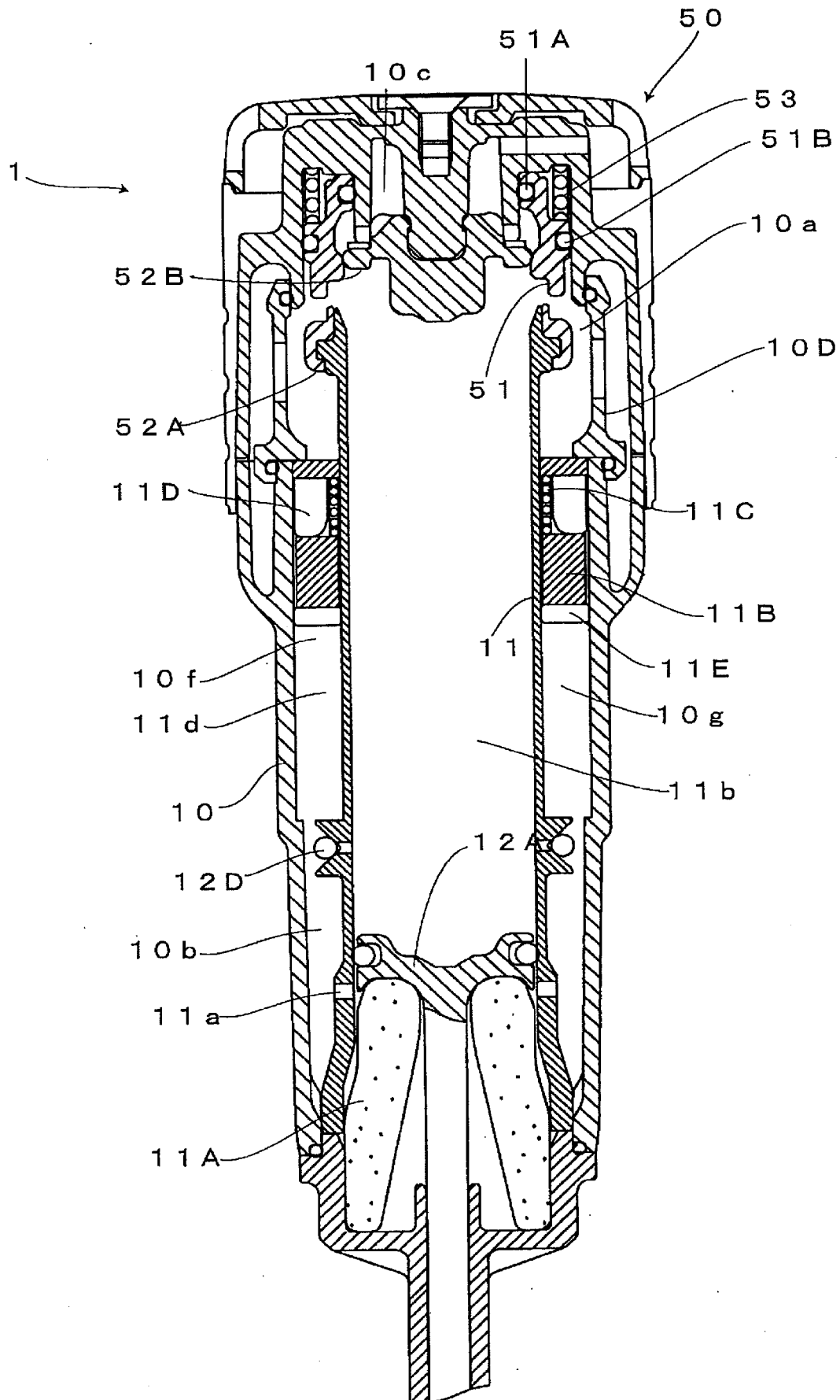
[Fig. 3]

FIG. 3



[Fig. 4]

FIG. 4



[Fig. 5]

FIG. 5

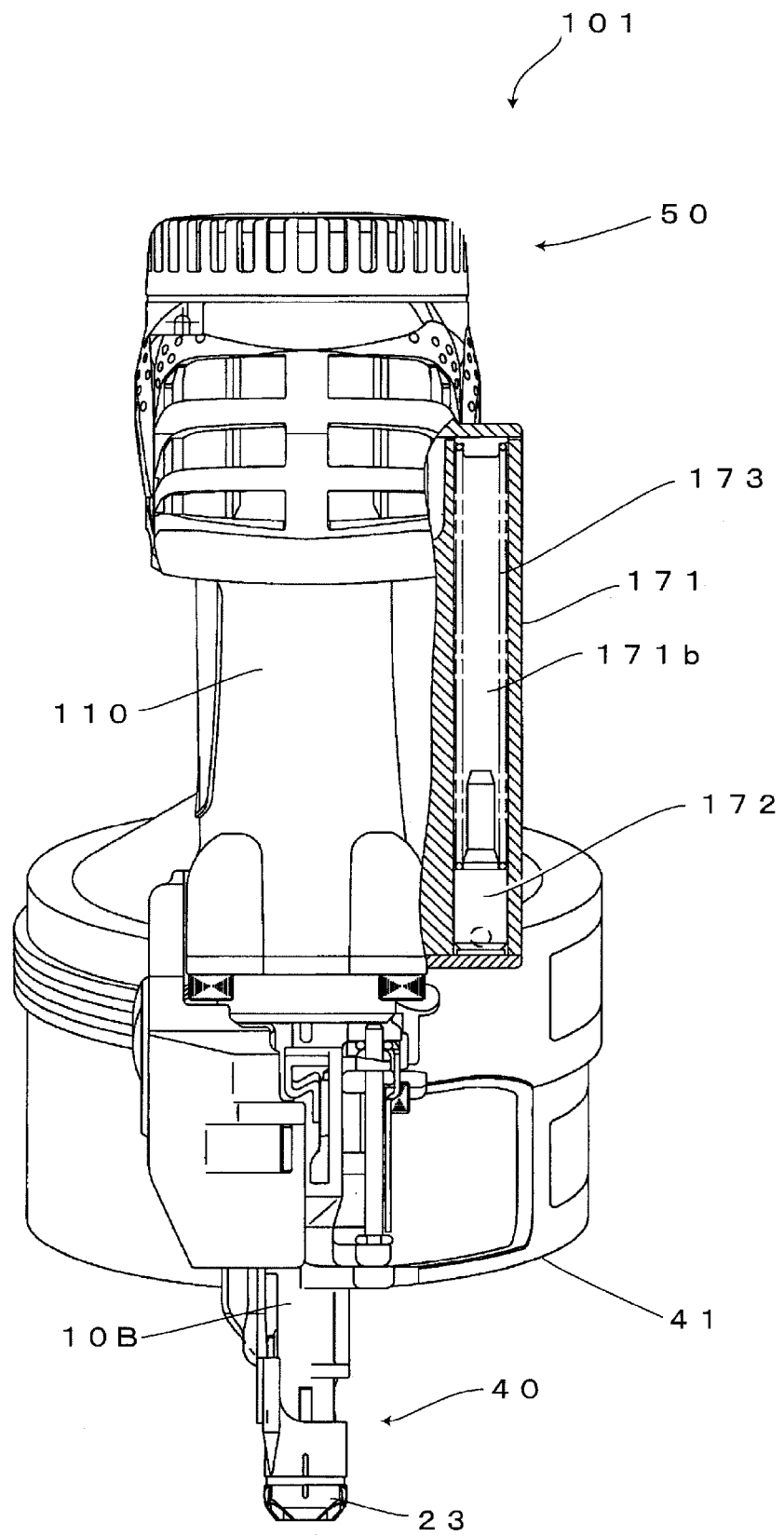


FIG. 7B

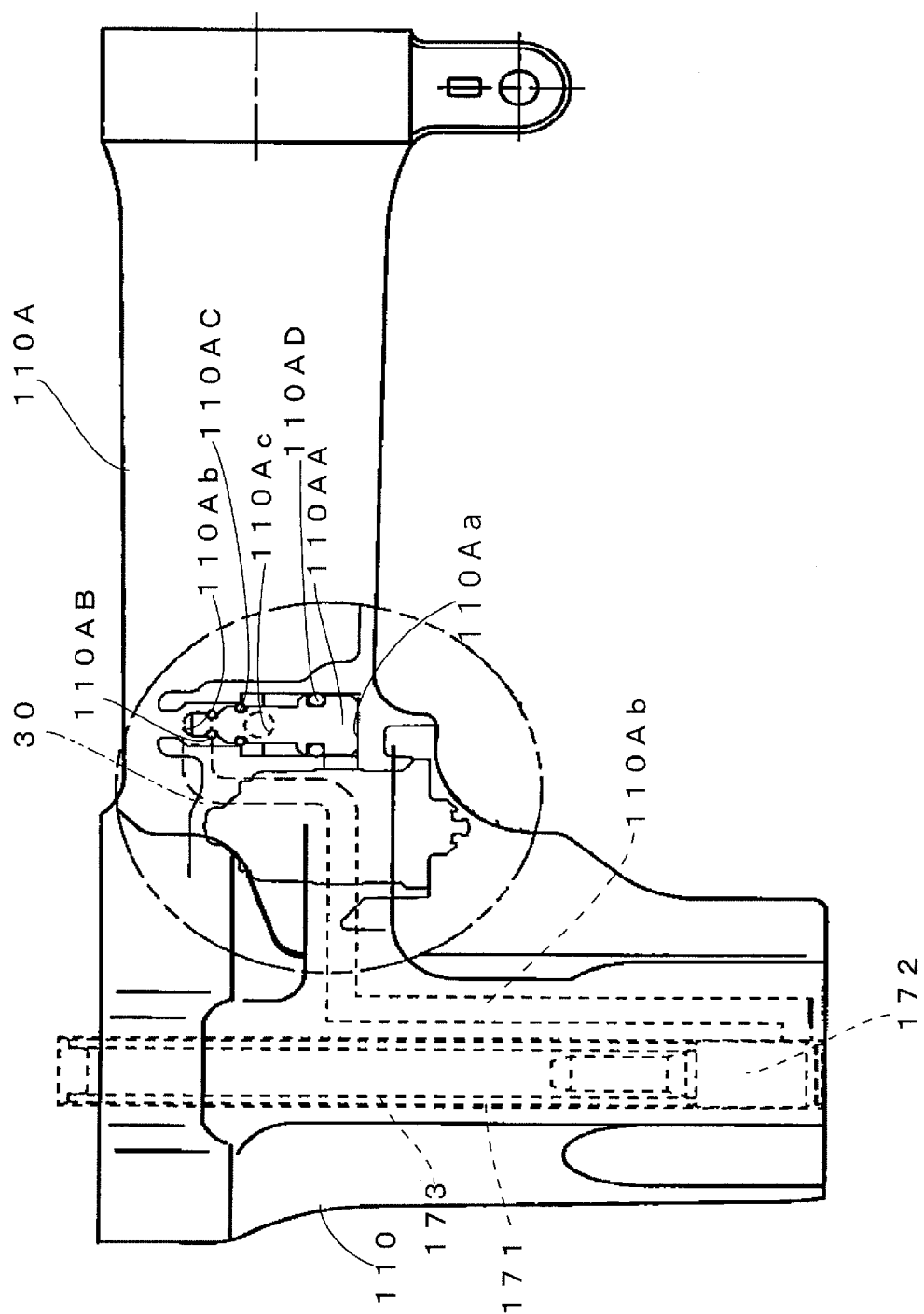
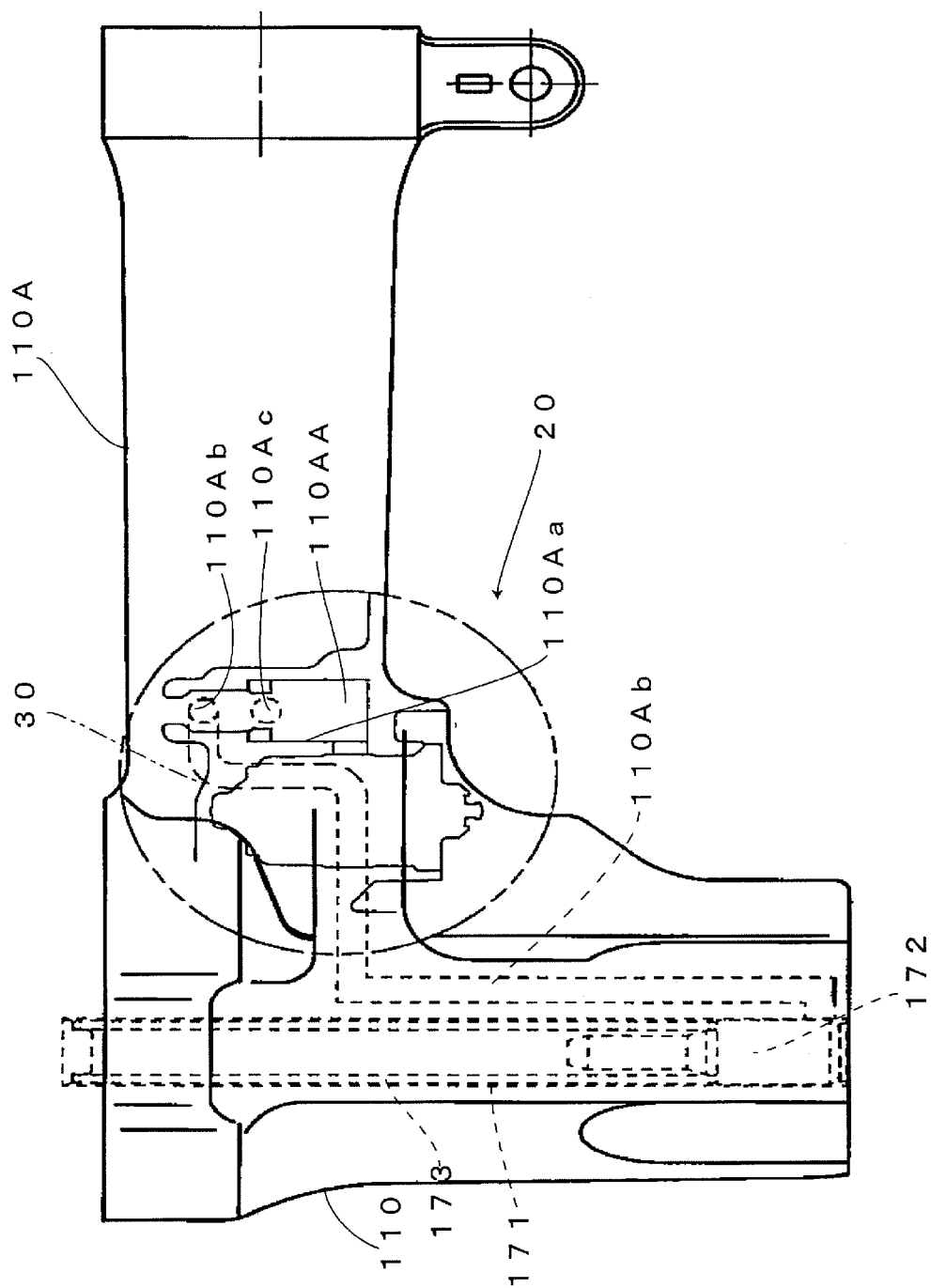
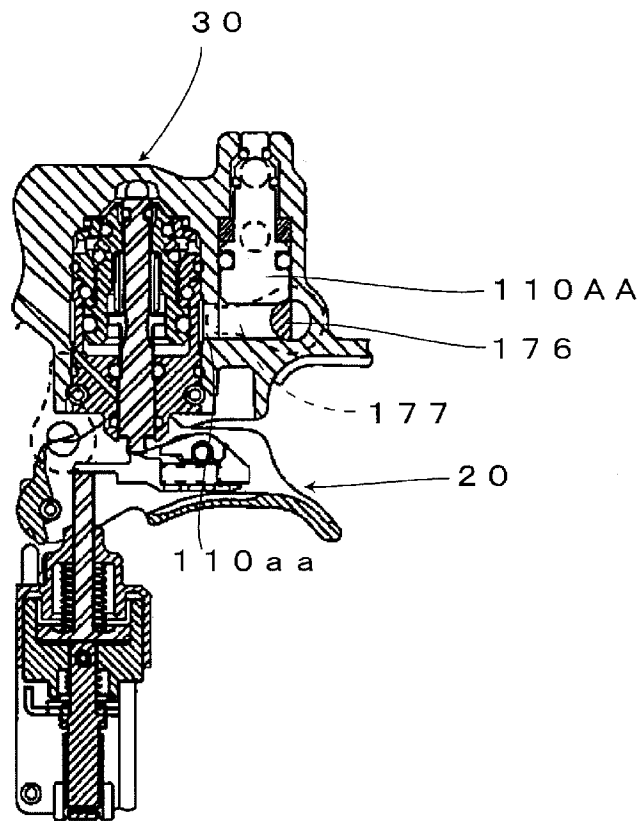


FIG. 7C



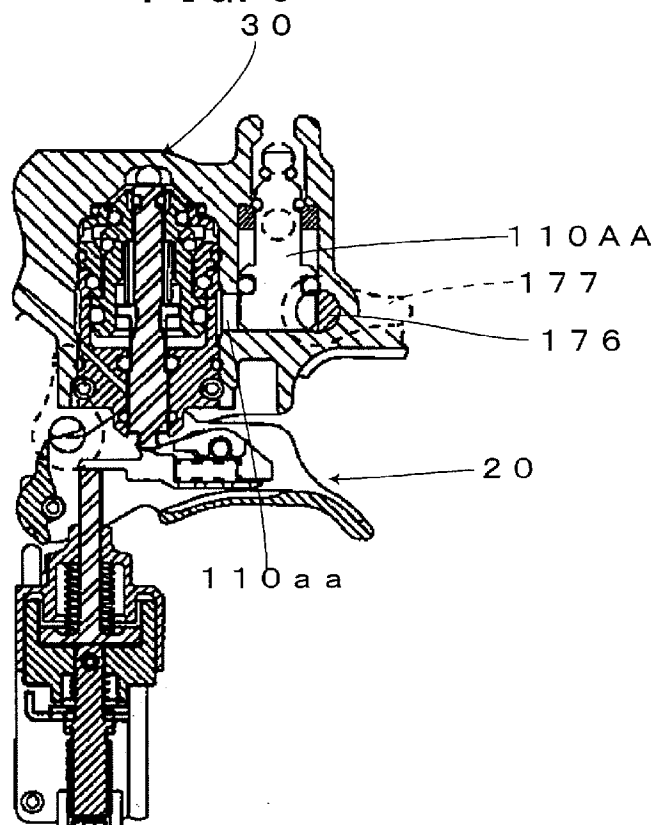
[Fig. 8]

FIG. 8



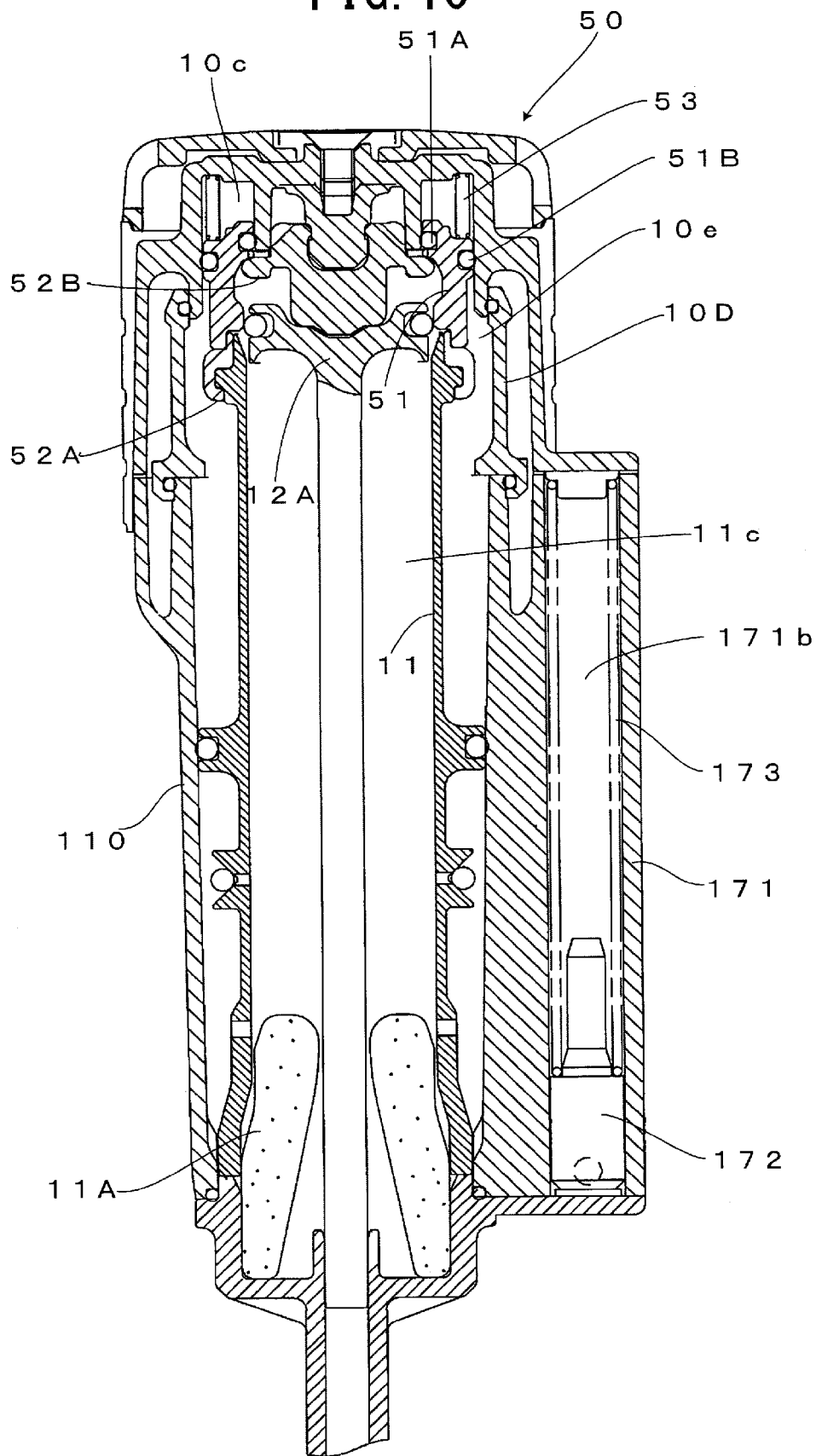
[Fig. 9]

FIG. 9



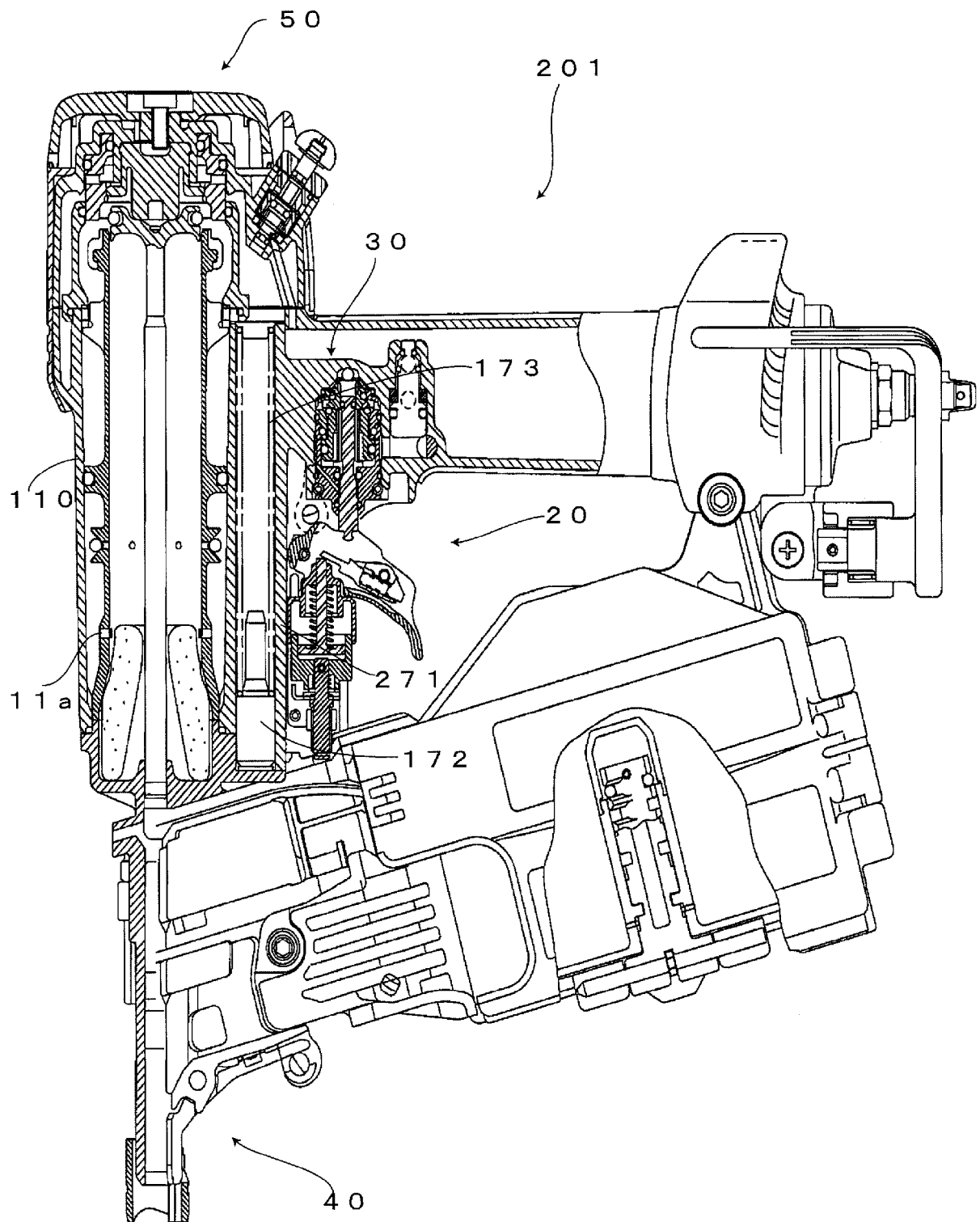
[Fig. 10]

FIG. 10



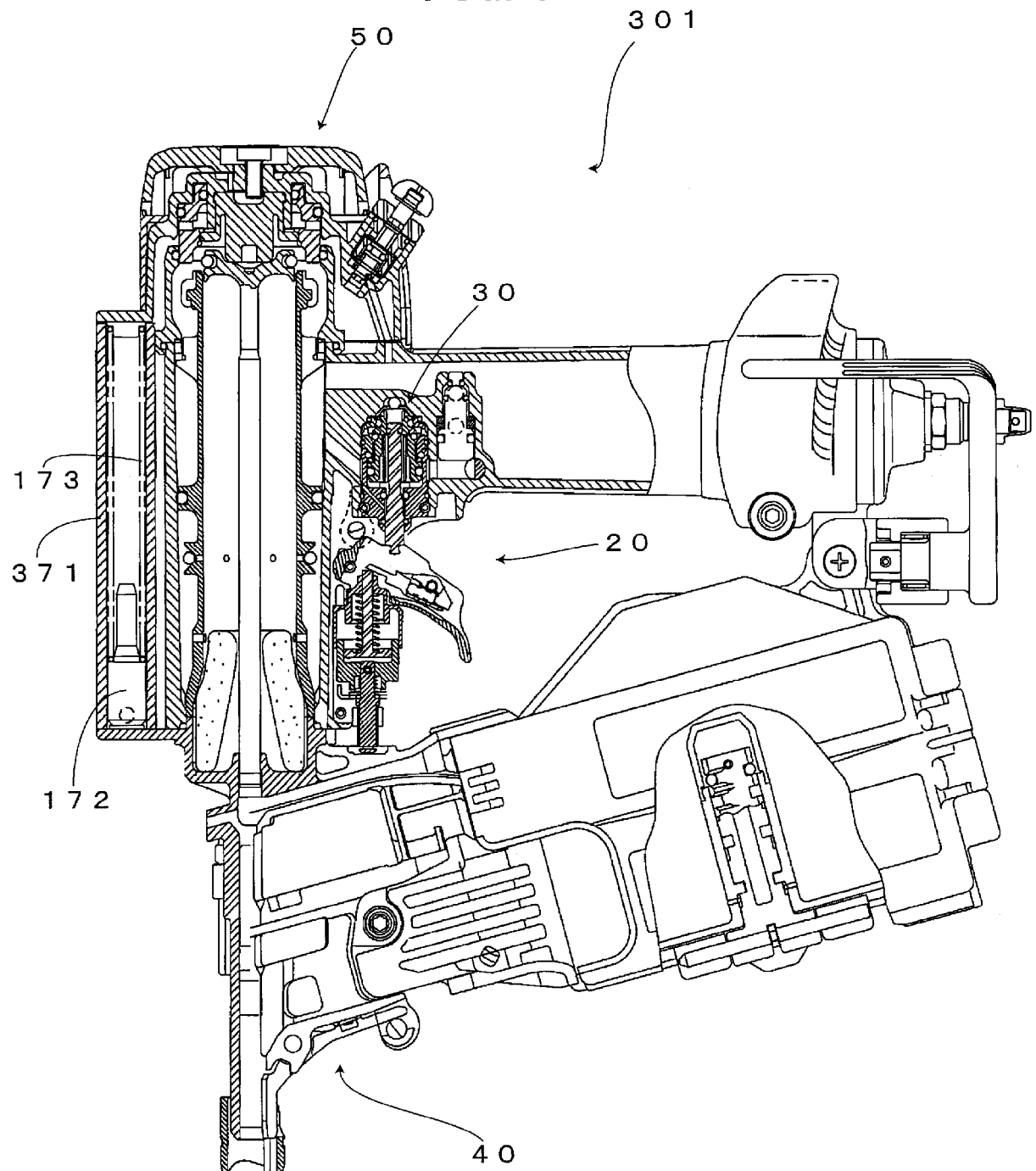
[Fig. 13]

FIG. 13



[Fig. 14]

FIG. 14



[Fig. 15]

FIG. 15

