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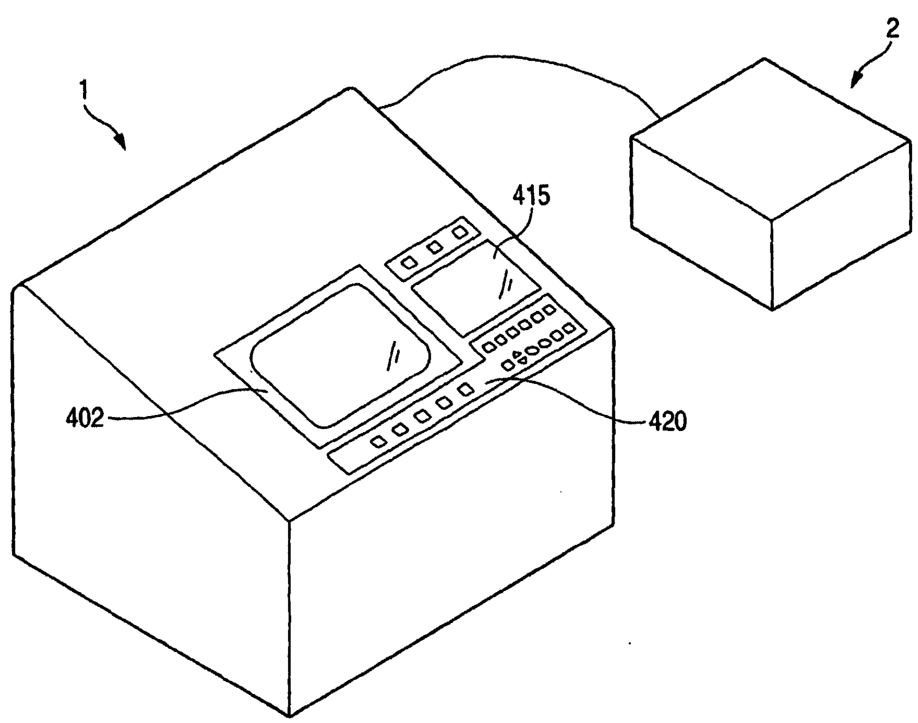
(54) Eyeglass lens processing apparatus

(57) An eyeglass lens processing apparatus (1) for processing a periphery of an eyeglass lens (LE) includes: lens rotating means including lens rotating shafts (110L, 110R) for holding the lens; first grinding means including a first grindstone rotating shaft (203) arranged with a first beveling grindstone for forming a bevel on the periphery of the lens; second grinding means including a second grindstone rotating shaft (260) arranged with a secondbeveling grindstone (271) having a smaller diameter than that of the first beveling grindstone, for forming a bevel on the periphery of the lens; and selecting means (420, 450) for selecting either of the first grinding means and the second grinding means when processing the bevel.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

[0001] The present invention is related to an eyeglass lens processing apparatus forprocessingtheperipheryof the eyeglass lenses.

[0002] In the eyeglass lens processing apparatus for processing the lens periphery for fitting the lens into the eyeglass frame, in general, the processing is performed on the lens periphery to form a reverse V-shaped bevel to be fitted into a V-shaped groove in the inside of the frame. This beveling is carried out by a beveling grindstone having a V-shaped beveling groove. The beveling grindstone is ordinarily cylindrical having a diameter of more than 100 mm, in view of consumption, similarly to a roughing grindstone.

[0003] Recently, eyeglass frames have tight curves owing to varieties of designs. However, if the bevel is formed on the lens periphery with using the cylindrical beveling grindstone having the diameter of more than 100 mm so as to coincide with the tight frame curve, the beveling grindstone and the formed bevel interfere each other, and the bevel becomes thin (the bevel width and height become smaller).

SUMMARY OF THE INVENTION

[0004] Accordingly, it is a technical object of the invention to provide such an eyeglass lens processing apparatus enabling to form the bevel on the lens periphery so as to coincide with the curve in the eyeglass frame.

[0005] For accomplishing the above-mentioned object, the invention is characterized by providing the under mentioned structures.

[0006] As to the structures of the eyeglass lens processing apparatus of the present invention.

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

lens rotating means including lens rotating shafts (110L, 110R) for holding the lens;
first grindingmeans including a first grindstone rotating shaft (203) arranged with a first beveling grindstone for forming a bevel on the periphery of the lens;
second grinding means including a second grindstone rotating shaft (260) arranged with a second beveling grindstone (271) having a smaller diameter than that of the first beveling grindstone, for forming a bevel on the periphery of the lens; and
selecting means (420, 450) for selecting either of the first grinding means and the second grinding means when processing the bevel.

(2) The eyeglass lens processing apparatus according to (1), further comprising determining means (420, 450) for setting a shape of the bevel formed on the periphery of the lens,

wherein the selecting means includes determining means for determining either of the first grindingmeans and the second grinding means on the basis of the set bevel shape.

(3) The eyeglass lens processing apparatus according to (1) or (2), wherein the second grindstone rotating shaft has a rotation axis tilting with respect to a rotation axis of the lens rotating shaft.

(4) The eyeglass lens processing apparatus according to any one of (1) to (3), wherein the second beveling grindstone is a grindstone having a conical shape with a beveling groove.

(5) The eyeglass lens processing apparatus according to (1) or (2), wherein the second grindstone rotating shaft has a rotation axis tilting with respect to a rotation axis of the lens rotating shaft, and

wherein the second beveling grindstone is a grindstone having a conical shape with a beveling groove, processing faces formed at opposite sides of the beveling groove being parallel with the rotation axis of the lens rotating shaft.

(6) The eyeglass lens processing apparatus according to any one of (1) to (5), wherein the lens rotating shaft, the first grindstone rotating shaft and the second grindstone rotating shaft are arranged such that the respective rotation axes are positioned on the same plane, and the lens rotating shaft is arrangedbetween the first and second grindstone rotating shafts, and

the eyeglass lens processing apparatus further comprises moving means for moving the lens rotating shaft in a direction of changing a distance between the rotation axes with respect to the respective first and second grindstone rotating shafts.

(7) The eyeglass lens processing apparatus according to any one of (1) to (5), wherein the first grindstone rotating shaft is coaxially arranged with a roughing grindstones (201a, 201b), and

wherein the second grindstone rotating shaft is coaxially arranged with at least one of a chamfering grindstone (272, 273), a grooving grindstone (274) and a drilling tool (280).

BRIEF DESCRIPTION OF THE DRAWINGS

[0007]

Fig. 1 is a schematically external view of the eyeglass lens processing apparatus according to the invention;
Fig. 2 is a schematic diagram of the lens processing portion;
Fig. 3 is a schematic diagram of the lens processing portion;
Fig. 4 is a schematic diagram of the carriage;
Fig. 5 is a schematic diagram of the second grinding portion;
Fig. 6 is a schematic diagram of the measuring portion 2a of the measuring unit 2 of the eyeglasses frame shape;
Fig. 7 is a schematic block diagram of the control system of the present apparatus; and
Figs. 8A and 8B are views for explaining the method of obtaining the processing information of the beveling grindstone of small diameter.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0008] One embodiment of the invention will be explained on the basis of the attached drawings. Figure 1 is a schematic diagram of the eyeglass lens processing apparatus according to the invention. A main body 1 of the apparatus is connected to an eyeglass frame shape (target lens shape) measuring unit 2. The main body 1 is equipped with a display 415 for displaying processing information and an operation panel portion 420 with various switches. Reference number 402 designates an opening window for a processing room.

[0009] Figs. 2 and 3 are schematic diagram of a lens processing portion equipped within the main body 1. Fig. 2 is a view seen from the upper part of the processing portion 5. Fig. 3 is a view seen from the right side of the processing portion 5. Incidentally, the main body 1 is provided with a lens shape measuring unit to which known units (described in US Re.35, 898 (Japanese Patent Laid Open No.212661/1993), or EP1310326 A1 (Japanese Patent Laid Open No. 2003-145400)) may be applied, and thus explanation will be omitted.

[0010] A carriage 100, a first grinding portion 200 and a second grinding portion 250 are arranged on a base 10. An eyeglass lens LE to be processed is chucked and held by two lens rotating shafts 110L, 110R of the carriage portion 100, and is subjected to a grinding (edging) on the periphery by the first and second grinding portions 200 and 250.

<First grinding portion>

[0011] The first grinding portion 200 is disposed on the front side of the carriage portion 100, and includes a roughing grindstone 201a for glasses, a roughing grindstone 201b for plastics, and a large diameter bevel finishing grindstone 201c (beveling and flat-edging grindstone) 201c having a V-shaped beveling groove 202a for beveling (finishing) and a flat processing face 202b for flat-edging (finishing). The finishing grindstone 201c may be the beveling grindstone having only the beveling groove 202a. These grindstones 201a, 201b, 201c are coaxially (each of the rotation axes is coaxial) disposed (attached) on a grindstone rotating shaft 203. The shaft 203 is rotatably pivoted on a spindle unit 205 secured on the base 10, and is connected at its end to a motor 207. The shaft 203 is rotated by driving of the motor 207, thereby to rotate the grindstones 201a, 201b, 201c. Further, the grindstones 201a, 201b, 201c are cylindrical, and approximately 100 mm in diameter for lengthening lives to abrasion. Incidentally, the grindstone 201c is used when a path of the bevel to be formed has a comparatively moderate curve (in case a curve value Crv is less than 6).

<Carriage>

[0012] The carriage portion 100 includes a carriage base 101 which is movable along two rail shafts 107 extending in a direction of the rotation axis of the shaft 203 (called as "X-axial direction" hereafter) and secured on the base 10. A rack 103 extending in the X-axial direction is fixed to a rear side of the carriage base 101, and is connected to a pinion 104 mounted on a rotation shaft of a pulse motor 105 secured on the base 10. The rack 103 is moved by driving the motor 105, so that the carriage base 101 is moved in the X-axial direction.

[0013] A carriage 112 having approximately U-shape seen from a front side is mounted on the carriage base 101.

Fig. 4 is a schematic diagram of the carriage 112 seen from the front side. The carriage 112 is provided with an upward extending left arm 112L and right arm 112R, the left arm 112L holding the shaft 110L and the right arm 112R holding the shaft 110R, and both shafts 110L, 110R being held rotatably and coaxially in the X-axial direction (each of the rotation axes is coaxial). The shaft 110R is movable in the direction of the rotation axis (X-axial direction) by the motor 115 fixed to the right side of the carriage 112 and by a moving mechanism 116 such as a feed screw provided inside of the right arm 112R, so that the lens LE is chucked and held by the shafts 110L, 110R. On the other hand, a shaft 120 extending in the X-axial direction and disposed within the carriage 112 is connected to the rotating shaft of the motor 117 fixed to the right side of the carriage 112. The shaft 120 is connected to the shaft 110L via a belt 121 and also to the shaft 110R via a belt 122. The shaft 120 is rotated by driving of the motor 117, so that the shafts 110L, 110R are simultaneously (synchronously) rotated.

[0014] The carriage base 101 is secured with two rail shafts 131 extending in parallel in a direction of changing a distance between the rotation axis of the shaft 203 and the rotation axes of the shafts 110L, 110R (called as "Y-axial direction" hereafter). The Y-axial direction in the present embodiment tilts approximately 15 degrees toward this side (the front side) , and the upper surface of the carriage base 101 also tilts toward this side (see Figure 3). The carriage 112 is displaced movably in the Y-axial direction along the shafts 131. The motor 135 is fixed to a rear side of the carriage base 101, and is connected, on its rotating shaft, to a feed screw 133 extending in the Y-axial direction. The screw 133 is rotated by driving of the motor 135, so that the carriage 112 is moved in the Y-axial direction. For the motor 135, a servomotor provided with an encoder 136 for detecting rotation is employed. During processing, rotation torque (motor load current) of themotor 135 is detected, and voltage supplied to the motor 135 is controlled on the basis of detected results, so that a processing pressure of the lens LE to the grindstone is controlled. Position information of moving the carriage 112 is detected on the basis of a signal issued from the encoder 136, and the processing finish is judged.

<Second grinding portion>

[0015] The second grinding portion 250 is secured on the base 10 via an attaching member 201 so as to be positioned at the inner part of the carriage portion 100. Fig. 5 is a schematic diagram of the second grinding portion 250. The second grinding portion 250 is provided with a motor 253, an L-shaped support 257 rotatably supporting a rotating shaft 255 connected to the motor 253 and a grindstone rotating shaft 260, a grinding portion 270 and a drilling tool 280 disposed (attached) to the shaft 260. The rotation of the shaft 255 by driving of the motor 253 is transmitted to the shaft 260 via bevel gears 258, 261, so that the grinding portion 270 and the drilling tool 280 are rotated.

[0016] The rotation axis of the shaft 260, the rotation axes of the shafts 110L, 110R and the rotation axis of the shaft 203 are arranged to be positioned on the same plane 01 (see Fig. 3). The rotation axis of the shaft 260 tilt with respect to the rotation axes of the shafts 110L, 110R (X-axial direction) on the same plane 01 (see Fig. 5). The tilting angle $\alpha 1$ is preferably 5 to 15 degrees, and in the present embodiment, it is approximately 10 degrees.

[0017] The grinding portion 270 is provided with a small diameter conically shaped beveling grindstone 271 having a V-shaped beveling groove 271a, a chamfering grindstone 272 for a lens front surface, a chamfering grindstone 273 for a lens rear surface, and a grooving grindstone 274. The grindstone 271 is smaller in diameter than the grindstone 201c, desirably less than half of the grindstone 201c. Thereby, the bevel can be restrained from becoming thin, even if the path of the bevel to be formed has a comparatively tight curve (in case the curve value Crv is more than 6). In the present embodiment, the diameter of the grindstone 271 (the smallest diameter of the groove 271a) is approximately 30 mm. An angle (angle with respect to the rotation axis of the shaft 260) of a conical shaped processed face (processing faces at both outsides of the groove 271a) of the grindstone 271 is the same as the tilting angle α of the shaft 260. Therefore, the processing face of the grindstone 271 is parallel with the direction of the rotation axes of the shafts 110L, 110R (X-axial direction) (see Figure 5). The respective largest outer diameters of the grindstones 272, 273 are positioned on the extension of the processing face of the grindstone 271. The largest outer diameter of the grindstone 274 is positioned somewhat inside than the extension of the processing face of the grindstone 271. The drilling tool 280 is coaxial with the shaft 260 (the respective rotation axes are coaxial), and is disposed (attached) at the end part thereof.

[0018] By the way, it is sufficient that the shaft 260 is not tilted and kept parallel with the direction of the rotation axes of the shafts 110L, 110R (x-axial direction) , but for preventing the bevel frombecoming thin also in case the curve of the beveled path is more tight, the shaft 260 is preferably tilted.

[0019] The carriage 112 is movable in the Y-axial direction for forcing the lens LE chucked and held by the shafts 110L, 110R to the grinding portion 270, and the distance between the rotation axes of the shafts 110L, 110R and the rotation axis of the shaft 203 is changed by controlling driving of the motor 135.

[0020] Figure 6 is a schematic diagram of a measuring portion 2a of the eyeglasses frame shape measuring unit 2. The measuring portion 2a includes: a first base 21 movable horizontally; a second base 22 to be rotated by a pulse motor 30 fixed to the first base 21; holding plates 35a, 35b provided perpendicular with the second base 22; a moving block 37 movable along two shafts 36a, 36b fixed to the holding plates 35a, 35b and extend in parallel with each other; a gauge shaft 23 passing through the moving block 37 and being rotatable and vertically movable; a gauge head 24 provided at the upper end of the gauge shaft 23, the distal end of the gauge head 24 being on the axis of the gauge shaft 23; an arm 41 rotatably attached to the lower end of the gauge shaft 23 and fixed to a pin 42 vertically extending from the moving block 37; a shielding plate 25 provided to the front end of the arm 41 and formed with a vertical slit 26 and a slit 27 tilting 45 degrees with respect to the vertical slit 26; a pair of light emitting diode 28 and linear image sensor 29 provided on the second base 22 as holding the shielding plate 25 therebetween; and a constant torque spring 43 attached on a drum 44 rotatably pivoted on the second base 22 and always pulling the moving block 37 to the front end side of the gauge head 24.

[0021] With such constructed measuring portion 2a, the shape of the eyeglass frame is measured as described hereinafter. At first, the frame is held and secured to a frame holding portion (not shown, see US Re.35,898 (Japanese Patent Laid Open No.212,661/1993)), and the gauge head 24 is contacted at its front end to the inside groove of the frame. Subsequently, the motor 30 is rotated per each of pulse numbers of predetermined unit rotation. At this time, the gauge shaft 23 integrally with the gauge head 24 move along the shafts 36a, 36b following radius vector of the frame, and vertically moves following the curve of the frame. According to their movement, the shielding plate 25 moves vertically and laterally between the light emitting diode 28 and the linear image sensor 29, and cuts off the light from the light emitting diode 28. The light passing through the slits 26, 27 formed in the shielding plate 25 reaches a light reception part of the linear image sensor 29, and a moving amount thereof is read out. The moving amount is read out in a manner that the position of the slit 26 is the radius vector r of the frame, and the difference in position between the slit 26 and the slit 27 is read out as a height z of the frame. By measuring N points in this manner, the shapes of the frames are measured as (rn, θn, zn) (n = 1, 2, ... N) (as to details, see US Patent No.5,138,770 (Japanese Patent Laid Open No.105864/ 1992).

[0022] In the apparatus having the above mentioned structure, the operation thereof will be explained with reference to a schematic block diagram of the control system in Fig. 7. At first, the frame shape is measured by the unit 2. The data (rn, θn, zn) of the frame shape are input and stored in the data memory 451 by depressing a switch 421 of the operation panel portion 420. A target lens shape figure 310 based on the frame shape data is displayed on the display 415, and processing conditions is ready for being set or input. An operator inputs the processing conditions such as layout data including PD value and FPD value of a wearer of the eyeglass and height of an optical center, material of the lens to be processed, material of the frame, processing mode, and the like. Herein, assuming that the lens LE is processed to coincide with the frame of tight curve, the processing mode is set to a bevel forcing mode by the mode switch 422. When the processing condition is inputted, the lens LE is chucked and held by the shafts 110L, 110R, and the start switch 423 is depressed to activate the apparatus.

[0023] The controller 450 activates the lens shape measuring portion 500 by a start signal, and measures a position of an edge of the lens LE corresponding to the frame shape data and the layout data. Then, the controller 450 carries out a bevel calculation for obtaining a path of an apex of the bevel to be formed on the periphery of the lens LE on the basis of the edge position information according to a predetermined program. The bevel apex path is one of methods for representing the bevel shape data. The bevel calculation at this stage divides, for example, the lens edge thickness with a predetermined ratio (for example, 3 : 7 from the front surface side of the lens), and positions the bevel apexes on the full radius vector periphery.

[0024] When finishing the bevel calculation, the screen of the display 415 switches, as shown in Fig. 7, to a simulation screen image in which the bevel shape can be changed. An approximate curve value (Bevel curve) obtained from the bevel apex path obtained by the above bevel calculation is displayed on an item 301 "Curve" of an initial screen. An approximate curve value (Frame curve) of the frame measured by the unit 2 is displayed on the item 302 "FC". The item 303 "Position" is an item for inputting an offset amount of moving the bevel apex path in parallel to the front or rear surface side of the lens. The item 304 "TILT" is an item for inputting the data for tilting the bevel apex path.

[0025] The value of the item 301 "Curve" is obtained, for example, as follows. From arbitrary four points in the path of the bevel apex path obtained by the bevel calculation, it is assumed that the four points are positioned on the spherical surface having the same centers (a, b, c) and radius r.

[0026] An equation of the spherical surface is

Equation 1

$$(x-a)^2 + (y-b)^2 + (z-c)^2 = r^2$$

[0027] By substituting the arbitrary four points of the bevel apex position into this equation, the centers (a, b, c) and radius r of the spherical surface passing through the four points are obtained respectively. This calculation is carried out to make several couples of the calculation (4 or 5 couples) for getting an average. The curve value Crv is determined based on the obtained radius r of the lens. The curve value Crv customarily expresses the lens curve in the eyeglass lens, and is obtained by the following equation.

Equation 2

$$Crv = (n-1)/r$$

[0028] In this equation, n designates refractive index, and in general given 1.523. The curve value of the frame (Frame curve) of the item 302 is obtained in the same manner.

[0029] Herein, if difference between the bevel curve and the frame curve is too large, the lens cannot be fitted into the frame, and in such a case, the bevel curve is adjusted to coincide with the frame curve with reference to the curve value displayed in the item 302. The adjusting is carried out as follows. A highlight cursor 300 (reversingdisplay) displayed by depressing two switches 425 is met to the item 301, and the curve value is changed to a desired value by operating the switches 430a and 430b. To move the bevel apexes position in parallel, the highlight cursor 300 is met to the item 303 and the offset value is input. The controller 450 obtains, on the basis of the changed input data, a coordinate of a center point of the spherical surface on which the bevel apex stands at the position of the minimum lens edge thickness, and recalculates the bevel apex position on the basis of the radius of the bevel curve obtained based on the coordinate of the center point and the curve value.

[0030] Incidentally, the target lens shape figure 310 based on the frame shape data, a mark 311 showing the position of the minimum lens edge thickness, the mark 312 showing the position of the maximum lens edge thickness, and a rotation cursor 313 designating the radius vector position for showing the bevel forming condition in a bevel cross sectional displaying portion 320 are displayed on the simulation screen. By changing the position of the rotation cursor 313 by the switch of the operation panel 420, the operator can confirm the bevel forming condition planned after processing all over the periphery.

[0031] Based on whether the bevel curve set at the item 301 is tight or moderate, the operator selects by the switch 427 the beveling grindstone used at the time of beveling. For example, in case the curve value Crv of the bevel is more than 6 (tight) , the grindstone 271 is selected, and in case the curve value Crv of the bevel is less than 6 (moderate), the grindstone 201C is selected. The selection information is displayed on the display item 330 on the display 415. When selecting the grindstone 271, "Small" is displayed, and when selecting the grindstone 201c, "Large" is displayed.

[0032] The controller 450 obtains the processing information for beveling in response to the selection of the beveling grindstone. Calculation of the processing information will be explained. At first, in case of the cylindrical grindstone 201c, the processing information is obtained as follows. It is assumed that the radius vector information of the bevel apex path is (En, θn) (n = 1, 2, ...N). En is the radius vector length (radius), and θn is the radius vector angle. Further, the radius of the groove 202a in the grindstone 201c is assumed to be Rb. At this time, the axis-to-axis distance Lb between the rotation center (rotation axis) of the grindstone 201c and the processing center (rotational axis) of the lens LE (the distance between the rotation axis of the shaft 203 and the rotation axes of the shafts 110L, 110R) is obtained by the following equation.

Equation 3

$$Lb = En \cdot \cos\theta n + (Rb^2 - En^2 \cdot \sin^2\theta n)^{1/2} \qquad (n=1,2,3,...,N)$$

[0033] Herein, the radius vector information (En, θn) is rotated around the processing center by a minute arbitrary unit angle, and the maximum value of Lb at such time is demanded. This rotating angle is assumed to be ξi (i = 1, 2, 3, ... N). The maximum value of Lb at the respective ξi is assumed to be Lbi and θn at this time of the maximum value of Lb is assumed to be Θi. Byperforming the calculation all over the full periphery, the processing information in the direction of the axis-to-axis distance (Y-axial direction) is obtained as (ξi, Lbi, Θi)(i = 1, 2, 3, ... N).

[0034] In case of the grindstone 271, since the shaft 260 is not parallel to the shafts 110L, 110R, when seeing the grindstone shape from the direction of the rotation axes of the shafts 110L, 110R, it is oval as shown in Figure 8A. If the radius of the groove 271a in the grindstone 271 is assumed to be Rs, the axis-to-axis distance Ls between the rotating center (the rotation axis) of the grindstone 271 and the processing center (rotation axis) of the lens LE (the distance is between the rotation axis of the shaft 260 and the rotation axes of the shafts 110L, 110R) is obtained by the following equation.

Equation 4

$$Ls = En \cdot \cos\theta n + (Rs^2 - En^2 \cdot \sin^2\theta n)^{1/2} \cdot \cos\alpha \qquad (n=1,2,3,...,N)$$

[0035] Similarly to the above mentioned, the maximum value of Ls when the radius vector information (En, θn) is rotated around the processing center by the minute arbitrary unit angle is obtained. This rotating angle is assumed to be ξi (i = 1, 2, 3, ... N) . The maximum value of Ls in the respective ξI is assumed to be Lsi and θn at the time of the maximum value is assumed to be Θi. By performing this calculation all over the full periphery, the processing information in the direction of the axis-to-axis distance (Y-axial direction) is obtained as (ξi, Lbi, Θi) (i = 1, 2, 3, ... N).

[0036] Since the shaft 260 tilts, when seeing the grindstone shape from the side of the lens LE, it is oval as shown in Figure 8B. Therefore, using the grindstone 271, the direction of the rotation axes axial of the shafts 110L, 110R (X-axial direction) must be corrected. The dislocation amount Xs in the X-axial direction is obtained by the following equation.

Equation 5

$$Xs = \sin\alpha \cdot \{Rs - (Rs^2 - En^2 \cdot \sin^2\theta n)^{1/2}\} \qquad (n=1,2,3,...N)$$

[0037] Similarly to the above mentioned, the radius vector information (En, θn) is rotated around the processing center by the minute arbitrary unit angle, and the maximum value of Xs at such time is obtained, whereby it is obtained as the correcting information in the X-axial direction (ξi, Lsi, Θi) (i = 1, 2, 3, ... N).

[0038] After confirming the bevel forming condition through the bevel cross sectional displaying portion 320, if there is no problem, the start switch 423 is depressed to start the processing. The controller 450 controls the operation of the carriage portion 100 in accordance with a processing sequence and executes the processing. In the case that the material of the lens LE is plastic, the carriage base 101 is moved in the X-axial direction by controlling drive of the motor 105 such that the chucked and held lens LE is positionedon the grindstone 201b. Subsequently, the carriage base 112 is moved in the Y-axial direction by controlling drive of the motor 135, so that a roughing is executed on the periphery of the lens LE.

[0039] Finishing the roughing, the processing is shifted to the beveling. If the grindstone 271 has been selected, the motor 207 is stopped rotating and the motor 253 is rotated, and the carriage base 101 is moved to the X-axial direction such that the lens LE is positioned on the groove 271a of the grindstone 271. Then, the carriage 112 is moved to the Y-axial direction on the basis of the processing information (ξi, Lsi, Θi) in the Y-axial direction, and the carriage 112 is moved to theX-axial direction on the basis of the bevel apex path data and the correcting information (ξi, Xsi, Θi) in the X-axial direction, and while rotating the lens LE, the periphery of the lens LE is pressed to the grindstone 271 to perform the beveling. Using the conical grindstone 271 in such a way, even if the bevel curve is tight, it is possible to carry out the process as restraining the bevel from being thin.

[0040] Incidentally, at the time of processing the lens LE, the controller 450 controls the pressing pressure of the lens LE with respect to the grindstone on the basis of the detection of the rotation torque of the motor 135, and controls the moving position in the Y-axial direction of the carriage 112 on the basis of a signal issued from the encoder 136, and judges the processing finish.

[0041] When the grindstone 201c has been selected, the lens LE is positioned on the groove 202a of the grindstone 201C after finishing the roughing, and the carriage 112 is moved in the Y-axial direction on the basis of the processing information (ξi, Xsi, Θi) in the Y-axial direction while the carriage 112 is moved in the X-axial direction on the basis of the bevel apex path data to carry out the beveling process by pressing the periphery of the lens LE to the grindstone 201c. If dealing with all the beveling with only the conical grindstone 271, in case the beveled curve is contrary moderate, the bevel becomes thin due to the interference. Therefore, in the case that the beveled curve is moderate, the process can be carried out by preventing the bevel from being thin by using the cylindrical grindstone 201c.

[0042] Although, in the above description, the beveling grindstone is selected by the operator depressing the switch 427, the controller 450 may be designed so as to make a determination on the basis of the curve value (this is one of the methods displaying the bevel shape data). That is, similarly to the above example, when the beveled curve value Crv is less than 6, the grindstone 201c is determined to use, and when the bevel curve value Crv is more than 6, the grindstone 271 is determined to use. Incidentally, as to the control in which the controller 450 automatically determines the beveling grindstone on the basis of the bevel curve values, at the time of processing a right and left eye lenses, when one curve value Crv is more than 6, and the other curve value Crv is less than 6, it is sufficient to use, for the later processing, the same grindstone used in initial processed processing.

[0043] In the present apparatus, the shaft 260 is equipped with the chamfering grindstone 272, 273, the grooving grindstone 274 and the drill 280. Therefore, the present apparatus may be also applied to the chamfering of the lens LE, the grooving and the drilling.

[0044] In case that the chamfering has been selected by the switch of the operation panel 420, the controller 450 controls the carriage 112 to move in the X- and Y-axial directions on the basis of separately obtained chamfering data. For chamfering the front surface, the grindstone 272 is controlled to contact the front edge of the lens LE, while for chamfering the lens rear surface, the grindstone 273 is controlled to contact the rear edge of the lens LE.

[0045] In case the processing mode is set to the grooving mode, after the roughing and the flat-edging, the controller 450 controls the carriage 112 to move in the X- and Y-axial directions on the basis of the separately obtained grooving data, and the grindstone 274 is pressed to the periphery of the lens LE to carry out the grooving. The grooving data can be obtained basically in the similar manner in the processing information of the grindstone 271.

[0046] In case that the processing mode is set to the drilling mode, the drilling position data is input by using the switch of the operation panel 420. The drillingposition data is given, for example, at the radius vector length and angle with respect to the rotating center of the lens. The controller 450 converts the drilling position data into the data of the X- and Y-axial directions and the lens rotating angle, and positions the front end of the drilling tool 280 to the drilling position of the front surface of the lens. Then, the carriage 112 is controlled to move in the X- and Y-axial directions, such that the lens LE is moved to the tilting angle α of the shaft 260.

[0047] The second grinding portion 250 in the above embodiment has been explained in the arrangement in the direction opposite to the first grinding portion 200 with respect to the shaft 110L, 110R, and such an arranging structure is also available. That is, when using the first grinding portion 200, the second grinding portion 250 is at a retreating position, and when using the second grinding portion 250, it is moved between the shafts 110L, 110R and the first grinding portion 200.

[0048] Further, by providing a third beveling grindstone having an intermediate diameter set between the diameter of the small diameter beveling grindstone 271 and the diameter of the large diameter beveling grindstone 271, it is possible to restrain the bevel from being thin with respect to an intermediate bevel curve of the curve value Crv being 4 to 6. In this case, for the structures shown in Figures 2 and 3, it is sufficient to move the third beveling grindstone from the retreating position to the using position.

Claims

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

   lens rotating means including lens rotating shafts (110L, 110R) for holding the lens;
   first grinding means including a first grindstone rotating shaft (203) arranged withafirstbeveling grindstone for forming a bevel on the periphery of the lens;
   second grinding means including a second grindstone rotating shaft (260) arranged with a second beveling grindstone (271) having a smaller diameter than that of the first beveling grindstone, for forming a bevel on the periphery of the lens; and
   selecting means (420, 450) for selecting either of the first grinding means and the second grinding means when processing the bevel.

2. The eyeglass lens processing apparatus according to claim 1, further comprising determining means (420, 450) for setting a shape of the bevel formed on the periphery of the lens,
   wherein the selecting means includes determining means for determining either of the first grinding means and the second grinding means on the basis of the set bevel shape.

3. The eyeglass lens processing apparatus according to claim 1 or 2, wherein the second grindstone rotating shaft has a rotation axis tilting with respect to a rotation axis of the lens rotating shaft.

4. The eyeglass lens processing apparatus according to any one of claims 1 to 3, wherein the second beveling grindstone is a grindstone having a conical shape with a beveling groove.

5. The eyeglass lens processing apparatus according to claim 1 or 2, wherein the second grindstone rotating shaft has a rotation axis tilting with respect to a rotation axis of the lens rotating shaft, and
   wherein the second beveling grindstone is a grindstone having a conical shape with a beveling groove, processing faces formed at opposite sides of the beveling groove being parallel with the rotation axis of the lens rotating shaft.

6. The eyeglass lens processing apparatus according to any one of claims 1 to 5, wherein the lens rotating shaft, the first grindstone rotating shaft and the second grindstone rotating shaft are arranged such that the respective rotation

axes are positioned on the same plane, and the lens rotating shaft is arranged between the first and second grindstone rotating shafts, and

the eyeglass lens processing apparatus further comprises moving means for moving the lens rotating shaft in a direction of changing a distance between the rotation axes with respect to the respective first and second grindstone rotating shafts.

7. The eyeglass lens processing apparatus according to any one of claims 1 to 5, wherein the first grindstone rotating shaft is coaxially arranged with a roughing grindstones (201a, 201b), and

wherein the second grindstone rotating shaft is coaxially arranged with at least one of a chamfering grindstone (272, 273), a grooving grindstone (274) and a drilling tool (280).

FIG. 1

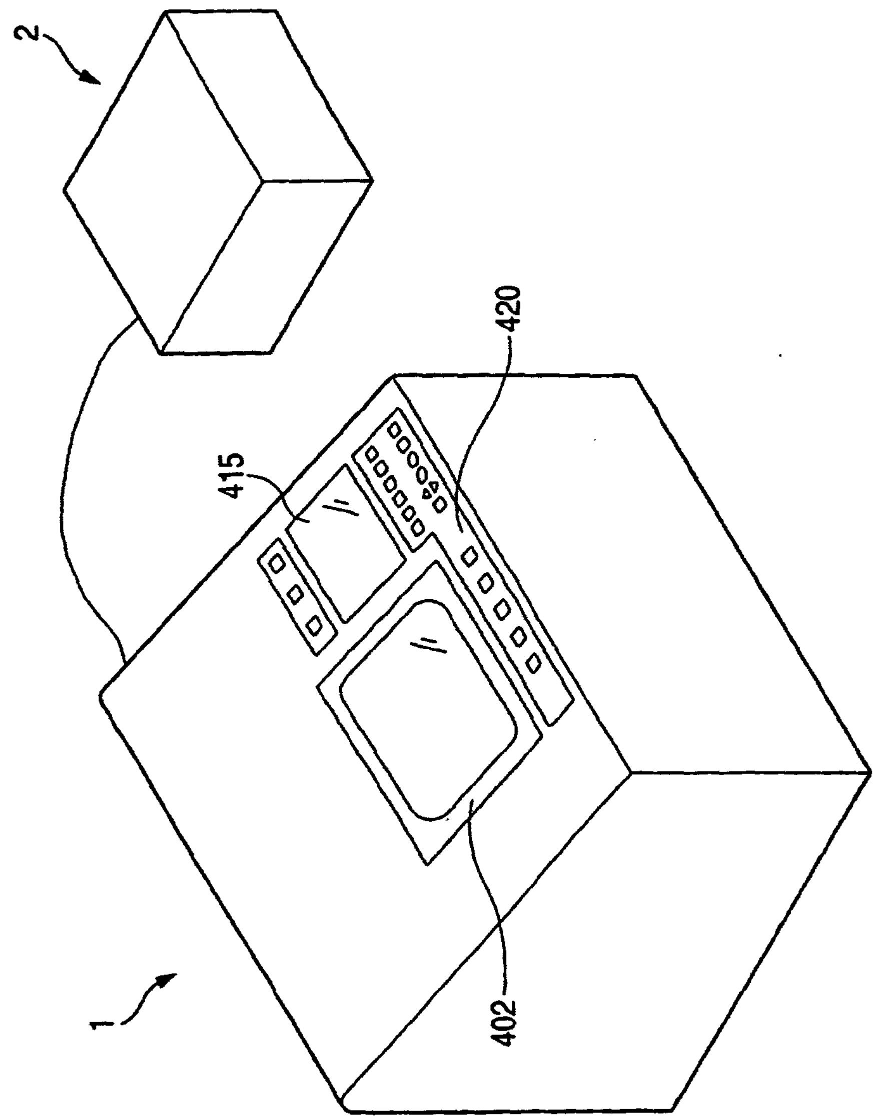


FIG. 2

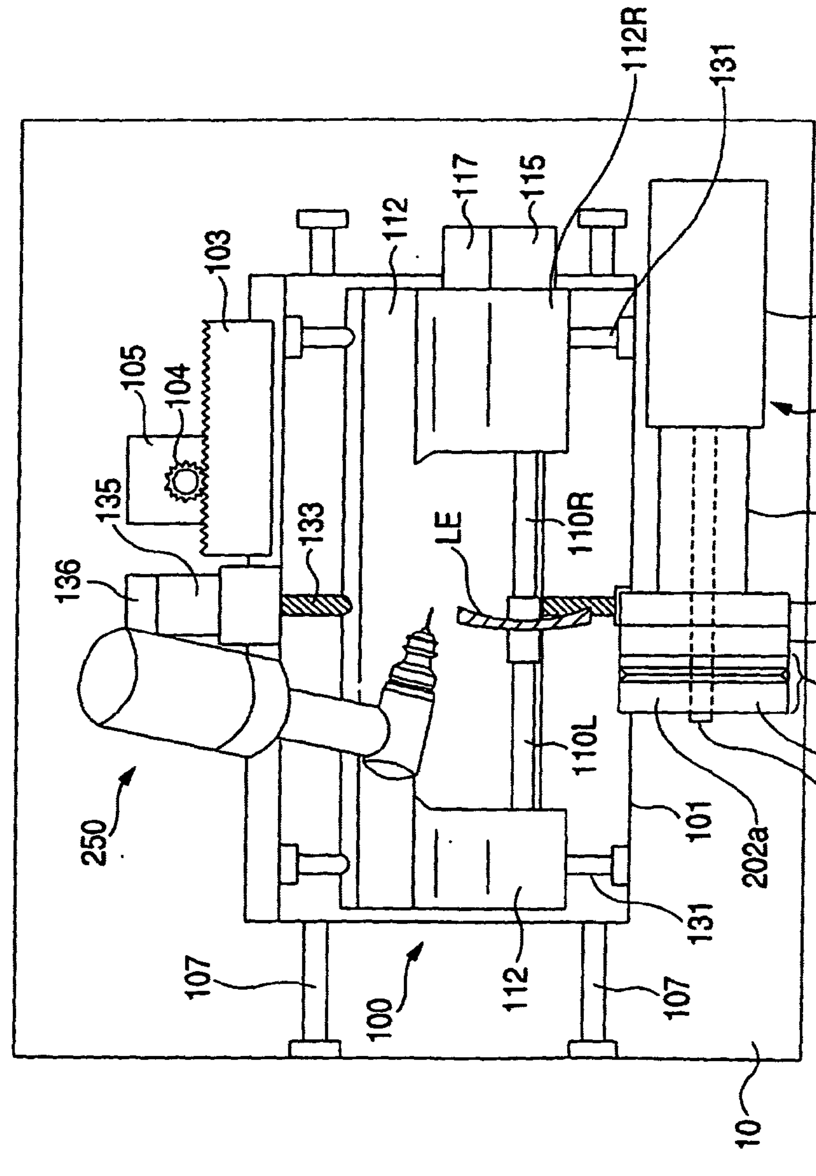

112R
131
117
115
112
103
105
104
135
136
133
LE
110R
110L
207
200
205
201a
201b
201c
202a
203
202b
101
131
112
100
107
107
250
10

FIG. 3

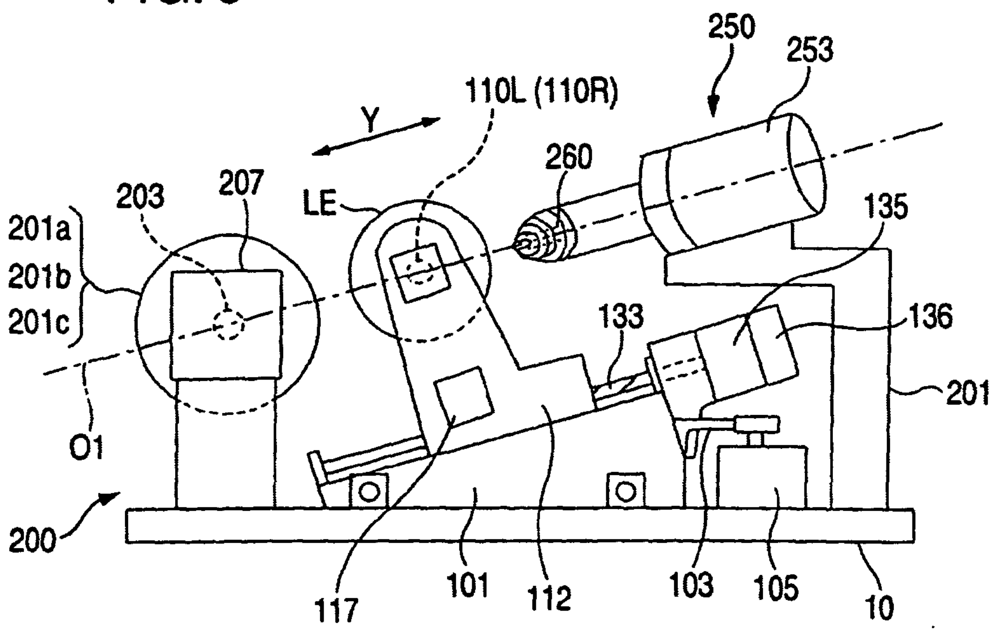

250
253
Y
110L (110R)
260
LE
203
207
201a
201b
201c
135
133
136
201
O1
200
117
101
112
103
105
10

FIG. 4

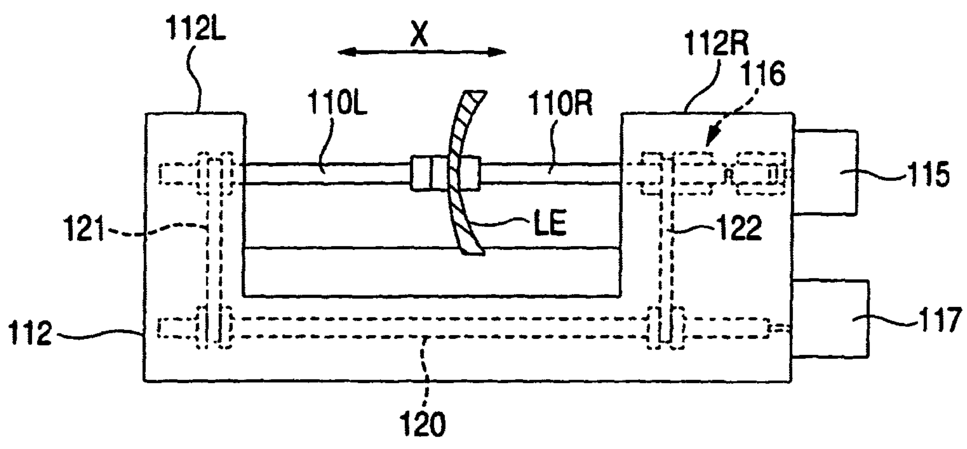

112L
X
112R
116
110L
110R
115
121
LE
122
112
117
120

FIG. 5

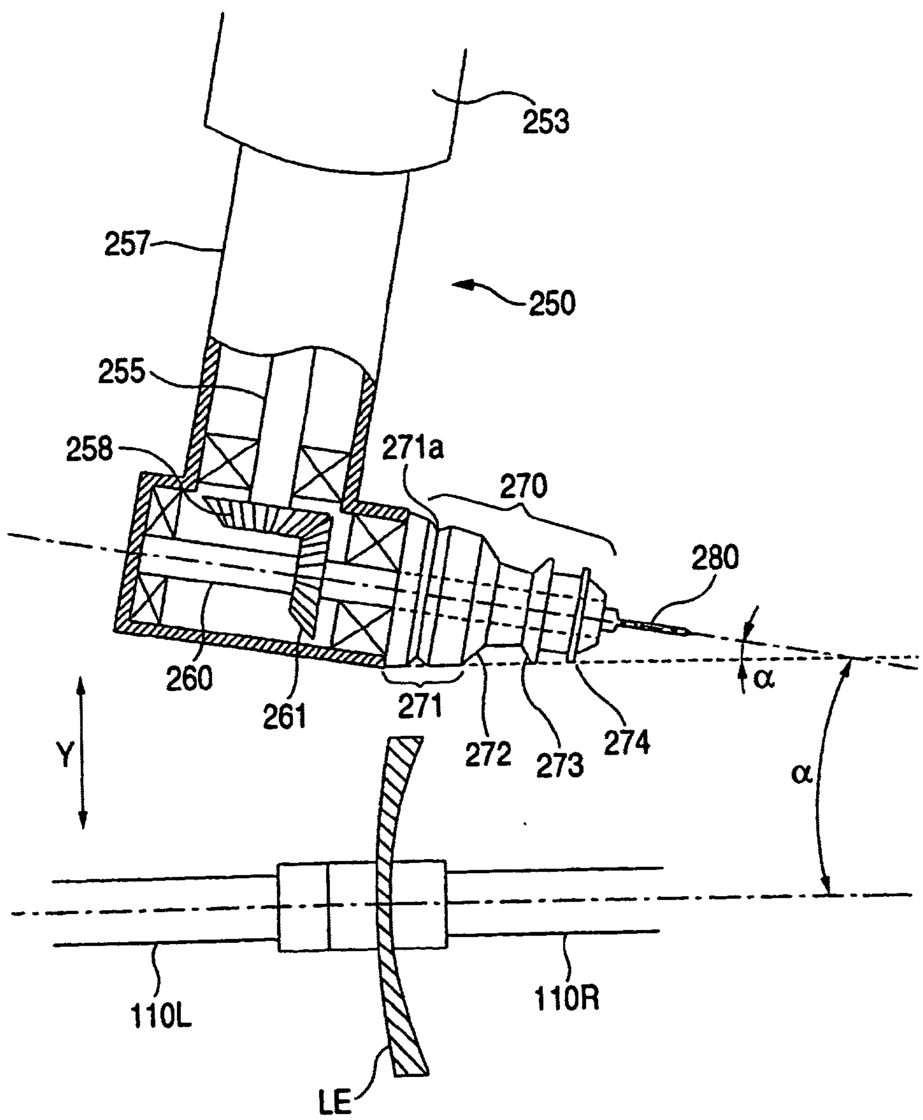

253
257
250
255
258
271a
270
280
α
260
261
271
272
273
274
Y
α
110L
110R
LE

FIG. 6

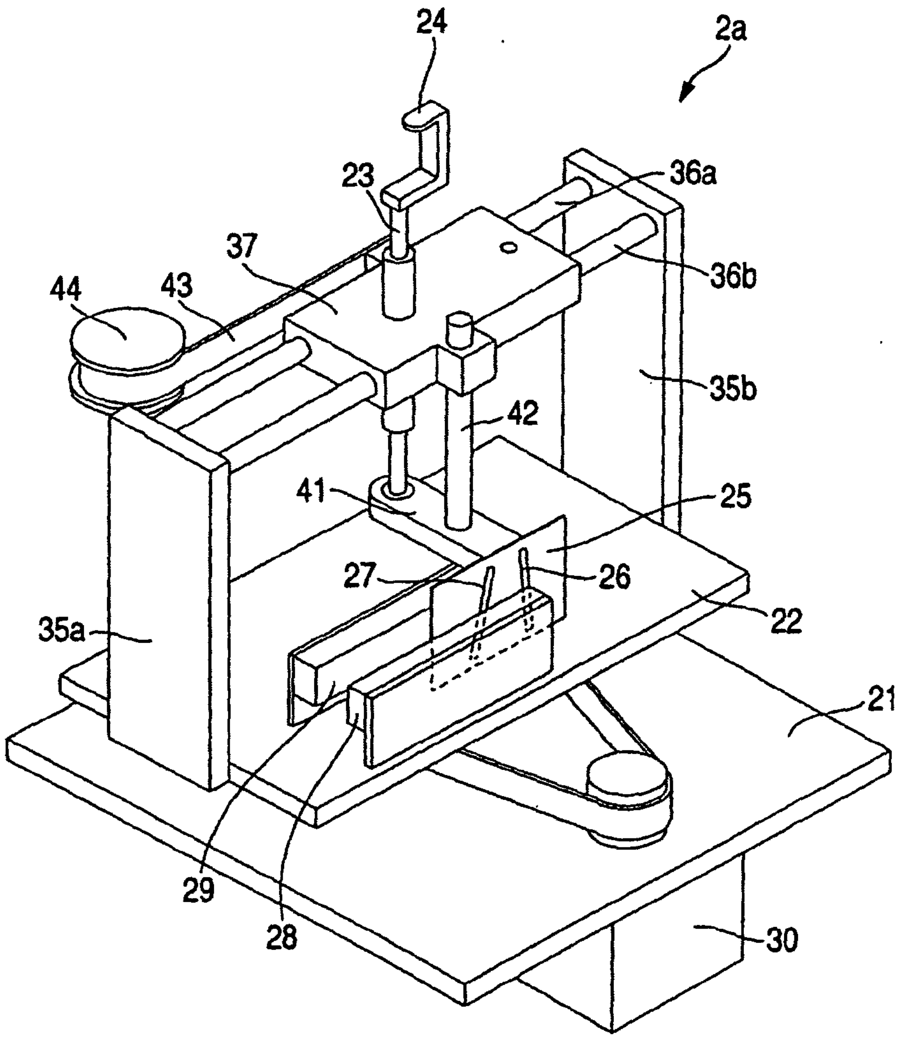


FIG. 7

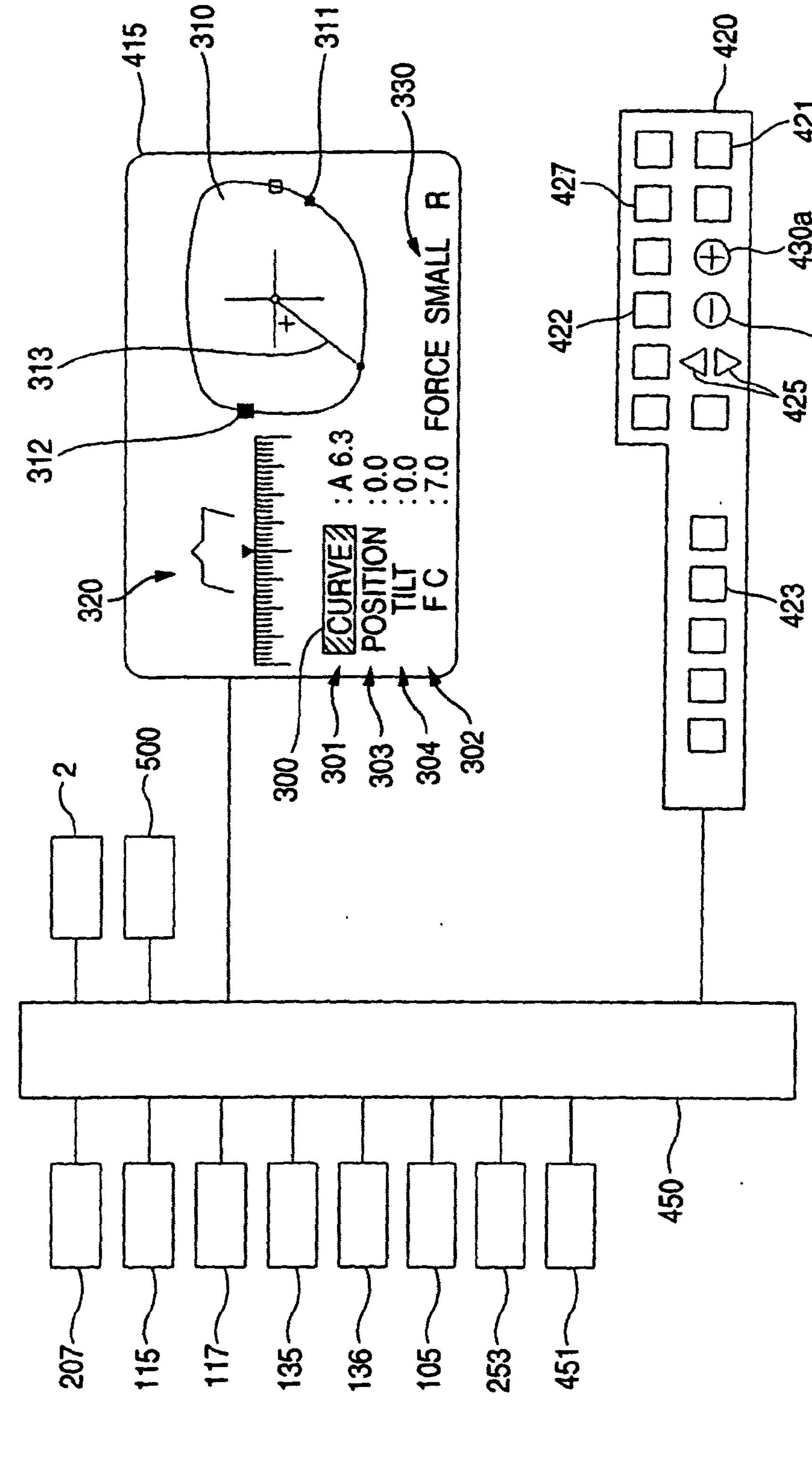

415
310
311
330
313
312
320
CURVE : A 6.3
POSITION : 0.0
TILT : 0.0
F C : 7.0
FORCE SMALL
R
300
301
303
304
302
420
421
427
422
430a
430b
425
423
2
500
450
207
115
117
135
136
105
253
451

FIG. 8A

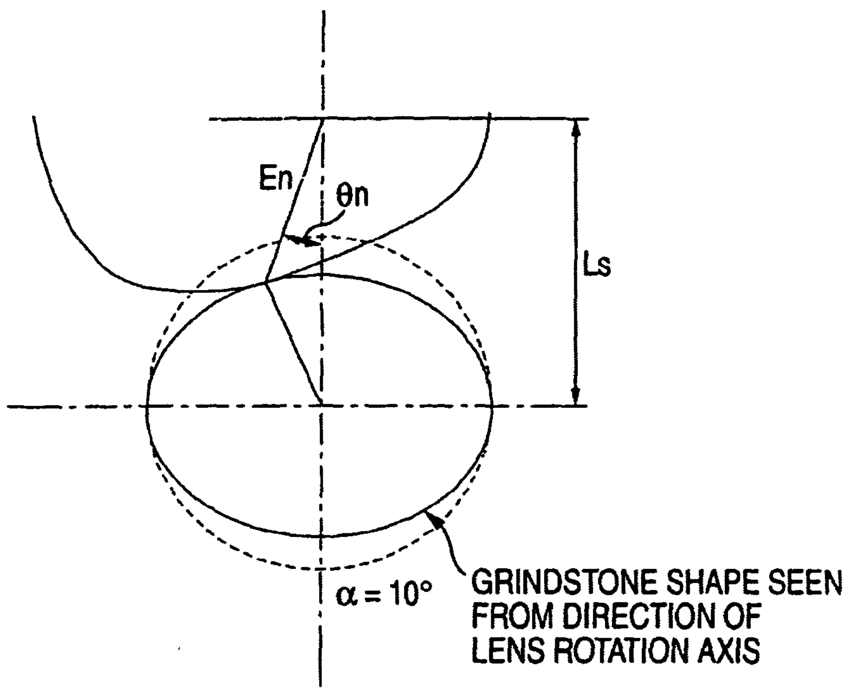
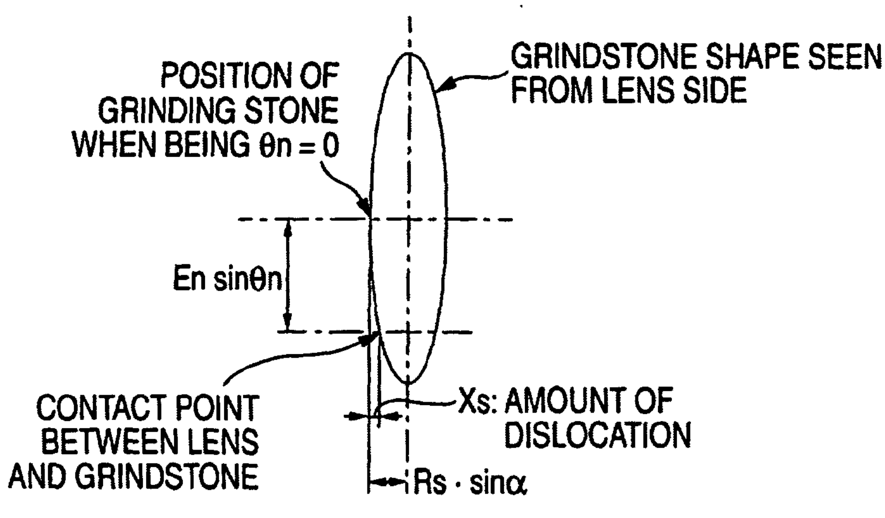

En
θn
Ls
α = 10°
GRINDSTONE SHAPE SEEN FROM DIRECTION OF LENS ROTATION AXIS

FIG. 8B


POSITION OF GRINDING STONE WHEN BEING θn = 0
GRINDSTONE SHAPE SEEN FROM LENS SIDE
En sinθn
CONTACT POINT BETWEEN LENS AND GRINDSTONE
Xs: AMOUNT OF DISLOCATION
Rs · sinα

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 04 02 0466

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	EP 1 310 326 A (NIDEK KK) 14 May 2003 (2003-05-14) * paragraphs [0001], [0003], [0005], [0009], [0019], [0022], [0025], [0026], [0030], [0042] - [0050] * * figures 1,2,4,6,12,13 *	1,3,7	B24B9/14
X	EP 0 857 540 A (NIDEK KK) 12 August 1998 (1998-08-12) * column 6, line 39 - column 7, line 15 * * column 8, line 43 - column 14, line 42 * * figures 1,2,6,16 *	1,4-6	
X	EP 1 155 775 A (NIDEK KK) 21 November 2001 (2001-11-21) * paragraphs [0032] - [0036] * * figures 1,2,10 *	1,3-5	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)

B24B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	4 November 2004	Eder, R

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