

MANUFACTURING METHOD AND
MANUFACTURING APPARATUS OF GLASS SUBSTRATE FOR MAGNETIC DISC
AND MANUFACTURING METHOD OF MAGNETIC DISC

The present disclosure relates to subject matters contained in Japanese Patent Application No. 2007-173581 filed on June 30, 2007, which are expressly incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001]

The present invention relates to a manufacturing method and a manufacturing apparatus of a glass substrate for a magnetic disc and a manufacturing method of a magnetic disc using a glass substrate manufactured thereby. Specifically, the present invention relates to a polishing technique on inner circumference edge surface of an inner hole formed in the glass substrate.

2. Description of the Prior Art

[0002]

Along with advancement of information technology, information recording technology, especially magnetic recording technology has been significantly improving. As a substrate for a magnetic recording medium such as a hard disc drive (HDD), which is one of the magnetic recording media,

aluminum substrate has been widely used. However, along with space saving, flattening, and high density recording of the magnetic disc, the aluminum substrate is replaced by a glass substrate having superior flatness and substrate strength of the substrate surface to an aluminum substrate.

[0003]

Moreover, as density growth of magnetic recording technology is progressed, a magnetic head has changed from a thin film head to a magneto-resistive head (MR head) to a giant magneto-resistive head (GMR head) and floating amount of a magnetic head from a substrate has been narrowed to 8nm or less. Due to this, there may be a case where a head crash or thermal asperity occurs. Head crash occurs when a magnetic head crashes a magnetic disc due to uneven surface of the magnetic disc and the thermal asperity is a trouble which causes a reading error when heat is generated by adiabatic compression of air or by contact between the magnetic head and the magnetic disc. In such a condition, importance of flatness of substrate edge surface has been conventionally recognized. In the Patent Document 1, each edge surface of an outer circumference and an inner circumference is polished until the surface is mirror surfaced to prevent generation and adhesion of a particle on the substrate edge surface, resultingly solving the above-mentioned problem.

[0004]

As a technique to polish inner circumference edge surface of a glass substrate, a polishing method by use of a rotary brush

as described in the Patent Document 2 has been known. This polishing method enables to polish inner circumference edge surface by laminating disc-shaped glass substrates having an inner hole which are stored in a substrate case and a tightening cover (work holder), inserting a rotary brush into a communicating inner hole of the glass substrates after the glass substrates are fixed on a rotation holder (table), and rotating both the rotation holder and the rotary brush while dipping the glass substrates into polishing liquid.

[Patent Document 1]

Japanese Published Unexamined Patent Application No.
H10-154321

[Patent Document 2]

Japanese Published Unexamined Patent Application No.
H11-221742

[0005]

Recently, to further improve recording density, a perpendicular magnetic recording method has been adopted. In case of a perpendicular magnetic recording medium, influence of a glass substrate appears more significantly than the case of a longitudinal magnetic recording method. Therefore, lower roughness and more precise flatness and shape are required for a glass substrate. Especially, for the improvement of reading speed by an HDD, rotation speed of a magnetic disc has been increasing. Because center of the rotation of the magnetic disc is very important, smaller dimension tolerance of an inner hole (inner circumference edge surface), higher circularity, and

smaller fitting tolerance with a spindle are required.

[0006]

Meanwhile, because a small HDD has been recently required for a device such as a cellular phone, a digital camera, an a portable music player, it is required for a magnetic disc to have a smaller shape and higher recording density while lowering production cost thereof.

[0007]

Here, to lower production cost while polishing an inner circumference edge surface of a glass substrate, increasing the number of glass substrate laminated when polishing is conceivable. For example, if 100 pieces of glass substrates were laminated and polished, if the number is increased to 300, it becomes possible to produce the same amount of glass substrates within a one-third of takt time (processing time). However, there is a tendency that if the number of lamination is increased, tolerance or circularity of the inner hole is lowered.

SUMMARY OF THE INVENTION

[0008]

Therefore, the present invention aims at providing a manufacturing method and a manufacturing apparatus of a glass substrate for a magnetic disc which can polish inner circumference edge surface with high accuracy and can improve tolerance and circularity of an inner hole while ensuring a number of laminated glass substrate and providing a

manufacturing method of a magnetic disc using a glass substrate manufactured thereby.

[0009]

As a result of keen investigation on the above-mentioned problems by the inventors of the present invention, the inventors found out that if a plurality of laminated glass substrates are inclined to a rotation axis when an inner circumference edge surface is polished, tolerance or circularity of an inner hole is lowered. Then, as a result of keen discussion to solve this problem, the inventors found out that if the number of the glass substrates laminated is increased in a stage where the glass substrates are laminated and retained by a work holder, matching degree of a shaft center of the inner hole and a rotation axis is prone to be lowered and even if the glass substrates could be retained by the work holder with high accuracy, the glass substrates are prone to incline when the glass substrates are set on a table. Moreover, the inventors found out that it is possible to improve matching degree of the shaft center of the inner hole and the rotation axis by setting the glass substrates on the work holder after setting the work holder on the table and thus completed the present invention.

[0010]

That is, to solve the above-mentioned problem, a typical configuration of a manufacturing method of a glass substrate for a magnetic disc according to the present invention is a method of manufacturing a glass substrate for a magnetic disc

including an inner circumference edge surface polishing step for laminating glass substrates having an inner hole and for inserting a polishing body into a communicating inner hole for polishing further including: a step of installing a positioning member instead of a polishing body of a polishing apparatus in a manner that the center axis of the positioning member matches the center axis of the polishing body at a position where the polishing body is to be provided; a step of laminating a plurality of glass substrates; a step of causing the positioning member to penetrate a communicating inner hole of the laminated glass substrates; a step of fixing the laminated glass substrates; a step of removing the positioning member from the communicating inner hole of the positioned glass substrates; a step of attaching a polishing body to the polishing apparatus instead of the positioning member; and a step of inserting the polishing body into the communicating inner hole of the positioned glass substrates.

[0011]

According to the above configuration, installing the positioning member at a position where the polishing body of the polishing apparatus for polishing an inner circumference edge surface is to be attached enables to position laminated glass substrates by the positioning member having exactly same position and posture of the polishing body. Therefore, even if the number of laminated glass substrates is large, inner circumference edge surface of each glass substrate can be polished with high accuracy and tolerance and circularity of

the inner hole and matching degree of cores can be improved.

[0012]

Moreover, another typical configuration of a manufacturing method of a glass substrate for a magnetic disc according to the present invention includes: a step of attaching a lower retaining portion of a work holder which sandwiches glass substrates in a condition where a plurality of the glass substrates are laminated by an upper retaining portion and the lower retaining portion on a table of a polishing apparatus for polishing an inner circumference edge surface of an inner hole formed in the glass substrate; a step of laminating a plurality of glass substrates on the lower retaining portion; a step of providing a shaft perpendicularly to the lower retaining portion so that the shaft penetrates a communicating inner hole of the glass substrates laminated on the lower retaining portion; a step of positioning the laminated glass substrates by use of the shaft; a step of pressing the glass substrates thus positioned on the lower retaining portion with the upper retaining portion from above; a step of removing the shaft from the communicating inner hole of the positioned glass substrate; a step of inserting a polishing body into the communicating inner hole of the positioned glass substrates; and a step of polishing the inner circumference edge surface by the polishing body by relatively rotating or moving the table and the polishing body.

[0013]

In the present invention, upper and lower do not

necessarily mean direction of application of gravity and the direction farther from the table may be "upper" direction while the direction nearer from the table may be "lower". Joint of the upper and lower retaining portions may be any position as long as there is no influence to operation. When attaching the lower retaining portion on the table, any member may be intervened therebetween. Perpendicular condition of the shaft may be accurate enough to enable positioning of the glass substrate by the shaft. When the inner circumference edge surface is polished by the polishing body, the table and the polishing body are relatively rotated or moved. Here, "relatively" means a condition where either or both of the two are driven and the polishing body is in sliding contact with the inner circumference edge surface (through polishing liquid). "Move" includes, for example, a condition where the polishing body reciprocates in a direction approximately orthogonal to the table (axis direction of the inner hole).

[0014]

According to the above configuration, the lower retaining portion of the work holder is attached on the table, a plurality of the glass substrates are laminated on the lower retaining portion, the shaft is provided perpendicularly to the lower retaining portion to penetrate the communicating inner hole of the laminated glass substrate so that the glass substrates are positioned on the lower retaining portion, the positioned glass substrates are pressed from the above by the upper retaining portion to be fixed and in that condition, the shaft is removed

from the communicating inner hole of the glass substrates, and the polishing body is inserted into the inner hole for polishing. Therefore, positioning and fixing of the glass substrate are carried out immediately before polishing and therefore tolerance and circularity of the inner hole can be improved. That is, the shaft is removed between the positioning/fixing step of the glass substrate and the polishing step. This removing step does not disarrange positioned and fixed laminated glass substrates (inner holes) in a radial direction to disarray the position of the glass substrate toward the table. Moreover, when the work holder is fixed on the table after the laminated glass substrates are stored in the work holder, there may be a case where a grain particle or the like intrudes between the work holder and the table and fixing accuracy of the work holder to the table is lowered and along with this, positioning accuracy of the glass substrate to the table is lowered. However, according to the above-mentioned configuration, the work holder is attached to the table in advance (before retaining the glass substrate) and therefore even if there is any problem in fixing accuracy of the work holder toward the table, such an error can be corrected in the subsequent positioning step of the glass substrate.

[0015]

The shaft may be enabled to stretch or contract in radial direction and in the step where the laminated glass substrates are positioned by the shaft, the shaft may be stretched in radial direction for positioning and in the step where the shaft is

removed from the communicating inner hole of the positioned glass substrates, the shaft may be contracted in radial direction to be removed. Thus, it becomes possible by the contraction of the shaft to avoid the glass substrates from an excessive stress when the shaft is removed and also possible to carry out positioning of the glass substrates with high accuracy by the diameter expansion of the shaft.

[0016]

In the above-mentioned configuration, the step of laminating a plurality of glass substrates on the lower retaining portion may include a step of storing the glass substrates in a bottomed cylindrical work cover having an open upper part in a condition where a plurality of the glass substrates are laminated and a step of setting the glass substrates stored with the work cover as a whole on the lower retaining portion together with the work cover. In the present invention, cylindrical shape of the work cover may not be entirely constructed by the wall and may be constructed by frames to form a cylindrical shape as a whole. By use of such a work cover, the glass substrate can be easily set to the work holder with its lower retaining portion fixed to the table.

[0017]

A typical configuration of a manufacturing apparatus of a glass substrate for a magnetic disc according to the present invention includes a work holder which sandwiches a plurality of glass substrates having an inner hole in a laminated condition by upper and lower retaining portions, a table to

which the lower retaining portion is attached, a shaft which can expand or contract in radial direction, and a polishing body attaching portion for attaching a polishing body which polishes an inner circumference edge surface of the inner hole by relative rotation or movement of the table and the polishing body; wherein the shaft can be stretched in radial direction to determine the position of the glass substrate when a plurality of glass substrates are laminated on the lower retaining portion attached to the table and also can be contracted in radial direction to be removed from the inner hole while the positioned glass substrate is pressed from the above by the upper retaining portion, and the polishing body attached to the polishing body attaching portion is inserted into the communicating inner hole of the glass substrate positioned by the shaft after the shaft is removed therefrom to polish the inner circumference edge surface.

[0018]

According to the above-mentioned configuration, the lower retaining portion of the work holder is attached on the table, the shaft is provided perpendicularly to the lower retaining portion so that the shaft penetrates the communicating inner hole of a plurality of the glass substrates laminated on the lower retaining portion to position the glass substrates on the lower retaining portion, the shaft is removed from the communicating inner hole of the glass substrate while the positioned glass substrate is pressed from above by the upper retaining portion, and the polishing body is inserted into

the inner hole for polishing. Therefore, positioning and fixing of the glass substrate can be carried out immediately before polishing and tolerance and circularity of the inner hole can be improved. Moreover, it becomes possible by the contraction of the shaft to avoid the glass substrates from an excessive stress when the shaft is removed and also possible to carry out positioning of the glass substrates with high accuracy by the diameter expansion of the shaft.

[0019]

The manufacturing apparatus may be configured to include a bottomed cylindrical work cover having an open upper part in which a plurality of the glass substrates are stored in a laminated condition and the glass substrates stored in the work cover are set on the lower retaining portion in an integrated manner with the work cover. By use of such a work cover, the glass substrate can be easily set to the work holder with its lower retaining portion fixed to the table.

[0020]

A typical configuration of a manufacturing method of a magnetic disc according to the present invention includes a step of attaching a lower retaining portion of a work holder, which holds a plurality of glass substrates in a laminated condition between an upper retaining portion and the lower retaining portion, on a table of a polishing apparatus for polishing an inner circumference edge surface of an inner hole formed on the glass substrate, a step of laminating a plurality of glass substrates on the lower retaining portion, a step of providing

a shaft perpendicularly to the lower retaining portion so that the shaft penetrates the communicating inner hole of the glass substrates laminated on the lower retaining portion, a step of positioning the laminated glass substrates by the shaft, a step of pressing the glass substrates thus positioned on the lower retaining portion with the upper retaining portion from above, a step of removing the shaft from the communicating inner hole of the positioned glass substrate, a step of inserting a polishing body into the communicating inner hole of the positioned glass substrates, a step of polishing the inner circumference edge surface by relatively rotating or moving the table and the polishing body, and a step of forming a magnetic layer on the surface of the glass substrate after the glass substrate is polished.

[0021]

According to the above configuration, the lower retaining portion of the work holder is attached on the table, the shaft is provided perpendicularly to the lower retaining portion so that the shaft penetrates the communicating inner hole of a plurality of the glass substrates laminated on the lower retaining portion to position the glass substrates on the lower retaining portion, the positioned glass substrates are pressed from the above by the upper retaining portion to be fixed and in that condition, the shaft is removed from the communicating inner hole of the glass substrates, and the polishing body is inserted into the inner hole for polishing. Therefore, positioning and fixing of the glass substrate is carried out

immediately before polishing and therefore tolerance and circularity of the inner hole can be improved.

[0022]

The shaft may be enabled to stretch or contract in radial direction and in the step where the laminated glass substrates are positioned by the shaft, the shaft may be stretched in radial direction for positioning and in the step where the shaft is removed from the communicating inner hole of the positioned glass substrates, the shaft may be contracted in radial direction to be removed. Thus, it becomes possible by the contraction of the shaft to avoid the glass substrates from an excessive stress when the shaft is removed and also possible to carry out positioning of the glass substrates with high accuracy by the diameter expansion of the shaft.

[0023]

In the above-mentioned configuration, the step of laminating a plurality of glass substrates on the lower retaining portion may include a step of storing the glass substrates in a bottomed cylindrical work cover having an open upper part in a condition where a plurality of the glass substrates are laminated and a step of setting the glass substrates stored with the work cover as a whole on the lower retaining portion together with the work cover in an integrated manner. By use of such a work cover, the glass substrate can be easily set to the work holder with its lower retaining portion fixed to the table.

Effect of the Invention

[0024]

According to the present invention, even if the number of laminated glass substrates is large, inner circumference edge surface of the glass substrates can be polished with high accuracy, and tolerance and circularity of the inner hole and matching degree of cores can be improved.

BRIEF DESCRIPTION OF THE DRAWINGS

The various features of novelty which characterize the invention are pointed out with particularity in the claims attached to and forming a part of this specification. For a better understanding of the invention, its operating advantages, and specific objects attained by its use, reference should be had to the accompanying drawing and descriptive matter in which there is illustrated and described a preferred embodiment of the invention.

FIG. 1 is a cross-sectional view showing a polishing apparatus of a glass substrate for a magnetic disc.

FIG. 2 is a plan view showing a table.

FIG. 3 is a plan view showing a holder main body of a work holder.

FIG. 4 is a cross-sectional view showing a work cover.

FIG. 5 is a side elevational view showing a shaft.

FIG. 6 shows installation procedures of the holder main body on the table. (A) is a graphical illustration showing inclination adjustment of the holder main body and (B) is a

graphical illustration showing coaxial adjustment of the holder main body.

FIG. 7 shows procedures to cause the work holder to hold laminated glass substrates.. (A) is a graphical illustration showing how a polishing target stored in the work cover is stored in the holder main body, (B) is a graphical illustration showing a condition where a shaft is attached to a tool axis, (C) is a graphical illustration showing a condition where the shaft is inserted in the inner hole of the polishing target, (D) is a graphical illustration showing a condition where a holder cover is attached to a holder main body, and (E) is a graphical illustration showing a condition where the shaft is removed from the inner hole of the polishing target.

FIG. 8 is a flowchart showing a manufacturing method of a magnetic disc.

FIG. 9 is a flowchart showing a polishing method by a polishing apparatus.

FIG. 10 shows a shaft which can be expanded or contracted. (A) is a side elevational view and (B) is a longitudinal-sectional view of the shaft.

FIG. 11 shows procedures to cause the work holder to hold laminated glass substrates by use of the shaft which can be expanded or contracted. (A) is a graphical illustration showing how a polishing target stored in the work cover is stored in the holder main body, (B) is a graphical illustration showing a condition where the shaft with contracted diameter is installed to the tool axis, (C) is a graphical illustration

showing a condition where the shaft with contracted diameter is inserted in the inner hole of the polishing target, (D) is a graphical illustration showing a condition where the shaft with expanded diameter positions the glass substrate included in the polishing target, (E) is a graphical illustration showing a condition where the holder cover is attached to the holder main body, and (F) is a graphical illustration showing a condition where the shaft is removed from the inner hole of the polishing target by contracting diameter of the shaft.

FIG. 12 is a graphical illustration showing another example of a shaft which can be expanded or contracted.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0025]

Best modes for realizing the present invention will be explained on the basis of figures.

[0026]

FIG. 1 is a cross-sectional view showing a polishing apparatus (manufacturing apparatus) of a glass substrate for a magnetic disc; FIG. 2 is a plan view showing a table; FIG. 3 is a plan view showing a holder main body of a work holder; FIG. 4 is a cross-sectional view showing a work cover; FIG. 5 is a side elevational view showing a shaft; FIG. 6 is a graphical illustration showing installation procedures of the holder main body; FIG. 7 is a graphical illustration showing procedures to cause the work holder to hold laminated glass substrates; FIG. 8 is a flowchart showing a manufacturing method of a magnetic

disc; FIG. 9 is a flowchart showing a polishing method by a polishing apparatus; FIG. 10 is a graphical illustration showing a shaft which can be expanded or contracted; FIG. 11 is a graphical illustration showing how to cause the work holder to retain laminated glass substrates by use of the shaft which can be expanded or contracted; and FIG. 12 is a graphical illustration showing another example of a shaft which can be expanded or contracted. Here, specific dimension, shape, material, and other numerical values and the like in the following embodiments are examples for easy of understanding of the present invention and except for a case where there is a notice, the present invention is not limited thereto.

[0027]

As shown in FIG. 1, a polishing apparatus 1 of a glass substrate for a magnetic disc is for polishing an inner circumference edge surface 3a of a cylindrical polishing target 3 formed by laminating glass substrates 2 and includes a base 4, a table 5, a work holder 6, a work cover 7, a tool axis 8, a drive motor 9, a polishing brush 10, a nozzle 11, and a shaft 12 as an example of a positioning member (refer to FIG. 5).

[0028]

The polishing target 3 is configured by laminating a plurality of (e.g. 300) glass substrates 2 alternately with a toric spacer 13 including nonwoven fabric or the like. The glass substrate 2 has an inner hole at the center of a discotic glass and outer circumference edge surface and an inner circumference edge surface 2a of the inner hole are chamfered

(in FIG. 1, reference numerals 2b and 2c indicate chamfered portion of the inner circumference edge surface 2a). The spacer 13 is provided to surely prevent residue of chamfering and damage or the like when polishing the glass substrate 2. The inner hole of the polishing target 3 (a space inside cylinder) is configured by the communicating inner hole of the glass substrate 2 and the inner circumference edge surface 3a of the polishing target 3 is configured by continuation of the inner circumference edge surfaces 2a of the glass substrates 2 (with the spacer 13 in between glass substrates).

[0029]

The base 4 is provided on a plan surface and the table 5 is supported by the base 4 in a rotatable manner via a bearing 14. Planar view of the table 5 is, as shown in FIG. 2, a circular form and is driven by a drive unit (not shown) to be rotated in both directions.

[0030]

On an upper surface 5a of the table 5, threaded holes 15 are provided at positions which trisects perimeter of a radius r_1 with a rotation axis O1 as the center (at positions for 120° respectively). On an outer circumference surface 5b of the table 5, a later-described jig 16 can be attached in a detachable manner.

[0031]

The work holder 6 includes a holder main body 17 and a holder cover 18. The holder main body 17 is configured by including a bottom wall part 19 which has circular shape when

viewed planarly, a cylindrical surrounding wall part 20 standing from outer periphery of the bottom wall part 19, and a flange part 21 stretching from the lower part of the surrounding wall part 20 toward external direction of radial which are formed in an integrated manner. The holder cover 18 includes a discotic pressing portion 22 and a surrounding wall part 23 stretching downward from outer periphery of the pressing portion 22 and, for example, forms a male screw on an upper outer circumference surface 20a of the surrounding wall part 20 and at the same time forms a female screw on an inner circumference surface 23a of the surrounding wall part 23. The male screw and the female screw are caused to be screwed together and the holder cover 18 is attached and fixed on the surrounding wall part 20 as a lid of the holder main body 17.

[0032]

At the center of the bottom wall part 19 of the holder main body 17, as shown in FIG. 3, a penetration portion 24 which penetrates the bottom wall part 19 above and below is provided. The penetration portion 24 includes an inverted cone shaped concave portion 26 which corresponds to the shape of a tapered portion 25 (refer to FIG. 5) of the shaft 12 and a round hole 27 communicating with the concave portion 26 which are provided above and below as a skeleton framework. The flange part 21 includes insertion holes 28 having a slightly larger radius than the threaded hole 15 provided at positions which trisects perimeter of a radius r_2 ($r_2 = r_1$) with a shaft center O2 of the round hole 27 as the center. Moreover, threaded holes 29

are provided at a position equidistant from the insertion holes 28 on the perimeter. On the outer circumference surface 21a of the flange part 21, a later-described jig 30 can be attached in a detachable manner. The holder main body 17 is attached to the upper surface 5a of the table as a tip of a knurling bolt 31 which passes through the insertion hole 28 is screwed with the threaded hole 15.

[0033]

The work cover 7 is, as shown in FIG. 4, configured by including a metal cylinder 32 including metal such as stainless steel and a discotic resin ring 33 including resin such as polyacetal. The metal cylinder 32 includes a folded portion 34 folded inside at the lower end of the cylinder and as the resin ring 33 is locked by the folded portion 34, an insertion hole 35 (an inner hole of the resin ring 33) is formed at the bottom of the work cover 7 as a whole to have a bottomed cylindrical shape with an open upper part.

[0034]

The polishing target 3 is stored in the metal cylinder 32 of the work cover 7 and is set on the bottom wall part 19 of the holder main body 17 in an integrated manner with the work cover 7. Then, a discotic spacer 36 including resin such as polyacetal is placed on the polishing target 3 and is pressed from above by a pressing portion 22 of the holder cover 18 so that the polishing target 3 is retained by the work holder 6 in a condition where the polishing target 3 is sandwiched between the bottom wall part 19 and the pressing portion 22.

[0035]

The tool axis 8 is provided on an upper part of the table 5, is driven by the drive motor 9, and is rotated in both directions concentrically with the rotation axis 01 of the table 5. The tool axis 8 and the drive motor 9 are driven by an elevator (not shown) to move up and down.

[0036]

The polishing brush 10 is attached to the tool axis 8 in a detachable manner, penetrates the inner hole of the polishing target 3, and a lower end thereof reaches the vicinity of the concave portion 26 of the holder main body 17. Lower end side of the polishing brush 10 may penetrate the bottom wall part 19 of the work holder 6 and the table 5 and may be pivotally supported by the base 4 or the like. Supporting the polishing brush from the lower side in such a manner, it becomes possible to prevent wobbling of the polishing brush when polishing is carried out and to improve polishing accuracy.

[0037]

The nozzle 11 is provided to face the tool axis 8 and supplies polishing liquid from the upper part of the polishing brush 10. The supplied polishing liquid flows between the polishing brush 10 and the inner circumference edge surface 3a of the polishing target 3, passes through the penetration portion 24, and is collected at a waste liquid vent (not shown).

[0038]

The shaft 12 has an approximately columnar shape as shown in FIG. 5, is provided in the work holder 6 instead of the

polishing brush 10, and is used for positioning of the glass substrate 2 included in the polishing target 3 as described later. The shaft 12 includes an attachment portion 37 which is attached to the tool axis 8, a columnar large-diameter shaft part 38 having approximately same diameter as the inner hole of the glass substrate 2 continuously formed from the attachment portion 37, a tapered portion 25 continuously formed from the large-diameter shaft part 38 and has a diameter which becomes smaller toward the lower side, and a columnar small-diameter shaft part 39 continuously formed from the tapered portion 25 and has an approximately same diameter as the round hole 27.

[0039]

To polish the polishing target 3 by use of the polishing apparatus 1, the holder main body 17 of the work holder 6 is attached on the upper surface 5a of the table 5 first.

[0040]

As shown in FIGs. 6 and 9, the knurling bolt 31 is inserted into the insertion hole 28 of the flange part 21, in a condition where the tip of the bolt is temporarily jointed (Step 401 (in the figure referred to as S401 and same is applied below)), a knurling bolt 40 is screwed to the threaded hole 29 of the flange part 21, and protruding amount of the knurling bolt 40 from the lower surface 21a of the flange part 21 is adjusted so that the holder main body 17 is leveled off. Specifically, a gauge 41 for displacement measurement is attached to the tool axis 8, a sensing pin 42 of the gauge 41 is caused to be in contact with the bottom wall part 19, and three knurling bolts 40 are screwed

back and forth along the threaded holes 29 while rotating the table 5 at low speed so that the gauge 41 indicates a fixed value. If tips of the three knurling bolts 40 come into contact with the upper surface 5a of the table 5 in a well-balanced manner, instrument reading of the gauge 41 becomes constant despite rotation of the table 5 and inclination adjustment of the holder main body 17 is complete (Step 402, FIG. 6 (A)).

[0041]

Next, the jigs 16 are attached to two points on the outer circumference surface 5b of the table 5 (preferably the jigs are attached in positions where two lines between each position and the rotation axis O1 becomes orthogonal when seen planarly), and the jigs 30 are attached to two points on the outer circumference surface 21a of the outer circumference surface 21a of the flange part 21 (on positions opposite to the positions for the jigs 16 with the rotation axis O1 as the center). As an attachment method of the jigs 16 and 30, for example, the jigs can be magnetically attached to the outer circumference surfaces 5b and 21a.

[0042]

The jig 16 protrudes upward more than the upper surface 5a of the table 5 and on the protruding portion, a threaded hole 43 is formed along horizontal direction. A knurling bolt 44 is screwed in the threaded hole 43. Meanwhile, the jig 30 has an L-shape which stretches to horizontal direction from the outer circumference surface 21a of the flange part 21 and bends downward. To the portion bent downward, a threaded hole 45 is

formed along horizontal direction and a knurling bolt 46 is screwed in the threaded hole 45.

[0043]

Here, since the holder main body 17 is temporarily jointed to the table 5, the insertion hole 28 is slightly larger than the threaded hole 15, and there is room for the holder main body 17 to be moved in horizontal direction for the allowance between the insertion hole 28 and the knurling bolt 31, if the knurling bolts 44 and 46 are screwed back and forth along the threaded holes 43 and 45, tips of the knurling bolts 44 and 46 come into contact with the outer circumference surfaces 21a and 5b to horizontally move the holder main body 17. Using this, knurling bolts 44 and 46 are screwed back and forth to adjust protruding amount of the knurling bolts from the jig and to adjust position of the holder main body 17 so that the shaft center O2 matches the rotation axis O1. That is, the sensing pin 42 of the gauge 41 attached to the tool axis 8 is caused to be in contact with the concave portion 26, and each of two pairs of the knurling bolts 44 and 46 are screwed back and forth while rotating the table 5 at low speed so that the gauge 41 indicates a fixed value. If tips of the knurling bolts 44 and 46 come into contact with the outer circumference surfaces 21a and 5b in a well-balanced manner and instrument reading of the gauge 41 becomes constant, coaxial adjustment (centering) of the holder main body 17 is complete (Step 403, FIG. 6 (B)).

[0044]

Then, three knurling bolts 31 which have been temporarily

jointed are equally clenched, the jigs 16 and 30 and the gauge 41 are removed, and the holder main body 17 is completely fixed on the table 5 (Step 404).

[0045]

After finishing installation of the holder main body 17 to the table 5, the polishing target 3 is retained by the work holder 6.

[0046]

As shown in FIGs. 7 and 9, the polishing target 3 which is stored in the work cover in advance is stored in the holder main body 17 with the work cover 7 in an integrated manner (Step 405, FIG. 7 (A)).

[0047]

Next, the attachment portion 37 of the shaft 12 is attached to the tool axis 8 at an elevated position, the spacer 36 is provided on the polishing target 3, the holder cover 18 is provided on the holder main body 17 (FIG. 7 (B)), and the tool axis 8 is lowered to cause the shaft 12 to be inserted into the inner hole of the polishing target 3 (FIG. 7 (C)). Thus, the tapered portion 25 is engaged with the concave portion 26, the small-diameter shaft part 39 is inserted into the round hole 27, the shaft 12 is provided perpendicularly to the bottom wall part 19 while being supported from at top and bottom thereof by the tool axis 8 and the penetration portion 24 respectively, and the shaft center of the shaft 12 matches the rotation axis 01. As the shaft 12 is inserted, part of the inner circumference edge surface 2a of the glass substrates 2 of the polishing target

3 which is not in a predetermined position is pressed by the tapered portion 25 or by the outer circumference surface of the large-diameter shaft part 38. Thus, the glass substrate 2 is positioned so that the axis of the inner hole thereof matches the rotation axis 01.

[0048]

Next, the holder cover 18 is installed to the holder main body 17 and the polishing target 3 having positioned glass substrates 2 is caused to be sandwiched between the bottom wall part 19 and the pressing portion 22 to be fixed (Step 406, FIG. 7 (D)).

[0049]

After the positioning and fixing, the tool axis 8 is elevated to pull out the shaft 12 upward to remove the shaft 12 from the inner hole of the polishing target 3 (Step 407, FIG. 7 (E)). The polishing target 3 is fixed in the previous step and therefore it is prevented that the positioned condition is misaligned by the removal of the shaft 12.

[0050]

The shaft 12 is detached from the tool axis 8 after being removed, the polishing brush 10 is attached to the tool axis 8 instead of the shaft 12, and the polishing brush 10 is inserted into the inner hole of the polishing target 3 (Step 408).

[0051]

Then, both of the table 5 and the tool axis 8 are rotated at different angular rate or either one is rotated to cause the both to be relatively rotated so that the polishing brush 10

is in sliding contact with the inner circumference edge surface 3a of the polishing target 3 via polishing liquid supplied from the nozzle 11 and polishes the inner circumference edge surface 3a (Step 409). Here, the polishing brush 10 may be repeatedly elevated up and down by the elevator when polishing.

[0052]

In the present embodiment, the wall bottom part 19 of the holder main body 17 of the work holder 6 is attached on the table 5, a plurality of the glass substrates 2 are laminated on the bottom wall part 19, the shaft 12 is provided perpendicularly to the bottom wall part 19 so that the shaft 12 penetrates the communicating inner hole of the laminated glass substrates 2 (inner hole of the polishing target) and that the glass substrates 2 are positioned on the lower retaining portion, the shaft 12 is removed from the inner hole of the inner hole of the polishing target 3 while the positioned glass substrates 2 are fixed by being pressed from above by the pressing portion 22 of the holder cover 18, and the polishing brush 10 is inserted into the inner hole for polishing. Therefore, positioning and fixing of the glass substrate 2 is carried out immediately before polishing and tolerance and circularity of the inner hole can be improved. That is, although the shaft 12 is removed between the positioning/fixing step and the polishing step of the glass substrate 2, the removal step does not misalign laminated glass substrates 2 (inner hole) which are positioned and fixed to radial direction to misalign position of the glass substrate 2 toward the table 5. Moreover, when the work holder

is fixed on the table after the laminated glass substrates are stored in the work holder, there may be a case where a grain particle or the like intrudes between the work holder and the table and fixing accuracy of the work holder to the table is lowered and along with this, positioning accuracy of the glass substrate to the table is lowered. However, according to the above-mentioned configuration, the holder main body 17 of the work holder 6 is attached to the table 5 in advance (before retaining the glass substrate 2) and therefore even if there is any problem in fixing accuracy of the work holder 6 toward the table 5, such an error can be corrected in the subsequent positioning step of the glass substrate 2.

[0053]

Here, especially when a plurality of the glass substrates 2 are laminated on the bottom wall part 19, the glass substrates 2 are stored in the bottomed cylindrical work cover 7 which is open upward in a condition where the plurality of the glass substrates 2 are laminated and the glass substrates 2 stored in the work cover 7 are positioned on the bottom wall part 19 in an integrated manner with the work cover 7. Therefore, the glass substrate 2 can be easily set to the work holder 6 having the holder main body 17 which is fixed on the table 5.

[0054]

Meanwhile, the polishing apparatus 1 may include a shaft which can be expanded or contracted in radial direction. For example, a shaft 47 shown in FIG. 10 includes an attachment portion 48 to be attached on the tool axis 8, a rod-shaped part

49 having a conical surface 49a which has the same axis as the attachment portion and has the diameter which becomes smaller downward, and interlocking parts 50 which can slide in vertical direction relatively to the rod-shaped part 49 and can move to radial direction. A total of three interlocking parts 50 are provided in the outer circumference of the rod-shaped part 49. While an outer surface 50a of the interlocking part 50 configures a columnar surface, whole of an inner surface 50b thereof is caused to be in contact with the conical surface 49a of the rod-shaped part 49 and is biased by an elastic member (not shown) to inner side of radial direction. If the rod-shaped part 49 slides relatively downward to the interlocking part 50, the conical surface 49a of the rod-shaped part 49 expands space between the inner surfaces 50b of each of the interlocking part 50 so that the interlocking parts 50 are moved to outer side of radial direction, resulting in expanded diameter of the shaft 47 which is regulated by the outer surfaces 50b of the interlocking parts 50. On the other hand, if the rod-shaped part 49 slides upward relatively to the interlocking part 50, due to the bias of the elastic member, space between the inner surfaces 50b of each of the interlocking parts 50 is narrowed and each of the interlocking parts 50 is moved to inner side of radial direction, resulting in reduced diameter of the shaft 47.

[0055]

To position the glass substrate 2 by use of the shaft 47, as shown in FIG. 11, the work holder 7 in which the polishing

target 3 is stored is put into the holder main body 17 attached on the table 5 (FIG. 11 (A)), the shaft 47 in a contracted condition is attached to the tool axis 8 (FIG. 11 (B)), and the shaft 47 is brought down with its diameter contracted so that the shaft 47 is inserted into the inner hole of the polishing target 3 (FIG. 11 (C)). Then, by the relative sliding of the rod-shaped part 49 and the interlocking part 50, the shaft 47 is expanded in radial direction and by applying pressing force to the whole of the inner circumference edge surface 2a of each glass substrate 2 by the outer surfaces 50a of the three interlocking parts 50, each of the glass substrates 2 are positioned in a predetermined position (FIG. 11 (D)). After the positioned condition is fixed by the holder cover 18 (FIG. 11 (E)), the shaft 47 is contracted in radial direction and is pulled out upward from the inner hole of the polishing target 3 (FIG. 11 (F)). When the shaft 47 is thus inserted/removed, the shaft 47 is contracted in radial direction and when the glass substrate 2 is positioned, the shaft 47 is expanded in radial direction. Thus, thanks to contraction of diameter of the shaft 47, it becomes possible to prevent the glass substrates 2 from being applied excessive force and it becomes possible to carry out positioning of the glass substrate by expansion of diameter of the shaft 47 with high accuracy.

[0056]

Here, in the above-mentioned explanation, the shaft 12 is set after the holder main body 17 is set to the polishing apparatus and the work holder 7 in which a laminated body

including the substrates laminated in advance is provided is put therein. However, the present invention is not limited thereto and, for example, without using the work holder 7, the glass substrate 2 may be set on the holder main body 17.

[0057]

Moreover, other than the configuration in which the holder cover 18 is threadably mounted, the holder cover 18 itself and a portion where the holder cover 18 and the holder main body 17 come into contact may have screw thread function (male screw, female screw) so that the laminated body of the glass substrates 2 can be fixed by turning the holder cover 18.

[0058]

Further, a configuration in which a part of the holder main body 17 is removed (the surrounding wall part 20 is removed and only the bottom wall part 19 is left) and the holder cover 18 and the part of the holder main body 17 (the surrounding wall part 20) are integrated may be used. Specifically, the holder cover may have a cylindrical shape and the holder cover and the bottom wall part 19 may be fixed when the glass substrate 2 is set. In this case, since there is not the surrounding wall part 20 when the glass substrate is set, the holder cover 18 can be removed and the laminated body of the glass substrates can be easily set.

[0059]

[Embodiment]

Hereinafter, an embodiment of a manufacturing method of a glass substrate for a magnetic disc and a magnetic disc to

which the present invention is applied will be explained. This embodiment can be applied to any of a 0.8-inch disc, a 1.0-inch disc, a 1.8-inch disc, a 2.5-inch disc, or 3.5-inch disc.

[0060]

(1) Shape processing step and first wrapping step (Step 1: Refer to FIG. 8)

First, aluminosilicate glass is cast into disc-shape by direct press using upper, lower, and body molds to obtain a plate-shaped amorphous glass. The disc-shaped glass substrate for a magnetic disc may be obtained by, other than the direct press, cutting the substrate out by a grinding wheel from a sheet glass formed by down draw method or float method.

[0061]

Next, both main surfaces of the plate glass is wrapping-processed to make a disc-shaped glass base material. The wrapping process is carried out by an apparatus for both surfaces wrapping using planetary gear mechanism and alumina system loose grain is used. Specifically, wrapping platen is pressed both from top and bottom of the plate glass, grinding fluid containing loose grain is supplied on the main surface of the plate glass, and they are relatively moved to carry out the wrapping process. By this wrapping process, a glass base material having smooth main surface is obtained.

[0062]

(2) Cutting step (Step 2)

The glass base material obtained in the previous step is cut by a diamond cutter and a disc-shaped glass substrate is

cut. Next, using a cylindrical diamond drill, an inner hole is formed (coring) and the glass substrate comes to have a discotic shape. Then, inner circumference edge surface and outer circumference edge surface are ground by a diamond grinder to carry out predetermined chamfering process (forming, chamfering).

[0063]

(3) Second wrapping step (Step 3)

Next, on both surfaces of the glass substrate thus obtained in the previous step, second wrapping process is carried out in a similar manner as the first wrapping process. By carrying out the second wrapping process, it is possible to remove minute convex or concave shape formed on the main surface in the cutting step or edge surface polishing step, which are previous steps, in advance and it becomes possible to finish later-described main surface polishing step in a short period of time.

[0064]

(4) Edge surface polishing step (Step 4)

Next, by brush polishing method, outer circumference edge surface of the glass substrate is mirror-polished. At this time, slurry including cerium oxide abrasive grain (loose grain) is used as polishing grain.

[0065]

For the inner circumference edge surface, mirror polishing by the polishing apparatus 1 was carried out. This polishing procedure has already been described and therefore,

explanation thereof is omitted (refer to FIGs. 6, 7, and 9).

[0066]

The glass substrate after the polishing of outer and inner circumference edge surfaces was washed by water. By this polishing, the edge surfaces of the glass substrate were processed to have mirror surfaces that can prevent separation of sodium or potassium. Especially, the inner circumference edge surface was polished to have fine dimension tolerance or circularity of the inner hole even when a few hundreds of glass substrates are laminated and polished.

[0067]

(5) Main surface polishing step (Step 5)

As a main surface polishing step, the first polishing step was performed. The first polishing step is mainly aimed at removing crack or distortion remaining on the main surface after the wrapping step. In the first polishing step, the main surface was polished by an apparatus for both surfaces polishing using planetary gear mechanism, using hard resin polisher. As polishing liquid, cerium oxide abrasive grain was used.

[0068]

The glass substrate after the first polishing step was sequentially dipped in cleansing tanks of neutral detergent, pure water, and isopropyl alcohol (IPA) to be cleansed.

[0069]

Next, second polishing step aimed at finishing the main surface to have a mirror surface was performed. In the second polishing step, main surface was polished by an apparatus for

both surfaces polishing using planetary gear mechanism, using flexible resin foam polisher. As polishing liquid, cerium oxide abrasive grain having finer grain than the cerium oxide abrasive grain used in the first polishing step was used.

[0070]

The glass substrate after the second polishing step was sequentially dipped in cleansing tanks of neutral detergent, pure water, and isopropyl alcohol (IPA) to be cleansed while ultrasonic wave was applied to the tanks.

[0071]

(6) Chemical strengthening step (Step 6)

Next, chemical strengthening was conducted to the glass substrate obtained in the previous step. The chemical strengthening was conducted by preparing chemical strengthening solution in which potassium nitrate and sodium nitrate are mixed. The chemical strengthening solution was heated and the cleansed glass substrate was also heated. Then, the glass substrate was dipped into the chemical strengthening solution. To chemically strengthen the whole surfaces of the glass substrate, the dipping was conducted while the glass substrate was placed in a holder which retains a plurality of glass substrates by their edge surface.

[0072]

By dipping the glass substrate into the chemical strengthening solution, lithium ion and sodium ion on the surface layer of the glass substrate are replaced by sodium ion and potassium ion in the chemical strengthening solution and

the glass substrate is strengthened.

[0073]

The glass substrate after the chemical strengthening step was dipped into a water tank to be rapidly cooled down and was dipped in concentrated sulfuric acid to be cleansed. Moreover, the glass substrate was sequentially dipped into tanks of pure water and IPA to be cleansed while ultrasonic wave was applied to the tanks.

[0074]

Through these steps, a flat, smooth, and highly rigid glass substrate for a magnetic disc was obtained.

[0075]

(7) Magnetic disc manufacturing step (Step 7)

On the both main surfaces of the glass substrate obtained through the steps (1) to (6), an attachment layer including Cr alloy, a soft magnetic layer including FeCoCrB alloy, a ground layer including Ru, a vertical magnetic recording layer including CoCrTi alloy, a protection layer including carbon hydroxide, and a lubrication layer including perfluoropolyether are sequentially formed to manufacture a vertical magnetic recording disc. Here, a vertical magnetic recording disc was manufactured in the present embodiment. However, a magnetic layer or the like may be formed as longitudinal magnetic recording method.

[0076]

A preferable embodiment of the present invention has been explained with reference to attached figures. However, it is

needless to say that the present invention is not limited to the examples shown here. As will be understood by the skilled persons, various modifications and variations of the present invention are possible in the light of the scope of the subjoined claims and therefore all the modifications and variations fall within the technical scope of the present invention.

[0077]

For example, in the above-mentioned embodiment, the shaft 47 was taken as a shaft which can be expanded/contracted. However, needless to say, the expansion/contraction method is not limited thereto. As shown in FIG. 12, the shaft 47 may include a rod-shaped part 49 which is coaxial with the attachment portion 48 and can rotate in both direction and three interlocking parts 50 which can move in radial direction and provided on an outer circumference of the rod-shaped part 49. The rod-shaped part 49 includes a cum surface 49a having three outer circumference surfaces (a surface having a traverse trajectory of the surface which is a curve gradually getting farther (nearer) toward the shaft center of the rod-shaped part 49), and a traverse surface of the interlocking part 50 has a sector form while the outer circumference surface 50a configures a columnar surface and a peak portion 50b is brought into contact with the cum surface 49a by a bias of an elastic member (not shown). Then, when the rod-shaped part 49 rotates in the arrow A direction, the shaft 47 expands in radial direction and when the rod-shaped part 49 rotates in the arrow B direction, the shaft 47 is contracted in the radial direction.

[0078]

The present invention can be utilized for manufacturing a glass substrate for a magnetic disc, especially for polishing an inner circumference edge surface.

What Is Claimed Is:

1. A manufacturing method of a glass substrate for a magnetic disc comprising an inner circumference edge surface polishing step for laminating a glass substrate having an inner hole and for inserting a polishing body into a communicating inner hole for polishing, further comprising:

a step of installing a positioning member instead of a polishing body of a polishing apparatus in a manner that the center axis of the positioning member matches the center axis of the polishing body at a position where the polishing body is to be provided;

a step of laminating a plurality of glass substrates;

a step of causing the positioning member to penetrate a communicating inner hole of the laminated glass substrates;

a step of fixing the laminated glass substrates;

a step of removing the positioning member from the communicating inner hole of the positioned glass substrates;

a step of attaching a polishing body to the polishing apparatus instead of the positioning member; and

a step of inserting the polishing body into the communicating inner hole of the positioned glass substrates.

2. A manufacturing method of a glass substrate for a magnetic disc comprising:

a step of attaching a lower retaining portion of a work holder which sandwiches glass substrates in a condition where

a plurality of the glass substrates are laminated by an upper retaining portion and the lower retaining portion on a table of a polishing apparatus for polishing inner circumference edge surface of an inner hole formed in the glass substrate;

a step of laminating a plurality of glass substrates on the lower retaining portion;

a step of providing a shaft perpendicularly to the lower retaining portion so that the shaft penetrates a communicating inner hole of the glass substrates laminated on the lower retaining portion;

a step of positioning the laminated glass substrates by use of the shaft;

a step of pressing the glass substrates thus positioned on the lower retaining portion with the upper retaining portion from above;

a step of removing the shaft from the communicating inner hole of the positioned glass substrate;

a step of inserting a polishing body into the communicating inner hole of the positioned glass substrates;
and

a step of polishing the inner circumference edge surface by the polishing body by relatively rotating or moving the table and the polishing body.

3. The manufacturing method of a glass substrate for a magnetic disc according to Claim 2, wherein;

the shaft can stretch or contract in radial direction,

in the step where the laminated glass substrates are positioned by the shaft, the shaft is stretched in radial direction for positioning, and

in the step where the shaft is removed from the communicating inner hole of the positioned glass substrates, the shaft is contracted in radial direction to be removed.

4. The manufacturing method of a glass substrate for a magnetic disc according to either Claim 2 or 3, wherein;

the step of laminating a plurality of glass substrates on the lower retaining portion further includes;

a step of storing the glass substrates in a bottomed cylindrical work cover having an open upper part in a condition where a plurality of the glass substrates are laminated, and

a step of setting the glass substrates stored with the work cover as a whole on the lower retaining portion together with the work cover.

5. A manufacturing apparatus of a glass substrate for a magnetic disc comprising:

a work holder which sandwiches a plurality of glass substrates having an inner hole in a laminated condition by upper and lower retaining portions;

a table to which the lower retaining portion is attached,

a shaft which can expand or contract in radial direction;

and

a polishing body attaching portion for attaching a

polishing body which polishes an inner circumference edge surface of the inner hole by relative rotation or movement with the table; wherein

the shaft can be provided perpendicularly to the table so that the shaft stretches in radial direction to determine the position of the glass substrate when a plurality of glass substrates are laminated on the lower retaining portion attached to the table and also can be contracted in radial direction to be removed from the inner hole while the positioned glass substrate is pressed from the above by the upper retaining portion; and

the polishing body to be attached to the polishing body attaching portion is inserted into the inner hole of the glass substrate positioned by the shaft after the shaft is removed therefrom to polish the inner circumference edge surface.

6. The manufacturing apparatus of a glass substrate for a magnetic disc according to Claim 5, further comprising:

a bottomed cylindrical work cover having an open upper part in which a plurality of the glass substrates are stored in a laminated condition; wherein

the glass substrates stored in the work cover are set on the lower retaining portion in an integrated manner with the work cover.

7. A manufacturing method of a magnetic disc comprising:
a step of attaching a lower retaining portion of a work

holder, which sandwiches a plurality of glass substrates in a laminated condition between an upper retaining portion and the lower retaining portion, on a table of a polishing apparatus for polishing an inner circumference edge surface of an inner hole formed on the glass substrate;

a step of laminating a plurality of glass substrates on the lower retaining portion;

a step of providing a shaft perpendicularly to the lower retaining portion so that the shaft penetrates the communicating inner hole of a plurality of the glass substrates laminated on the lower retaining portion;

a step of positioning the laminated glass substrates by the shaft;

a step of pressing the glass substrates thus positioned on the lower retaining portion with the upper retaining portion from above;

a step of removing the shaft from the communicating inner hole of the positioned glass substrate;

a step of inserting a polishing body into the communicating inner hole of the positioned glass substrates;

a step of polishing the inner circumference edge surface by the polishing body by relatively rotating or moving the table and the polishing body; and

a step of forming a magnetic layer on the surface of the glass substrate after the glass substrate is polished.

8. The manufacturing method of a magnetic disc according to

Claim 7, wherein;

the shaft can stretch or contract in radial direction,
in the step where the laminated glass substrates are positioned by the shaft, the shaft is stretched in radial direction for positioning; and

in the step where the shaft is removed from the communicating inner hole of the positioned glass substrates, the shaft is contracted in radial direction to be removed.

9. The manufacturing method of a magnetic disc according to either Claim 7 or 8, wherein the step of laminating a plurality of glass substrates on the lower retaining portion includes;

a step of storing the glass substrates in a bottomed cylindrical work cover having an open upper part in a condition where a plurality of the glass substrates are laminated, and

a step of setting the glass substrates stored with the work cover as a whole on the lower retaining portion together with the work cover in an integrated manner.