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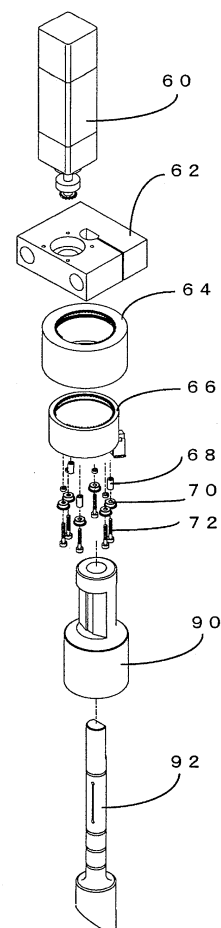
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(54) **PLATE BENDING METHOD AND BENDING ANGLE DETECTION DEVICE**

(57) The invention relates a bending angle detection apparatus in which labor required for a work of bending a plate can be reduced. According to the invention, a bending angle detection apparatus (50) has a sensor ring L (64), a holder (62), bearings (70), the motor body of a servomotor (60), and a rotation angle sensor (102). The sensor ring L (64) produces a signal corresponding to whether the apparatus is contacted with a blade member plate or not. The holder (62) and the bearings (70) rotatably connect the sensor ring L (64) to a bending machine. The motor body of the servomotor (60) drives the sensor ring L (64) so that it is rotated. The rotation angle sensor (102) detects the rotation angle of the sensor ring L (64). In addition, the holder (62) and the bearings (70) connect the sensor ring L (64) to the bending machine so that the rotation axis of the blade member plate in the case where the bending machine bends the blade member plate coincides with that of the sensor ring L (64).

Fig. 2



## Description

### Technical Field

**[0001]** The present invention relates to a method of bending a plate and a bending angle detection apparatus, and more particularly to a method of bending a plate and bending angle detection apparatus in which labor required for a work of bending a plate can be reduced.

### Background Art

**[0002]** Patent Literature 1 discloses an apparatus for bending a strip material. The apparatus comprises a stationary die having a slit, and a movable die which is rotatably fitted onto a shaft body of the stationary die.

**[0003]** According to the invention disclosed in Patent Literature 1, the parallelism of a pair of opposing pressing die portions of the movable die is not impaired during a bending process, and only the shaft body can be easily replaced without disassembling gears of a rotation transmission mechanism, and the movable die.

**[0004]** Patent Literature 2 discloses a method of bending a plate. In the method, a plate is fed out from an outlet, and, during when the feeding of the plate is stopped, the plate is pressed against an end portion of the outlet side, thereby bending the plate.

**[0005]** According to the invention disclosed in Patent Literature 2, even an unskilled person can bend easily and rapidly a plate into a desired shape in a similar manner as a skilled person.

**[0006]** Patent Literature 3 discloses a method of bending a plate. In the method, the below-described two steps are repeated. In the first step, a feed bearing is contacted with a plate. In the second step, while the plate is intermittently fed out through a slit formed in a stationary die, each time when the feeding of the plate is stopped by a stop of operation of a servomotor, the plate is pressed by a pressing member against an outlet corner portion of the slit, thereby being a plate.

**[0007]** According to the invention disclosed in Patent Literature 3, when a plurality of places of a plate such as a blade member are automatically bent in a sequential manner, the plurality of bent places can be accurately determined.

**[0008]** Patent Literature 4 discloses an apparatus for processing a plate. The apparatus comprises a bending process shape inputting unit, a characteristic data inputting unit, and a calculating unit. The bending process shape inputting unit receives an input of a geometric bending process shape of a long plate. The characteristic data inputting unit receives characteristic data related to a process of bending the plate. The calculating unit calculates bending data of the plate based on the geometric bending process shape which is received by the bending process shape inputting unit, and the characteristic data which are received by the characteristic data inputting unit.

**[0009]** According to the invention disclosed in Patent Literature 4, characteristics related to the process of bending the plate are considered, whereby the plate can be accurately processed.

Patent Literature 1: Pamphlet of International Publication No. 95/00266

Patent Literature 2: Japanese Patent Application Laid-Open No. 2001-353528

Patent Literature 3: Japanese Patent Application Laid-Open No. 8-215761

Patent Literature 4: Japanese Patent Application Laid-Open No. 6-304685

### Disclosure of the Invention

### Problem to be Solved by the Invention

**[0010]** In the inventions disclosed in Patent Literatures 1 to 3, however, there is a problem in that it is difficult to bent a plate to an angle desired by the user, because, when a force is applied in order to bend a plate and thereafter the force is cancelled, springback occurs and the angle of the bent portion is varied. The term "springback" means a phenomenon that, when a force is applied to a plate at a degree by which plastic deformation occurs and thereafter the force is removed from the plate, deformation due to elastic deformation is eliminated from deformation of the plate. It is difficult to estimate the degree by which the angle of the bent plate is varied by springback.

**[0011]** In the invention disclosed in Patent Literature 4, a long plate can be accurately processed, but there is a problem in that it is difficult to obtain characteristic data required in the process. Usually, characteristic data are produced from data of the degree by which a plate is bent in a bending process, and a result of a measurement of the angle of a portion which is bent by the bending process. When the characteristic data are produced in this way, it is necessary to process the data after the bending process and the measurement of a sample produced by the process are repeated. The work requires a prolonged time period and much labor. The work increases the labor and required time period of the whole bending process.

**[0012]** The invention has been conducted in order to solve the above-discussed problems. It is an object of the invention to provide a method of bending a plate and bending angle detection apparatus in which labor required for a work of bending a plate can be reduced.

### Means for Solving the Problem

**[0013]** In order to attain the object, according to a certain aspect of the invention, the method of bending a plate is a method of bending a plate by a bending machine. In the method of bending a plate, a work of bending the plate is repeated a plurality of times until it is detected that an angle of a bent portion of the plate reaches a

predetermined angle, in a state where the plate is attached to the bending machine and springback is completed network of bending the plate is repeated a plurality of times until it is detected that the angle of the bent portion of the plate reaches the predetermined angle, in a state where the plate is attached to the bending machine and springback is completed. Therefore, it is not necessary to remove the plate and measure the angle of the bent portion. It is not necessary also to consider springback. As a result, labor required for the work of bending the plate can be reduced.

**[0014]** Furthermore, preferably, the above-described method of bending a plate is a method in which the plate is further bent until a bending angle detection apparatus connected to the bending machine detects it.

**[0015]** Furthermore, preferably, the above-described bending angle detection apparatus is contacted with the plate to measure a direction of the plate before the bending machine bends the plate, and a direction of the plate after the bending machine bends the plate.

**[0016]** According to another aspect of the invention, the bending angle detection apparatus detects an angle. The bending angle detection apparatus is an apparatus which is connected to a bending machine. The angle is an angle of a bent portion of a plate which is bent by the bending machine. The bending angle detection apparatus comprises a signal production device, a connecting portion, a drive device, and a rotation angle detection device. The signal production device produces a signal corresponding to whether the apparatus is contacted with the plate or not.

**[0017]** The connecting portion rotatably connects the signal production device to the bending machine. The drive device drives the signal production device so that the signal production device is rotated. The rotation angle detection device detects a rotation angle of the signal production device. The connecting portion has a holder which is fixed to the bending machine, and bearings which are connected to the holder. The bearing rotatably positions the signal production device so that, when the bending machine bends the plate, the rotation axis of the plate coincides with that of the signal production device.

**[0018]** By the connecting portion, the signal production device is rotatably connected to the bending machine so that a rotation axis of the plate in the case where the bending machine bends the plate coincides with that of a rotation member. Furthermore, the signal production device is driven by the drive device so that the signal production device is rotated. The rotation angle of the signal production device is detected by the rotation angle detection device. Therefore, the rotation angle of the signal production device coincides with that of the plate which is bent by the bending machine. The signal production device produces the signal corresponding to whether the apparatus is contacted with the plate or not.

**[0019]** When the rotation angle detection device detects the rotation angle of the signal production device at the time when the signal is produced, therefore, it is

possible to detect the rotation angle of the plate which is bent by the bending machine, without detaching the plate from the bending machine. When the rotation angle of the plate is measured in a state where springback is completed, it is not required to consider an error due to springback. As a result, labor required for the work of bending the plate can be reduced.

## Effects of the Invention

**[0020]** In the method of bending a plate and bending angle detection apparatus of the invention, labor required for a work of bending a plate can be reduced.

## Brief Description of the Drawings

### [0021]

[Fig. 1] Fig. 1 is an external view of a bending angle detection apparatus of an embodiment of the invention.

[Fig. 2] Fig. 2 is a stereoscopic exploded view of the bending angle detection apparatus of the embodiment of the invention.

[Fig. 3] Fig. 3 is an external view of a servomotor in the embodiment of the invention.

[Fig. 4] Fig. 4 is a sectional view of a part of the servomotor in the embodiment of the invention.

[Fig. 5] Fig. 5 is an external view of a spring joint in the embodiment of the invention.

[Fig. 6] Fig. 6 is a stereoscopic exploded view of the spring joint in the embodiment of the invention.

[Fig. 7] Fig. 7 is a sectional view of the spring joint in the embodiment of the invention.

[Fig. 8] Fig. 8 is a first view showing the operation of the spring joint in the embodiment of the invention, in the case where a torque is applied.

[Fig. 9] Fig. 9 is a second view showing the operation of the spring joint in the embodiment of the invention, in the case where a torque is applied.

[Fig. 10] Fig. 10 is an external view of a holder in the embodiment of the invention.

[Fig. 11] Fig. 11 is an external view and sectional view of a sensor ring L in the embodiment of the invention.

[Fig. 12] Fig. 12 is a perspective view of the sensor ring L in the embodiment of the invention.

[Fig. 13] Fig. 13 is an external view and sectional view of a sensor ring R in the embodiment of the invention.

[Fig. 14] Fig. 14 is a perspective view of the sensor ring R in the embodiment of the invention.

[Fig. 15] Fig. 15 is an arrow viewing view of the bending angle detection apparatus of the embodiment of the invention.

[Fig. 16] Fig. 16 is an arrow viewing view of the bending angle detection apparatus of the embodiment of the invention in a situation where the sensor ring L

is removed.

[Fig. 17] Fig. 17 is a first sectional view of the bending angle detection apparatus of the embodiment of the invention in a state where the servomotor is removed.

[Fig. 18] Fig. 18 is a second sectional view of the bending angle detection apparatus of the embodiment of the invention in a state where the servomotor is removed.

[Fig. 19] Fig. 19 is a perspective view of a bending machine.

[Fig. 20] Fig. 20 is a perspective view showing a situation where the bending angle detection apparatus of the embodiment of the invention is attached to the bending machine.

[Fig. 21] Fig. 21 is a control block diagram of the bending machine.

[Fig. 22] Fig. 22 is a conceptual diagram showing a situation where a blade member plate is passed through a slit of a bending shaft.

[Fig. 23] Fig. 23 is a conceptual diagram showing a situation where a claw of a rotary cylinder is contacted with the blade member plate.

[Fig. 24] Fig. 24 is a conceptual diagram showing a situation where a microswitch R in the embodiment of the invention is contacted with the blade member plate for preparation.

[Fig. 25] Fig. 25 is a conceptual diagram showing a situation at a timing when the blade member plate is bent by the claw of the rotary cylinder.

[Fig. 26] Fig. 26 is a conceptual diagram showing a situation where the microswitch R in the embodiment of the invention is contacted with the blade member plate in order to measure an angle.

[Fig. 27] Fig. 27 is a conceptual diagram showing a situation where the microswitch R in the embodiment of the invention is reversely rotated.

[Fig. 28] Fig. 28 is a flowchart showing a control procedure of a process of bending the blade member plate in the embodiment of the invention.

#### Description of Reference Numerals

#### [0022]

50 bending angle detection apparatus  
60 servomotor  
62 holder  
64 sensor ring L  
66 sensor ring R  
68 spacer  
70 bearing

72

80

5 90

91

92

10

93

94, 95

15

96, 97

98

100

20

102

104

25

106

108

110

30

112

114

35

116

118

130, 132, 134

40

140, 142, 144

150,

45

152

154, 164

156

50

158, 168

162

55

166

170, 172

bolt

bending machine

rotary cylinder

touch panel

bending shaft

cylinder rotation motor

top plate

gear case

controlling portion

motor body

rotation angle sensor

spring joint

first gear

second gear

upper rotary cylinder

first spring

middle rotary cylinder

second spring

lower rotary cylinder

projection

hole

160 body

microswitch L

gear

sector plate

groove

microswitch R

protrusion

rotation axis

|     |                             |
|-----|-----------------------------|
| 180 | cylinder rotation motor I/O |
| 182 | first external I/O          |
| 184 | second external I/O         |
| 186 | third external I/O          |
| 188 | touch panel I/O             |
| 190 | flash memory reading device |
| 300 | blade member plate          |
| 350 | flash memory                |

#### Mode for Carrying Out the Invention

**[0023]** Hereinafter, an embodiment of the invention will be described with reference to the drawings. The foregoing summary of the invention and the following detailed description of the preferred embodiment of the invention are better understood when read in conjunction with the accompanying drawings. For the purpose of illustrating the invention, the drawings depict the present preferred embodiment. In the following description, the identical components are denoted by the same reference numerals, and also their names and functions are identical. Therefore, they will not be described repeatedly in detail.

**[0024]** Fig. 1 is an external view of a bending angle detection apparatus 50 of the embodiment. Fig. 2 is a stereoscopic exploded view of the bending angle detection apparatus 50 of the embodiment. Fig. 3 is an external view of a servomotor 60. Fig. 4 is a sectional view of a part of the servomotor 60. Fig. 5 is an external view of a spring joint 104. Fig. 6 is a stereoscopic exploded view of the spring joint 104. Fig. 7 is a sectional view of the spring joint 104. Figs. 8 and 9 are views showing the operation of the spring joint 104 in the case where a torque is applied. Fig. 10 is an external view of a holder 62. Fig. 11 is an external view and sectional view of a sensor ring L 64. Fig. 12 is a perspective view of the sensor ring L 64. Fig. 13 is an external view and sectional view of a sensor ring R 66. Fig. 14 is a perspective view of the sensor ring R 66. Fig. 15 is a view looking in the direction of the arrow A in Fig. 1. Fig. 16 is a view showing a situation where the sensor ring L 64 is removed in Fig. 15. Fig. 17 is a sectional view of the bending angle detection apparatus 50 in a state where the servomotor 60 is removed. Fig. 18 is a sectional view of the bending angle detection apparatus 50 as viewing in a direction perpendicular to Fig. 17. Fig. 19 is a perspective view of a bending machine 80 to which the bending angle detection apparatus 50 of the embodiment is to be attached. Fig. 20 is a perspective view showing a situation where the bending angle detection apparatus 50 is attached to the bending machine 80. Fig. 21 is a control block diagram of the bending machine 80. Fig. 22 is a conceptual

diagram showing a situation where a blade member plate 300 is passed through a slit (not shown) of a bending shaft 92 in order to be bent by a claw of a rotary cylinder 90. Fig. 23 is a conceptual diagram showing a situation where the claw of the rotary cylinder 90 is contacted with the blade member plate 300 in order to start the bending of the blade member plate 300. Fig. 24 is a conceptual diagram showing a situation where a microswitch R 162 is contacted with the blade member plate 300 for preparation of measurement of the angle of the bent blade member plate 300. Fig. 25 is a conceptual diagram showing a situation at a timing when the blade member plate 300 is bent by the claw of the rotary cylinder 90. Fig. 26 is a conceptual diagram showing a situation where, after the blade member plate 300 is bent, the microswitch R 162 is contacted with the blade member plate in order to measure the angle. Fig. 27 is a conceptual diagram showing a situation where, after the angle of the blade member plate 300 is measured, the microswitch R 162 is reversely rotated. Fig. 28 is a flowchart showing a control procedure of a process of accurately bending the blade member plate 300 without previously measuring springback.

**[0025]** The bending angle detection apparatus 50 of the embodiment is attached to the bending machine 80. The bending angle detection apparatus 50 is connected to the bending machine 80, and measures the angle of a plate which is bent by the bending machine 80. The bending machine 80 will be described later.

**[0026]** The bending angle detection apparatus 50 of the embodiment comprises the servomotor 60, the holder 62, the sensor ring L 64, the sensor ring R 66, spacers 68, and bearings 70.

**[0027]** The servomotor 60 is controlled by a controlling portion 98 of the bending machine 80 which will be described later. The servomotor 60 drives the sensor ring L 64 and the sensor ring R 66. The servomotor 60, the sensor ring L 64, and the sensor ring R 66 are attached to the holder 62. The tip end of the bending shaft 92 of the bending machine 80 is fitted into the holder 62. The bending shaft 92 is passed through the rotary cylinder 90 which is similarly a component of the bending machine 80, and then fitted into the holder 62. The sensor ring L 64 measures the angle of the bent portion of the blade member plate 300, from one side face of the blade member plate 300. The sensor ring R 66 measures the angle of the bent portion of the blade member plate 300, from the side face opposite to the sensor ring L 64. The spacers 68 are members for maintaining the bearings 70 to adequate positions. The bearings 70 are members for rotatably positioning the sensor ring L 64 and the sensor ring R 66 so that, when the blade member plate 300 is bent by the bending machine 80, the rotation axis of the blade member plate 300 coincides with the rotation axes of the sensor ring L 64 and the sensor ring R 66. The spacers 68 and the bearings 70 are connected to the holder 62 by bolts 72.

**[0028]** The servomotor 60 will be described with reference to Figs. 3 and 4. The servomotor 60 comprises the

motor body 100, a rotation angle sensor 102, a spring joint 104, a first gear 106, and a second gear 108. The motor body 100 produces a torque for rotating the first gear 106 and the second gear 108. The sensor ring L 64 and the sensor ring R 66 are driven by the torque. The rotation angle sensor 102 detects the rotation angle of the rotor of the motor body 100. The spring joint 104 is attached to the rotor of the motor body 100, and the rotation shafts of the first gear 106 and the second gear 108, to transmit the torque produced by the motor body 100 to the first gear 106 and the second gear 108. The first gear 106 meshes with a gear 154 of the sensor ring L 64 to transmit the torque to the sensor ring L 64. The second gear 108 meshes with a gear 164 of the sensor ring R 66 to transmit the torque to the sensor ring R 66.

**[0029]** The structure of the spring joint 104 will be described with reference to Figs. 5 to 7. The spring joint 104 comprises an upper rotary cylinder 110, a first spring 112, a middle rotary cylinder 114, a second spring 116, and a lower rotary cylinder 118.

**[0030]** The rotor of the motor body 100 is fitted into the upper rotary cylinder 110. The upper rotary cylinder 110 transmits the torque produced by the motor body 100 to the middle rotary cylinder 114. A projection 130 is disposed on the lower end of the upper rotary cylinder 110. The first spring 112 is fitted to the upper rotary cylinder 110 and the middle rotary cylinder 114, and, when the upper rotary cylinder 110 cannot directly transmit the torque to the middle rotary cylinder 114, transmits the torque produced by the motor body 100 to the middle rotary cylinder 114. The middle rotary cylinder 114 is fitted into the upper rotary cylinder 110 and the lower rotary cylinder 118 while being passed through the first spring 112 and the second spring 116. The middle rotary cylinder 114 transmits the torque which is transmitted by the upper rotary cylinder 110 or the first spring 112, to the second spring 116. A projection 132 is disposed on a middle portion of the middle rotary cylinder 114. The second spring 116 is fitted to the middle rotary cylinder 114 and the lower rotary cylinder 118, and, when the middle rotary cylinder 114 cannot directly transmit the torque to the lower rotary cylinder 118, transmits the torque produced by the motor body 100 to the lower rotary cylinder 118. The rotation shafts of the first gear 106 and the second gear 108 are fitted into the lower rotary cylinder 118. The lower rotary cylinder 118 transmits the torque produced by the motor body 100 to the rotation shafts of the first gear 106 and the second gear 108. A projection 134 is disposed on the upper end of the lower rotary cylinder 118.

**[0031]** The operation of the spring joint 104 will be described with reference to Figs. 8 and 9. It is assumed that a torque which is clockwise as viewed from the motor body 100 is transmitted to the spring joint 104. At this time, the upper rotary cylinder 110 is rotated in the same direction as the rotor of the motor body 100. When the upper rotary cylinder 110 is rotated, the projection 130 of the upper rotary cylinder 110 pushes the projection

132 of the middle rotary cylinder 114. When the projection 132 is pushed, also the middle rotary cylinder 114 is rotated in the same direction as the rotor of the motor body 100. When the middle rotary cylinder 114 is rotated, the torque produced by the motor body 100 is transmitted through the second spring 116 to the lower rotary cylinder 118. In this case, however, the second spring 116 is deformed, and hence the torque transmitted to the lower rotary cylinder 118 is not so large. When a resistance is applied to the lower rotary cylinder 118 for any reason, the lower rotary cylinder 118 is not rotated.

**[0032]** By contrast, it is assumed that a torque which is counterclockwise as viewed from the motor body 100 is transmitted to the spring joint 104. At this time, the upper rotary cylinder 110 is rotated in the same direction as the rotor of the motor body 100. However, the projection 130 of the upper rotary cylinder 110 does not push the projection 132 of the middle rotary cylinder 114. The torque produced by the motor body 100 is transmitted to the middle rotary cylinder 114 by the first spring 112.

**[0033]** In this case, however, the first spring 112 is deformed, and hence the torque transmitted to the middle rotary cylinder 114 is not so large. When a resistance is applied to the lower rotary cylinder 118 for any reason, the resistance is applied also to the middle rotary cylinder 114 through the projection 132 and the projection 134, and hence the middle rotary cylinder 114 is not rotated.

**[0034]** The structure of the holder 62 will be described with reference to Fig. 10. The holder 62 comprises a hole 140, a hole 142, and a hole 144. The rotation shafts of the first gear 106 and the second gear 108 are passed through the hole 140. The tip end of the bending shaft 92 of the bending machine 80 is fitted into the hole 142. A bolt for fixing the holder 62 to the bending machine 80 is passed through the hole 144. The sensor ring L 64 and the sensor ring R 66 are connected to the holder 62 in a state where the rings are rotatable, by the bearings 70.

**[0035]** The configuration of the sensor ring L 64 will be described with reference to Figs. 11 and 12. In the sensor ring L 64, the body 150 comprises a microswitch L 152 and a gear 154. The body 150 has a shape similar to an article in which the sidewall is cylindrical and a circular hole is opened in the bottom, and which is turned upside down. A sector plate 156 is attached to the upper end of the sidewall, i.e., the portion which is formed as the bottom of the body 150 in Fig. 11, and the microswitch L 152 is fixed to the sector plate 156 and the upper end of the sidewall. The microswitch L 152 comprises a switch box which incorporates a push button type switch, and a contact plate which is attached to the switch box via a hinge. When the contact plate is contacted with the blade member plate 300 which is to be bent by the bending machine 80, the contact plate pushes the switch in the switch box. This causes the sensor ring L 64 to function as a device which produces a signal corresponding to whether the apparatus is contacted with the blade member plate 300 or not. The gear 154 is disposed on the edge of the hole in the portion which is formed as the top plate of the body

150 in Fig. 11. However, the gear 154 is not disposed over the whole circumference of the edge. In the edge, there is a portion where the gear 154 is not disposed. A groove 158 into which flanges of the bearings 70 are to be fitted is disposed slightly below the gear 154.

**[0036]** The configuration of the sensor ring R 66 will be described with reference to Figs. 13 and 14. In the sensor ring R 66, the body 160 comprises a microswitch R 162 and a gear 164. The body 160 has a cylindrical shape.

**[0037]** A protrusion 166 is disposed on the lower end of the sidewall of the body 160. The microswitch R 162 is attached to the protrusion. The microswitch R 162 is structured in a similar manner as the microswitch L 152. Similarly with the sensor ring L 64, therefore, the sensor ring R 66 produces a signal corresponding to whether the apparatus is contacted with the blade member plate 300 or not. The gear 164 is disposed on the edge of the upper end of the body 160 in Fig. 13. However, the gear 164 is not disposed over the whole circumference of the edge. In the edge, there is a portion where the gear 164 is not disposed. A groove 168 into which flanges of the bearings 70 are to be fitted is disposed slightly below the gear 164.

**[0038]** The placement of the sensor ring L 64 and other components will be described with reference to Figs. 15 to 18. As described above, the sensor ring L 64 and the sensor ring R 66 are connected to the holder 62. The sensor ring L 64 and the sensor ring R 66 are not directly connected to the holder 62. Members which are directly connected to the holder are the spacers 68. The bearings 70 are connected to the holder 62 through the spacers 68. The flanges of the bearings 70 are fitted into the groove 158 of the sensor ring L 64 and the groove 168 of the sensor ring R 66, whereby the sensor ring L 64 and the sensor ring R 66 are indirectly connected to the holder 62.

**[0039]** At this time, the gear 154 of the sensor ring L 64 meshes with the first gear 106, and the gear 164 of the sensor ring R 66 meshes with the second gear 108. According to the configuration, the torque produced by the motor body 100 of the servomotor 60 is transmitted to the sensor ring L 64 and the sensor ring R 66.

**[0040]** The position where the sensor ring L 64 is fixed is different from that where the sensor ring R 66 is fixed. Since they are different from each other, the rotation axis 170 of the sensor ring L 64 is different from the rotation axis 172 of the sensor ring R 66. The rotation axis 170 and the rotation axis 172 are located in the vicinity of an edge of the blade member plate 300 which is bent by the rotary cylinder 90. More specifically, the rotation axis 170 is placed so as to coincide with the rotation axis when the blade member plate 300 is bent toward one side by the rotary cylinder 90, and the rotation axis 172 is placed so as to coincide with the rotation axis when the blade member plate 300 is bent toward the other side. Since the rotation axis 170 and the rotation axis 172 coincide with the rotation axis when the blade member plate 300

is bent, the rotation angle of the sensor ring L 64 or the sensor ring R 66 coincides with the bending angle of the plate. In many cases, the rotation axis when the blade member plate 300 is bent is located at a distance which is equal to one half of the thickness of the blade member plate 300, from the tip end of the claw of the rotary cylinder 90, and at a distance which is equal to one half of the thickness of the blade member plate 300, from the side face thereof.

**[0041]** The manner of the attachment of the bending angle detection apparatus 50 will be described with reference to Figs. 19 and 20. The bending machine 80 comprises a top plate 94 and a gear case 96. The bending shaft 92 is fitted into a hole of the top plate 94. The gear case 96 houses gears which are not shown. The gears transmit a torque to a feed bearing which is used for feeding the blade member plate 300, and which is not shown. In order to attach the bending angle detection apparatus 50, the top plate 94 and the gear case 96 are replaced with another top plate 95 and another gear case 97. No hole into which the bending shaft 92 is to be fitted is formed in the top plate 95, and a screw hole into which the bolt that is passed through the holder 62 is to be screwed is disposed in the gear case 97. Namely, the bending angle detection apparatus 50 is connected to the bending machine 80 by screwing the holder 62 to the gear case 97.

**[0042]** The bending machine 80 further comprises a touch panel 91 and a cylinder rotation motor 93. The touch panel 91 is a device which displays information, and through which the user inputs information. The cylinder rotation motor 93 drives the rotary cylinder 90.

**[0043]** The controlling portion 98 of the bending machine 80 will be described with reference to Fig. 21. The bending machine 80 further comprises the controlling portion 98 in addition to the touch panel 91 and the cylinder rotation motor 93. When the bending angle detection apparatus 50 is not connected, the controlling portion 98 controls the bending process on the blade member plate 300. When the bending angle detection apparatus 50 is connected, the controlling portion 98 controls also the angle measurement by the bending angle detection apparatus 50, in addition to the bending process on the blade member plate 300. The controlling portion 98 comprises a cylinder rotation motor I/O (input/output) 180, a first external I/O 182, a second external I/O 184, a third external I/O 186, a touch panel I/O 188, a flash memory reading device 190, a ROM (Read Only Memory) 192, a RAM (Random Access Memory) 194, and a CPU (Central Processing Unit) 196.

**[0044]** The cylinder rotation motor I/O 180 outputs a control signal to the cylinder rotation motor 93. The first external I/O 182 is connected to the servomotor 60, receives an input of information indicative of the rotation angle from the rotation angle sensor 102, and outputs a control signal to the motor body 100. The second external I/O 184 receives a signal input by the microswitch L 152. The third external I/O 186 receives a signal input by the

microswitch R 162. The touch panel I/O 188 outputs an image signal to the touch panel 91, and receives an input of information by the user through the touch panel 91. The flash memory reading device 190 reads control programs which are to be executed by the CPU 196, from a flash memory 350. The control programs are used for performing not only the process of bending the blade member plate 300 but also the control on the bending angle detection apparatus 50. The ROM 192 stores programs for reading the control programs from the flash memory 350, and executing them. The RAM 194 temporarily stores the control programs read from the flash memory 350. Furthermore, the RAM 194 temporarily stores data for enabling the CPU 196 to process information. The CPU 196 sequentially executes the control programs stored in the RAM 194, thereby controlling the process of bending the blade member plate 300 and the angle measurement by the bending angle detection apparatus 50.

**[0045]** The procedure of measuring the angle of the blade member plate 300 in the bending angle detection apparatus 50 of the embodiment will be described with reference to Figs. 22 to 27.

**[0046]** It is assumed that the sector plate 156 and the protrusion 166 are placed in a state where they contact with each other, at a position which is opposite to the servomotor 60 with respect to the bending shaft 92. In the embodiment, the positions of the sensor ring L 64 and the sensor ring R 66 at this time are referred to as "reference position". In this state, feed rollers (not shown) of the bending machine 80 feed the blade member plate 300 through the slit of the bending shaft 92. Fig. 22 shows this situation.

**[0047]** When the blade member plate 300 is fed, the controlling portion 98 outputs the control signal to the cylinder rotation motor 93 through the cylinder rotation motor I/O 180, thereby driving the cylinder rotation motor 93. Therefore, the rotary cylinder 90 is rotated, and the tip end of the claw reaches the bending start position. Fig. 23 shows this situation.

**[0048]** When the tip end of the claw of the rotary cylinder 90 reaches the bending start position, the servomotor 60 produces a torque in accordance with the control of the controlling portion 98. The torque is transmitted to the sensor ring L 64 and the sensor ring R 66 through the first gear 106 and the second gear 108. Therefore, the sensor ring R 66 is rotated. The sensor ring L 64 is rotated at first, but the rotation is stopped in mid-course because, as shown in Fig. 11, the gear 154 is not disposed over the whole circumference of the edge of the body 150, and, as a result, the first gear 106 does not mesh with the gear 154. On the basis of the rotation angle data which are input by the rotation angle sensor 102, the controlling portion 98 knows the rotation angle of the second gear 108. As a result, the controlling portion 98 indirectly knows also the rotation angle of the microswitch R 162. When contacted with the blade member plate 300, the microswitch R 162 inputs a signal into the third ex-

ternal I/O 186. The CPU 196 detects the rotation angle of the microswitch R 162 based on the rotation angle of the second gear 108 at the timing when the microswitch R 162 inputs the signal. Fig. 24 shows this situation.

**[0049]** When the rotation angle of the microswitch R 162 is detected, the controlling portion 98 causes the cylinder rotation motor 93 to drive. Therefore, the rotary cylinder 90 is rotated, and the tip end of the claw of the rotary cylinder 90 bends the blade member plate 300. Fig. 25 shows this situation.

**[0050]** When the blade member plate 300 is bent, the servomotor 60 produces a torque in accordance with the control of the controlling portion 98. The torque is transmitted to the sensor ring R 66 through the second gear 108. Therefore, the microswitch R 162 is again rotated. When again contacted with the blade member plate 300, the microswitch R 162 again inputs the signal into the third external I/O 186. Fig. 26 shows this situation.

**[0051]** The CPU 196 detects the rotation angle of the microswitch R 162 based on the rotation angle of the second gear 108 at the timing when the microswitch R 162 again inputs the signal. When the rotation angle of the microswitch R 162 is detected, the CPU 196 calculates the angle difference between the rotation angle and that of the microswitch R 162 which is initially detected. As described above, the rotation axis of the microswitch R 162 or i.e., the sensor ring R 66 exists on the rotation axis when the blade member plate 300 is bent. Therefore, the calculated angle difference is equal to the rotation angle of the bent portion of the blade member plate 300. The angle difference is enabled to be calculated by previously storing the tooth number of the second gear 108 and that of the gear 164 in the RAM 194. The tooth numbers can be stored in the RAM 194 by reading them from the flash memory 350 as a part of the control programs, or a data file which is independent from the control programs.

**[0052]** When the angle difference is calculated, the servomotor 60 produces a torque in accordance with the control of the controlling portion 98. The torque is transmitted to the sensor ring R 66 through the second gear 108. Therefore, the microswitch R 162 is again rotated. As a result of the rotation, the microswitch R 162 is returned to the reference position. When returned to the reference position, the protrusion 166 pushes the sector plate 156. Therefore, the gear 154 again meshes with the first gear 106. Fig. 27 shows this situation.

**[0053]** The control procedure for accurately bending the blade member plate 300 without previously measuring springback will be described with reference to Fig. 28. The control procedure performed when the blade member plate 300 is rightward bent is not particularly described, but is similar to that performed when the blade member plate 300 is leftward bent, except that the direction of the blade member plate 300 is measured by the microswitch L 152.

**[0054]** In step S250, the CPU 196 of the bending machine 80 causes the feed rollers which are not shown, to

drive to feed the blade member plate 300 by a predetermined length.

**[0055]** In step S252, the CPU 196 outputs a control signal for producing a torque, to the servomotor 60. The servomotor 60 produces a torque in accordance with the control signal. When the torque produced by the servomotor 60 is transmitted, the sensor ring R 66 is rotated. In this case, one of the sensor ring L 64 is rotated at first, and then does not mesh with the first gear 106, so that the sensor ring is not rotated finally.

**[0056]** In step S254, the CPU 196 determines whether the sensor ring R 66 detects the blade member plate 300 or not, based on the signal which is input to the third external I/O 186 by the microswitch R 162. If it is determined that the blade member plate 300 is detected (YES in step S254), the process is transferred to step S256. If not (NO in step S254), the process is transferred to step S252.

**[0057]** In step S256, the CPU 196 outputs a control signal for stopping the production of a torque, to the servomotor 60. Therefore, the rotations of the first gear 106 and the second gear 108 are stopped.

**[0058]** In step S258, the CPU 196 calculates the rotation angle of the sensor ring R 66 based on the rotation angle data which are input by the rotation angle sensor 102. When the rotation angle of the sensor ring R 66 is calculated, the CPU 196 stores the rotation angle in the RAM 194. The rotation angle indicates the starting point of the process of bending the blade member plate 300.

**[0059]** In step S260, the CPU 196 the CPU 196 outputs a control signal for producing a torque, to the servomotor 60. When the control signal is input, the rotor of the motor body 100 rotates. In the embodiment, the rotation angle at this time is an angle satisfying the following requirement. The requirement is that the angle of the bent portion of the blade member plate 300 equal to an angle which is designated by the user through the touch panel 91. In accordance with the rotation of the rotor, the sensor ring R 66 tries to rotate. However, the sensor ring is blocked by the blade member plate 300, and hence the sensor ring R 66 does not rotate. Therefore, the upper rotary cylinder 110 of the spring joint 104 is relatively rotated with respect to the lower rotary cylinder 118.

**[0060]** In step S262, the CPU 196 causes the cylinder rotation motor 93 to drive. Therefore, the rotary cylinder 90 is rotated, and the blade member plate 300 is bent in the direction in which it is separated from the microswitch R 162. At this time, the first spring 112 and second spring 116 of the spring joint 104 are returned from the state where the springs are elastically deformed, to that where the springs are not elastically deformed. Therefore, the microswitch R 162 tracks the blade member plate 300.

**[0061]** In step S264, based on the signal which is input by the microswitch R 162, the CPU 196 determines whether the microswitch R 162 becomes not to detect the blade member plate 300 or not. If it is determined that the microswitch becomes not to detect the blade member plate 300 (YES in step S264), the process is transferred

step to S266. If not (NO in step S264), the process is transferred to step S262.

**[0062]** In step S266, the CPU 196 again causes the cylinder rotation motor 93 to drive. This causes the rotary cylinder 90 to be further rotated, and the blade member plate 300 is further bent. Namely, the blade member plate 300 is further pressed. The rotation angle of the rotary cylinder 90 is an angle at which the elastic deformation of the blade member plate 300 slightly advances.

**[0063]** Thereafter, the CPU 196 causes the cylinder rotation motor 93 to reversely rotate. Because of the reverse rotation of the cylinder rotation motor 93, the rotation angle of the rotary cylinder 90 is returned to the angle at the timing when the microswitch R 162 becomes not to detect the blade member plate 300 as a result of the rotation of the rotary cylinder 90 in step S262. At this time, the direction of the blade member plate 300 is slightly returned by springback, but is not returned in the direction before the further pressing because of advancement of the elastic deformation. As a result, the angle of the blade member plate 300 when the claw of the rotary cylinder 90 is separated approaches the angle which is designated by the user.

**[0064]** In step S268, based on the signal which is input by the microswitch R 162, the CPU 196 determines whether the microswitch R 162 becomes not to detect the blade member plate 300 or not. If it is determined that the microswitch becomes not to detect the blade member plate 300 (YES in step S268), the process is transferred to step S270. If not (NO in step S268), the process is transferred to step S266.

**[0065]** In step S270, the CPU 196 causes the servomotor 60 to drive so that the microswitch R 162 is returned to the reference position.

**[0066]** In step S272, the controlling portion 98 updates information in order to perform the next bending process.

**[0067]** As described above, the bending machine 80 in the embodiment accurately bends the blade member plate 300 based on the direction of the blade member plate 300 which is detected by the bending angle detection apparatus 50 as a result of the angle measurement. Springback is not measured. Therefore, the user of the bending machine 80 is not required to manually measure springback each time. To begin with, it becomes unnecessary to know in detail what extent of rotating of the rotary cylinder 90 corresponds to accurate bending of the blade member plate 300. Therefore, labor required for the work of bending the blade member plate 300 can be correspondingly reduced.

**[0068]** All points of the disclosed embodiment are exemplifications. The scope of the invention is not limited based on the above-described embodiment. It is a matter of course that various design changes may be made without departing the spirit of the invention.

**[0069]** For example, the spring joint 104 is not limited to the above-described configuration. In place of the above-described spring joint 104, a plate spring or a rubber-made cylinder may be used which transmits the

torque supplied by the motor body 100 of the servomotor 60 to the signal production device, and which is elastically deformed by the torque. In place of the spring joint 104, another buffer member may be used. In the case where a buffer member is used, the buffer member is requested to transmit the torque supplied by the motor body 100 to the sensor ring L 64 or the sensor ring R 66, and to be elastically deformed by the torque supplied by the motor body 100. The spring joint 104 may be omitted.

**[0070]** In place of the configuration in which the rotation angles of the sensor ring L 64 and the sensor ring R 66 are indirectly measured by the rotation angle sensor 102, the rotation angles may be directly measured. A specific measure for directly measuring the rotation angles, a method may be employed in which a spur gear meshes with the gear 154 of the sensor ring L 64 and the gear 164 of the sensor ring R 66, and an angle sensor is connected to its shaft.

**[0071]** In place of the servomotor 60, another drive device may drive the sensor ring L 64 and the sensor ring R 66. The mechanism for the driving is particularly limited.

**[0072]** In place of the sensor ring L 64 and the sensor ring R 66, a signal production device which produces a signal corresponding to whether the apparatus is contacted with the blade member plate 300 or not, in a mechanism that is different from the rings may be disposed in the bending angle detection apparatus 50. As an example of such a signal production device, there is a device in which a microswitch is caused to linearly run, and its rotation angle is calculated based on the positional relationship between the position where the microswitch is contacted with the blade member plate 300, and the position of the rotation axis of the blade member plate 300 that is bent.

**[0073]** The bending angle detection apparatus 50 may comprise a controlling portion. In this case, the controlling portion may be configured in a similar manner as the controlling portion 98. According to the configuration, the bending angle detection apparatus 50 can measure the angle of the bent portion of the blade member plate 300 without depending on the controlling portion 98 of the bending machine 80. In the case where springback is to be measured, the controlling portion of the bending angle detection apparatus 50 may cooperate with the controlling portion 98 of the bending machine 80.

**[0074]** The program recording medium from which the controlling portion 98 reads control programs is not limited to the flash memory 350. For example, the medium may be a USB memory. Alternatively, control programs may be received via the Internet.

## Claims

1. A method of bending a plate in which a plate is bent by a bending machine (80), wherein a work of bending the plate is repeated a plurality of times until it is detected that an angle of a bent portion

of the plate reaches a predetermined angle, in a state where the plate is attached to said bending machine and springback is completed.

2. A method of bending a plate according to claim 1, wherein the plate is further bent (S286) until it is detected (S284) by a bending angle detection apparatus (50) connected to said bending machine detects, that the angle of the bent portion of the plate reaches the predetermined angle.
3. A method of bending a plate according to claim 2, wherein said bending angle detection apparatus is contacted with the plate to measure a direction of the plate before said bending machine bends the plate, and a direction of the plate after said bending machine bends the plate.
4. A bending angle detection apparatus which is a bending angle detection apparatus (50) for detecting an angle, wherein said bending angle detection apparatus is connected to a bending machine (80), the angle is an angle of a bent portion of a plate which is bent by said bending machine, said apparatus comprises:

a signal production device (64, 66) which produces a signal corresponding to whether the apparatus is contacted with the plate or not;  
a connecting portion (62, 70) which rotatably connects said signal production device to said bending machine;  
a drive device (100) which drives said signal production device so that said signal production device is rotated; and  
a rotation angle detection device (102) which detects a rotation angle of said signal production device,  
said connecting portion has:

a holder (62) which is fixed to said bending machine;  
and  
bearings (70) which are connected to said the holder,  
and  
said bearings rotatably position said signal production device so that, when said bending machine bends the plate, a rotation axis of the plate coincides with a rotation axis of said signal production device.

Fig. 1

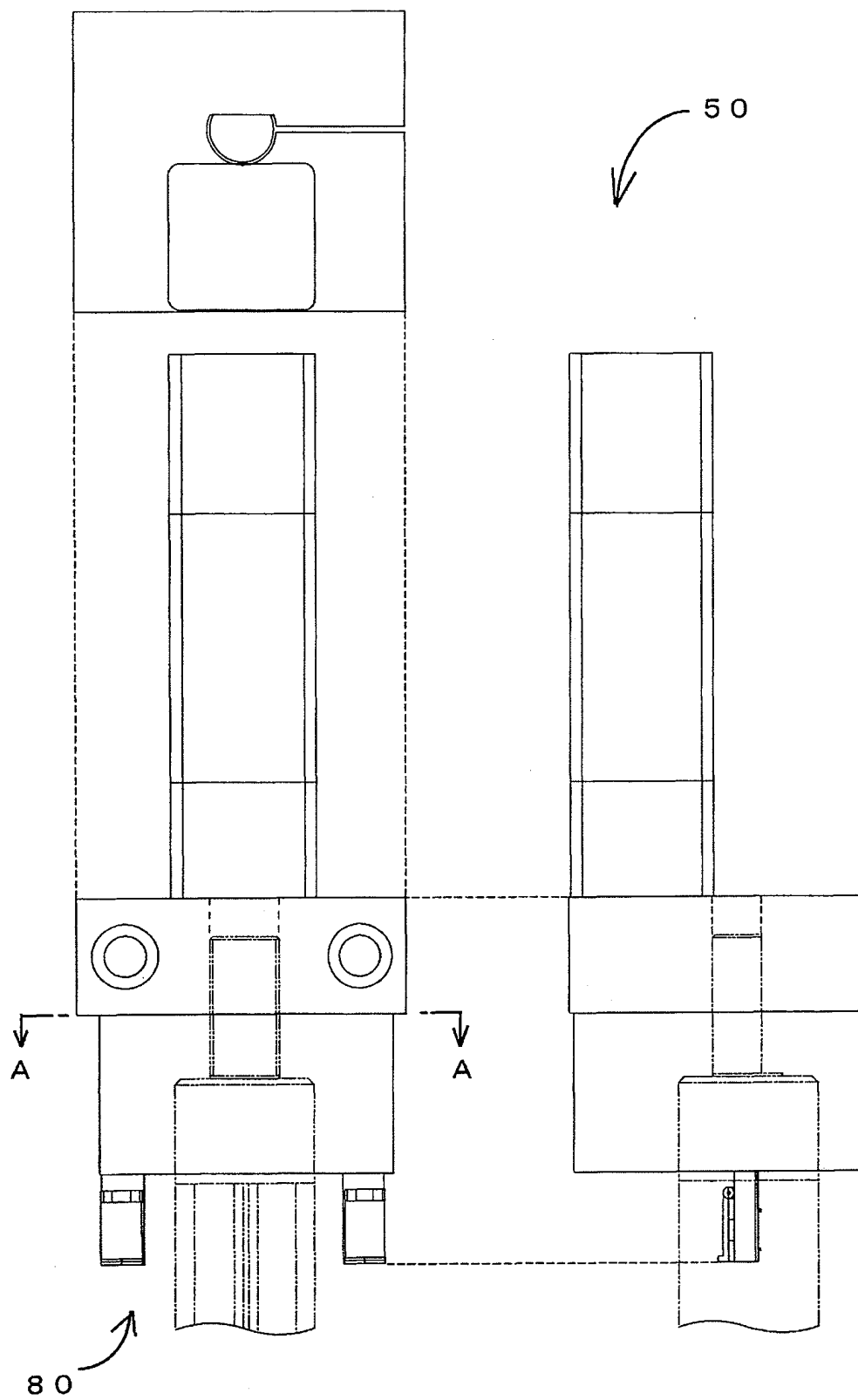


Fig. 2

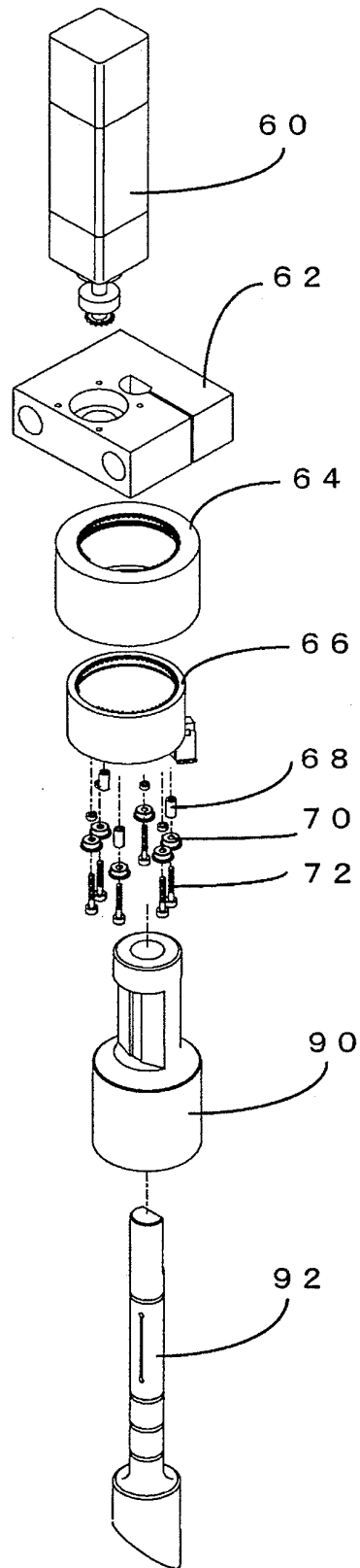


Fig. 3

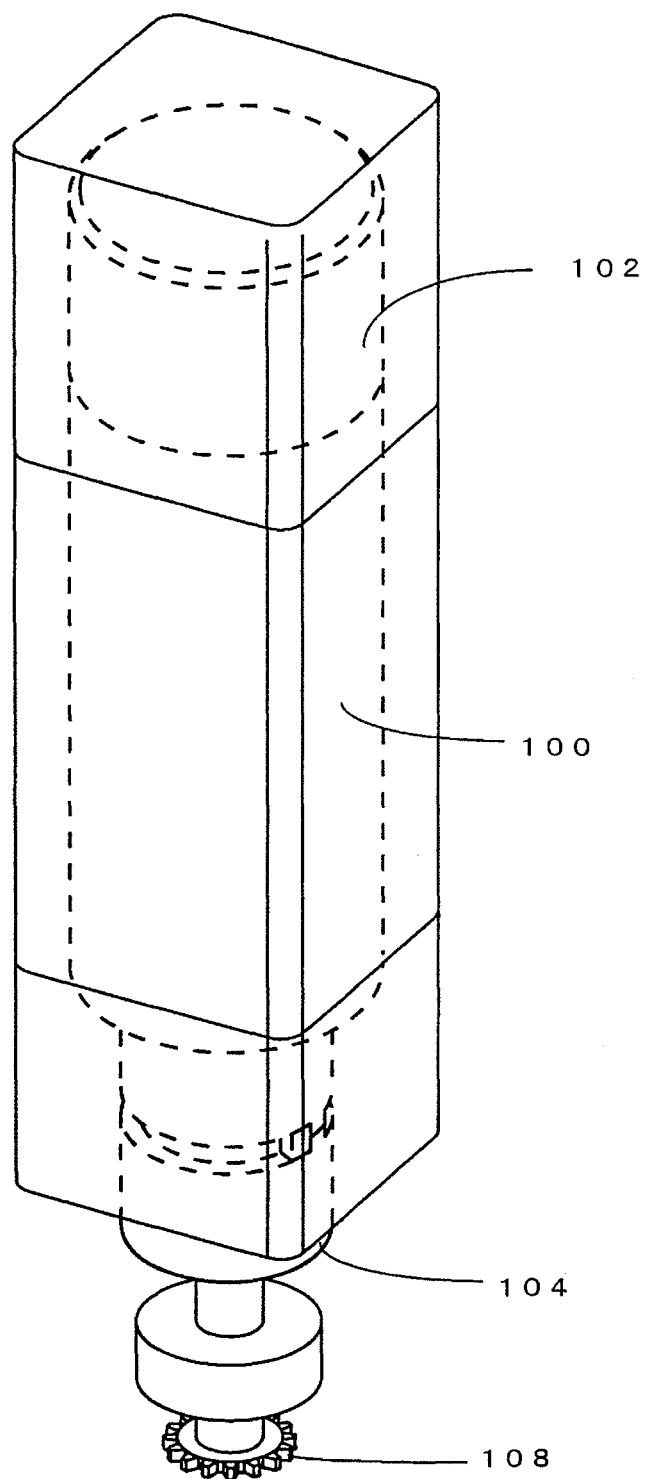


Fig. 4

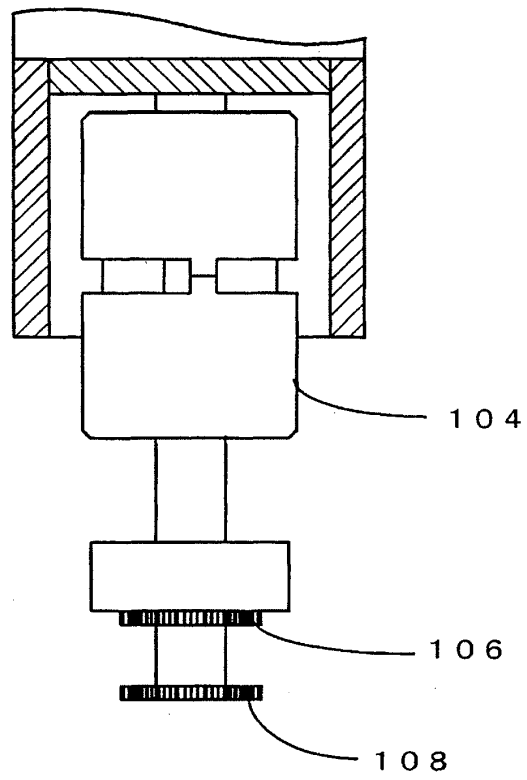


Fig. 5

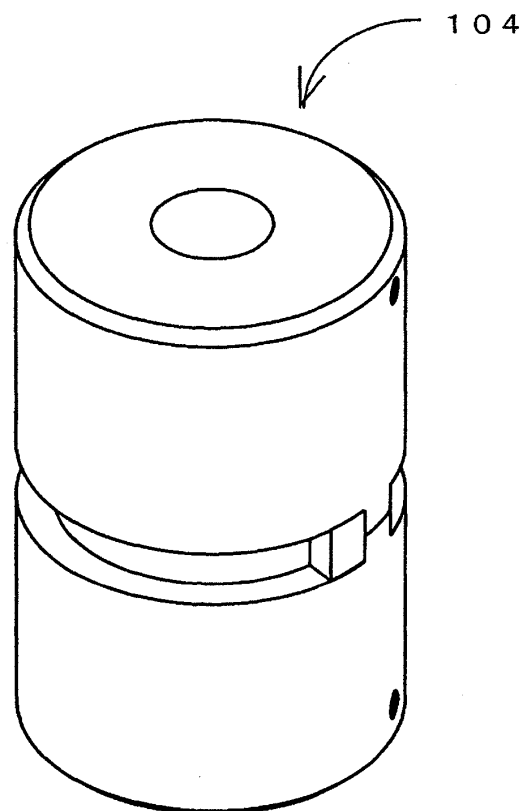


Fig. 6

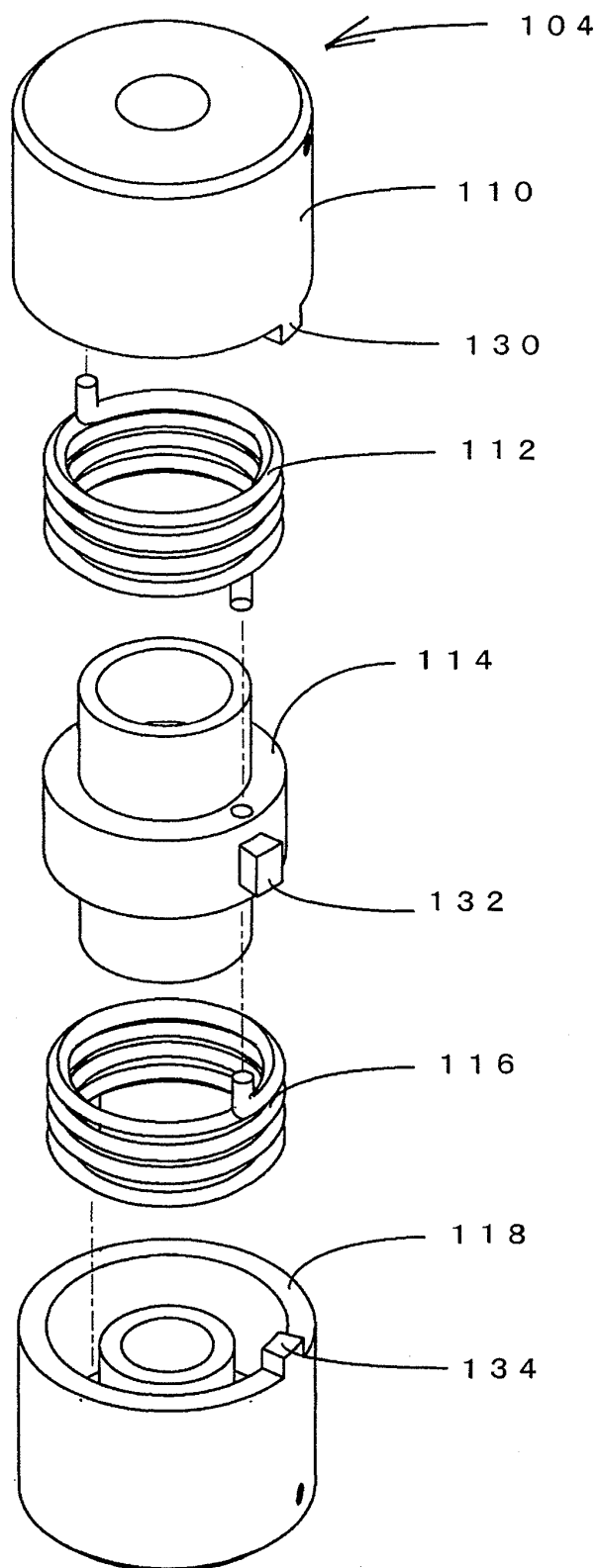


Fig. 7

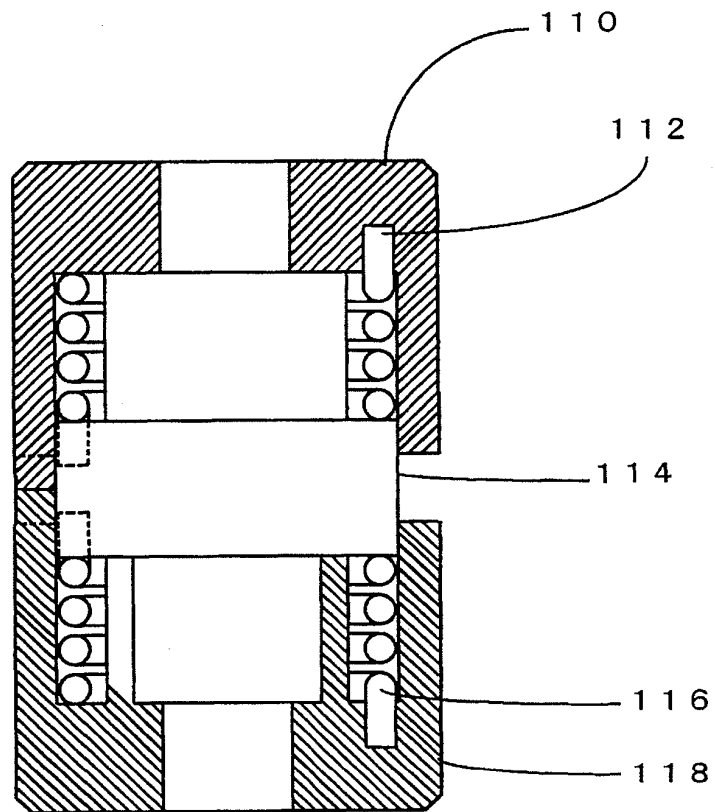


Fig. 8

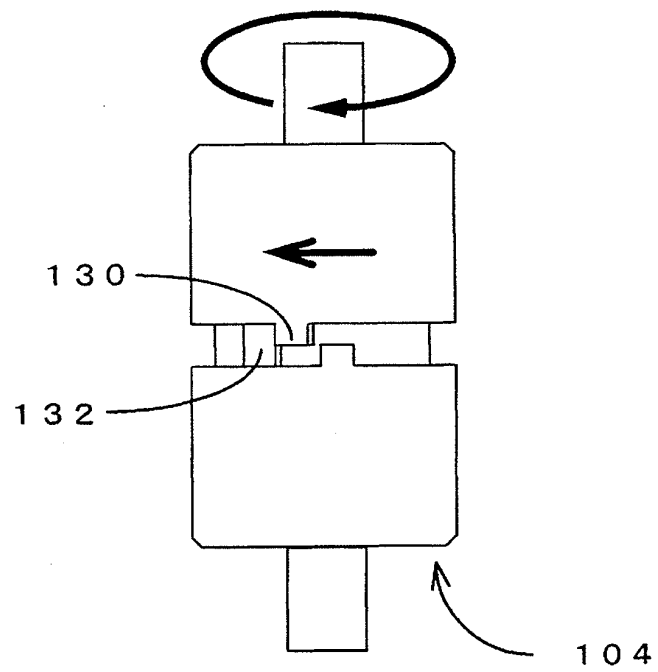


Fig. 9

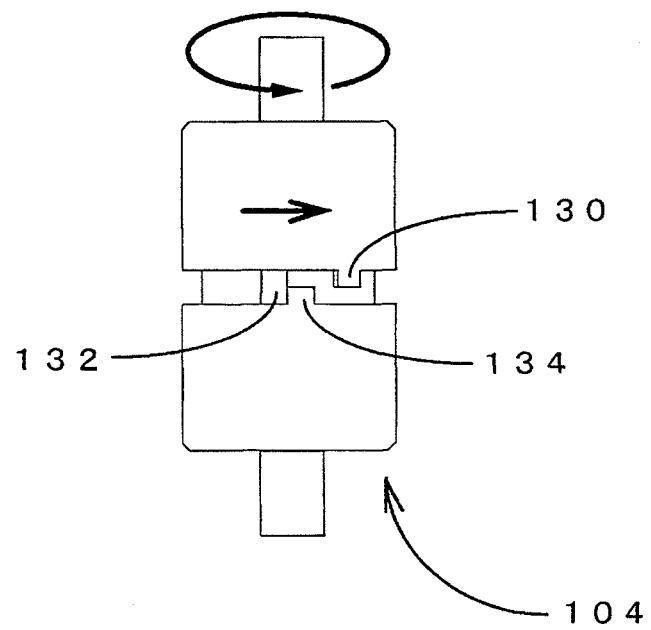


Fig. 10

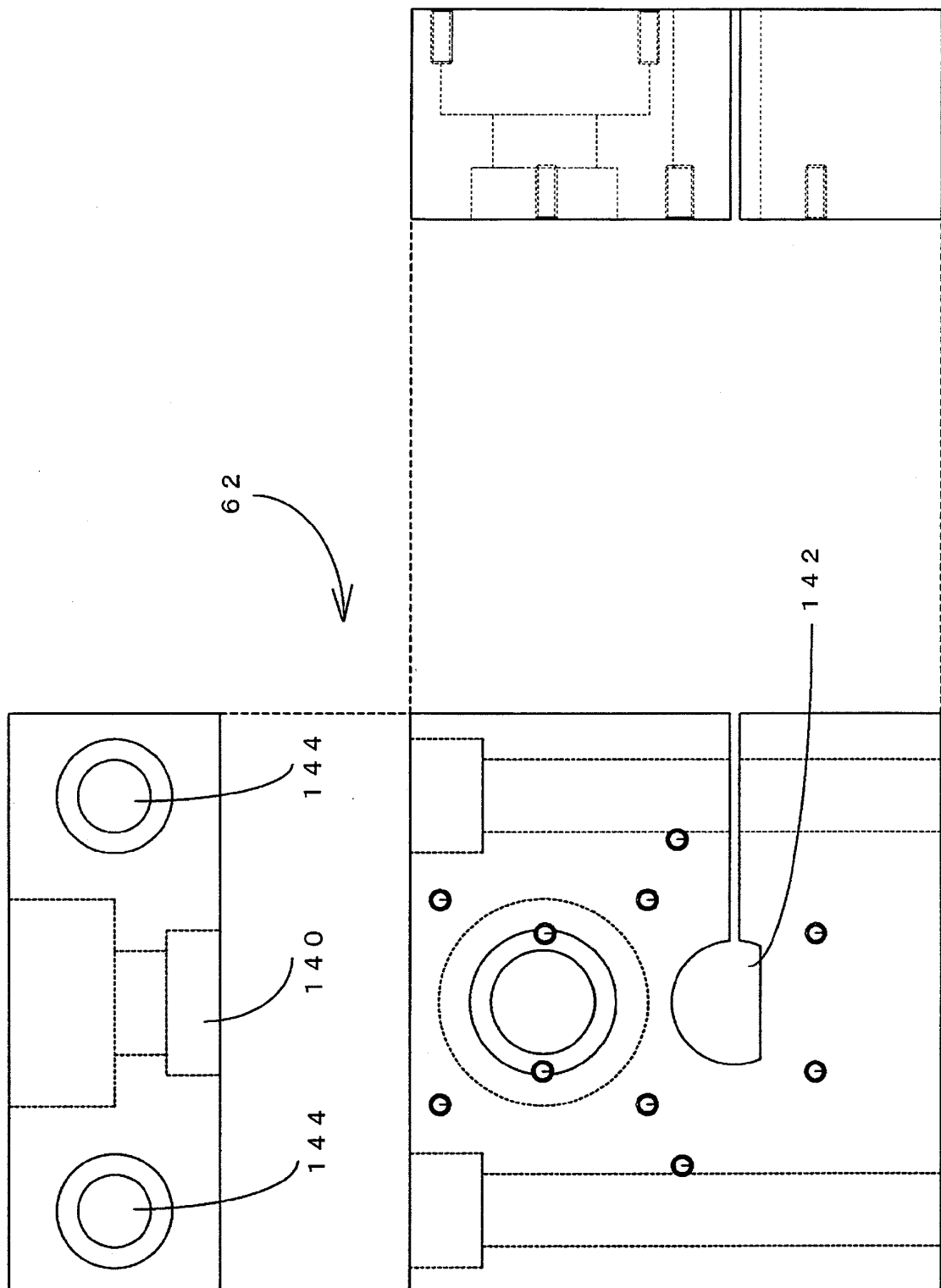


Fig. 11

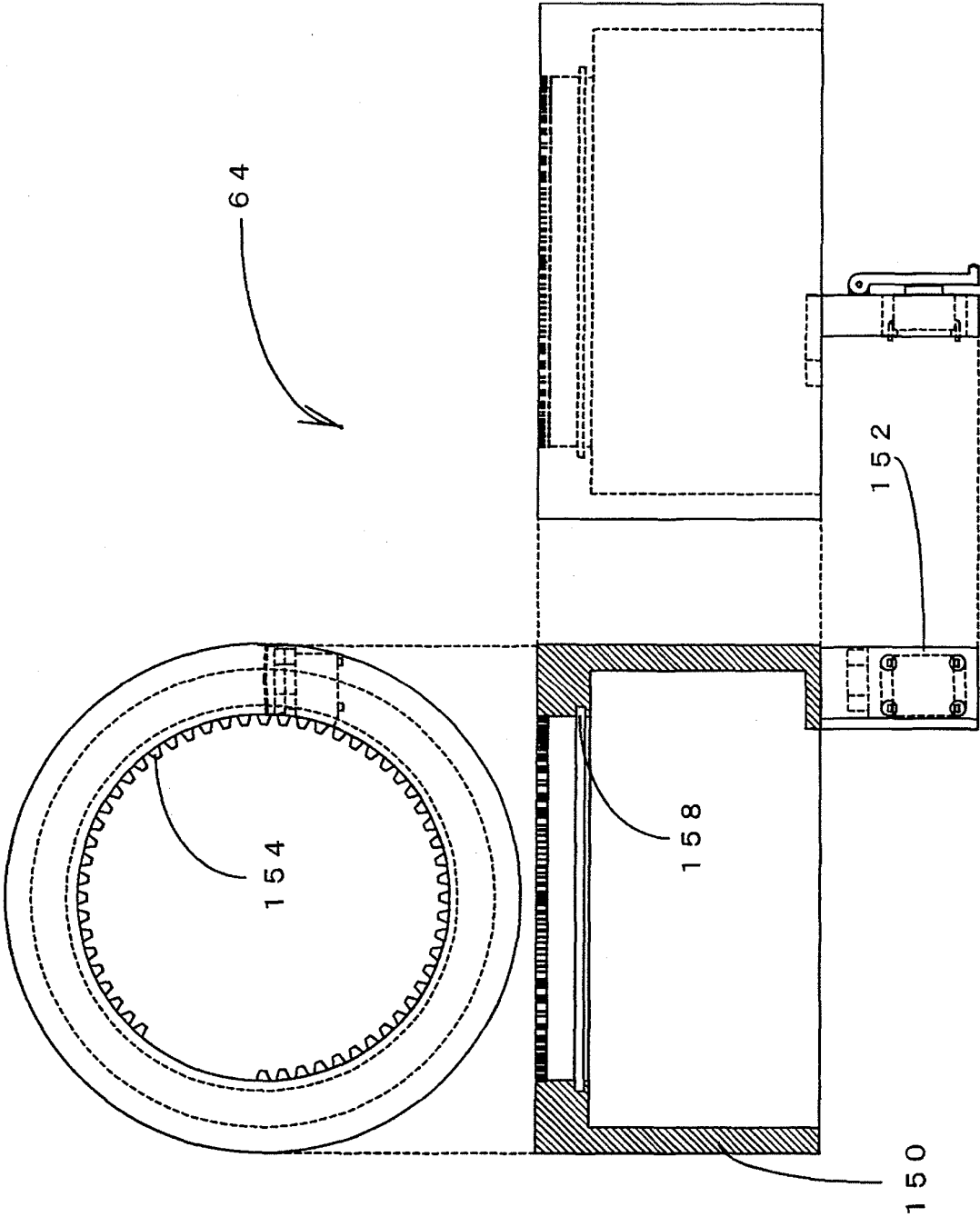


Fig. 12

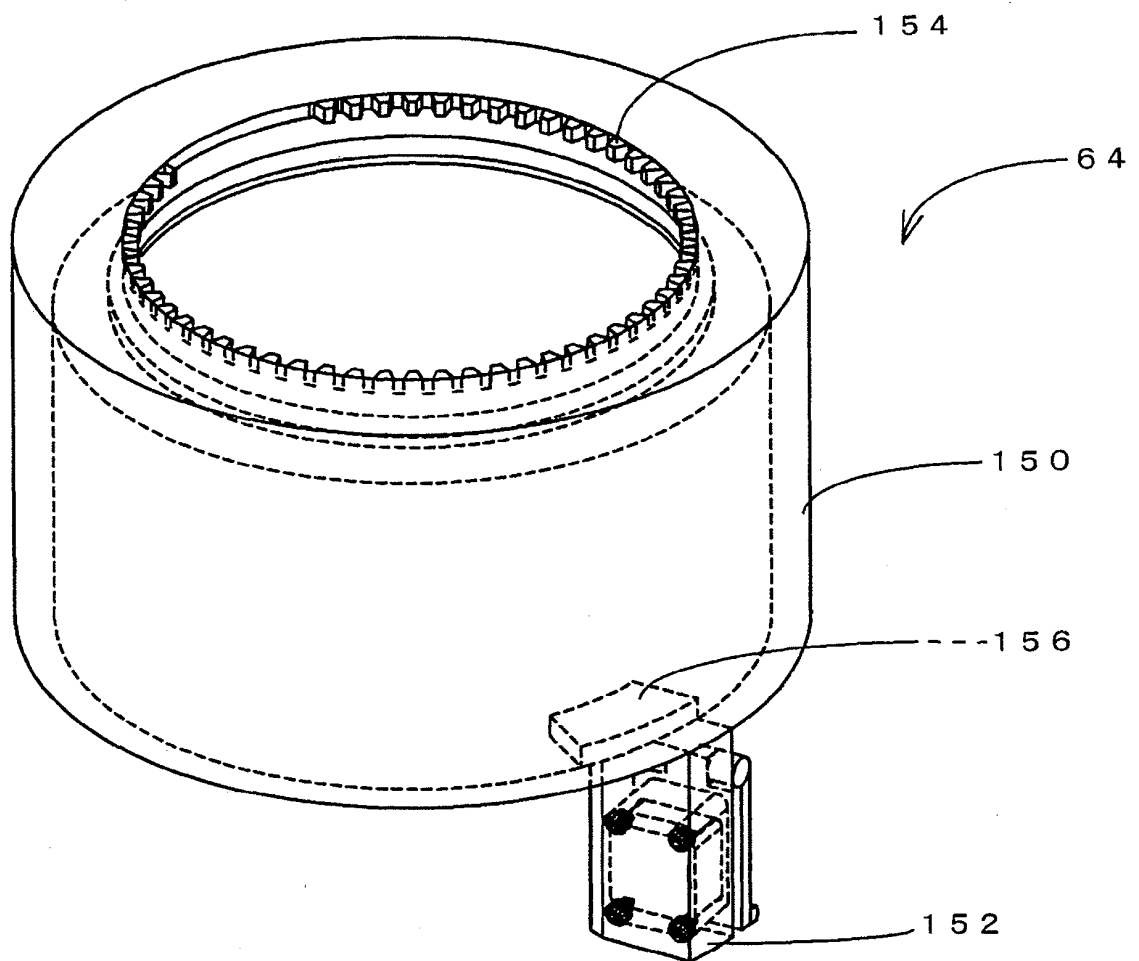


Fig. 13

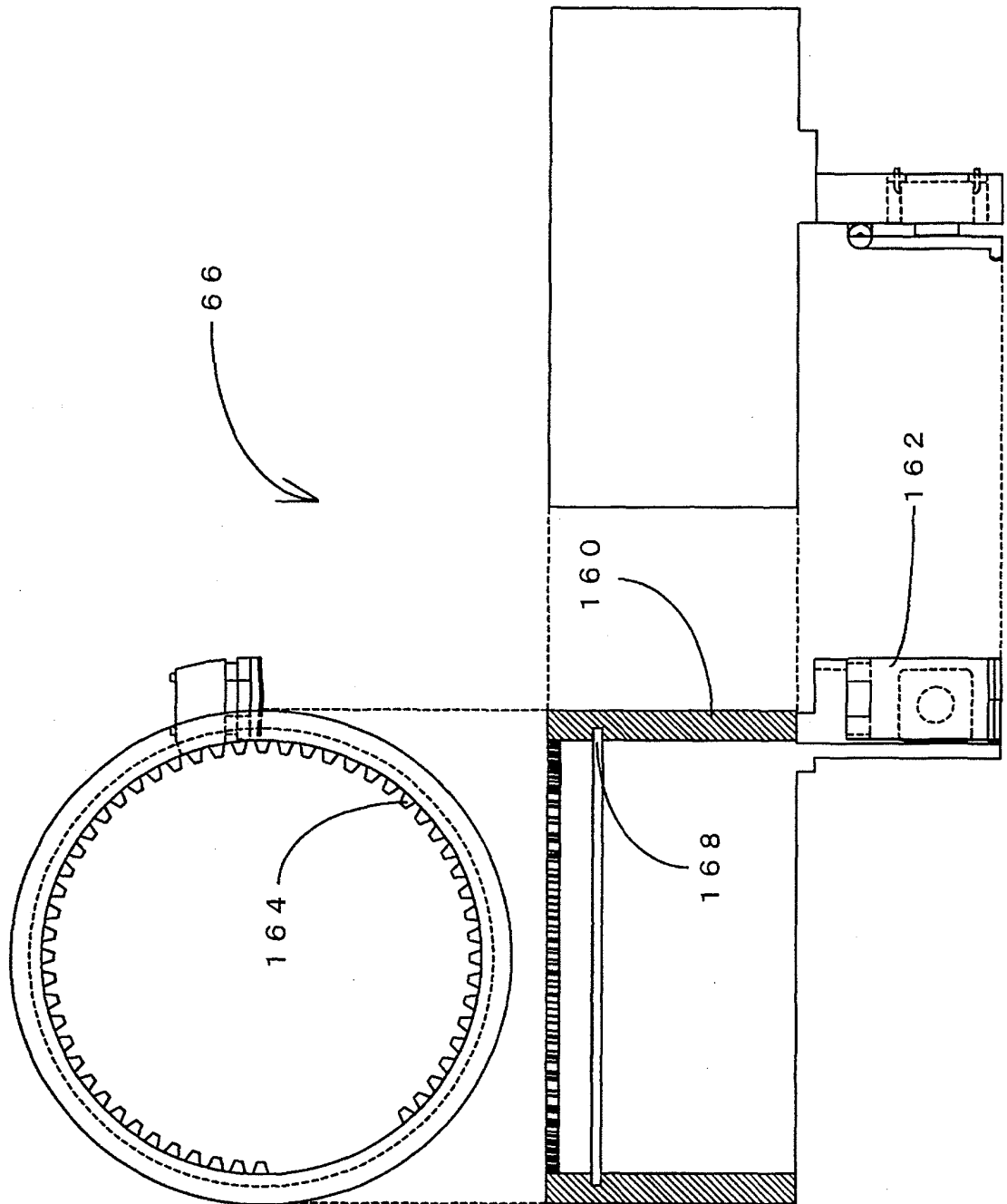


Fig. 14

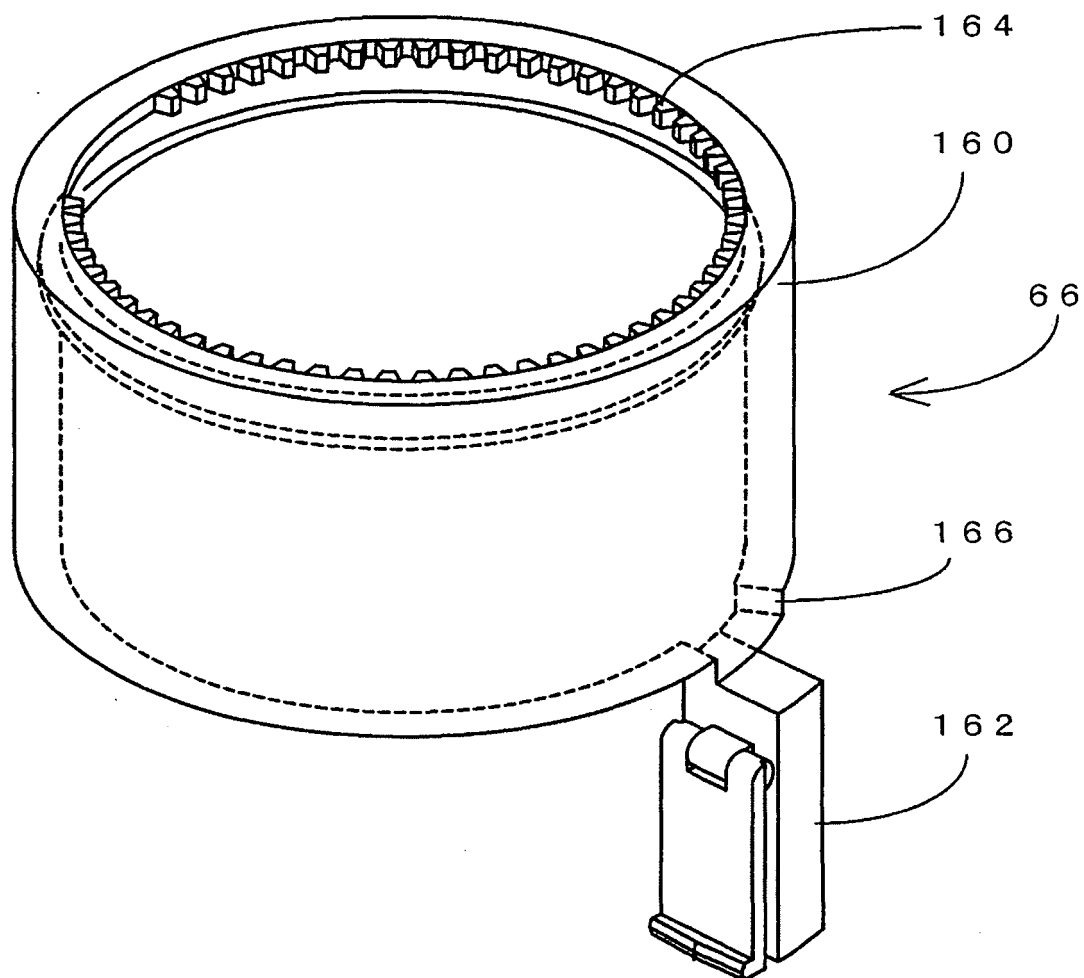


Fig. 15

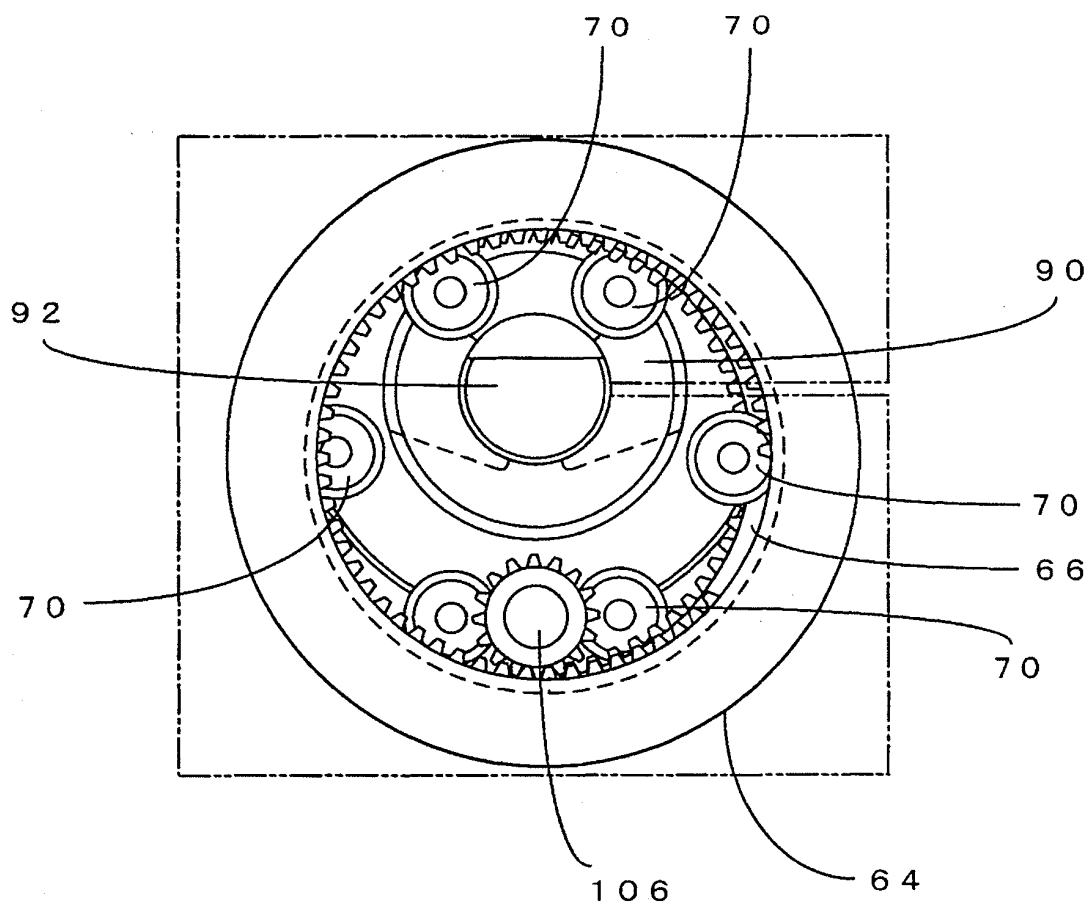


Fig. 16

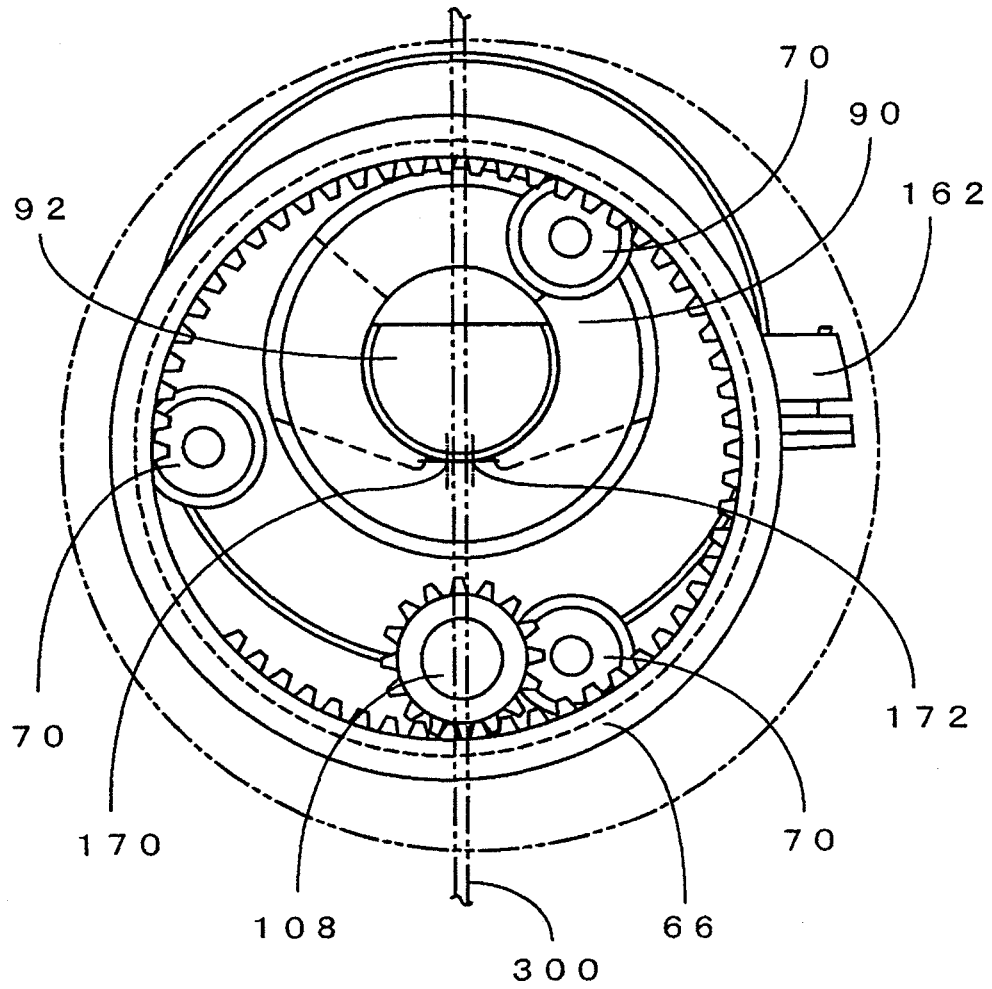


Fig. 17

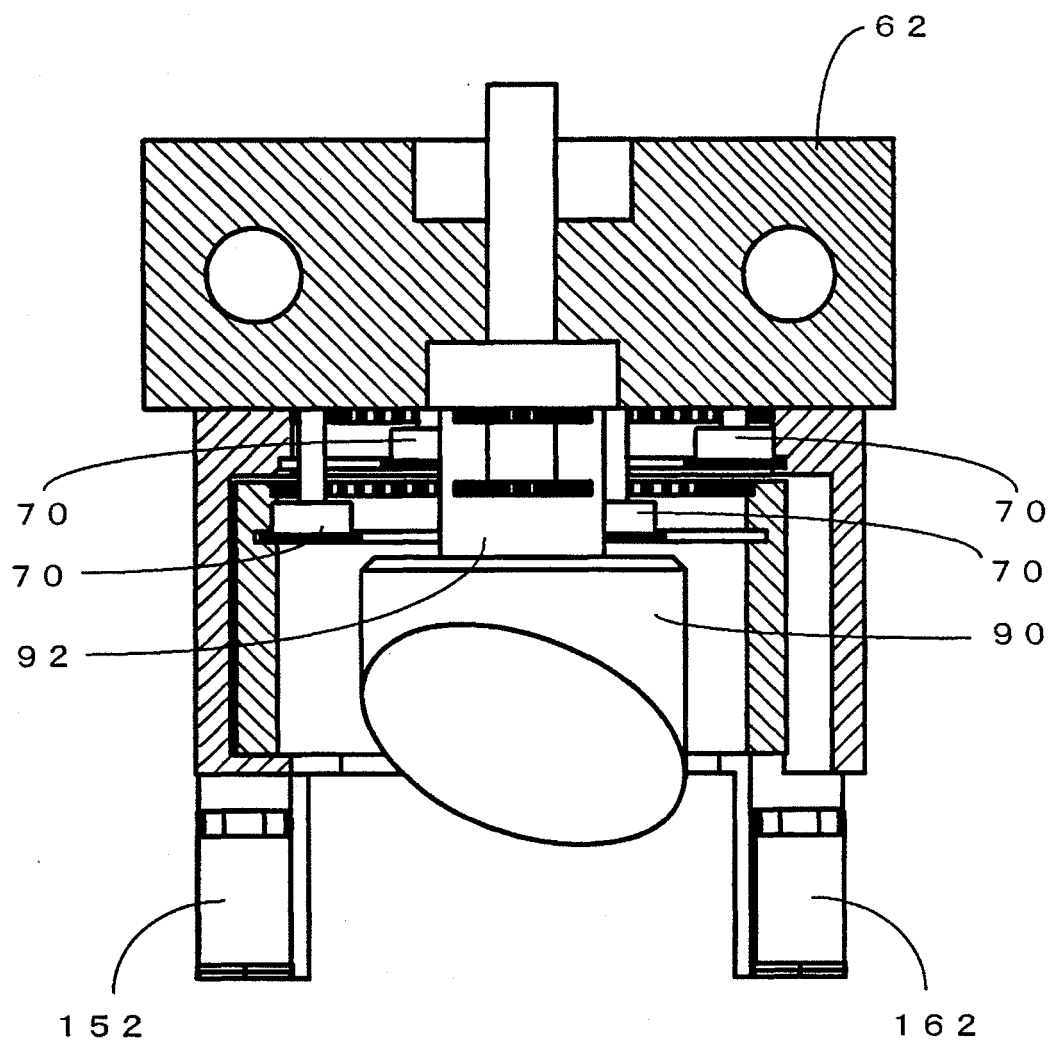


Fig. 18

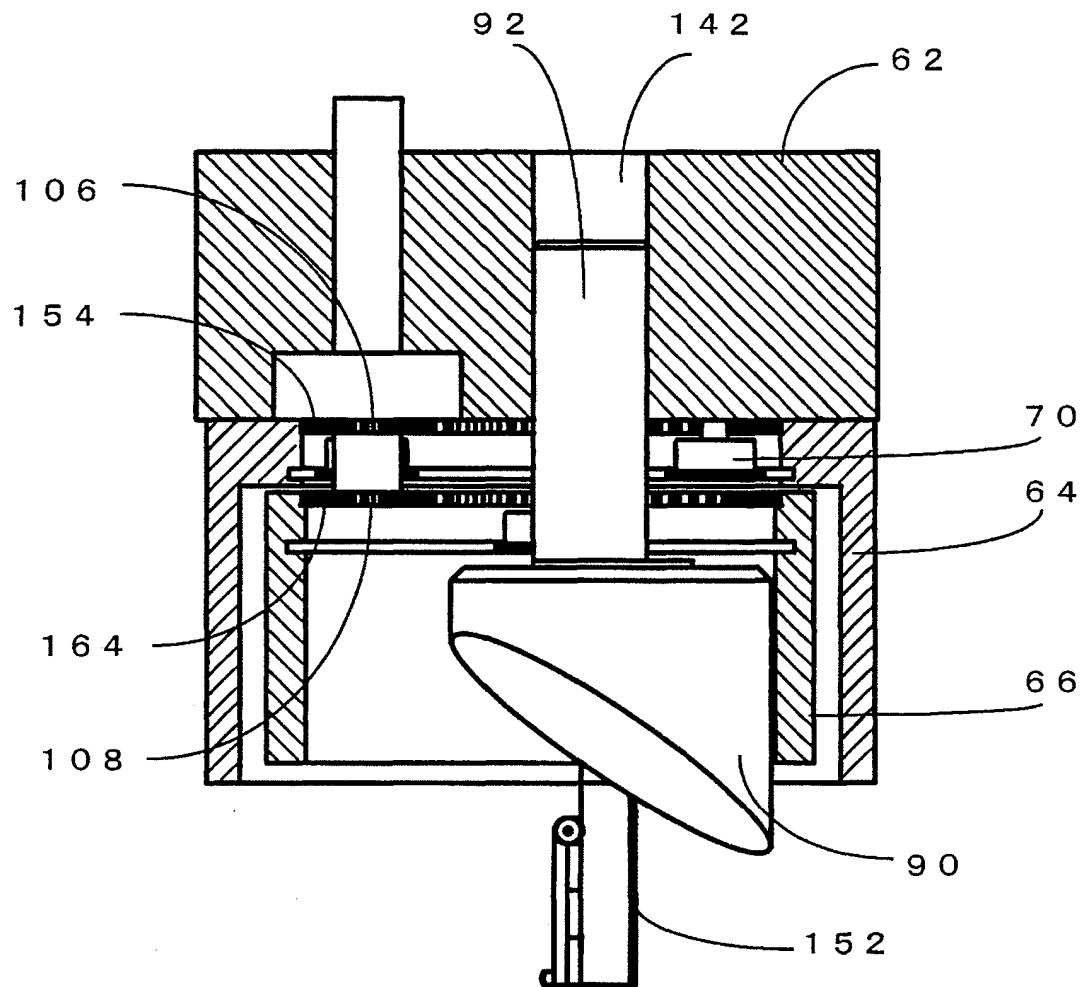


Fig. 19

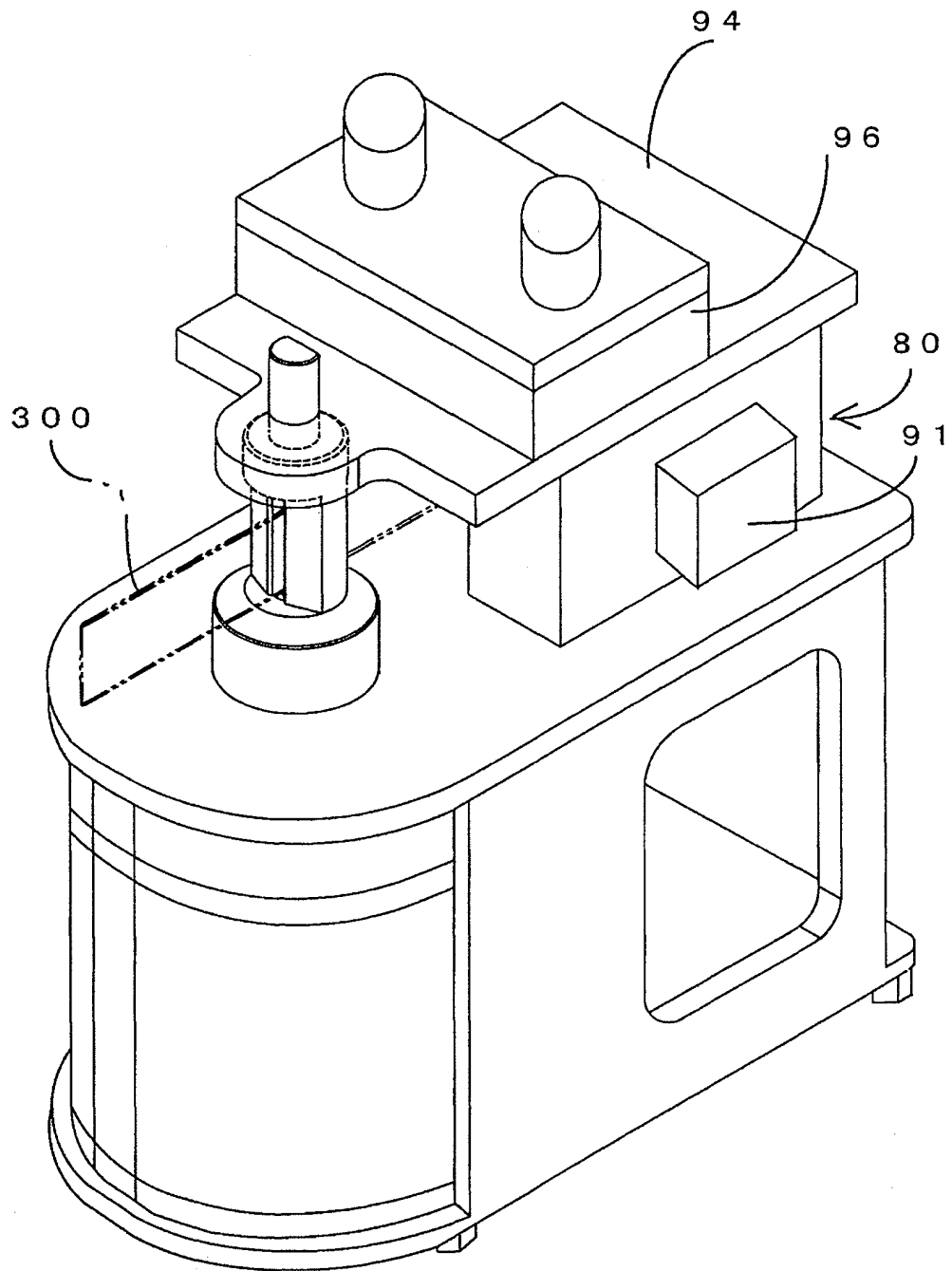


Fig. 20

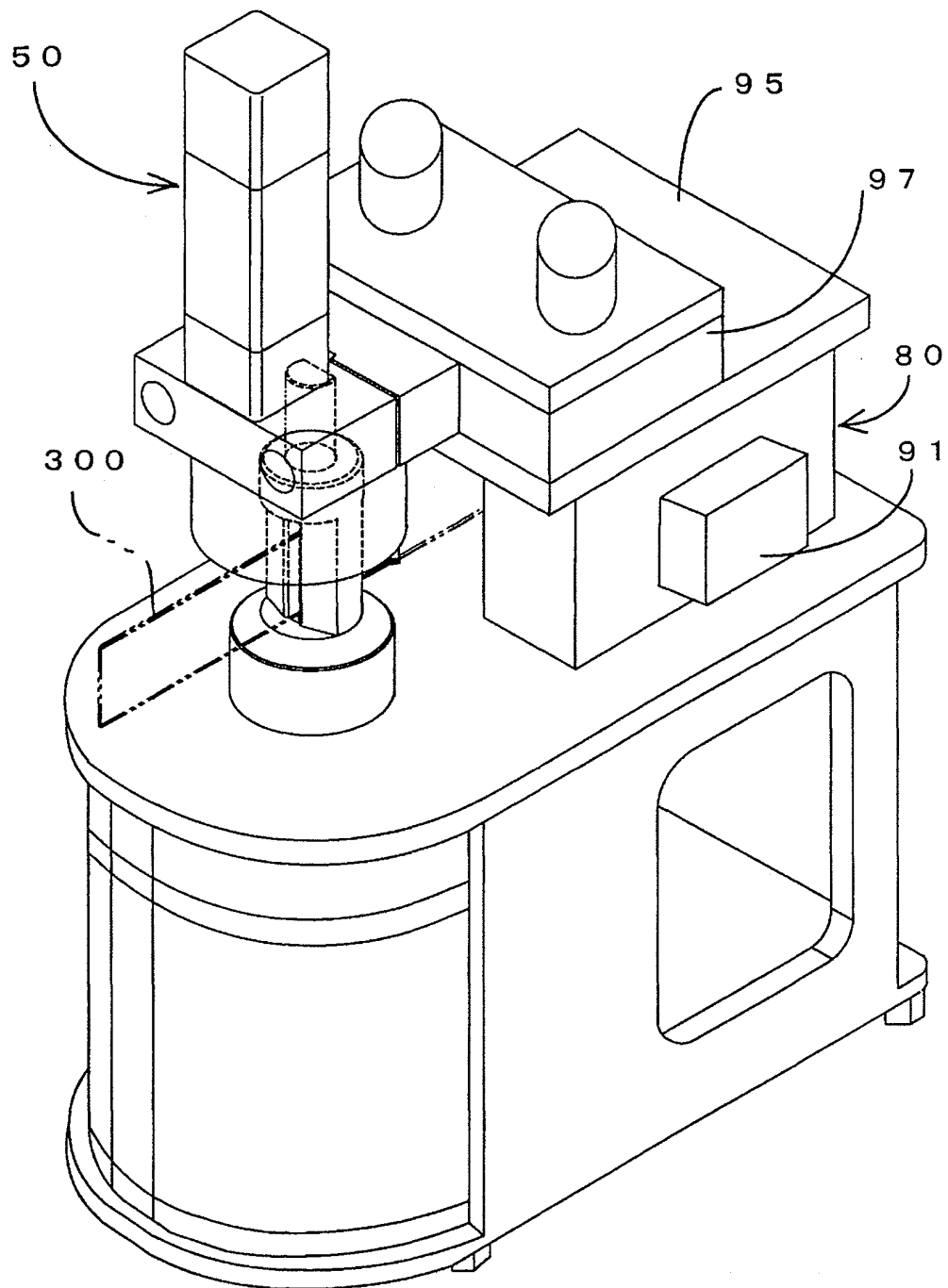


Fig. 21

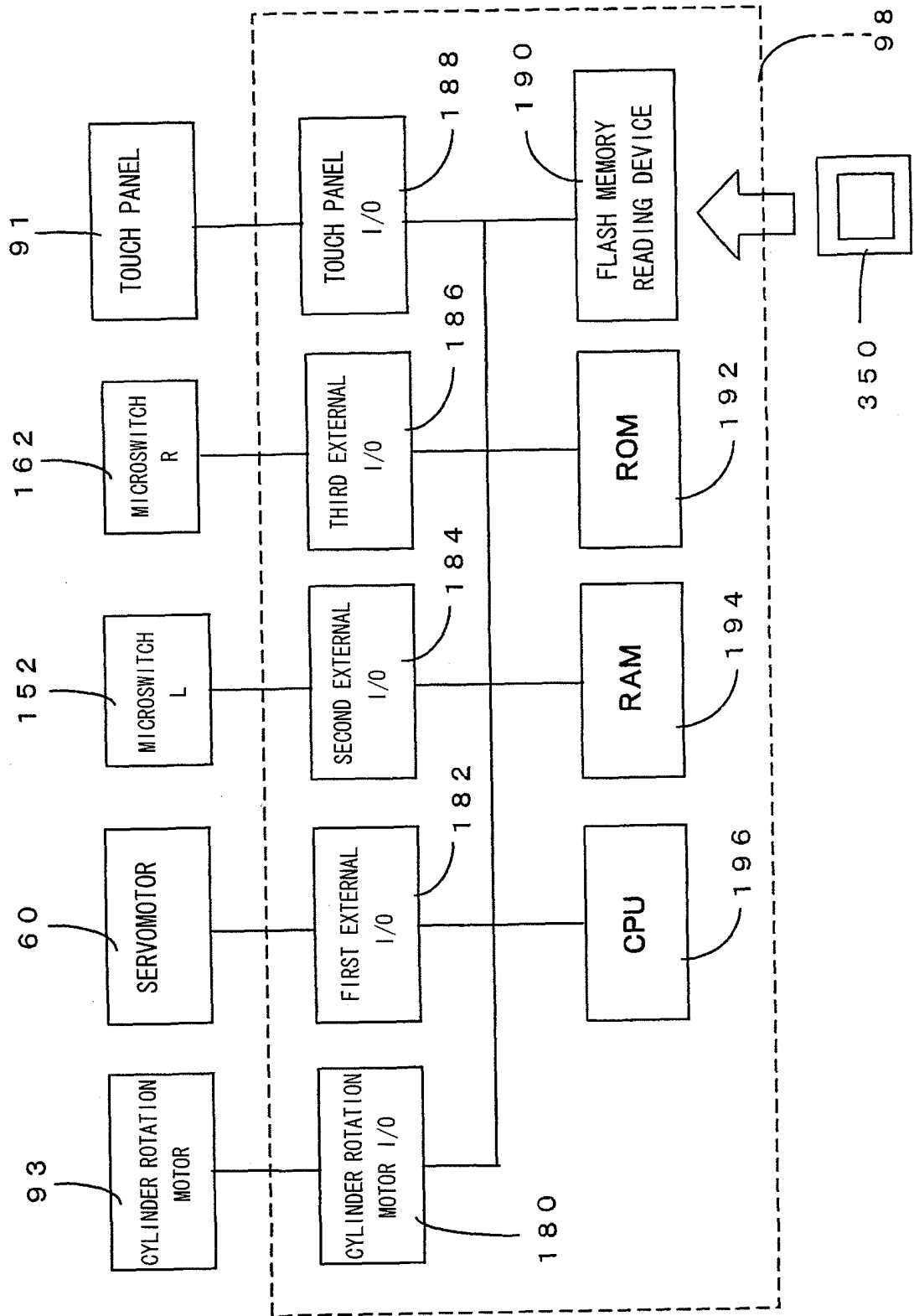


Fig. 22

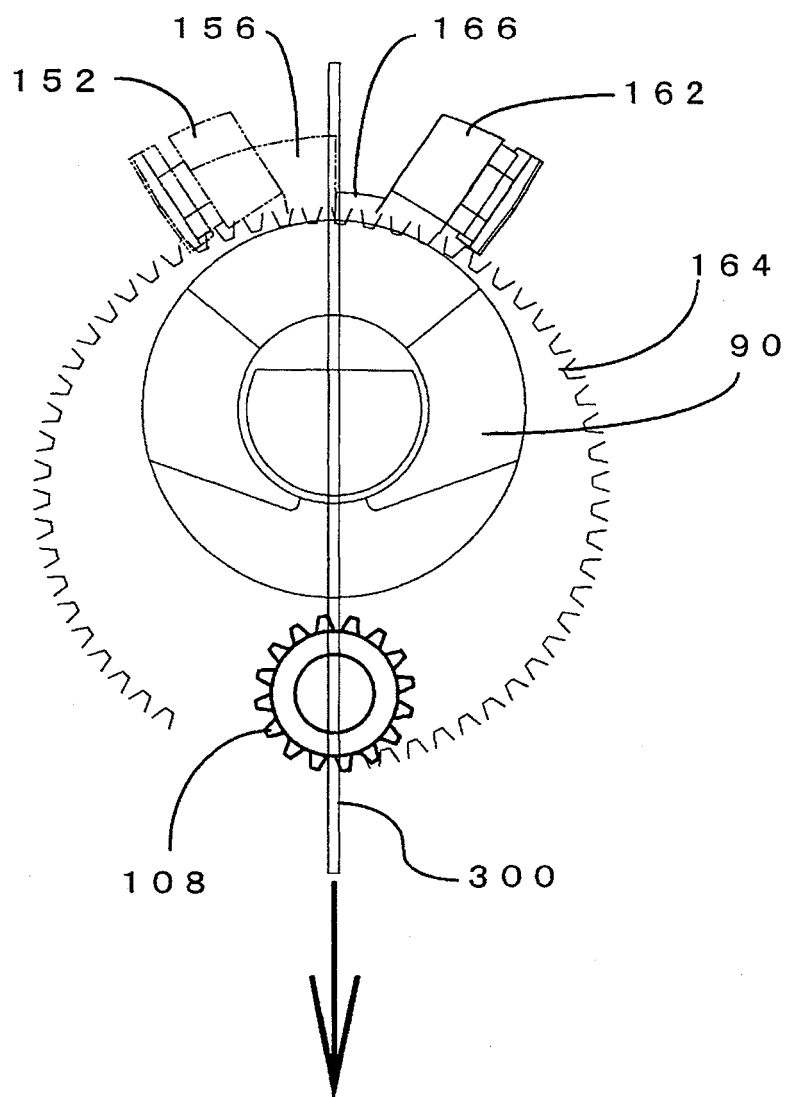


Fig. 23

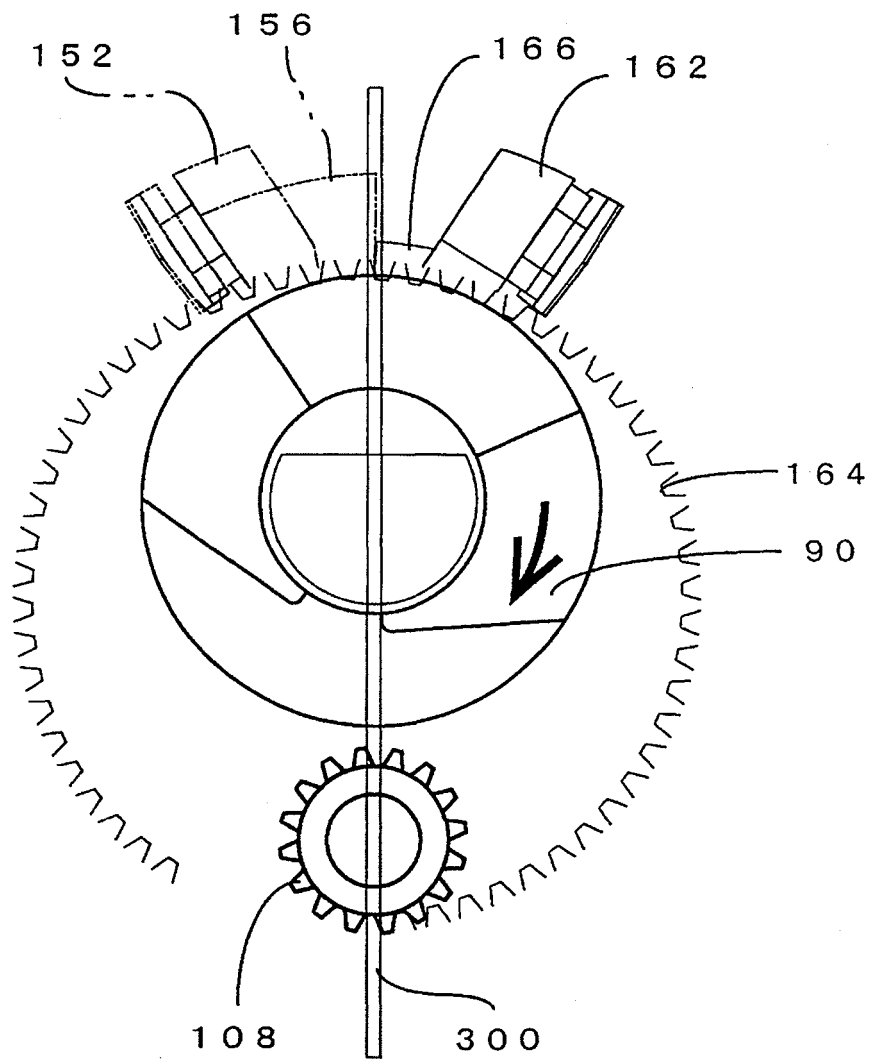


Fig. 24

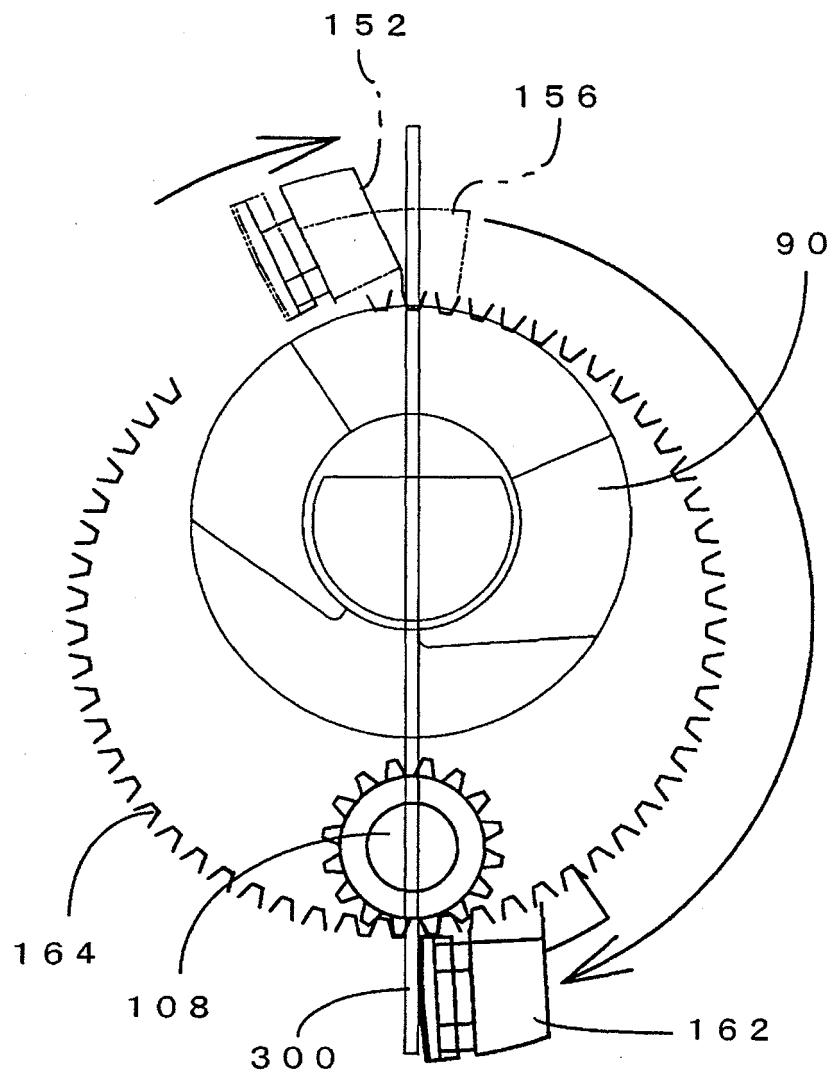


Fig. 25

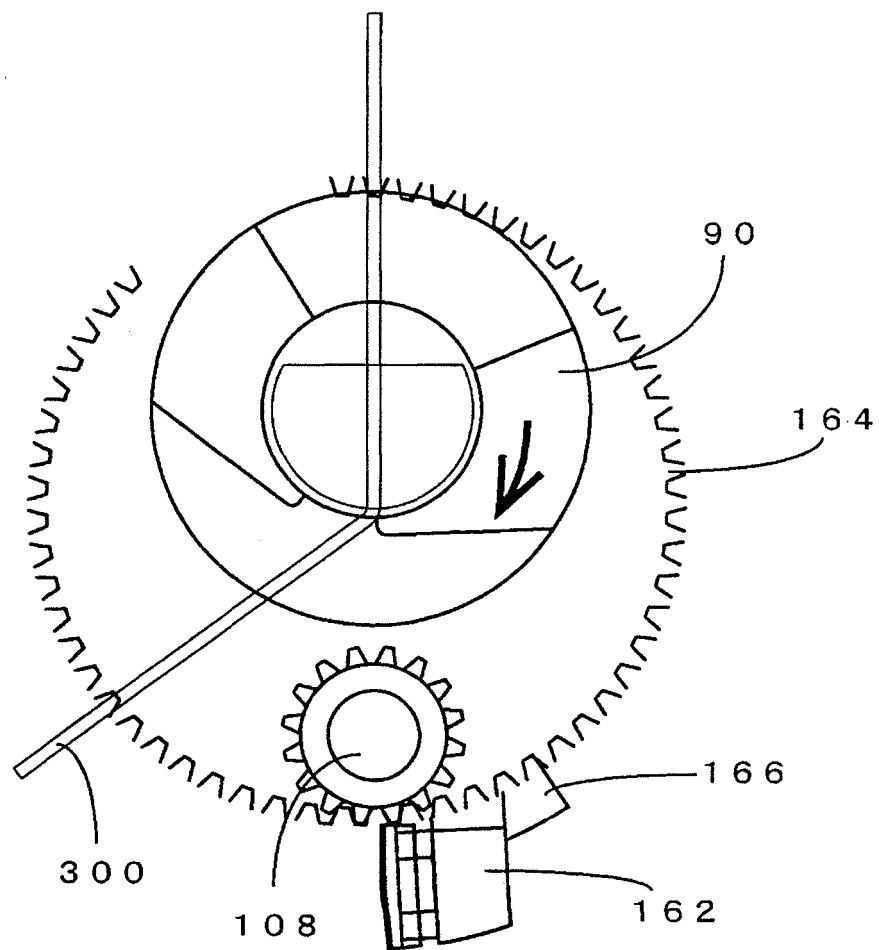


Fig. 26

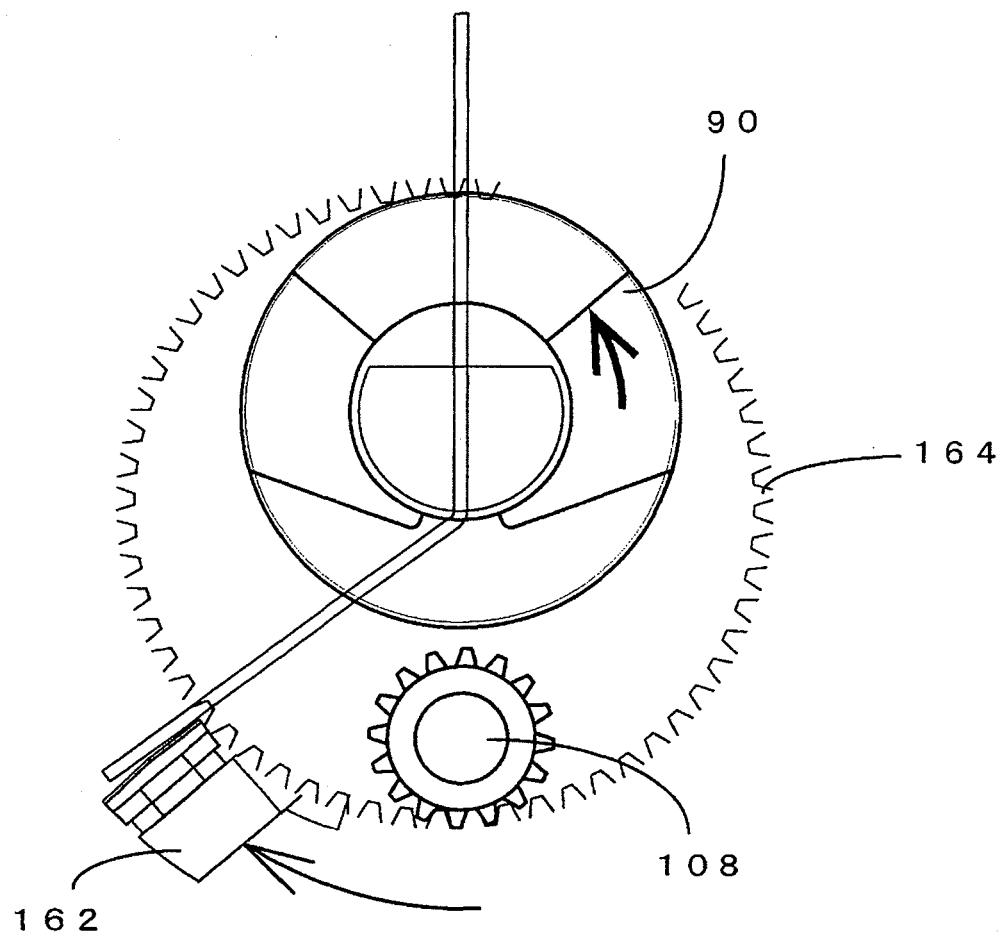


Fig. 27

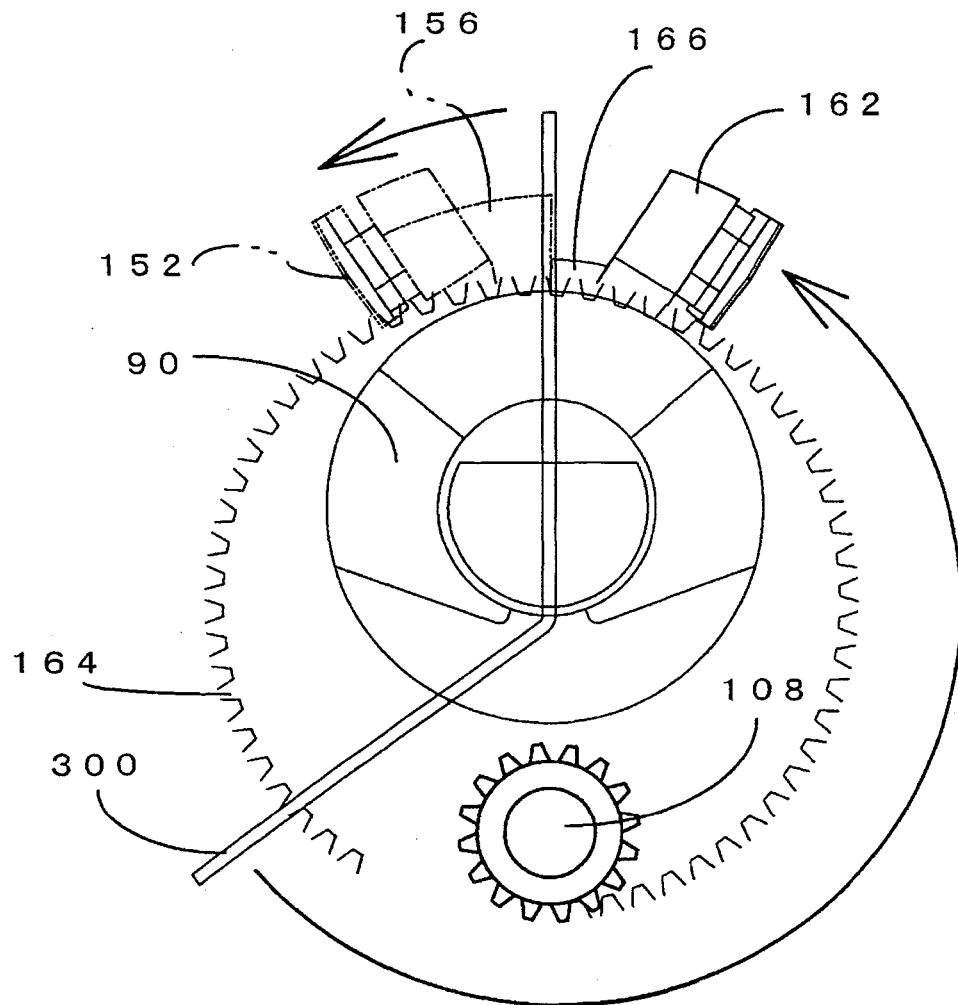
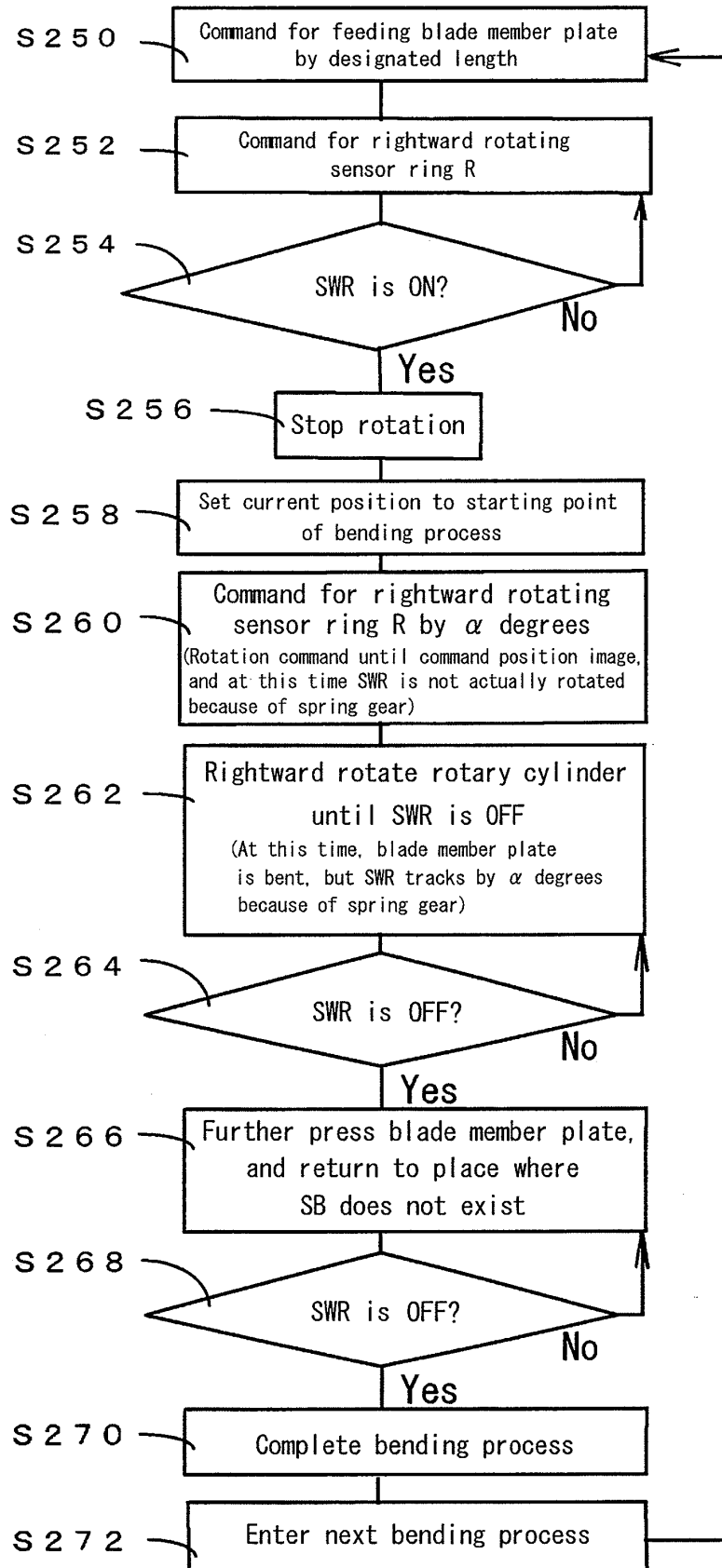


Fig. 28



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2008/059208

## A. CLASSIFICATION OF SUBJECT MATTER

B21D5/00 (2006.01) i

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

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B21D5/00-9/18, G01B5/00-5/30

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2008

Kokai Jitsuyo Shinan Koho 1971-2008 Toroku Jitsuyo Shinan Koho 1994-2008

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

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                             | Relevant to claim No. |
|-----------|--------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| X<br>Y    | JP 7-116737 A (Komatsu Ltd.),<br>09 May, 1995 (09.05.95),<br>Par. Nos. [0010] to [0022]; Fig. 2<br>(Family: none)              | 1, 2<br>3             |
| Y         | JP 2007-114077 A (Murata Machinery Ltd.),<br>10 May, 2007 (10.05.07),<br>Par. Nos. [0020] to [0024]; Fig. 3<br>(Family: none)  | 3                     |
| A         | JP 8-215760 A (Suehiro MIZUKAWA),<br>27 August, 1996 (27.08.96),<br>Par. Nos. [0014] to [0019]; Figs. 1 to 4<br>(Family: none) | 1-4                   |

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

\* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&amp;" document member of the same patent family

Date of the actual completion of the international search

11 June, 2008 (11.06.08)

Date of mailing of the international search report

24 June, 2008 (24.06.08)

Name and mailing address of the ISA/  
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2008/059208

**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
  
2. ☐ Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
  
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

See extra sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
  
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

**Remark on Protest**  
the

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (April 2007)

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2008/059208

Continuation of Box No.III of continuation of first sheet(2)

The matter common to the inventions in claims 1-4 is to so bend a plate that the angle of the bent portion of the plate reaches a predetermined value.

However, the result of search has revealed that the matter of "bending the plate that the angle of the bent portion of the plate reaches the predetermined value" is not novel, it is disclosed in the document JP 7-116737 A (Komatsu Ltd.), 9 May, 1995 (09.05.95), paragraphs [0010] - [0022].

Since it makes no contribution over the prior art to so bend the plate that the angle of the bent portion of the plate reaches the predetermined one, the common matter is not a special technical feature in the meaning of the second sentence of PCT rule 13.2.

Therefore, the invention in claim 1 relates to a method of bending a plate for so bending the plate that the angle of the bent portion of the plate reaches a predetermined value.

The invention in claim 2 relates to a method of bending a plate for so bending the plate after detecting the angle by a bending angle detection device.

The invention in claim 3 relates to a method of bending a plate for bending the plate after detecting the angle by contacting with the plate.

The invention in claim 4 relates to a bending angle detection device having a connection part where the rotation axis of a plate coincides with the rotation axis of a signal generating device when the plate is bent, a drive device, and a rotation angle detection device.

**REFERENCES CITED IN THE DESCRIPTION**

*This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.*

**Patent documents cited in the description**

- JP 7000266 A [0009]
- JP 2001353528 A [0009]
- JP 8215761 A [0009]
- JP 6304685 A [0009]