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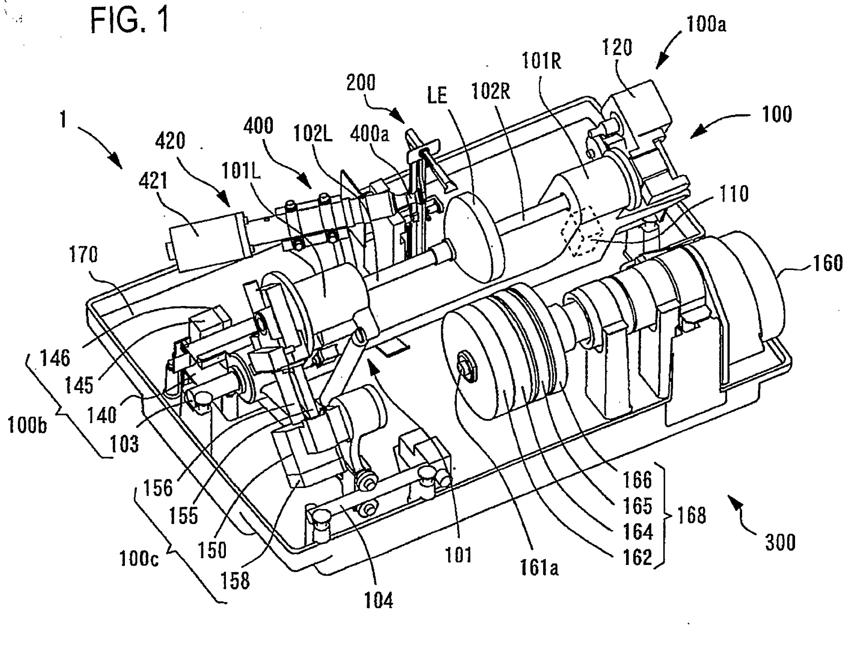
(54) **Eyeglass lens processing apparatus**

(57) An eyeglass lens processing apparatus (1) for processing a periphery of a lens, includes: lens rotating means (100a) for rotating a pair of lens chuck shafts (102) that hold an eyeglass lens; processing tool rotating means (300, 420) for rotating a processing tool rotating shaft (161a, 400a) to which a processing tool (168, 400) for processing the periphery of the lens is mounted; moving means (100c) for moving about the lens chuck shafts or the processing tool rotating shaft as a moving shaft in an axis-to-axis direction in which an axis-to-axis distance between the lens chuck shafts and the processing tool rotating shaft is changed; a waterproof cover (61) provided with a first elongated hole (75L, 75R) through which the moving shaft is inserted, the waterproof cover configuring a processing chamber (60); and a shield unit (70) provided in the waterproof cover for preventing grinding water from leaking out of the first elongated hole, the shield unit being configured to be rotated in response to movement of the moving shaft.

FIG. 1



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Description

BACKGROUND

[0001] The present invention relates to an eyeglass lens processing apparatus for processing a periphery of an eyeglass lens.

[0002] In an eyeglass lens processing apparatus, when the periphery of a lens is beveled or the edge of the lens is chamfered, it is necessary to obtain the shape of the refractive surface of the lens (the positions of the edges of the front surface and the rear surface of the lens) along the radius of a target lens shape before processing. Therefore, in the eyeglass lens processing apparatus, a lens shape measuring mechanism (lens edge position measuring mechanism) which has a tracing stylus that is controlled to come into contact with the front surface and the rear surface of the lens is provided (for example, refer to JP-A-2000-317796).

[0003] In the eyeglass lens processing apparatus, when processing of the lens is performed, a waterproof cover is provided so that cooling water (grinding water) ejected toward the lens and processing tools does not scatter over driving mechanisms and the like in the apparatus. In the waterproof cover, an opening portion is provided in the waterproof cover along the path of a lens chuck shaft, and the lens chuck shaft is inserted through the opening portion. As the lens chuck shaft moves in the opening portion, a lens shape measuring mechanism and a lens processing tool used for lens processing are switched to be used. In the opening portion, a shield unit (shield mechanism) that moves together with the lens chuck shaft is provided to prevent the cooling water from scattering toward outside from the inside of the waterproof cover.

SUMMARY

[0004] However, in a case where a lens processing tool unit or the lens shape measuring mechanism is to be provided in the movement direction of the lens chuck shaft and in the vicinity thereof, when the lens chuck shaft approaches the lens processing tool or the lens shape measuring mechanism, a moving member of the shield unit interferes with the lens processing tool or the lens shape measuring mechanism, resulting in reduction in the degree of freedom in designing of the apparatus. When a retracting mechanism for the lens processing tool unit is provided in order to prevent the interference with the moving member, the configuration of the apparatus becomes complex, and this easily causes degradation in processing quality (see Fig. 19). A large space is needed as an area of the moving member of the shield unit in the movement direction of the lens chuck shaft, resulting in increase in the size of the apparatus. In the configuration according to the related art of Fig. 19, regarding the distance of a elongated hole provided in the waterproof cover that allows the movement range of the lens chuck shaft, the moving member having a distance twice the distance of the elongated hole is needed.

[0005] The invention has been made taking the foregoing problems according to the related art into consideration, and a technical object thereof is to provide an eyeglass lens processing apparatus capable of increasing the degree of freedom in designing of the apparatus by reducing an area needed by a shield unit. In addition, another technical object thereof is to provide an eyeglass lens processing apparatus capable of simplifying the configuration of the apparatus and suppressing increase in the size of the apparatus.

[0006] In order to accomplish the objects, the invention has the following configurations.

[0007]

(1) An eyeglass lens processing apparatus (1) for processing a periphery of a lens, comprising:

> lens rotating means (100a) for rotating a pair of lens chuck shafts (102) that hold an eyeglass lens;
> processing tool rotating means (300, 420) for rotating a processing tool rotating shaft (161a, 400a) to which a processing tool (168, 400) for processing the periphery of the lens is mounted;
> moving means (100c) for moving about the lens chuck shafts or the processing tool rotating shaft as a moving shaft in an axis-to-axis direction in which an axis-to-axis distance between the lens chuck shafts and the processing tool rotating shaft is changed;
> a waterproof cover (61) provided with a first elongated hole (75L, 75R) through which the moving shaft is inserted, the waterproof cover configuring a processing chamber (60); and
> a shield unit (70) provided in the waterproof cover for preventing grinding water from leaking out of the first elongated hole, the shield unit being configured to be rotated in response to movement of the moving shaft.

(2) The eyeglass lens processing apparatus according to (1), wherein
the shield unit includes a first rotating plate (76, 81) rotatably held by the waterproof cover,
the first rotating plate is provided with a second elongated hole (76b, 81a) through which the moving shaft is inserted and which enables the moving shaft to move between a first position (PC3) at which the moving shaft approaches a rotational center (O) of the first rotating plate and a second position (PC1, PC2) at which the moving shaft is separated from the rotational center of the first rotating plate during the movement of the moving shaft in the axis-to-axis direction, and
the shield unit further includes a moving member (77, 82, 83) which is connected to the moving shaft and

is configured to block a gap that otherwise occurs due to an overlap of the first elongated hole and the second elongated hole.

(3) The eyeglass lens processing apparatus according to (2), wherein
the moving member includes:

a second rotating plate (83) which has such a size that covers the first elongated hole and is able to rotate about the rotational center of the first rotating plate (81); and
a plate (82) which is connected to the moving shaft and is provided to be movable in the axis-to-axis direction in response to the movement of the moving shaft in the axis-to-axis direction,
the second rotating plate has a third elongated hole (83a) through which the moving shaft is inserted and which enables the moving shaft to move between the first position and the second position about a rotational center of the second rotating plate during the movement of the moving shaft in the axis-to-axis direction, and is formed in a direction different from that of the second elongated hole (81a), and
the plate is configured to have such a size that blocks a gap that otherwise occurs due to an overlap of the first elongated hole, the second elongated hole, and the third elongated hole at each position where the first rotating plate and the second rotating plate are rotated.

(4) The eyeglass lens processing apparatus according to (3), wherein
the moving shaft is the lens chuck shaft (102),
the processing tool rotating means includes a first processing tool rotating unit (300) for rotating a first processing tool rotating shaft (161a) to which a first processing tool (168) that is configured to process the periphery of the lens and has a large diameter is mounted, and a second processing tool rotating unit (420) for rotating a second processing tool rotating shaft (400a) to which a second processing tool (400) that is configured to process the periphery of the lens and has a smaller diameter than that of the first processing tool is mounted,
the first processing tool and the second processing tool oppose each other with the lens chuck shafts interposed therebetween, and the second processing tool is disposed to be non-retractable,
the rotational centers of the first rotating plate and the second rotating plate are disposed on a perpendicular bisector of a line segment that connects both ends of a range in which the lens chuck shafts are movable in the axis-to-axis direction, and
outside diameters of the first rotating plate and the second rotating plate are formed to have such sizes that do not interfere with the second processing tool rotating unit.

(5) The eyeglass lens processing apparatus according to (3) or (4), wherein the plate is provided with a slit (82b) which is engaged with a shaft member that passes through the rotational centers of the first rotating plate and the second rotating plate, and is movably held by any of the waterproof cover, the first rotating plate and the second rotating plate.

(6) The eyeglass lens processing apparatus according to (4) or (5), wherein the second elongated hole formed in the first rotating plate and the third elongated hole formed in the second rotating plate are formed to be bilaterally symmetrical with respect to a straight line that connects the rotational centers of the lens chuck shaft, the first rotating plate, and the second rotating plate as a reference line.

(7) The eyeglass lens processing apparatus according to any one of (4) to (6), wherein the first rotating plate and the second rotating plate are configured to rotate as the lens chuck shafts press inner walls of the second elongated hole and the third elongated hole when the lens chuck shafts are moved.

(8) The eyeglass lens processing apparatus according to any one of (4) to (7), further comprising a shaft member held by the waterproof cover so that the first rotating plate and the second rotating plate are rotatable, the shaft member being rotational centers of the first rotating plate and the second rotating plate.

(9) The eyeglass lens processing apparatus according to any one of (3) to (8), wherein a length of the third elongated hole in a longitudinal direction thereof is shorter than a length of the first elongated hole in the axis-to-axis direction.

(10) The eyeglass lens processing apparatus according to (2), wherein the moving member includes a sliding plate (77) which is held by the first rotating plate to be able to slide in a longitudinal direction of the second elongated hole (76b) in response to movement of the lens chuck shaft or the processing tool rotating shaft, and is formed to have such a size that blocks the second elongated hole when the moving shaft is moved between the first position and the second position.

(11) The eyeglass lens processing apparatus according to (10), wherein
the moving shaft is the lens chuck shaft (102),
the processing tool rotating means includes a first processing tool rotating unit (300) for rotating a first processing tool rotating shaft (161a) to which a first processing tool (168) that is configured to process

the periphery of the lens and has a large diameter is mounted, and a second processing tool rotating unit (420) for rotating a second processing tool rotating shaft (400a) to which a second processing tool (400) that is configured to process the periphery of the lens and has a smaller diameter than that of the first processing tool is mounted,
the first processing tool and the second processing tool oppose each other with the lens chuck shafts interposed therebetween, and the second processing tool is disposed to be non-retractable,
the rotational center of the first rotating plate is disposed on a perpendicular bisector of a line segment that connects both ends of a range in which the lens chuck shafts are movable in the axis-to-axis direction, and
an outside diameter of the first rotating plate is formed to have such a size that does not interfere with the second processing tool rotating unit.

(12) The eyeglass lens processing apparatus according to (11), wherein the longitudinal direction of the second elongated hole is disposed to intersect the first elongated hole so that when the lens chuck shafts are moved to a position closest to the second processing tool, a part of the sliding plate is moved to an outside of the first rotating plate and does not interfere with the second processing tool rotating unit.

(13) The eyeglass lens processing apparatus according to (12), wherein the longitudinal direction of the second elongated hole is disposed to intersect the first elongated hole so that when the lens chuck shafts are moved to a position closest to the first processing tool, the part of the sliding plate is moved to the outside of the first rotating plate and does not interfere with the first processing tool rotating unit.

(14) The eyeglass lens processing apparatus according to (11) or (12), wherein the longitudinal direction of the second elongated hole and the sliding plate are tilted with respect to a direction in which the first position and the rotational center are connected so that the sliding plate does not interfere with the shaft member that rotatably supports the first rotating plate when the lens chuck shaft is moved to the first position.

(15) The eyeglass lens processing apparatus according to any one of (11) to (14), wherein a length of the sliding plate in a sliding direction is shorter than twice a length of the first elongated hole in the axis-to-axis direction.

[0008] According to the invention, the degree of freedom in designing of the apparatus can be increased. In addition, the configuration of the apparatus is simplified, and increase in the size of the apparatus can be suppressed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

Fig. 1 is a schematic configuration diagram of a processing mechanism portion of an eyeglass lens processing apparatus.
Fig. 2 is a perspective view of a lens shape measuring unit.
Fig. 3 is a front view of the lens shape measuring unit.
Fig. 4 is a side view of the lens shape measuring unit.
Fig. 5 is a side view of a second lens processing tool.
Fig. 6A is a side view of the eyeglass lens processing apparatus.
Fig. 6B is a diagram illustrating the arrangement of members of the eyeglass lens processing apparatus.
Fig. 7 is a diagram illustrating a perspective view of a processing chamber where lens processing is performed.
Fig. 8 is a diagram illustrating the configuration of a first embodiment of a shield unit.
Fig. 9 illustrates a schematic configuration diagram of the cross-section of a lens chuck shaft 102L side in the first embodiment.
Figs. 10A to 10C are diagrams illustrating the movement of the shield unit in the first embodiment.
Fig. 11 is a diagram illustrating the configuration of a second embodiment of the shield unit.
Fig. 12 illustrates a schematic configuration diagram of the cross-section of a lens chuck shaft 102L side in the second embodiment.
Figs. 13A to 13C are diagrams illustrating the movement of the shield unit in the second embodiment.
Fig. 14 is a control block diagram of an apparatus for processing an eyeglass lens periphery.
Figs. 15A and 15B are explanatory views of a state of contact between a lens and a tracing stylus.
Fig. 16 is an explanatory view of a change in the position of the measurement surface of a lens at each lens rotational angle.
Figs. 17A and 17B are explanatory views of a change in the position of the refractive surface of the lens according to a change in the distance from a rotational center to each measurement point.
Fig. 18 is an explanatory view of a modification example of predictive control.
Fig. 19 is an explanatory view of a shield unit according to the related art.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0010] Hereinafter, an embodiment of the invention will be described with reference to the drawings. Fig. 1 is a schematic configuration diagram of a processing mechanism portion of an eyeglass lens processing apparatus.

[0011] A processing apparatus body 1 includes: a lens holding portion 100 that has lens chuck shafts to hold a lens LE to be processed; a lens shape measuring unit 200 that includes a tracing stylus 260 that contacts a lens refractive surface in order to measure the refractive surface shape of a lens (the front surface and the rear surface of a lens); a first processing tool rotating unit 300 that rotates a processing tool rotating shaft (grindstone spindle) 161a to which a first lens processing tool 168 for processing the periphery of the lens is mounted; and a second processing tool rotating unit 420 that rotates a processing tool rotating shaft (grindstone spindle) 400a to which a second lens processing tool 400 for processing the periphery of the lens is mounted.

[0012] The lens holding portion 100 includes: a lens rotating unit 100a that rotates a pair of lens chuck shafts 102L and 102R; and an X-direction moving unit (chuck shaft moving unit) 100b that moves the lens chuck shafts 102L and 102R in an axial direction (this is referred to as an X direction). The lens holding portion 100 includes a Y-direction moving unit (axis-to-axis distance changing unit) 100c that moves the lens chuck shafts 102L and 102R or a processing tool rotating shaft 161a as a moving shaft in such a direction to change the axis-to-axis distance between the lens chuck shafts 102L and 102R and the processing tool rotating shat 161a. In the example of Fig. 1, the Y-direction moving unit 100c is configured to move the lens chuck shafts 102L and 102R in such a direction (Y direction) to approach or to be distant from the grindstone spindle 161a or the grindstone spindle 400a. In this case, the Y-direction moving unit 100c is also used as a lens moving unit that relatively moves the lens LE in a direction in which the distance between the lens chuck shafts 102L and 102R and the tracing stylus 260 is changed. The lens chuck shafts 102L and 102R are moved in the forward, rearward, leftward, and rightward directions (XY directions) during measurement of the shape of the lens LE and during processing of the periphery of the lens LE.

[0013] Hereinafter, a specific example of the processing apparatus body 1 will be described in detail. The lens holding portion 100 is mounted on a base 170 of the processing apparatus body 1. The lens chuck shaft 102L and the lens chuck shaft 102R are coaxially and rotatably held by a left arm 101L of a carriage 101 of the lens holding portion 100 and a right arm 101R, respectively. The lens chuck shaft 102R is moved toward the lens chuck shaft 102L by a motor 110 mounted to the right arm 101R, and the lens LE is held by the two lens chuck shafts 102R and 102L. The two lens chuck shafts 102R and 102L are rotated in synchronization with each other via a rotation transmitting mechanism such as a gear by a motor 120 mounted to the right arm 101R. These constitute the lens rotating unit 100a.

[0014] The carriage 101 is mounted on an X-axis movement support base 140 that is able to move along shafts 103 and 104 extending in parallel to the lens chuck shafts 102R and 102L and the grindstone spindle 161a. A ball screw (not illustrated) that extends in parallel to the shaft 103 is mounted to the rear portion of the support base 140, and the ball screw is mounted to the rotating shaft of a motor 145 for X-axis movement. The carriage 101 is linearly moved in the X direction (the axial direction of the lens chuck shaft) together with the support base 140 by the rotation of the motor 145. The X-direction moving unit 100b is constituted as described above. An encoder 146 which is a detector for detecting movement in the X direction of the carriage 101 is provided on the rotating shaft of the motor 145.

[0015] The movement positions in the X direction of the lens chuck shafts 102R and 102L detected by the encoder 146 as the detector in this embodiment are used when the refractive surface shapes of the front surface and the rear surface of a lens are obtained.

[0016] A shaft 156 that extends in a direction in which the lens chuck shafts 102R and 102L are connected to the grindstone rotating shaft 161a is fixed to the support base 140. The Y-direction moving unit 100c which is moved in a direction (Y direction) in which the axis-to-axis distance between the lens chuck shafts 102R and 102L and the grindstone rotating shaft 161a is changed with respect to the shaft 103 is configured (see Figs. 6A and 6B). The Y-direction moving unit of the apparatus has a configuration in which the lens chuck shafts 102R and 102L are turned about the shaft 103 but may also have a configuration in which the distance between the lens chuck shafts 102R and 102L and the grindstone rotating shaft 161a is linearly changed.

[0017] A motor 150 for Y-axis movement is fixed to the support base 140. Rotation of the motor 150 is transmitted to the ball screw 155 extending in the Y direction, and the carriage 101 is moved in the Y direction by the rotation of the ball screw 155. Accordingly, the Y-direction moving unit 100c is configured. The rotating shaft of the motor 150 is provided with an encoder 158 which is a detector for detecting movement in the Y direction of the carriage 101.

[0018] In Fig. 1, at positions which are on the upper side of the carriage 101 and are in an opposite direction to the first lens processing tool 168 with the carriage 101 interposed therebetweeen, the lens shape measuring unit 200 and the second lens processing tool 400 are provided. The lens shape measuring unit 200 includes the tracing stylus 260 (260a and 260b) for measuring the refractive surface shapes of the front and rear surfaces of a lens.

<Lens Shape Measuring Unit>

[0019] Fig. 2 is a perspective view of the lens shape measuring unit 200, Fig. 3 is a front view of the lens shape measuring unit 200, and Fig. 4 is a side view of the lens shape measuring unit 200.

[0020] The lens shape measuring unit 200 is constituted by a fixed unit 200a fixed to the base 170 of the processing apparatus body 1 and a movable unit 250 which is oscillated (tilted) in the forward, rearward, leftward, and rightward directions (the X direction and the Y direction) with respect to the fixed unit 200a. Furthermore, the movable unit 250 is constituted by a combination of a first movable portion 250a that causes the tracing stylus 260 to be tilted in the forward and rearward direction (H direction: a direction to approach and to be separated from the chuck shafts 102L and 102R) with respect to the fixed unit 200a, and a second movable portion 250b that causes the tracing stylus 260 to be tilted in the leftward and rightward direction (X direction) with respect to the fixed unit 200a.

[0021] The fixed unit 200a includes: a shaft 201 that extends in parallel (the X direction) to the lens chuck shafts 102R and 102L; a pin 202 that restricts the forward movement (in a direction toward the lens chuck shafts) of the movable unit 200a; and a pin 203 that restricts the rearward movement (in a direction to be separated from the lens chuck shafts) (see Fig. 4).

[0022] The first movable portion 250a includes: a bearing 251 through which the shaft 201 is inserted; a shaft 252 that extends in the forward and rearward direction that is perpendicular to the lens chuck shafts 102R and 102L; pins 253a and 253b for restricting the tilt in the X direction of the second movable portion 250b; and springs 254a and 254b that hold the initial position in the X direction of the second movable portion 250b and add a measurement pressure to a lens during lens shape measurement (see Fig. 3).

[0023] The second movable portion 250b includes: a bearing 261 through which the shaft 252 is inserted; the tracing stylus 260 that abuts on the refractive surface (the front or rear surface) of a lens LE to be processed; an arm 262 having the tracing stylus 260 at the tip end; and a support shaft 263 for supporting the arm 262. The arm 262 and the support shaft 263 constitute a holding unit 250c. In the rear of the tracing stylus 260 and on the axis of the arm 262, a waterproof plate 270 is mounted for preventing processing water that flows into a processing chamber when the lens shape measuring unit 200 is mounted to the apparatus body from infiltrating into the lens shape measuring unit 200 side.

[0024] The support shaft 263 is a columnar member that extends in the upward and downward direction (Z direction) in a state where the lens shape measuring unit 200 is fixed to the base 170, and is constituted by a columnar portion 263a at the center and a plate portion 263b provided on the left and the right with respect to the columnar portion 263a. The plate portion 263b is formed to be thinner than the columnar portion 263a. As the left and right ends of the plate portion 263b abut on the pins 253a and 253b, the maximum value of a tilt angle in the leftward and rightward direction of the movable unit 250 is determined, and as the front and the rear of the plate portion 263b abut on the pins 202 and 203, the maximum value of a tilt angle in the forward, rearward, leftward, and rightward directions of the movable unit 250 (the tracing stylus 260) is determined. For example, a tilt angle in the X direction of the movable unit 250 (the support shaft 263) of this embodiment is about ± 3 degrees, and as the movable range of the tracing stylus 260, the tracing stylus 260 is movable in a distance range of ± 8 mm in the leftward and rightward direction. In this case, during lens shape measurement, the tracing stylus 260 has a range of 8 mm on the left (a movable range during measurement of the front surface of a lens) and has a range of 8 mm on the right (a movable range during measurement of the rear surface of a lens). This is a distance shorter than a change amount of the refractive surface of a high-curve lens. A tilt angle in the forward and rearward direction is about 4 degrees, and a movable distance of the tracing stylus 260 is about ± 10 mm.

[0025] The holding unit 250c is formed in an L shape by mounting the arm 262 to extend toward the lens chuck shafts 102R and 102L from the position of the upper end of the support shaft 263.

[0026] The tracing stylus 260 mounted to the tip end of the arm 262 has a contact surface 260c that is formed in an elliptical shape extending in a direction perpendicular to the axis of the arm 262 (the leftward and rightward direction) when viewed from the front surface as illustrated in Fig. 3, and at both longitudinal ends of the contact surface 260c, a tip end 260a as a tracing stylus that comes into contact with the front surface of the lens LE and a tip end 260b as a tracing stylus that comes into contact with the rear surface of the lens LE are respectively formed. The tip ends 260a and 260b that come into contact with the lens LE have roundness and thus are less likely to be caught even when the measurement surface of the lens is uneven.

[0027] The contact surface 260c is a part that comes into contact with the peripheral surface of the lens LE and the surface shape thereof is formed as a curved surface so that the contact area between the contact surface 260c and the edge of the lens LE is reduced during measurement of the position of the edge using the tracing stylus 260 described later.

[0028] The tracing stylus 260 is formed to have a thickness with sufficient strength that failure such as breakage does not occur during shape measurement, and the tip ends 260a and 260b have tapered shapes of which thicknesses are gradually reduced in order to prevent interference between the lens LE and the holding unit 250c during the shape measurement.

[0029] In this embodiment, considering that the curve of the rear surface of a lens has a tendency to become sharper than the front surface thereof, the tip end 260b that comes into contact with the rear surface of the lens protrudes in the axial direction from the tip end 260a that comes into contact with the front surface of the lens LE. Accordingly, occurrence of the interference between the holding unit 250c and the lens LE during measurement of the front and rear surfaces of the lens LE is suppressed.

[0030] In the holding unit 250c having the configuration as described above, the height of the support shaft 263 and the length of the arm 262 (the tilt angle with respect to the chuck shafts 102R and 102L) are determined so that the tracing stylus 260 (the tip ends 260a and 260b) are positioned on a movement path L in the Y direction of the lens chuck shafts 102R and 102L (see Figs. 6A and 6B). As the tracing stylus 260 is placed on the movement path L of the lens chuck shafts 102R and 102L, measurement of the shapes of the front and rear surfaces of a lens is performed using the movement of the lens LE by the lens holding portion 100.

[0031] The waterproof plate 270 is formed to have such a size to cover a range in which the tracing stylus 260 is moved when the holding unit 250c is tilted to the left or right. In this embodiment, since shape measurement is performed mainly by moving the lens LE side, the movement distance (tilt angle) of the tracing stylus 260 is narrowed as much as possible, and thus the waterproof plate 270 may be reduced in size, thereby further simplifying the configuration of the apparatus. Since the movement range of the tracing stylus 260 is narrow, water droplets are less likely to leak out of the processing chamber. Moreover, in this embodiment, the arm 262 having the tracing stylus 260 mounted thereto is tilted downward from the base end toward the tip end (the tracing stylus 260) side, thereby achieving a configuration in which water droplets that adhere to the tracing stylus 260 and the lens holding unit are guided into the processing chamber and water droplets are less likely to leak out of the processing chamber.

[0032] In the lens shape measuring unit 200 having the configuration as described above, the bearing 251 of the first movable portion 250a is attached to the shaft 201 of the fixed unit 200a and the bearing 261 of the second movable portion 250b is attached to the shaft 252 of the first movable portion 250a so as to be integrated with each other. Accordingly, the movable unit 250 is able to tilt in the forward and rearward direction about the shaft 201 as an axis S1 (first fulcrum) such that the tracing stylus 260 is moved in the forward and rearward direction. The movable unit 250a is able to tilt in the X direction about the shaft 252 as an axis S2 (second fulcrum) such that the tracing stylus 260 is moved in the leftward and rightward direction.

[0033] When the movable unit 250 is mounted to the fixed unit 200a, the springs 254a and 254b are positioned on both sides (the X direction) of the support shaft 263 of the movable unit 250. Accordingly, the initial position in the X direction of the movable unit 250 is maintained by the repulsion of the spring, and during measurement, by the impelling force added by the springs 254a and 254b, the tracing stylus 260 is appropriately pressed against the rotating lens LE.

[0034] The pins 253a and 253b are fixed at positions below the springs 254a and 254b and on the left and right of the support shaft 263. The pins 253a and 253b interfere with the support shaft 263 and restrict the tracing stylus 260 from being tilted at a predetermined or greater angle in the X direction about the axis S2.

[0035] As illustrated in Fig. 4, one end (upper end) of the fixed unit 200a and one end (lower end) of the movable unit 250 are connected with a tension spring 204 such that the initial position in the forward and rearward direction of the movable unit 250 is maintained by the tension of the spring 204. When the tracing stylus 260 is tilted rearward, the spring 204 is stretched and thus repulsion occurs in such a direction to return the tracing stylus 260 to the initial position.

[0036] The pins 202 and 203 that restrict the tracing stylus 260 from being tilted by a predetermined or greater angle in the H direction about the shaft S1 are fixed at the positions in the forward and rearward direction with the support shaft 263 interposed therebetween. The forward pin 202 in the initial state is fixed to the position close to the support shaft 263 and restricts a forward tilt of the movable unit 250. On the other hand, the rearward pin 203 is fixed in the rear separated from the support shaft 263 by a predetermined distance and restricts a rearward tilt of the movable unit 250. That is, the movable unit 250 is tilted further rearward than forward.

[0037] A change in the tilt angle (movement position) in the forward, rearward, leftward, and rightward directions of the movable unit 250 is detected by a sensor 257 which is a first detector that detects a tilt angle (movement position) in the X direction and by a sensor 258 which is a second detector that detects a tilt angle (movement position) in the forward and rearward direction. For example, well-known linear encoders or the like are used as the sensors 257 and 258. In this case, a detector 257a of the sensor 257 is mounted to the second movable portion 250b, and a scale 257b for position detection is provided on the opposing second movable portion 250b side. Accordingly, a movement amount in the X direction of the movable unit 250 is obtained from a change in the result of reading the scale 257b illuminated with a light beam emitted by a light source included in the detector 257a.

[0038] Similarly, the detector 258a of the sensor 258 is mounted to the second movable portion 250b side, and a scale 258b is provided on the opposing fixed unit 200a side. Accordingly, a movement amount in the Y direction of the movable unit 250 is obtained from a change in the result of reading the scale 258b by the detector 258a.

[0039] In the above description, an example in which a light reflective sensor is used is described. Besides, various types of sensors may also be used to detect the positions in the forward, rearward, leftward, and rightward directions of the movable unit 250. For example, a transmissive sensor which uses slits instead of the scale 257b may also be used. Moreover, a rotary sensor such as a rotary encoder may also be used as the sensors 257 and 258, and in this case, the sensors 257 and 258 are respectively mounted to the shaft 261 which is the second fulcrum and the shaft 201 which is the first fulcrum.

<First Lens Processing Tool>

[0040] On the base 170, the first lens processing tool 168 which is one of lens processing tools is installed on the opposing side to the lens shape measuring unit 200 with the carriage 101 interposed therebetween. The first lens processing tool 168 is constituted by a glass roughing grindstone 162, a finishing grindstone 164 having a V groove (bevel groove) VG to form a bevel on the lens and a flat processing surface, a flat-polish-finishing grindstone 165, a plastic roughing grindstone 166, and the like. The first lens processing tool 168 is attached coaxially with the grindstone spindle (grindstone rotating shaft) 161a rotated by a motor 160. The lens LE to be processed, which is chucked between the lens chuck shafts (lens rotating shafts) 102L and 102R included in the carriage 101 comes in pressing contact with the first lens processing tool 168 to be subjected to periphery processing. The first lens processing tool 168 is configured to have a large diameter of about 60 to 100 mm in order to efficiently perform roughing and finishing on the periphery of the lens.

<Second Lens Processing Tool>

[0041] On the base 170, the second lens processing tool 400 which is one of lens processing tools is installed on the opposing side (opposite side) to the first lens processing tool 168 with the carriage 101 interposed therebetween. The second lens processing tool 400 is fixed so as to be disposed side by side with the lens shape measuring unit 200 (the tracing stylus 260) outside the movement range of the tracing stylus 260 of the lens shape measuring unit 200 in the X-axis direction which is the axial direction of the lens chuck shaft. The second lens processing tool 400 and the lens shape measuring unit 200 are disposed on the movement path of the lens chuck shaft (details will be described later).

[0042] Fig. 5 illustrates a side view of the second lens processing tool 400. In Fig. 5, an enlarged view of a region (grindstone part) 430 surrounded by a dotted line portion is illustrated. For example, the second lens processing tool 400 is prepared as a processing tool that performs at least one processing of grooving and chamfering on the periphery of the lens subjected to finishing. In this embodiment, the second lens processing tool 400 is constituted by a chamfering grindstone 431, a grooving grindstone 432, and the like. The second lens processing tool 400 is mounted coaxially with the spindle (the processing tool rotating shaft) 400a rotated by a motor 421. The lens LE to be processed, which is chucked between the lens chuck shafts (lens rotating shafts) 102L and 102R included in the carriage 101 comes in pressing contact with the second lens processing tool 400 to be subjected to periphery processing.

[0043] A support base block 401 is fixed to the base 170. A holding member 423 is fixed to the support base block 401. The holding member 423 rotatably holds the grindstone rotating shaft 400a. The rotating shaft of the motor 421 is connected to the grindstone rotating shaft 400a inside the holding member 423. By driving of the motor 421, the grindstone rotating shaft 425 is rotated in response to the rotation of the rotating shaft of the motor 421.

[0044] The chamfering grindstone 431 and the grooving grindstone 432 are mounted to the right end of the grindstone rotating shaft 400a. The chamfering grindstone 431 includes a chamfering grindstone 431a for the rear surface of the lens and a chamfering grindstone 431b for the front surface of the lens. The grooving grindstone 432 is provided between the two chamfering grindstones 431a and 431b. That is, the two chamfering grindstones 431a and 431b and the grooving grindstone 432 are configured in one body. The diameters of the grooving grindstone 432 and the two chamfering grindstones 431a and 431b are smaller than that of the first lens processing tool 168 and are about 30 mm. The chamfering grindstones 431a and 431b at both ends have processing tilt surfaces of which the diameters are reduced outward from the grooving grindstone 432.

[0045] The grindstone rotating shaft 400a is disposed to be tilted at 8 degrees with respect to the axial line direction of the lens chuck shafts 102L and 102R, so that the groove formed by the groove grindstone 432 can easily follow the lens curve. The tilt surface of the chamfering grindstone 431a for the rear surface of the lens and the tilt surface of the chamfering grindstone 431b for the front surface of the lens are designed so that the chamfered angles of the edge corner portions of the lens LE chucked between the lens chuck shafts 102L and 102R respectively become 55 degrees and 40 degrees. Therefore, the lens LE chucked between the lens chuck shafts (lens rotating shafts) 102L and 102R included in the carriage 101 comes in pressing contact with the second lens processing tool 400 to be subjected to periphery processing.

[0046] Fig. 6A is a side view of the eyeglass lens processing apparatus. In the eyeglass lens processing apparatus 1 having the above configuration, the rotating shaft 161a of the first lens processing tool 168, the lens chuck shafts 102R and 102L of the lens holding portion 100, the grindstone part 430 of the second lens processing tool 400, and the tracing stylus 260 of the lens shape measuring unit 200 are disposed on the same arc path L about the axis (center) of the shaft 103. That is, the processing tool rotating shaft 161a, the processing tool rotating shaft 400a, and the tracing stylus 260 (the tip ends 260a and 260b of the tracing stylus) are disposed on the same path as the movement path L in the Y direction which is a direction in which the axis-to-axis distance between the lens chuck shafts 102R and 102L and the rotary shaft 161a is changed.

[0047] Accordingly, the lens holding portion 100 (the lens chuck shafts 102R and 102L) are moved in the forward and rearward direction (Y direction) by driving of the Y-direction movement unit 100c of the lens holding portion 100, and thus positioning of each member for lens shape measurement by the tracing stylus 260, lens periphery processing by the first lens processing tool 168, and chamfering and grooving by the second lens processing tool 400 are performed.

[0048] Fig. 6B is a diagram illustrating the arrangement of the elements of the eyeglass lens processing apparatus. Regarding the arrangement of the second lens processing tool 400 and the lens shape measuring unit 200, a first position of the second lens processing tool 400 which is closest to the lens chuck shafts 102L and 102R side in the Y direction and a second position of the tracing stylus 260 which is closest to the lens chuck shafts 102L and 102R side in the Y direction are arranged to be in a predetermined distance. For example, in this embodiment, the distance ΔD between the first position Y2 (the grindstone part 430) of the second lens processing tool 400 and the second position Y1 (the tip end surface 260c) of the tracing stylus 260 is arranged to be a predetermined distance. For example, the predetermined distance is a distance ΔD which is the difference between a minimum processing diameter D1 of the lens held by the lens chuck shafts 102L and 102R, and an outside diameter D2 of the lens chuck shafts 102L and 102R or an outside diameter D3 of holding members (a processing tool 130L mounted to the lens chuck shaft 102L and a lens pressing member 130R mounted to the lens chuck shaft 102R) mounted to the lens chuck shafts 102L and 102R. The minimum processing diameter D1 is a value set by adding a predetermined margin to the maximum diameter of the processing tool 130L.

[0049] In this configuration, during measurement of the lens shape, measurement of the lens shape for the minimum processing diameter of the lens LE may be performed without the interference in the lens chuck shaft 102L or the holding members (130R and 130L) by the grindstone part 430 of the second lens processing tool 400. During grooving and chamfering of the lens LE by the grindstone part 430, processing to reach the minimum processing diameter of the lens LE may be performed without the interference in the lens chuck shaft 102R or the holding members (130R and 130L) by the tracing stylus 260.

[0050] In this embodiment, the second lens processing tool 400 and the lens shape measuring unit 200 are arranged in parallel so that the grindstone part 430 and the tip end surface 260c are aligned with each other. That is, the second lens processing tool 400 and the lens shape measuring unit 200 are arranged to achieve ΔY=0. As such, the configuration of the aligned arrangement enables reduction in the movement range of the lens chuck shafts and enables reduction in the size of the apparatus, which is preferable. As a matter of course, the present invention is not limited to the configuration in which the grindstone part 430 and the tip end surface 260c are aligned with each other. A configuration in which they are arranged side by side in the X direction so that the distance ΔY from the first position Y1 of the second lens processing tool 400 to the second position Y2 of the tracing stylus 260 is in a predetermined distance ΔD may be employed.

[0051] The position of the motor 421 of the second lens processing tool 400 is disposed outside the movement range in the X direction of the carriage 101 by forming the holding member 423 in an elongated shape so as to prevent the interference with the carriage 101. That is, by causing the position of the motor 421 to be outside the movement range in the X direction of the carriage 101, when the carriage 101 is moved in the Y direction and approaches the second lens processing tool 400 (for example, when processing to reach the minimum processing diameter of the lens is performed), the carriage 101 and the motor 421 do not interfere with each other.

<Shield Unit>

[0052] Fig. 7 is a diagram illustrating a perspective view of a processing chamber 60 where lens processing is performed. A waterproof cover 61, the first lens processing tool 168, the lens shape measuring unit 200, the second lens processing tool 400, and the lens chuck shafts 102L and 102R are arranged in the processing chamber 60. The waterproof cover 61 included in the processing chamber 60 is fixed in a processing region that encloses the first lens processing tool 168, the lens shape measuring unit 200, the second lens processing tool 400, and the lens chuck shafts 102L and 102R so as to prevent grinding water from leaking from the processing chamber 60. The processing chamber 60 is divided from mechanism parts such as motors and the like by the waterproof cover 61. As means for supplying grinding water, as a nozzle 62 for the second lens processing tool and a nozzle for the first lens processing tool (not illustrated) extend inside the processing chamber 60. During grinding of the lens LE, the grinding water is supplied from each of the nozzles.

[0053] Here, in order to enable the lens LE chucked between the lens chuck shafts 102L and 102R to be positioned on the first lens processing tool 168, the lens shape measuring unit 200 and the second lens processing tool 400, elongated holes 75L and 75R having shapes along the movement path in the Y direction of the lens chuck shafts 102L and 102R are respectively formed in the side walls of a left cover (a cover on the lens chuck shaft 102L side) and a right cover (a cover on the lens chuck shaft 102R side) of the waterproof cover 61. The elongated holes 75L and 75R are through-holes. The lens chuck shafts 102L and 102R are inserted through the elongated holes 75L and 75R and are moved (lifted and lowered) in a predetermined range (a range that achieves the minimum processing diameter of the lens by the first lens processing tool 168 and the second lens processing tool 400) along the movement path in the Y direction.

[0054] Shield units 70 (70L and 70R) that are lifted and lowered along with the lens chuck shafts 102L and 102R are respectively connected to the lens chuck shafts 102L and 102R on the inside of the waterproof cover 61 where the elongated holes 75L and 75R are formed. That is, the shield units 70L and 70R are respectively connected to the lens chuck shafts 102L and 102R. The shield unit 70 is made of a member having waterproofing properties, and for example, is formed of a resin material.

[0055] In this embodiment, the shield unit 70 includes a first rotating plate and a moving member (moving portion). The first rotating plate has a size that covers the elongated holes 75L and 75R and is rotatably held by the waterproof cover 61. A second elongated hole through which the lens chuck shafts 102L and 102R are inserted is formed in the first rotating plate. The second elongated hole enables the lens chuck shafts 102L and 102R to move between a first position where the lens chuck shafts 102L and 102R are closest to the rotational center of the first rotating plate and a second position which becomes farthest, during the movement of the lens chuck shafts 102L and 102R in the axis-to-axis direction. The moving member is connected to the lens chuck shafts 102L and 102R and is moved in response to the movement of the lens chuck shafts 102L and 102R. The moving member is configured to block a gap that otherwise occurs due to an overlap of the first elongated hole and the second elongated hole when the lens chuck shafts 102L and 102R are moved between the first position and the second position. For example, the moving member may have a configuration in which a sliding plate, a second rotating plate, a plate, and the like are used. As a matter of course, the moving member may have a configuration having a combination of the above members or may have a configuration in which the members are individually used.

[0056] Hereinafter, the configuration of the shield unit 70 will be described by exemplifying a first embodiment and a second embodiment.

[0057] The first embodiment of the shield unit 70 will be described. Fig. 8 is a diagram illustrating the first embodiment of the configuration of the shield unit 70, and illustrates the shield unit 70 disposed on the left cover of the waterproof cover 61. Fig. 9 illustrates a schematic configuration diagram of the first embodiment of the cross-section of the lens chuck shaft 102L side, taken along line A-A' in Fig. 7. The shield unit 70 disposed on the right cover of the waterproof cover 61 is the reversal of Fig. 8, and thus description thereof will be omitted.

[0058] In the first embodiment, the shield unit 70 is constituted by a first rotating plate (rotating plate (outer member)) 76 and a moving member (sliding plate (inner member)) 77. The rotating plate 76 has a substantially circular shape and is formed to have a size that covers the elongated hole 75L. The rotating plate 76 is held by the waterproof cover 61 to be able to rotate about the center shaft O about the center of the center shaft (shaft member) O as the rotational center. A configuration in which a member that holds the outer peripheral side of the rotating plate 76 is provided as a holding mechanism for the rotation of the rotating plate 76 without using the shaft member O may be employed.

[0059] The lens chuck shaft 102L is inserted through an elongated hole 76b of the rotating plate 76, a hole 77a of the sliding plate 77, and the elongated hole 75L of the waterproof cover 61. That is, the lens chuck shaft 102L is inserted through the rotating plate 76, the sliding plate 77 and the waterproof cover 61 in this order from the inside to the outside of the processing chamber 60. A slight space (gap) is provided between the lens chuck shaft 102L and the hole 77a of the sliding plate 77. Accordingly, the lens chuck shafts 102L and 102R are held to be able to rotate relative to the sliding plate 77.

[0060] The rotational center of the rotating plate 76 is disposed on the perpendicular bisector LA of a line segment that connects a position PC1 and a position PC2 which are both ends of a range in which the lens chuck shaft 102L is movable in the Y direction (see Fig. 9). The rotational center may be at a position distant from the perpendicular bisector LA, but is preferably positioned on the perpendicular bisector LA in order to reduce the outside diameter of the rotating plate 76. The radius of the rotating plate 76 is formed to be smaller than the radius of the movement path in the Y direction of the lens chuck shaft 102L about the shaft 103. The outside diameter of the rotating plate 76 is formed to have a size (a radius smaller than the distance from the rotational center to the outside diameter of the processing tool rotating shaft 400a) that does not interfere with the second processing tool rotating unit 420 (the processing tool rotating shaft 400a). The position PC1 is a position where the lens chuck shaft 102L is closest to the processing tool rotating shaft 161a. The position PC2 is a position where the lens chuck shaft 102L is closest to the processing tool rotating shaft 400a.

[0061] The elongated hole 76b through which the lens chuck shaft 102L is inserted is formed in the rotating plate 76. The elongated hole 76b has a width to have the lens chuck shaft 102L inserted therethrough, and has a length that enables the lens chuck shaft 102L to move between the position PC3 where the lens chuck shaft 102L is closest to the rotational center of the rotating plate 76 and the farthest position (PC1 or PC2) during the movement of the lens chuck shaft 102L in the Y direction (axis-to-axis direction) (see Figs. 10(a), 10(b), and 10(c)). The elongated hole 76b has a length in the longitudinal direction shorter than the length in the Y direction of the elongated hole 75L.

[0062] The sliding plate 77 is connected to the lens chuck shaft 102L, and is held by the rotating plate 76 to be able to slide in the longitudinal direction of the elongated hole 76b in response to the movement in the Y direction of the lens chuck shaft 102L. In this embodiment, the sliding plate 77 is inserted between the waterproof cover 61 and the rotating plate 76. The sliding plate 77 is formed to have a size that blocks a gap that occurs due to an overlap of the elongated hole 75L and the elongated hole 76b when the lens chuck shaft 102L is moved between the positions PC1, PC3, and PC2. The length in the sliding direction of the sliding plate 77 may be a length that satisfies twice that in the longitudinal direction of the elongated hole 76b.

[0063] A groove (guide) 76a for guiding sliding of the sliding plate 77 is formed in the rotating plate 76. The depth of the guide 76a is formed to be substantially the same as the thickness of the sliding plate 77. The shape in the longitudinal direction of the guide 76a may be a shape in which the sliding plate 77 is slidable. For example, a straight line shape or an arc shape may be employed.

[0064] The sliding plate 77 has an elongated round shape and a hole 77a formed at the center. The shape of the sliding plate is not limited to the elongated round shape, and may be a shape that is able to slide along the guide 76a and blocks a gap that otherwise occurs due to an overlap of the elongated hole 75L and the elongated hole 76b. For example, a rectangular shape, an arc shape, and the like may be employed.

[0065] Here, the longitudinal direction of the elongated hole 76b is disposed in a direction tilted with respect to a direction (that is, the line segment LA) in which the position PC3 and the rotational center (the center of the center shaft O) are connected so that the sliding plate 77 does not interfere with the center shaft O when the lens chuck shaft 102L is moved to the position PC3 (see Fig. 10B). When the lens chuck shaft 102L is moved to the position PC2 from the position PC3, the lens chuck shaft 102L presses a side wall (an inward wall) of the elongated hole 76b such that the rotating plate 76 is rotated. When the lens chuck shaft 102L is moved to the position PC2, that is, when the lens chuck shaft 102L is moved to the position that is closest to the second lens processing tool 400, a part of the sliding plate 77 is moved further to the outside than the outside diameter of the rotating plate 76. At this time, so as not to cause the rotating plate 76 to interfere with the second processing tool rotating unit 420 (the processing tool rotating shaft 400a) disposed to be non-retractable, as illustrated in Fig. 10C, the longitudinal direction of the elongated hole 76b (that is, the sliding direction of the sliding plate 77) is disposed to intersect the elongated hole 75L. The shape of the elongated hole 76b is not limited to the elongated round shape and may be configured to enable the lens chuck shafts 102L and 102R to change the axis-to-axis distance with the rotating plate 76. For example, a rectangular shape, an arc shape, and the like may be employed.

[0066] As described above, in the configuration of the shield unit, since the length of the sliding plate 77 that moves in response to the movement in the Y direction of the lens chuck shaft 102L is much shorter than twice the length in the Y direction of the elongated hole 75L formed in the waterproof cover 61 (It is preferable that the length of the sliding plate 77 be shorter than the elongated hole 75L), and thus the degree of freedom in designing of the apparatus may be increased without increase in the size of the apparatus. Particularly, in the apparatus of this embodiment, the second lens processing tool 400 may be disposed to be non-retractable on the movement path in the Y direction of the lens chuck shaft 102L.

[0067] The shield unit 70 disposed on the lens chuck shaft 102R side is the same mechanism as illustrated in Figs. 8 and 9. The longitudinal direction of the elongated hole 76b is disposed to intersect the elongated hole 75R so that a part of the sliding plate 77 that moves outside the outside diameter of the rotating plate 76 does not interfere with the first processing tool rotating unit 300 when the lens chuck shaft 102R is moved to the position that is closest to the first lens processing tool 168.

[0068] A part of the side wall of the waterproof cover 61 protrudes toward the inside of the processing chamber 60 to provide an awning 63, which covers the upper side of the shield unit so as to prevent the grinding water from infiltrating between the shield unit 70 and the side wall of the waterproof cover 61 from the upper side of the shield unit 70. The awning 63 is configured so as not to interfere with the sliding plate 77 when the sliding plate 77 is moved on the guide 76b of the rotating plate 76.

[0069] Hereinafter, a relationship between the movement of the lens chuck shafts 102L and 102R and the movement of the shield unit 70 in the first embodiment will be described. Figs. 10A to 10C are diagrams illustrating the relationship between the movements of the lens chuck shaft 102L and the shield unit 70. When the lens chuck shaft 102L is driven in the Y direction, the lens chuck shaft 102L presses the side wall of the elongated hole 76b of the rotating plate 76, such that the rotating plate 76 is rotated in response to the movement in the Y direction of the lens chuck shaft 102L.

[0070] At this time, the sliding plate 77 (dotted line part) disposed on the guide 76b of the rotating plate 76 is also rotated in response to the rotation of the rotating plate 76, and thus the angle of the sliding plate 77 is changed due to driving of the lens chuck shaft 102L in the Y direction. Due to the position of the lens chuck shaft 102L, the sliding plate 77 is in a range of the longitudinal direction of the elongated hole 76b and moves along the guide 76a. The sliding plate 77 moves while changing its angle in synchronization with the rotation of the rotating plate 76, thereby always blocking the elongated hole 76b. For example, as illustrated in Figs. 10A to 10C, the sliding plate 77 moves while changing its angle at each position of the lens chuck shaft 102L when the lens chuck shaft 102L is lifted lowered along the elongated hole 75L. Accordingly, the elongated hole 76b of the rotating plate 76 is in a state of being always blocked.

[0071] As described above, by employing the configuration in which the rotating plate 76 of the shield unit 70 has rotational movement and by providing the elongated hole 76b and the sliding plate 77, the constituent members of the shield unit 70 do not move on the movement path in the Y direction of the lens chuck shaft. That is, the shield unit 70 does not have the same movement as the arc movement of the lens chuck shafts 102L and

102R as in the related art (see Fig. 19) but has movement due to the rotational movement, and thus interference with the members (for example, the second lens processing tool 400) other than the rotating plate 76 does not occur. Therefore, even in a case where a driving range in the Y direction of the lens chuck shaft is large, the shield unit 70 may be prevented from interfering with other members. Accordingly, the degree of freedom is added to the arrangement of the members, and a space-saving arrangement of the members is possible. In this embodiment, since the interference with the second lens processing tool 400 is able to be prevented, the rotating shaft 400a of the second lens processing tool 400 is able to be fixed (disposed to be non-retractable) to protrude from the waterproof cover 61.

[0072] Next, the second embodiment of the shield unit 70 will be described. Fig. 11 is a diagram illustrating the second embodiment of the configuration of the shield unit 70, and illustrates the shield unit 70 disposed on the left cover of the waterproof cover 61. Fig. 12 illustrates a schematic configuration diagram of the second embodiment of the cross-section of the lens chuck shaft 102L side, taken along line A-A'. The shield unit 70 disposed on the right cover of the waterproof cover 61 is the reversal of Fig. 11, and thus description thereof will be omitted.

[0073] In the second embodiment, the shield unit 70 is constituted by a first rotating plate 81 and moving members (a plate 82 and a second rotating plate 83). The first rotating plate 81 and the second rotating plate have substantially circular shapes and are formed to have sizes that cover the elongated hole 75L. The first rotating plate 81 and the second rotating plate 83 are held by the waterproof cover 61 to be able to rotate about the center of the center shaft (shaft member) O as the rotational center. A configuration in which a member that holds the outer peripheral side of the first rotating plate 81 and the second rotating plate 83 is provided as a holding mechanism for the rotation of the first rotating plate 81 and the second rotating plate 83 without using the shaft member O may be employed.

[0074] The lens chuck shaft 102L is inserted through a elongated hole 81a of the first rotating plate 81, a hole 82a of the plate 82, a elongated hole 83a of the second rotating plate 83, and the elongated hole 75L of the waterproof cover 61. That is, the lens chuck shaft 102L is inserted through the first rotating plate 81, the plate 82, the second rotating plate 83, and the waterproof cover 61 in this order from the inside to the outside of the processing chamber 60. A slight space (gap) is provided between the lens chuck shaft 102L and the hole 82a of the plate 82. Accordingly, the lens chuck shafts 102L and 102R are held to be able to rotate relative to the plate 82.

[0075] The rotational center of the first rotating plate 81 and the second rotating plate 83 is, as in the first embodiment, disposed on the perpendicular bisector LA of a line segment that connects a position PC1 and a position PC2 which are both ends of a range in which the lens chuck shaft 102L is movable in the Y direction (see Fig. 12). Since the sizes of the first rotating plate 81 and the second rotating plate 83 have the same configurations as those of the first rotating plate 76 in the first example, description thereof will be omitted. As in the first embodiment, the position PC1 is a position where the lens chuck shaft 102L is closest to the processing tool rotating shaft 161a. As in the first embodiment, the position PC2 is a position where the lens chuck shaft 102L is closest to the processing tool rotating shaft 400a.

[0076] The elongated hole 81a through which the lens chuck shaft 102L is inserted is formed in the first rotating plate 81. The elongated hole 81a has a width to have the lens chuck shaft 102L inserted therethrough, and has a length that enables the lens chuck shaft 102L to move between the position PC3 where the lens chuck shaft 102L is closest to the rotational center of the first rotating plate 81 and the farthest position (PC1 or PC2) during the movement of the lens chuck shaft 102L in the Y direction (axis-to-axis direction) (see Figs. 13A, 13B, and 13C). The elongated hole 81a has a length in the longitudinal direction shorter than the length in the Y direction of the elongated hole 75L.

[0077] The elongated hole 83a through which the lens chuck shaft 102L is inserted is formed in the second rotating plate 83. The elongated hole 83a has a width to have the lens chuck shaft 102L inserted therethrough, and has a length that enables the lens chuck shaft 102L to move between the position PC3 where the lens chuck shaft 102L is closest to the rotational center of the second rotating plate 83 and the farthest position (PC1 or PC2) during the movement of the lens chuck shaft 102L in the Y direction (axis-to-axis direction) (see Figs. 13A, 13B, and 13C). The elongated hole 83a has a length in the longitudinal direction shorter than the length in the Y direction of the elongated hole 75L.

[0078] The elongated hole 81a of the first rotating plate 81 and the elongated hole 83a of the second rotating plate 83 are formed in different directions. For example, the elongated hole 81a of the first rotating plate 81 and the elongated hole 83a of the second rotating plate 83 are formed to be bilaterally symmetrical with respect to a straight line LB which connects the rotational centers (shaft member) O of the lens chuck shaft 102L, the first rotating plate 81, and the second rotating plate 83 as a reference line. In the above description, the configuration in which the elongated hole 81a of the first rotating plate 81 and the elongated hole 83a of the second rotating plate 83 are formed in different directions so that the elongated hole 81a of the first rotating plate 81 and the elongated hole 83a of the second rotating plate 83 are bilaterally symmetrical with respect to the straight line LB as the reference line is employed, but the invention is not limited thereto. A configuration in which the elongated hole 81a of the first rotating plate 81 and the elongated hole 83a of the second rotating plate 83 are caused to be bilaterally symmetrical with respect to the straight line LB as the reference line by adjusting the arrangement of the first rotating plate 81 and the second rotating plate 83 when the first rotating plate 81 and the second rotating plate 83 are held by the waterproof cover 61 may also be employed. For example, in a case where rotating plates having the same structure are used as the first rotating plate 81 and the second rotating plate 83, a configuration in which the elongated hole 81a of the first rotating plate 81 and the elongated hole 83a of the second rotating plate 83 are caused to be bilaterally symmetrical with respect to the straight line LB as the reference line by reversing one of the first rotating plate 81 and the second rotating plate 83 may be employed.

[0079] The shapes of the elongated hole 81a and the elongated hole 83a are not limited to the arc shapes and may be configured to enable the lens chuck shafts 102L and 102R to change the axis-to-axis distance with the first rotating plate 81 and the second rotating plate 83. For example, a rectangular shape, a elongated round shape, and the like may be employed.

[0080] The plate 82 is connected to the lens chuck shaft 102L. The hole 82a and a slit 82b are formed in the plate 82. The slit 82b is formed to be engaged with the shaft member O that passes through the rotational center of the first rotating plate 81 and the second rotating plate 83. In the second embodiment, the plate 82 is inserted between the first rotating plate 81 and the second rotating plate 83. The plate 82 is configured to be movably held to any of the waterproof cover 61, the first rotating plate 81, and the second rotating plate 83 and is moved in response to the movement in the Y direction of the lens chuck shaft 102L as the hole 82a is connected to the lens chuck shaft and the slit 82b is connected to the shaft member O. In this embodiment, the configuration in which the plate 82 is inserted between the first rotating plate 81 and the second rotating plate 83 is exemplified, but the invention is not limited thereto. The shield unit 70 may be configured to be movable in response to the movement of the lens chuck shaft 102L and always block the elongated hole 75L of the lens chuck shaft 102L. Therefore, regarding the arrangement order of the members constituting the shield member in the second example, the members may be configured to be arranged in various orders. For example, a configuration in which the first rotating plate 81, the second rotating plate 83, and the plate 82 are arranged in this order from the inside to the outside of the processing chamber 60 may be employed.

[0081] In this embodiment, due to the parts excluding the slit 82b of the plate 82, the plate 82 is formed to a size that blocks a gap that otherwise occurs due to the elongated hole 75L, the elongated hole 81a, and the elongated hole 83a when the lens chuck shaft 102L is moved between the positions PC1, PC3, and PC2.

[0082] The plate 82 is formed in a elongated round shape. The shape of the plate 82 is not limited to the elongated round shape, and may be a shape that is able to move in response to the movement in the Y direction of the lens chuck shaft 102L and blocks a gap that otherwise occurs due to the elongated hole 75L, the elongated hole 81a, and the elongated hole 83a. For example, a rectangular shape, an arc shape, and the like may be employed.

[0083] As in the first embodiment, a part of the side wall of the waterproof cover 61 protrudes toward the inside of the processing chamber 60 to provide an awning 63, which covers the upper side of the shield unit so as to prevent the grinding water from infiltrating between the shield unit 70 and the side wall of the waterproof cover 61 from the upper side of the shield unit 70. The awning 63 is configured so as not to interfere with the plate 82 when the plate 82 is moved.

[0084] Hereinafter, a relationship between the movement of the lens chuck shafts 102L and 102R and the movement of the shield unit 70 in the second embodiment of the shield unit 70 will be described. Fig. 12 is a diagram illustrating the relationship between the movements of the lens chuck shaft 102L and the shield unit 70. When the lens chuck shaft 102L is driven in the Y direction, the lens chuck shaft 102L presses the side wall of the elongated hole 81a of the first rotating plate 81, such that the first rotating plate 81 (solid line portion) is rotated in response to the movement in the Y direction of the lens chuck shaft 102L. The lens chuck shaft 102L presses the side wall of the elongated hole 83a of the second rotating plate 83 (broken line portion), such that the second rotating plate 83 is rotated in response to the movement in the Y direction of the lens chuck shaft 102L.

[0085] Here, the plate 82 (dotted line portion) is rotated in response to the rotation of the first rotating plate 81 and the second rotating plate 83. Therefore, the angle of the plate 82 is changed with driving of the lens chuck shaft 102L in the Y direction. That is, the hole 82a of the plate 82 is moved in response to the movement in the Y direction of the lens chuck shaft 102L, and the plate 82 is moved while rotating (changing its angle) as the shaft member O presses the side wall of the slit 82b of the plate 82. Accordingly, the plate 82 moves while changing its angle in synchronization with the rotation of first rotating plate 81 and the second rotating plate 83, thereby always blocking a gap that otherwise occurs due to the elongated hole 75L, the elongated hole 81a, and the elongated hole 83a.

[0086] For example, as illustrated in Figs. 13A to 13C, the plate 82 moves while changing its angle at each position of the lens chuck shaft 102L when the lens chuck shaft 102L is lifted and lowered along the elongated hole 75L. Accordingly, the elongated hole 75L, the elongated hole 81a, and the elongated hole 83a are in a state of being always blocked.

[0087] As described above, in the second embodiment, by employing the configuration in which the first rotating plate 82 and the second rotating plate 83 of the shield unit 70 have rotational movement and by providing the elongated hole 81a, the elongated hole 83a, and the plate 82, the constituent members of the shield unit 70 do not move on the movement path in the Y direction of the lens chuck shaft. Accordingly, the degree of freedom of the arrangement of the members is increased, and a space-saving arrangement of the members is possible. In the second embodiment, even in a case where processing waste invades between the first rotating plate 81, the plate 82, and the second plate, the area of a part into which the processing waste invades is small, and thus the possibility of a malfunction is reduced. Particularly, this is useful for an eyeglass lens made of polyurethane as the material because processing waste is large. Moreover, even in the case where the processing waste invades between the members, the waste is removed by operating the shield mechanism. Therefore, the operation of the shield unit 70 can be suppressed from being deteriorated due to the infiltration of processing waste between the members of the shield unit 70 when an eyeglass lens is processed.

[0088] The invention has been described by exemplifying the configuration applied to the configuration in which the lens chuck shafts 102L and 102R move in the Y direction, but is not limited thereto. The invention may also apply a configuration in which the processing tool rotating shaft acts as a moving shaft and the processing tool rotating shaft moves in the Y direction so as to approach the lens chuck shafts 102L and 102R. In this case, for example, the shield unit is configured to block the elongated hole formed in a shape along the movement path in the Y direction of the processing tool rotating shaft.

<Controller>

[0089] Fig. 14 is a control block diagram of an apparatus for processing an eyeglass lens periphery. A switch portion 7, a memory 51, a carriage portion 100, the lens shape measuring unit 200, a display 5 as touch panel-type displaying means and inputting means, and the like are connected to a controller 50. The controller 50 receives an input signal through a touch panel function included in the display 5 and controls a display of figures and information of the display 5. Here, an eyeglass frame shape measuring portion 2 (those described in JP-A-4-93164 and the like may be used) is connected to the apparatus for processing an eyeglass lens periphery so that predictive control can be performed during lens shape measurement on the basis of target lens shape data acquired by the eyeglass frame shape measuring portion 2.

<Control Operation>

[0090] The operations of the eyeglass lens processing apparatus having the above configuration will be described. In this embodiment, during measurement of the shape of the lens LE, the controller 50 controls driving of the lens rotating unit 100a and the Y-direction moving unit 100c on the basis of the target lens shape input from the eyeglass frame shape measuring portion 2 or the like, and controls driving of the X-direction moving unit 100b on the basis of at least one of the curve of a lens refractive surface obtained before starting measurement, the detection result obtained by the sensor 257 after starting the measurement, and the target lens shape so that the movement position in the lens chuck shaft direction of the tracing stylus 260 during the measurement of the lens shape is in a predetermined range.

[0091] First, when the periphery of the lens is processed, target lens shape data (radial length rn and radial angle θn) (n=1, 2, ..., N) obtained by the eyeglass frame shape measuring portion 2 is input, and layout data such as a pupillary distance (PD value) of a wearer, a frame pupillary distance (FPD value) of eyeglass frames, and the height of an optical center with respect to the geometric center of the target lens shape is input by operating the keys of the display 5. Processing conditions such as the material of a lens, the type of a frame, and processing modes (bevel-processing, flat-processing, and grooving) are set by operating the keys of the display 5.

[0092] When inputting of data needed for processing is completed, the lens LE is held by the lens chuck shafts 102R and 102L, and an operation is started by pushing a start switch of the switch portion 7. The controller 50 controls driving of the motor 120 to cause the lens LE to make at least one revolution and measures the shape of the refractive surface of the lens LE at every predetermined angle $\Delta\theta$. For example, on the basis of the target lens shape data measured by the eyeglass frame shape measuring portion 2, an angle between measurement points is set to $\Delta\theta$=0.36 degrees, and 1000 points of measurement data are obtained through the one revolution of the lens LE.

[0093] The controller 50 moves the carriage 101 in the upward and downward direction (Y direction) to change the axis-to-axis distance between the tracing stylus 260 and the lens chuck shafts 102R and 102L on the basis of the radial data of the input target lens shape and the processing shape calculated from the layout data and aligns the measurement start position of the front surface of the lens LE and the position of the tracing stylus 260 (the tip end 260a).

[0094] The carriage 101 is moved in the X direction by driving the X-direction moving unit 100b so that the measurement start point P1 of the refractive surface of the lens LE comes into contact with the tip end 260a of the tracing stylus 260. After the tracing stylus 260 comes into contact with the lens LE (the front surface), the lens LE is further moved in the X direction so that the support shaft 263 is tilted at a predetermined tilt angle about the axis S2. For example, at the measurement start point P1, when the support shaft 263 is tilted at an angle α1 (for example, of 2 degrees) from the initial position, the tracing stylus 260 is moved in the X direction by about 4 mm.

[0095] Figs. 15A and 15B illustrate a state where the lens shape measuring unit 200 is tilted at a predetermined angle by coming into contact with the lens LE. As illustrated in Fig. 15A, after the lens LE and the tracing stylus 260 come into contact with each other, when the support shaft 263 is further tilted by an angle $\alpha 1$ from the initial position about the axis S2, repulsion of the spring 254a occurs, and the tracing stylus 260 comes into pressing contact with the measurement surface of the lens LE. Accordingly, even though a distance from the lens chuck shafts 102R and 102L to each measurement point is changed, the tracing stylus 260 follows the measurement point on the refractive surface of the lens LE by the impelling of the spring 254a (254b).

[0096] When a tilt of the support shaft 263 at a predetermined angle in the X direction about the axis S2 is detected by the sensor 257, the controller 50 acquires position information X1 in the X direction of the front surface of the lens LE at the measurement start point P1 on the basis of the detection results of the encoder 146 and the sensor 257.

[0097] Here, Fig. 16 is an explanatory view of a change in the position of the measurement surface of the lens LE at each lens rotational angle. When position information X1 is obtained at the measurement start point P1, the controller 50 rotates the lens LE using the lens rotating unit 100a in a predetermined step and aligns the positions of the next measurement point P2 and the tracing stylus 260. As described above, the tip ends 260a and 260b of the tracing stylus 260 have roundness and thus are smoothly moved on the refractive surface of the lens LE.

[0098] At the next measurement point P2, position information X2 in the X direction of the front surface of the lens LE is acquired in the same manner. However, when a distance from the axis (rotational center) of the lens chuck shafts 102R and 102L to a measurement point Pn (n=1, 2, ..., 1000) is changed depending on the target lens shape, the position in the X direction of the refractive surface of the lens LE is shifted such that a contact state of the lens LE against the tracing stylus 260 is changed.

[0099] Figs. 17A and 17B are explanatory views of a change in the position of the refractive surface of the lens LE according to a change in the distance from the rotational center to each measurement point Pn (n=1, 2, ...), Fig. 17A is a front view of the lens LE, and Fig. 17B is a side view of the lens LE. For example, with respect to the position X1 of the measurement surface of the lens LE at the measurement point P1 at a distance r1 from the rotational center FC, at the measurement point P2 at a distance r2 from the rotational center, the position of the measurement surface of the lens LE is X2, which is shifted in the X direction by ΔX.

[0100] As such, when the measurement surface of the lens LE is shifted in the X direction and the tracing stylus 260 comes into stronger pressing contact with the lens LE, there is a concern of the lens LE coming into pressing contact over the tiltable range of the tracing stylus 260, resulting in damage of the measurement surface. When the measurement surface of the lens LE is moved in a direction to be distant from the tracing stylus 260, there is a concern that a force of coming into pressing contact with the lens LE may be weakened and the tracing stylus 260 may deviate from the measurement surface.

[0101] Here, according to the invention, in order to measure a lens shape while maintaining a state of contact between the tracing stylus 260 and the lens LE in a predetermined range (that is, to cause a movement position in the X direction of the tracing stylus 260 to be in a predetermined range), the controller 50 performs predictive control for predicting the position of the measurement surface of the lens LE at the next measurement point Pn.

[0102] For example, the controller 50 predicts the position of the refractive surface of the lens LE at the next measurement point P3 on the basis of the measurement results of the position information X1 in the X direction of the refractive surface of the lens LE at the measurement start point P1 and the position information X2 at the next measurement point P2. First, the controller 50 obtains a difference ΔX between the position information X1 obtained at the measurement start point P1 and the position information X2 obtained at the next measurement point P2. As a result of performing a predetermined calculation based on the difference ΔX at the next measurement point P3, the controller 50 performs control so that the carriage 101 is moved in the opposite direction (in a direction to offset the ΔX) and thus the contact state of the lens LE against the tracing stylus 260 is maintained in a constant state. In this manner, a change in the position in the X direction of the tracing stylus 260 is reduced, and thus measurement of the shape of the refractive surface of the lens LE is appropriately performed.

[0103] When a change in the position of the tracing stylus 260 (the tip end 260a) acquired by the sensor 257 is used as a correction value for position information of the lens refractive surface at the measurement point, an influence of a minute change in the tilt angle of the tracing stylus 260 is eliminated, thereby obtaining the refractive surface shape of the lens LE with higher accuracy. For example, by adding a correction of $\Delta(Xn-\Delta X_{n-1})$ to position information Xn at a measurement point Pn, a movement error in a tilt angle range of the tracing stylus 260 is offset.

[0104] Hereinabove, a control method of predicting the position of the refractive surface at a measurement point of the next lens rotational angle on the basis of the measurement results of the shapes of the refractive surface at the two premeasured points including the measurement point P_{n-1} and the measurement point P_{n-2} with respect to the current measurement point Pn of the refractive surface of the lens LE as a reference has been described. Alternatively, an average ΔX of changes in the position of the refractive surface at a plurality of premeasured points m (m=2, 3, 4, ...) may be obtained and the position in the X direction of the refractive surface at the current measurement point Pn may be predicted on the basis of the value of the obtained average ΔX to control the position in the X direction of the lens LE. A calculation expression for obtaining the average ΔX is shown in Expression (1).

[0105]

[Expression 1]

$$\Delta X = \sum_{n=1}^{m} \frac{1}{n}(X_n - X_{(n-1)})$$

A case where the tracing stylus 260 deviates from the refractive surface of the lens LE by mistake during measurement of the shape of the refractive surface may be considered. Here, the deviation of the tracing stylus 260 from the measurement surface is detected from a change in the position in the H direction (a change in the tilt angle) by the sensor 258. That is, when the tracing stylus 260 deviates from the measurement surface of the lens LE, the tracing stylus 260 is returned to its initial position in the Y direction by the restoring force of the spring 204. Otherwise, the position in the H direction is significantly changed. Such a movement in the H direction of the tracing stylus 260 (a change in position) is detected by the sensor 258 before completing measurement, the controller 50 determines that the tracing stylus 260 deviates from the measurement surface of the lens LE and performs control so that the operation of measuring the shape of the refractive surface of the lens LE is temporarily stopped and measurement is performed again.

[0106] When measurement of the shape of the refractive surface of the front surface side of the lens LE is completed, the lens LE is moved in a direction to be separated from the tracing stylus 260 due to the movement of the carriage 101 by the motor 145. When the lens LE is separated from the tracing stylus 260, the tracing stylus 260 is returned to its initial position by the restoring force of the spring 203.

[0107] After the measurement of the shape of the refractive surface of the front surface of the lens LE is completed, roughing is performed on the periphery of the lens LE. In this case, even when the curve of the rear surface of the lens LE is sharp, measurement of the shape of the refractive surface is appropriately performed without an increase in the size of the tracing stylus 260. A roughing grindstone may be made more compact. In this embodiment, as lens processing, grooving is exemplified for the description. As a matter of course, as periphery processing, bevel-processing, polishing, and the like may be performed.

[0108] The controller 50 moves the carriage 101 in the XY directions by driving the motors 145 and 150 to position the lens LE on the first lens processing tool 168. Roughing of the periphery of the lens LE is performed by causing the lens LE rotated by driving of the motor 120 to come into pressing contact with the first lens processing tool 168 rotated in response to the rotation of the grindstone spindle 161a by the motor 160.

[0109] When roughing of the lens LE is completed, the controller 50 moves the carriage 101 toward the lens shape measuring unit 200 again and aligns the positions of the measurement start point of the rear surface of the lens LE and the tip end 260b of the tracing stylus 260. The controller 50 causes the tip end 260b of the tracing stylus 260 to come into pressing contact with the rear surface of the lens LE until the support shaft 263 is tilted at a predetermined tilt angle $\alpha 1$ about the axis S2 as illustrated in Fig. 15B by the movement in the X direction of the carriage 101 as described above, and performs measurement of the shape of the rear surface side of the lens LE based on the predictive control as described above. Here, since roughing is performed on the periphery of the lens in advance, the movable unit 250 and the lens LE are less likely to interfere with each other, and thus shape measurement is more appropriately performed.

[0110] When measurement of the shape of the refractive surface of the front and rear surfaces of the lens LE is completed, the thickness of the edge of the lens LE is obtained from the shapes of the refractive surfaces of the front and rear surfaces of the measured lens LE. The controller 50 performs finishing (flat-finishing) on the lens LE that comes into pressing contact with the first lens processing tool 168 on the basis of the calculated shape data of the lens edge.

[0111] The controller 50 moves the carriage 101 in the XY direction by driving the motor 145 and the motor 150, and positions the lens LE on the finishing grindstone 164 disposed in the first lens processing tool 168. The lens LE rotated by driving of the motor 120 comes into pressing contact with the first lens processing tool 168 rotated by the rotation of the grindstone spindle 161a by the motor 160, and finishing is performed on the periphery of the lens LE.

[0112] When finishing is completed, the controller 50 obtains grooving data (control data for rotation and XY movement of the lens chuck shafts) on the basis of the target lens shape data and the shape data of the lens edge, and grooving is performed on the basis of the grooving data. The controller 50 moves the carriage 101 in the XY direction by driving the motor 145 and the motor 150, and positions the lens LE on the second lens processing tool 400. The lens LE rotated by driving of the motor 120 comes into pressing contact with the grooving grindstone 432 of the second lens processing tool 400 rotated by the rotation of the grindstone rotating shaft 425 by the motor 421, and grooving is performed on the periphery of the lens LE.

[0113] Next, the controller 50 obtains chamfering data (control data for rotation and XY movement of the lens chuck shafts) on the basis of the target lens shape and the shape data of the lens edge, and chamfering is performed on the basis of the obtained processing data. The controller 50 moves the carriage 101 in the XY direction by driving the motor 145 and the motor 150, and positions the lens LE on the second lens processing tool 400. The lens LE rotated by driving of the motor 120 comes into pressing contact with the chamfering grindstone 431 of the second lens processing tool 400 rotated by the rotation of the grindstone rotating shaft 425 by the motor 421, and chamfering is performed on the periphery of the lens LE.

[0114] The predictive control method for measuring the shape of the refractive surface of the lens LE while maintaining the position (the tilt angle) of the tracing stylus 260 in a predetermined range is not limited to the above description.

[0115] For example, during predictive control using the above-described average, an average of the latest (for example, five) measurement points of the current measurement point Pn may also be used as a correction value. That is, in a case where the position of the measurement point is significantly changed on the refractive surface (the distance from the lens chuck shafts 102R and 102L is significantly changed), such as a case where the lens curve is sharp, the difference between the predicted value of the average and the actual position of the refractive surface of the lens LE is increased, and thus there is a concern of the tracing stylus 260 deviating.

[0116] Here, an average of the latest measurement points (for example, an average of the latest 5 measurement values) may be reflected in the above-described average as a correction value. In this case, even when a change amount of the average is great, the position of the current measurement point can be predicted with good accuracy.

[0117] Whether or not correction using the average of the latest measurement points is reflected may be determined by the controller 50 on the basis of a predetermined threshold. For example, in a case where the value of the average is greater than the predetermined threshold, predictive control using the correction value of the average of the latest measurement points may be performed.

[0118] For the predictive control, a movement amount (the tilt angle) of the tracing stylus 260 may also be used. For example, when the sensor 257 detects that the tracing stylus 260 is moved by a predetermined distance ΔXD (for example, of greater than ±2 mm in the X direction from the measurement start position) in the X direction, the controller 50 performs control so that the lens LE (the lens chuck shafts 102R and 102L) is moved by the distance ΔXD in the X-axis direction.

[0119] Moreover, a lens curve value may be predicted on the basis of target lens shape data input in advance and position control of the lens LE with respect to the tracing stylus 260 may be performed on the basis of the predicted lens curve value. Fig. 18 is an explanatory view of a modification example of the predictive control.

[0120] First, the controller 50 aligns the position of the tracing stylus 260 with the initial first point of the refractive surface of the lens LE as described above, and thereafter predicts a lens curve value from a change in the tilt amount of the tracing stylus 260 detected by the sensor 257 by causing the tracing stylus 260 to slide on the refractive surface to a second point separated by a predetermined distance in the radial direction in a state where the tracing stylus 260 comes into contact with the surface of the lens LE.

[0121] For example, the controller 50 controls the tracing stylus 260 to slide outward to the second point at a predetermined distance (for example, about 0.5 mm) in the radial direction from a state of being aligned with the first point of the position on the lens corresponding to the target lens shape acquired in advance, and obtains a change in the tilt amount of the lens surface. When measurement of the lens curve value is performed at the position according to the target lens shape, an influence of the spherical surface state of the lens is suppressed, and the lens curve value is predicted with good accuracy. In order to obtain the lens curve value, at least two points having different distances in the radial direction may be measured. In a case where the lens curve value of the lens refractive surface is obtained in advance by measuring design data of the lens or the sum of curves, a configuration in which the lens curve value is input by a switch of the display 5 may also be employed. Furthermore, a representative value (standard value) of a lens curve stored in advance in the memory 51 may also be used.

[0122] When the lens curve value is acquired as described above, a measurement position Xn of the lens surface at the measurement point Pn is obtained on the basis of Expression (2). In Fig. 18, the relationship between the radius R of the lens curve, the radial angle θn at the measurement point Pn, and the radial length rn is illustrated.

[0123]

[Expression 2]

$$X_n = R - \sqrt{R^2 - r_n^2}$$

Here, the movement distance ΔXn in the X direction of the measurement position Xn of the measurement point Pn with respect to the measurement position X1 at the initial measurement position P1 is obtained by Expression (3).

[0124]

[Expression 3]

$$\Delta X_n = X_n - X_1$$

The controller 50 moves the carriage 101 (the lens chuck shafts 102R and 102L) in the X direction on the basis of the calculated movement distance ΔXn while rotating the lens LE according to the radial data (rn, θn) so as to control the lens LE to come into contact with the tracing stylus 260 in a constant state and performs measurement of the shape of the refractive surface of the lens.

[0125] Here, in a case where a difference of a predetermined or greater value is present between the actual measurement position of the refractive surface of the lens LE and the position of the refractive surface of the lens LE predicted on the basis of the lens curve value, control for correcting the lens curve value may also be performed by the controller 50. For example, when a predetermined difference between the actual measurement point of the lens LE and the predicted value is detected from the detection result (a change in the tilt angle of the tracing stylus 260) by the sensor 257, the controller 50 resets the lens curve value using the shape measurement data of the measured lens. Otherwise, the lens curve value is obtained again by causing the tracing stylus 260 to slide on the refractive surface of the lens LE in the radial direction again. Predictive control as described above is performed on the basis of the newly set lens curve value such that the lens LE comes into contact with the tracing stylus 260 in a constant state.

[0126] Particularly, in a case where lens processing is performed while holding the geometric center of the target lens shape with the lens chuck shafts, the lens LE is likely to be tilted due to a change in the rotational angle of the lens LE. In this case, the correction process of the lens curve value as described above is performed so that lens shape measurement is appropriately continued.

[0127] As described above, deviation of the lens LE from the tracing stylus 260 can be predicted by performing measurement of the shape of the lens LE while predicting the position of the measurement point (the position in the X direction) on the refractive surface of the lens LE. Therefore, even in a case where the movable range of the tracing stylus 260 is narrow, the shape of the refractive surface of the lens LE is appropriately measured.

[0128] Even though avoiding means is not provided, the second lens processing tool 400 can be prevented from interfering with the lens shape measuring unit 200 or the first lens processing tool 168. For example, since the second lens processing tool 400 is disposed to oppose the first lens processing tool 168 with the carriage 101 interposed therebetween, when lens processing is performed by the first lens processing tool 168, the second lens processing tool 400 may not be prevented so as not to interfere with the lens LE and the second lens processing tool 400. That is, there is no need to provide avoiding means for avoiding the second lens processing tool 400. By narrowing the movable range of the tracing stylus 260, when lens shape measurement is performed by the lens shape measuring unit 200, the avoiding means for avoiding the second lens processing tool 400 so as to prevent the second lens processing tool 400 from interfering with the lens LE is not necessary. As such, since the second lens processing tool 400 can be disposed to be fixed, it is possible to prevent wobbling and the like of the second lens processing tool 400 during processing, resulting in enhancement in the accuracy of processing.

[0129] Moreover, a space in the X direction between the second lens processing tool 400 and the lens shape measuring unit 200 that are arranged side by side may be reduced, resulting in reduction in the size of the apparatus.

[0130] In this embodiment, avoiding means for avoiding the lens shape measuring unit 200 when processing is performed by the second lens processing tool 400 is not provided. As such, since the lens shape measuring unit 200 is disposed to be fixed, it is possible to prevent wobbling and the like of the tracing stylus 260 during lens shape measurement, resulting in enhancement in the accuracy of measurement.

[0131] By using the above configuration, measurement of the shape of the external form of the lens LE may be performed. In this case, the controller 50 controls the tip end surface 260c of the tracing stylus 260 to abut on the edge of the lens LE by driving the carriage 101. It is preferable that the tip end surface 260c have such a width that the edge of the lens LE does not easily deviate from the tip end surface.

[0132] The controller 50 moves the carriage 101 in the forward, rearward, leftward, and rightward directions in the state where the edge of the lens LE abuts on the tip end surface 260c on the basis of the data of the target lens shape input in advance so that the edge of the lens LE comes into contact with the tip end surface 260c at a constant pressure. Here, it is preferable that the position of the edge at the next measurement point be predicted through the predictive control as described above. In this manner, the lens LE can be prevented from deviating from the tracing stylus 260, and thus measurement of the position of the edge of the lens LE is appropriately performed.

[0133] In the above description, the example in which the tracing stylus 260 is mounted to the tip end of the arm 262 provided in a direction that extends toward the lens chuck shafts 102R and 102L is described. Moreover, the tracing stylus 260 may also be provided at the tip end of an arm that extends in a direction parallel to the lens chuck shafts 102R and 102L. Alternatively, the tracing stylus 260 may also be provided at a position at which both the front and rear surfaces of the lens are able to be measured using the single tracing stylus 260. Otherwise, as in JP-A-2000-317796, a configuration in which the tip end 260a and the tip end 260b oppose to face each other may also be employed.

[0134] Furthermore, in the above description, the positional relationship between the tracing stylus 260 and the lens LE is acquired by detecting a change in the tilt angle of the movable unit 250 that occurs when the tracing stylus 260 comes into contact with the lens LE by using the sensors 257 and 258. The positional relationship between the tracing stylus 260 and the lens LE may be contactlessly detected. For example, a light-emitting unit of an optical distance sensor is provided in the vicinity of the tracing stylus 260, and a light-receiving unit of the optical distance sensor is provided on the lens LE side. Accordingly, a phase difference between an illumination signal and a light-receiving signal is received by the light-receiving unit, and thus the positional relationship between the tracing stylus 260 and the lens LE is contactlessly acquired on the basis of the detection result.

[0135] In the above description, after measuring the shape of the front surface of the lens LE, measurement of the shape of the rear surface side of the lens LE is performed after performing roughing. However, in a case where the shape of the roughing grindstone is allowed to be sufficiently large, or in a case where the lengths of the tip ends 260a and 260b of the lens shape measuring unit 200 are ensured, roughing may be started after initially measuring the shapes of the front and rear surfaces of the lens LE.

Claims

1. An eyeglass lens processing apparatus (1) for processing a periphery of a lens, comprising:

    lens rotating means (100a) for rotating a pair of lens chuck shafts (102) that hold an eyeglass lens;
    processing tool rotating means (300, 420) for rotating a processing tool rotating shaft (161a, 400a) to which a processing tool (168, 400) for processing the periphery of the lens is mounted;
    moving means (100c) for moving about the lens chuck shafts or the processing tool rotating shaft as a moving shaft in an axis-to-axis direction in which an axis-to-axis distance between the lens chuck shafts and the processing tool rotating shaft is changed;
    a waterproof cover (61) provided with a first elongated hole (75L, 75R) through which the moving shaft is inserted, the waterproof cover configuring a processing chamber (60); and
    a shield unit (70) provided in the waterproof cover for preventing grinding water from leaking out of the first elongated hole, the shield unit being configured to be rotated in response to movement of the moving shaft.

2. The eyeglass lens processing apparatus according to claim 1, wherein
the shield unit includes a first rotating plate (76, 81) rotatably held by the waterproof cover,
the first rotating plate is provided with a second elongated hole (76b, 81a) through which the moving shaft is inserted and which enables the moving shaft to move between a first position (PC3) at which the moving shaft approaches a rotational center (O) of the first rotating plate and a second position (PC1, PC2) at which the moving shaft is separated from the rotational center of the first rotating plate during the movement of the moving shaft in the axis-to-axis direction, and
the shield unit further includes a moving member (77, 82, 83) which is connected to the moving shaft and is configured to block a gap that otherwise occurs due to an overlap of the first elongated hole and the second elongated hole.

3. The eyeglass lens processing apparatus according to claim 2, wherein
the moving member includes:

    a second rotating plate (83) which has such a size that covers the first elongated hole and is able to rotate about the rotational center of the first rotating plate (81); and
    a plate (82) which is connected to the moving shaft and is provided to be movable in the axis-to-axis direction in response to the movement of the moving shaft in the axis-to-axis direction,

    the second rotating plate has a third elongated hole (83a) through which the moving shaft is inserted and which enables the moving shaft to move between the first position and the second position about a rotational center of the second rotating plate during the movement of the moving shaft in the axis-to-axis direction, and is formed in a direction different from that of the second elongated hole (81a), and
    the plate is configured to have such a size that blocks a gap that otherwise occurs due to an overlap of the first elongated hole, the second elongated hole, and the third elongated hole at each position where the first rotating plate and the second rotating plate are rotated.

4. The eyeglass lens processing apparatus according to claim 3, wherein
the moving shaft is the lens chuck shaft (102),
the processing tool rotating means includes a first processing tool rotating unit (300) for rotating a first processing tool rotating shaft (161a) to which a first processing tool (168) that is configured to process the periphery of the lens and has a large diameter is mounted, and a second processing tool rotating unit (420) for rotating a second processing tool rotating shaft (400a) to which a second processing tool (400) that is configured to process the periphery of the lens and has a smaller diameter than that of the first processing tool is mounted,
the first processing tool and the second processing tool oppose each other with the lens chuck shafts interposed therebetween, and the second processing tool is disposed to be non-retractable,
the rotational centers of the first rotating plate and the second rotating plate are disposed on a perpendicular bisector of a line segment that connects both ends of a range in which the lens chuck shafts are movable in the axis-to-axis direction, and
outside diameters of the first rotating plate and the

second rotating plate are formed to have such sizes that do not interfere with the second processing tool rotating unit.

5. The eyeglass lens processing apparatus according to claim 3 or 4, wherein the plate is provided with a slit (82b) which is engaged with a shaft member that passes through the rotational centers of the first rotating plate and the second rotating plate, and is movably held by any of the waterproof cover, the first rotating plate and the second rotating plate.

6. The eyeglass lens processing apparatus according to claim 4 or 5, wherein the second elongated hole formed in the first rotating plate and the third elongated hole formed in the second rotating plate are formed to be bilaterally symmetrical with respect to a straight line that connects the rotational centers of the lens chuck shaft, the first rotating plate, and the second rotating plate as a reference line.

7. The eyeglass lens processing apparatus according to any one of claims 4 to 6, wherein the first rotating plate and the second rotating plate are configured to rotate as the lens chuck shafts press inner walls of the second elongated hole and the third elongated hole when the lens chuck shafts are moved.

8. The eyeglass lens processing apparatus according to any one of claims 4 to 7, further comprising a shaft member held by the waterproof cover so that the first rotating plate and the second rotating plate are rotatable, the shaft member being rotational centers of the first rotating plate and the second rotating plate.

9. The eyeglass lens processing apparatus according to any one of claims 3 to 8, wherein a length of the third elongated hole in a longitudinal direction thereof is shorter than a length of the first elongated hole in the axis-to-axis direction.

10. The eyeglass lens processing apparatus according to claim 2, wherein the moving member includes a sliding plate (77) which is held by the first rotating plate to be able to slide in a longitudinal direction of the second elongated hole (76b) in response to movement of the lens chuck shaft or the processing tool rotating shaft, and is formed to have such a size that blocks the second elongated hole when the moving shaft is moved between the first position and the second position.

11. The eyeglass lens processing apparatus according to claim 10, wherein
the moving shaft is the lens chuck shaft (102),
the processing tool rotating means includes a first processing tool rotating unit (300) for rotating a first processing tool rotating shaft (161a) to which a first processing tool (168) that is configured to process the periphery of the lens and has a large diameter is mounted, and a second processing tool rotating unit (420) for rotating a second processing tool rotating shaft (400a) to which a second processing tool (400) that is configured to process the periphery of the lens and has a smaller diameter than that of the first processing tool is mounted,
the first processing tool and the second processing tool oppose each other with the lens chuck shafts interposed therebetween, and the second processing tool is disposed to be non-retractable,
the rotational center of the first rotating plate is disposed on a perpendicular bisector of a line segment that connects both ends of a range in which the lens chuck shafts are movable in the axis-to-axis direction, and
an outside diameter of the first rotating plate is formed to have such a size that does not interfere with the second processing tool rotating unit.

12. The eyeglass lens processing apparatus according to claim 11, wherein the longitudinal direction of the second elongated hole is disposed to intersect the first elongated hole so that when the lens chuck shafts are moved to a position closest to the second processing tool, a part of the sliding plate is moved to an outside of the first rotating plate and does not interfere with the second processing tool rotating unit.

13. The eyeglass lens processing apparatus according to claim 12, wherein the longitudinal direction of the second elongated hole is disposed to intersect the first elongated hole so that when the lens chuck shafts are moved to a position closest to the first processing tool, the part of the sliding plate is moved to the outside of the first rotating plate and does not interfere with the first processing tool rotating unit.

14. The eyeglass lens processing apparatus according to claim 11 or 12, wherein the longitudinal direction of the second elongated hole and the sliding plate are tilted with respect to a direction in which the first position and the rotational center are connected so that the sliding plate does not interfere with the shaft member that rotatably supports the first rotating plate when the lens chuck shaft is moved to the first position.

15. The eyeglass lens processing apparatus according to any one of claims 11 to 14, wherein a length of the sliding plate in a sliding direction is shorter than twice a length of the first elongated hole in the axis-to-axis direction.

FIG. 1

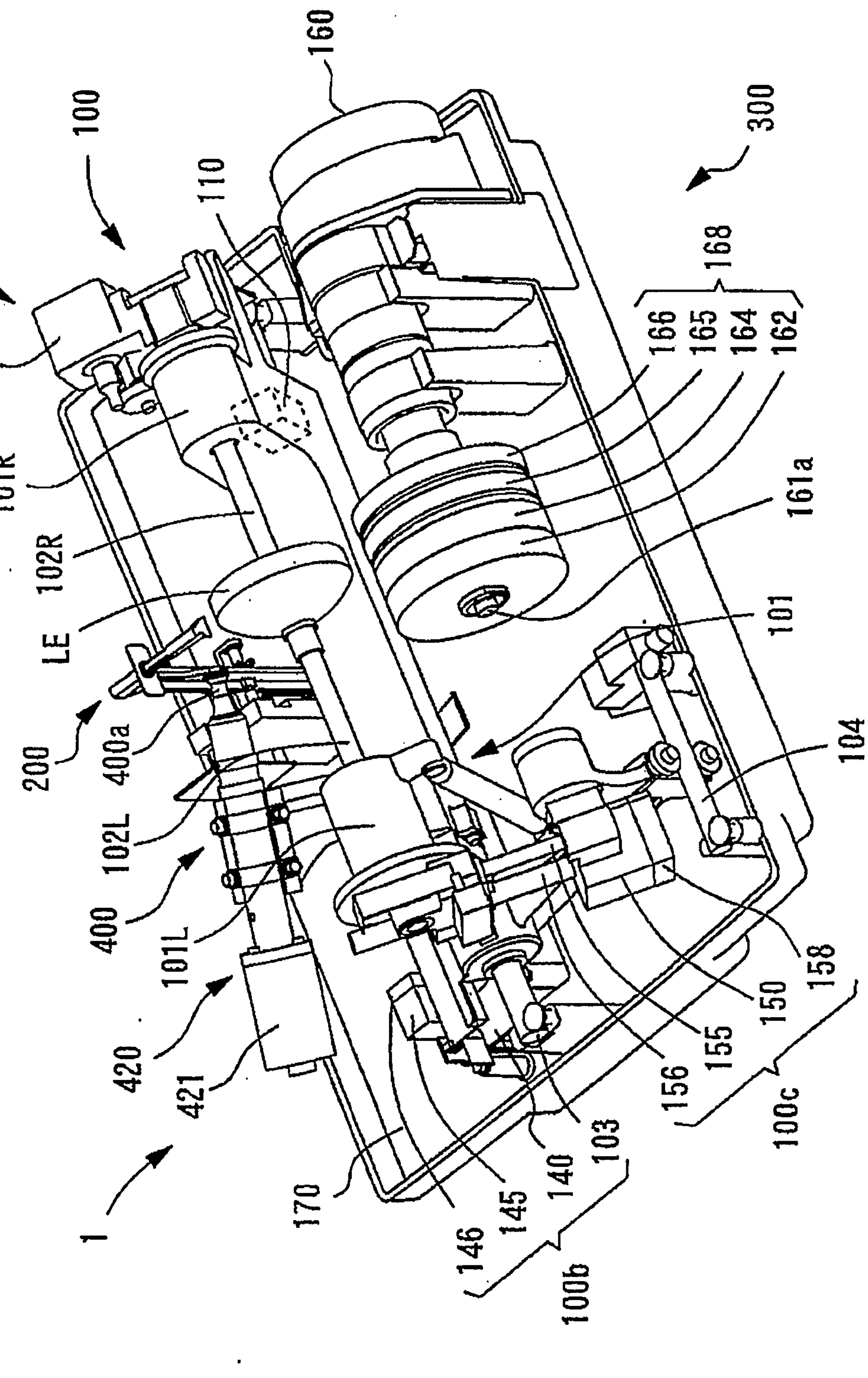
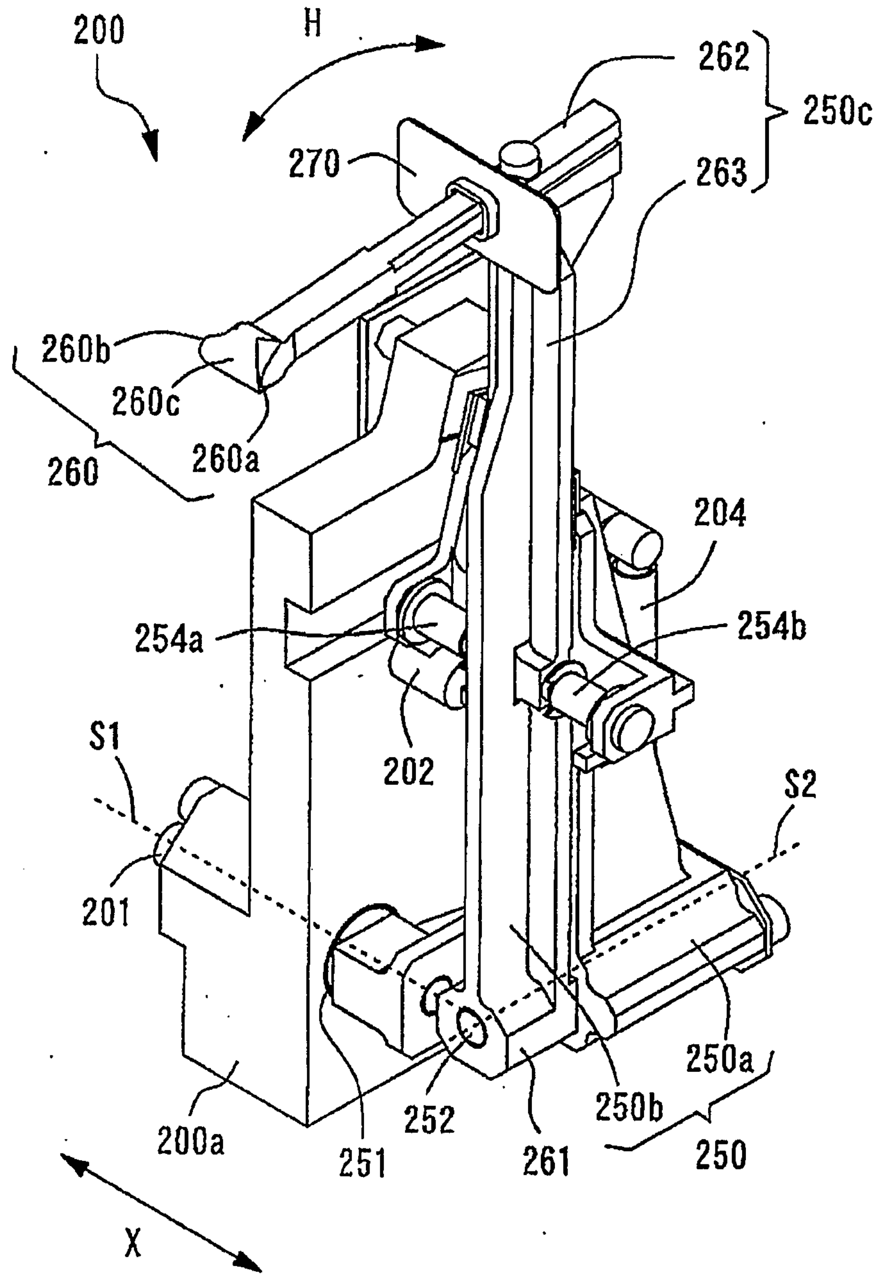

1
100
100a
110
120
160
300
168
166
165
164
162
161a
101R
102R
LE
200
400a
102L
400
101L
420
421
101
104
158
150
155
156
103
140
145
146
170
100b
100c

FIG. 2



200
H
262
250c
270
263
260b
260c
260
260a
204
254a
254b
202
S1
S2
201
250a
200a
251
252
261
250b
250
X

FIG. 3

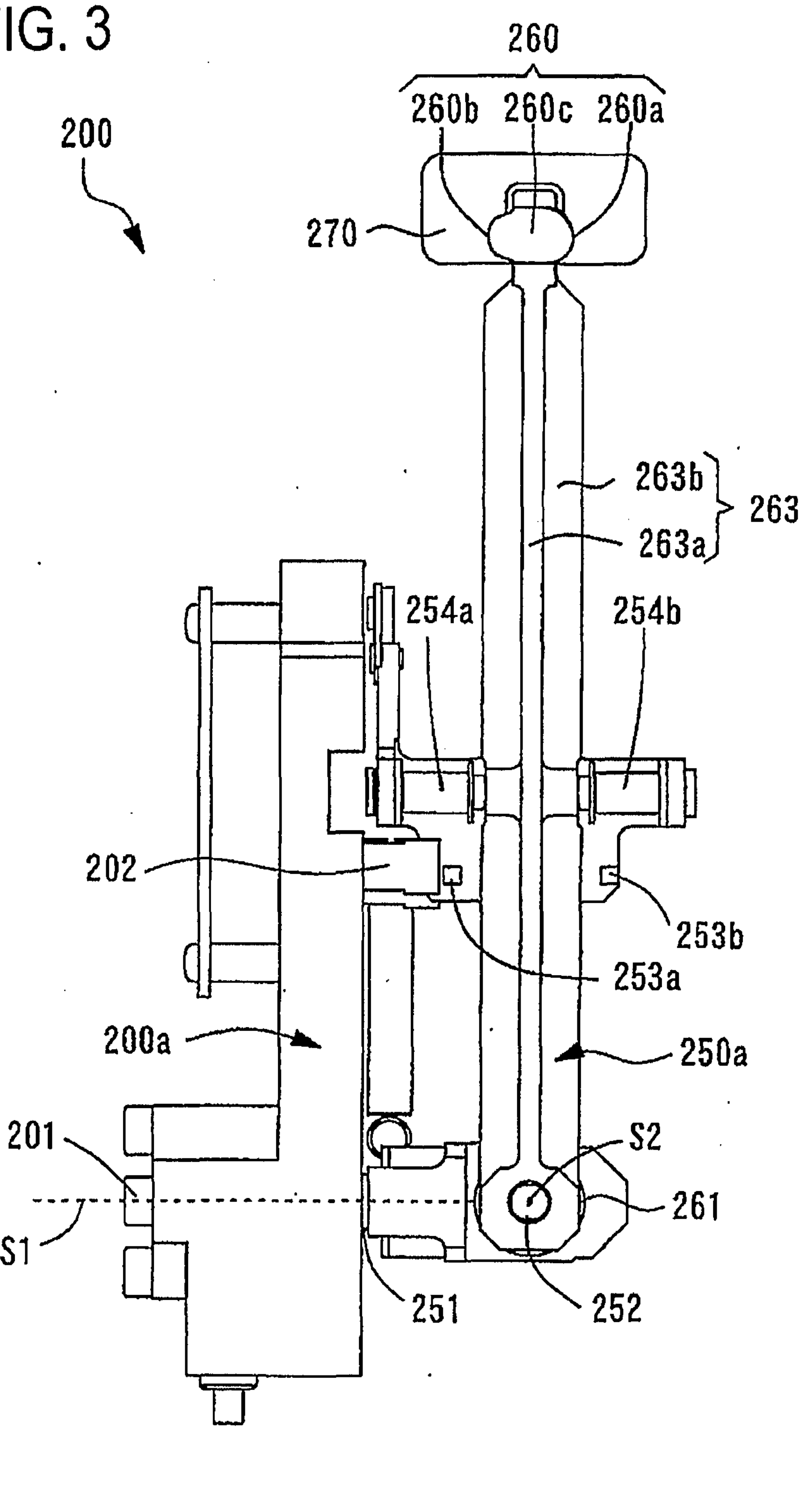

260
260b
260c
260a
200
270
263b
263
263a
254a
254b
202
253b
253a
200a
250a
201
S2
261
S1
251
252

FIG. 4

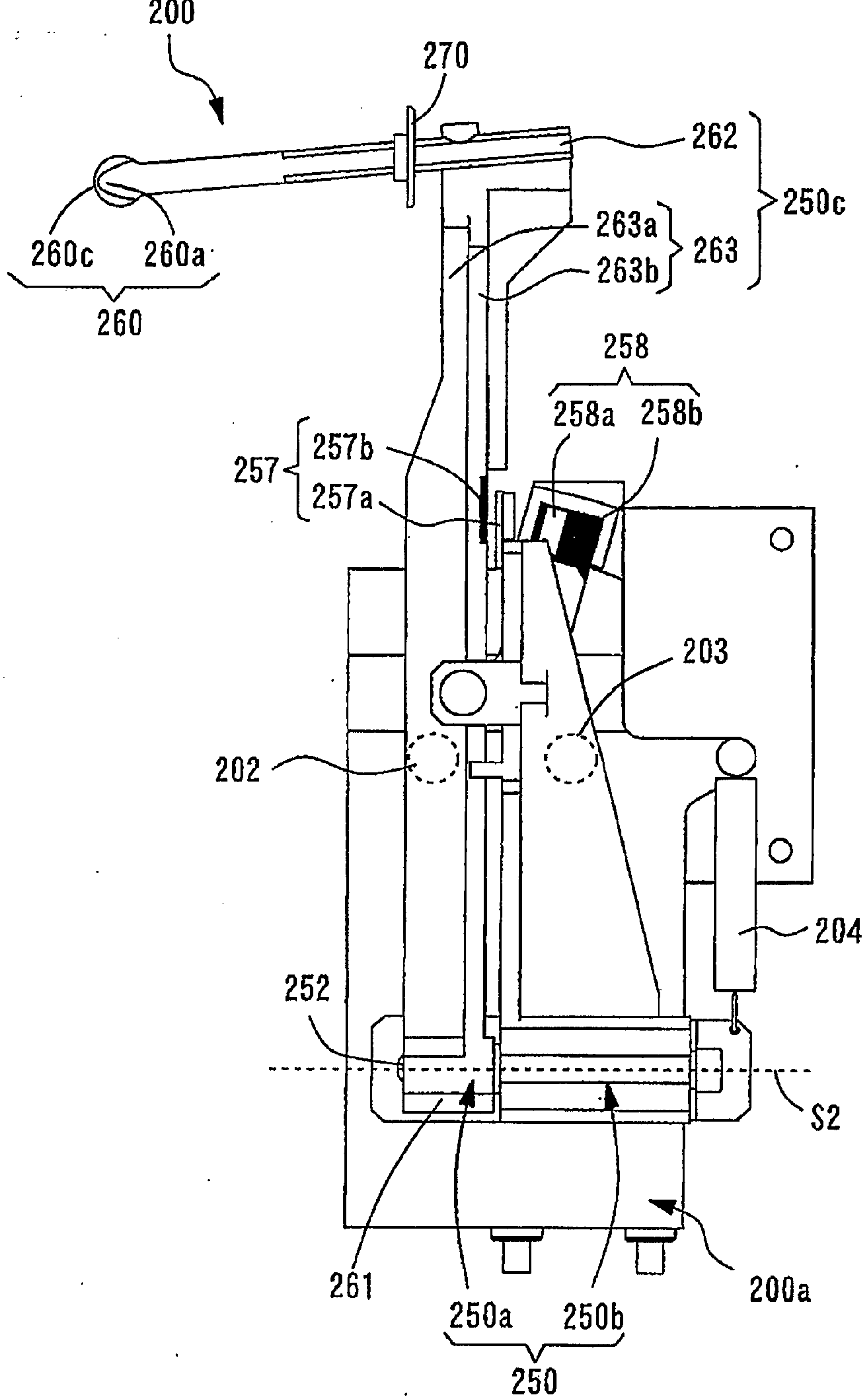

200
270
262
250c
263a
263
263b
260c
260a
260
258
258a
258b
257b
257
257a
203
202
204
252
S2
261
250a
250b
200a
250

FIG. 5

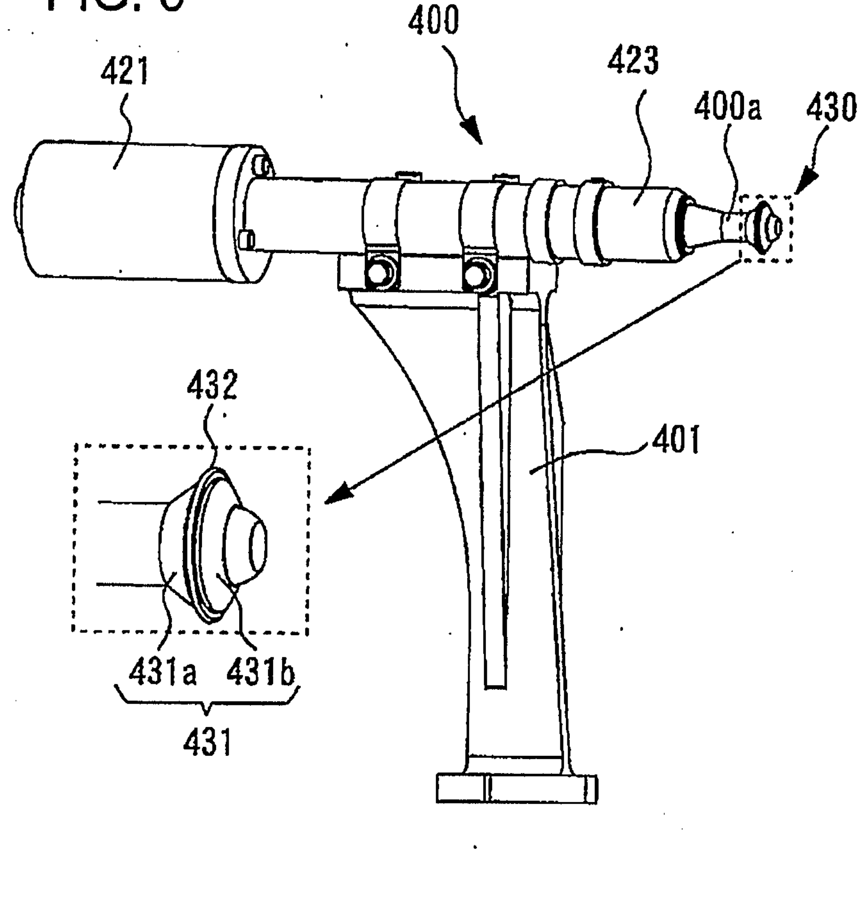


FIG. 6A

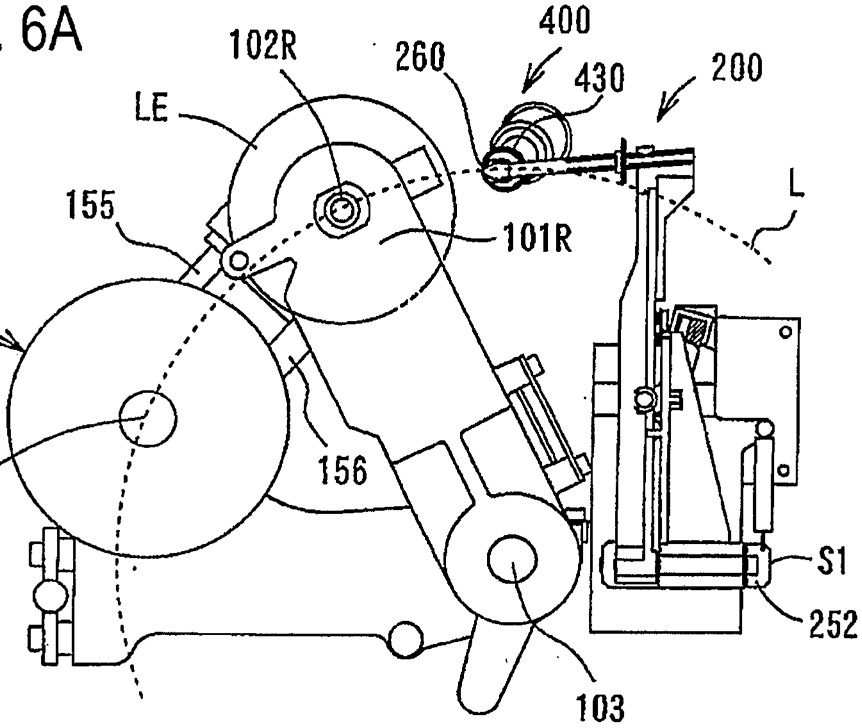

102R
260
400
430
200
LE
L
155
101R
168
161a
156
S1
252
103

FIG. 6B

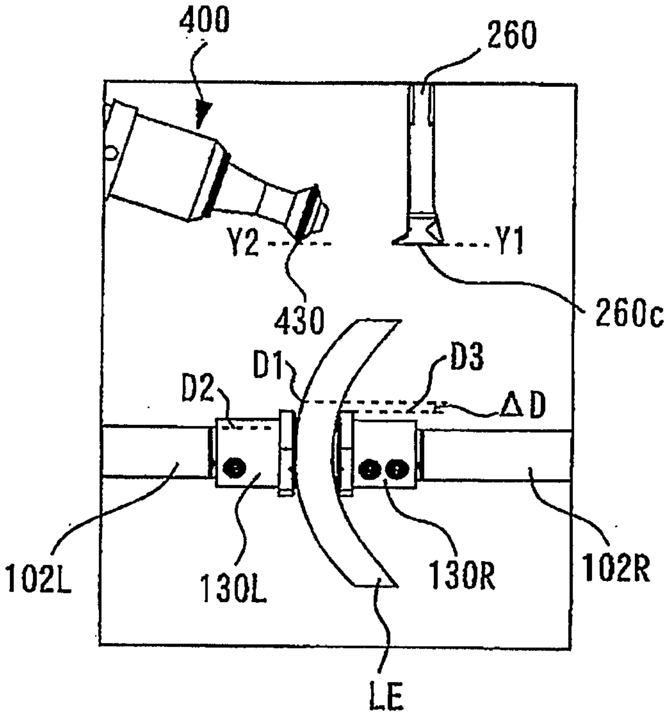

400
260
Y2
Y1
430
260c
D1
D3
D2
ΔD
102L
130L
130R
102R
LE

FIG. 7

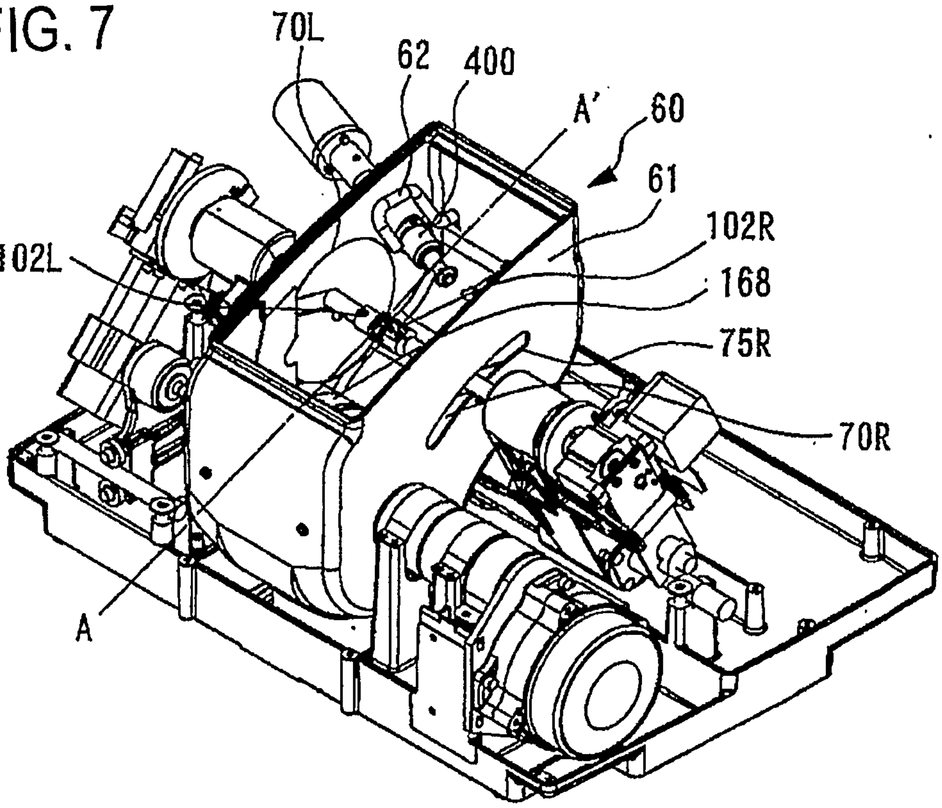


FIG. 8

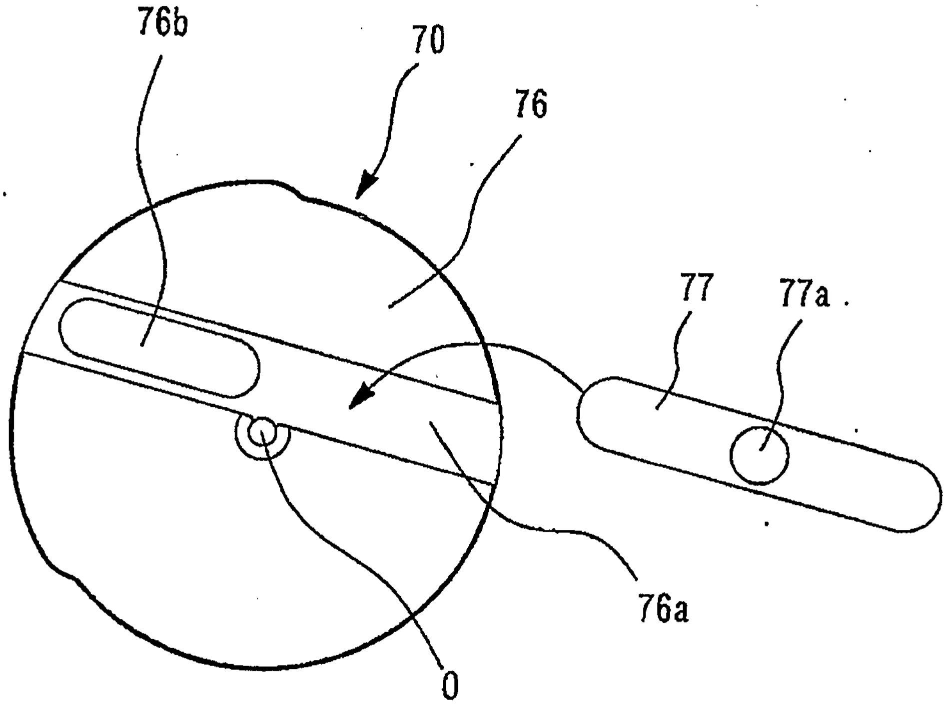


FIG. 9

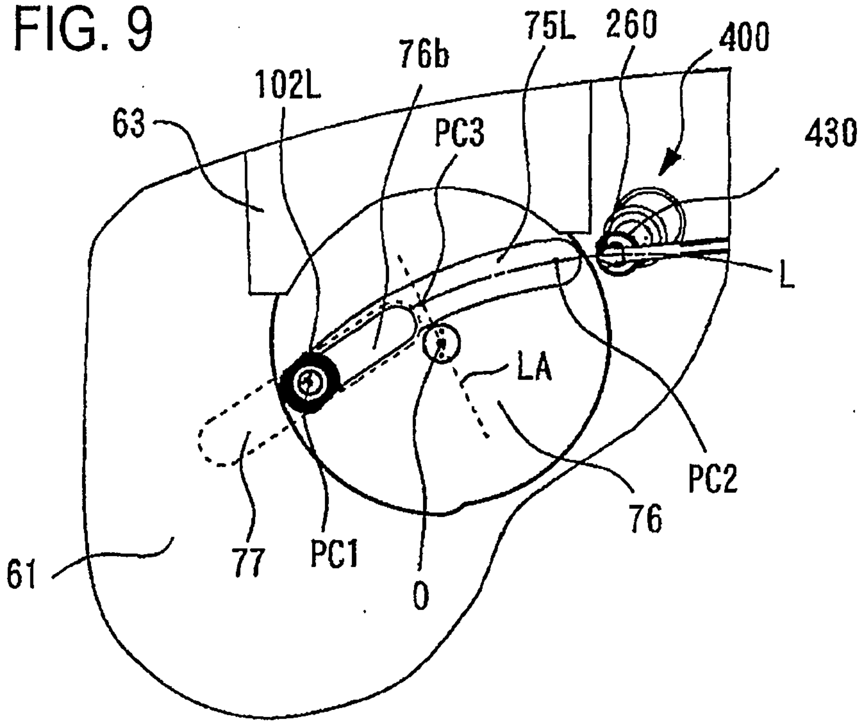


FIG. 10A

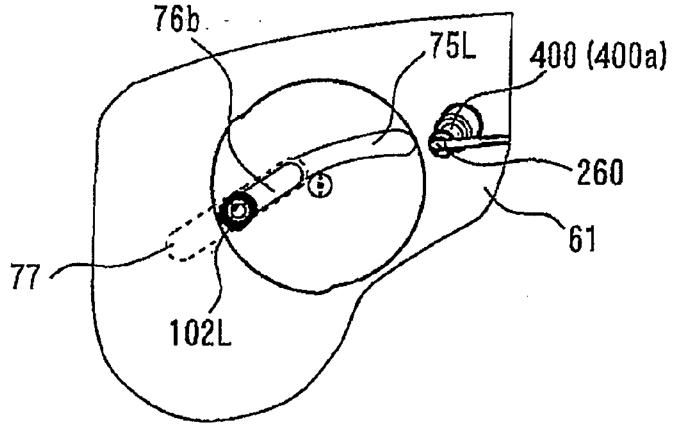


FIG. 10B

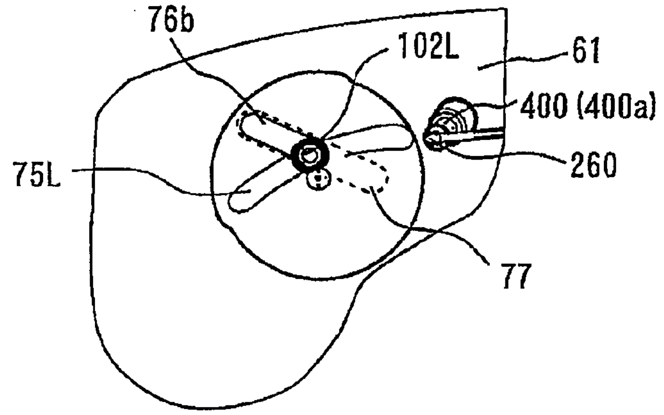


FIG. 10C

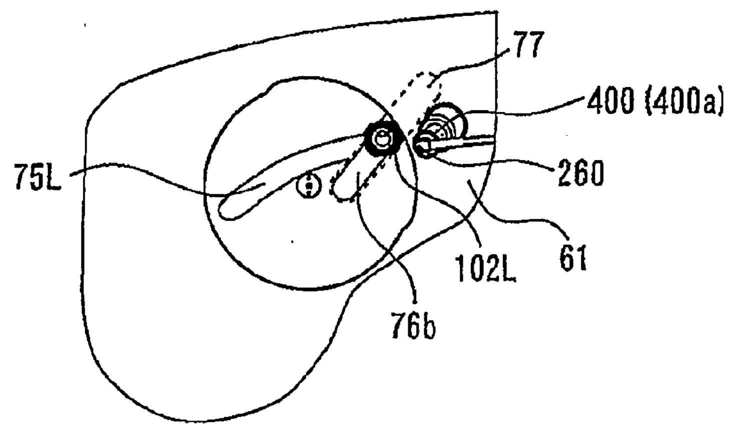


FIG. 11

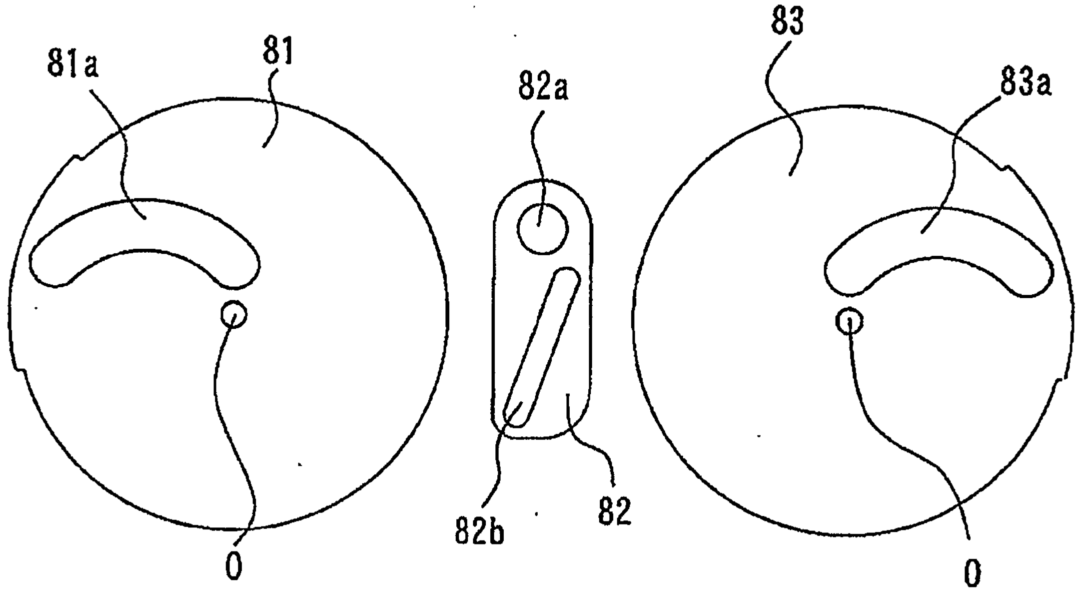

81a
81
82a
83
83a
0
82b
82
0

FIG. 12

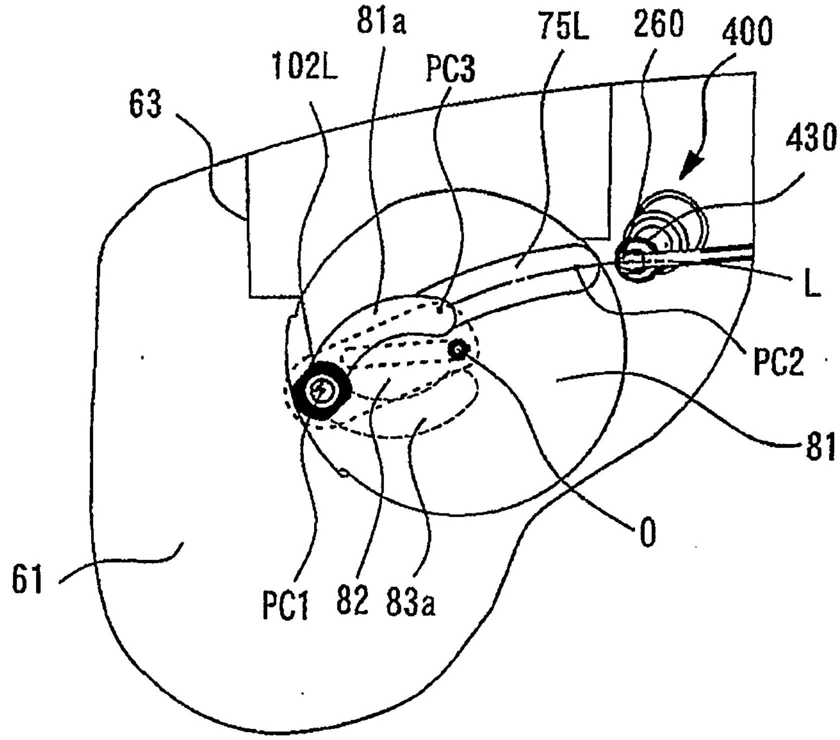

81a
75L
260
400
102L
PC3
63
430
L
PC2
81
0
61
PC1
82
83a

FIG. 13A

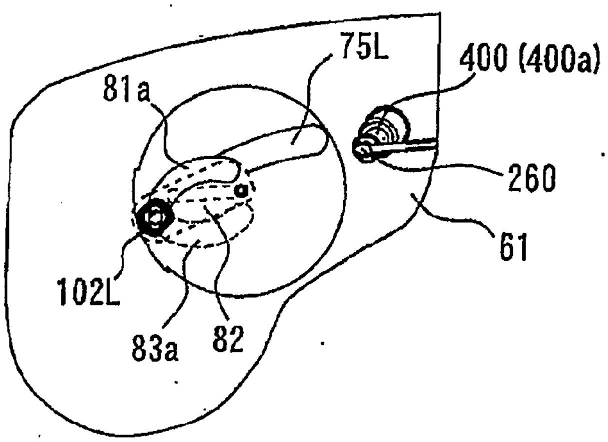


FIG. 13B

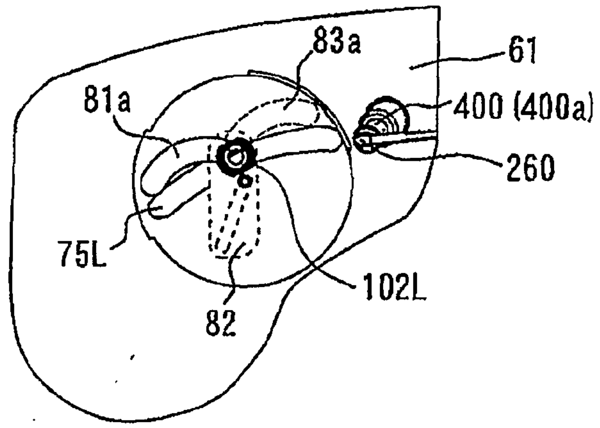


FIG. 13C

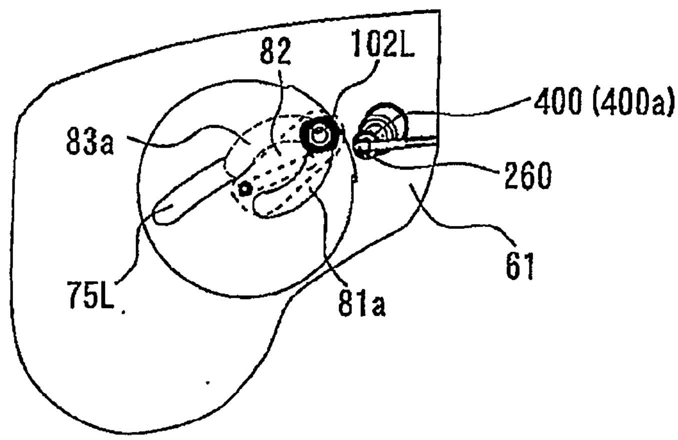


FIG. 14

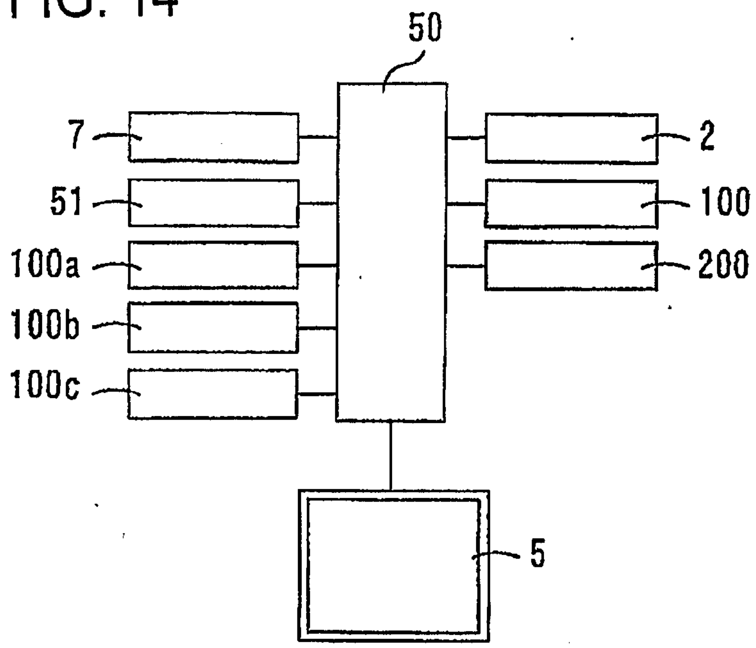


FIG. 15B

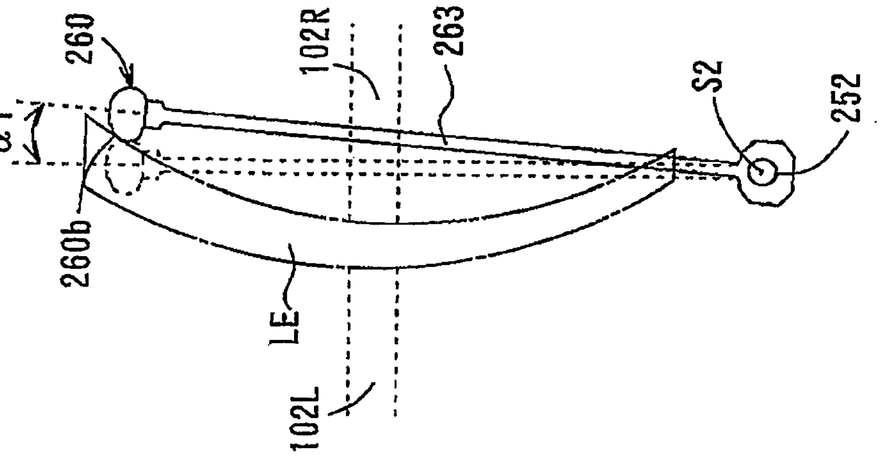


FIG. 15A

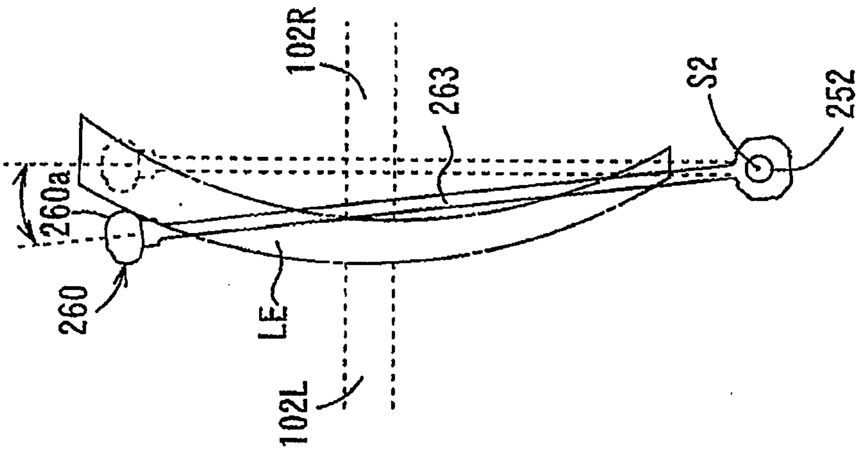


FIG. 16

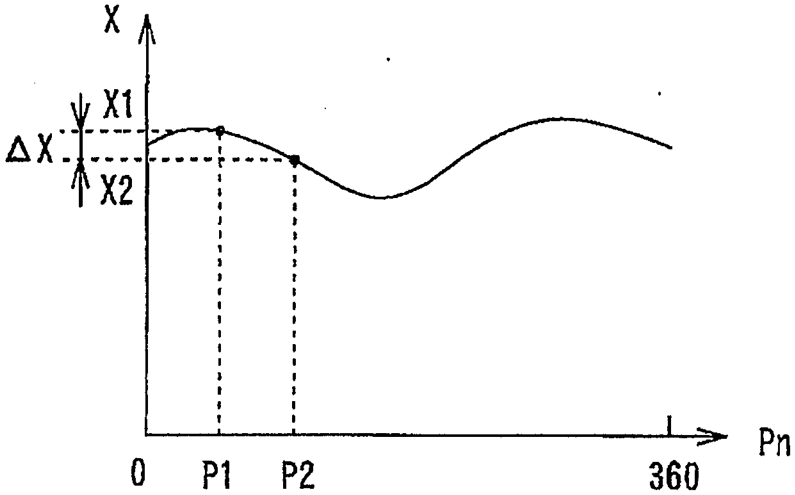


FIG. 17A

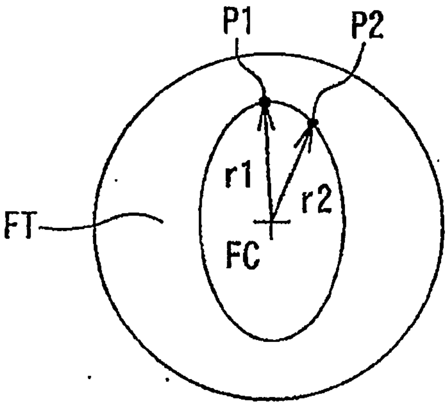


FIG. 17B

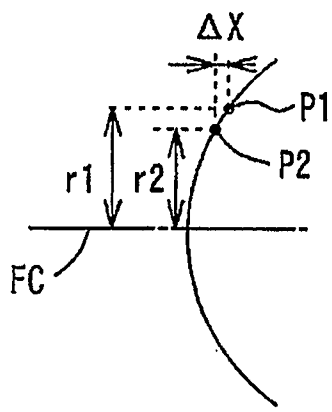


FIG. 18

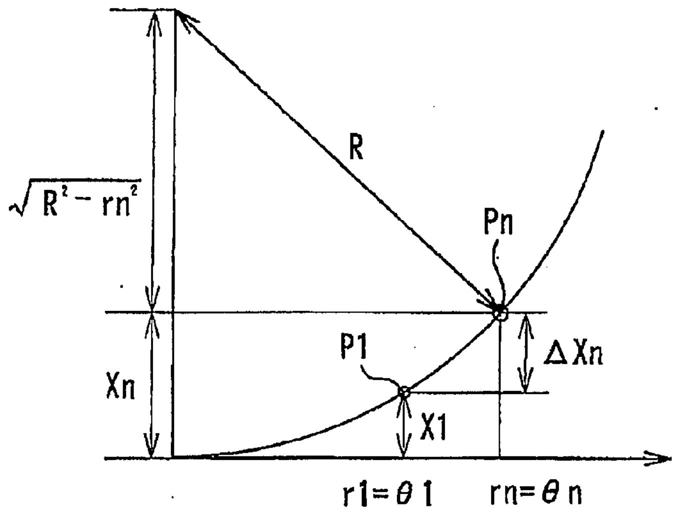
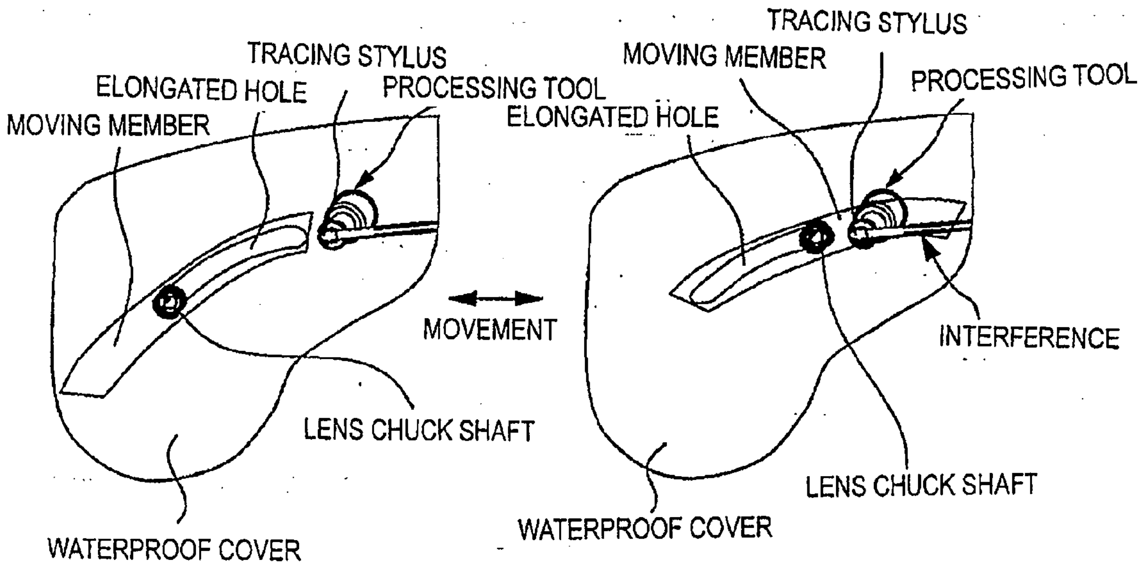

R
$\sqrt{R^2 - rn^2}$
Pn
P1
ΔXn
Xn
X1
$r1=\theta 1$
$rn=\theta n$

FIG. 19


TRACING STYLUS
ELONGATED HOLE
PROCESSING TOOL
MOVING MEMBER
MOVEMENT
LENS CHUCK SHAFT
WATERPROOF COVER
TRACING STYLUS
MOVING MEMBER
PROCESSING TOOL
ELONGATED HOLE
INTERFERENCE
LENS CHUCK SHAFT
WATERPROOF COVER

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- JP 2000317796 A **[0002] [0133]**
- JP 4093164 A **[0089]**