

Description

Title of Invention: MEASUREMENT DEVICE

Technical Field

[0001]

The present invention relates to a measurement device that measures an object of measurement having a plate-like shape.

Background Art

[0002]

As such a type of measurement device, the one as shown in Fig. 13(a) and Fig. 13(b) is disclosed (see Patent Literature 1), which includes a base block 1, a measuring table 2 provided on the base block 1 for horizontally holding thereon an object of measurement D such as a disk having a disk-like shape, and a sensor 3. This measurement device is configured to measure the flatness of the surface of the object of measurement D by moving the sensor in a non-contact fashion in parallel with the surface of the object of measurement D held on the measuring table 2.

Citation List

Patent Literature

[0003]

Patent Literature 1: JP H11-183115 A

Summary of Invention

Technical Problem

[0004]

Unfortunately, in the measurement device disclosed in Patent Literature 1, the object of measurement D is horizontally held on the measuring table 2, and thus

gravity acts in a direction that makes the object of measurement D sagged. That is, a sag is generated in the object of measurement D due to its own weight. The object of measurement D can be measured favorably when its thickness is relatively large and a sag due to its own weight is small. However, when the object of measurement D is relatively thin in shape, a sag due to its own weight is large, making the object of measurement D deformed, and thus it is impossible to precisely measure the flatness.

[0005]

In response to the above issue, it is an object of the present invention to provide a measurement device capable of more precisely measuring the flatness of an object of measurement even if the object of measurement is relatively thin in shape.

Solution to Problem

[0006]

(1) The measurement device according to the present invention is a measurement device that measures an object of measurement, including: a measuring means that measures a shape of at least one of a front surface or a back surface of the object of measurement; and a transfer means that transfers the object of measurement. The measuring means includes a measurement reference surface that is inclined by a predetermined angle with respect to a vertical direction. The transfer means includes a holding portion that holds the object of measurement such that the object of measurement is in parallel with the measurement reference surface. The holding portion attaches and detaches the object of measurement to and from the measuring means while maintaining a posture in which the object of measurement is inclined by the predetermined angle.

[0007]

(2) The measurement device according to the present invention is the

measurement device of (1), in which the transfer means includes an attachment holding portion that attaches the object of measurement to the measuring means and a detachment holding portion that detaches the object of measurement from the measuring means.

[0008]

(3) The measurement device according to the present invention is the measurement device of (1) or (2), in which when the transfer means transfers the object of measurement to face the measuring means, the object of measurement is transferred in parallel with the measurement reference surface.

[0009]

(4) The measurement device according to the present invention is the measurement device of (1), in which the measuring means includes a first measuring means and a second measuring means that are disposed to face each other.

[0010]

(5) The measurement device according to the present invention is the measurement device of (4), in which the transfer means includes a first transfer means that transfers the object of measurement to face the first measuring means and a second transfer means that transfers the object of measurement to face the second measuring means, and a transfer direction by the first transfer means and a transfer direction by the second transfer means are opposite to each other.

[0011]

(6) The measurement device according to the present invention is the measurement device of any one of (1) to (5), including a delivery portion that converts a vertical posture and an inclined posture between the vertical posture in which the object of measurement is located along a vertical direction and the inclined posture in which the object of measurement is located to be inclined by a predetermined angle with respect to the vertical direction.

[0012]

(7) The measurement device according to the present invention is the

measurement device of (1), including a drive means that drives the transfer means, the drive means being disposed below the measuring means in the vertical direction.
[0013]

(8) The measurement device according to the present invention is the measurement device of (1), in which the transfer means is configured to be able to reciprocate in a horizontal direction and in a direction perpendicular to the measurement reference surface, and the object of measurement is transferred by the transfer means from an entry side to an exit side of the measurement device while maintaining a primary surface of the object of measurement directed toward the measurement reference surface.

[0014]

(9) The measurement device according to the present invention is the measurement device of (1), in which the object of measurement has a through hole that penetrates in a thickness direction, and the holding portion holds an inner wall portion of the through hole.

[0015]

(10) The measurement device according to the present invention is the measurement device of (1), in which the measurement reference surface includes a support that supports the object of measurement and a steady rest that contacts the object of measurement supported by the support.

[0016]

In accordance with the measurement device according to the present invention of (1), the measurement device includes: a measuring means that measures a shape of at least one of a front surface or a back surface of the object of measurement; and a transfer means that transfers the object of measurement. The measuring means includes a measurement reference surface that is inclined by a predetermined angle with respect to a vertical direction. The transfer means includes a holding portion that holds the object of measurement such that the object of measurement is in parallel with the measurement reference surface. The

holding portion attaches and detaches the object of measurement to and from the measuring means while maintaining a posture in which the object of measurement is inclined by the predetermined angle.

[0017]

With this configuration, the issue of the conventional measurement device can be solved, that is, a sag of the object of measurement can be effectively suppressed by horizontally holding the object of measurement on the measuring table, and the issue of reduction of the accuracy of measuring the flatness of the object of measurement being thin in shape can be solved. According to this configuration, since the object of measurement is held in a posture in which the object of measurement is inclined by a predetermined angle, and the shape of at least one of the front surface or the back surface thereof is measured, it is possible to suppress generation of a sag of the object of measurement due to its own weight and to more precisely measure the shape of the object of measurement.

[0018]

In addition, the holding portion is configured to attach and detach the object of measurement to and from the measuring means while maintaining the inclined posture in which the object of measurement is inclined at the predetermined angle. With this configuration, the inclined posture can be maintained at high accuracy and the attachment and detachment of the object of measurement to and from the measuring means can be smoothly performed. Furthermore, it is possible to suppress influence of the sag due to the weight of object of measurement and stabilize the posture of the object of measurement when placed in the measurement device.

[0019]

In accordance with the measurement device according to the present invention of (2), an attachment transfer portion attaches the object of measurement to the measuring means and a detachment transfer portion detaches the object of measurement from the measuring means. With this configuration, the object of

measurement can be rapidly transferred, the attachment and detachment of the object of measurement to and from the measuring means can be smoothly performed, and the object of measurement can be effectively transferred.

[0020]

In accordance with the measurement device according to the present invention of (3), when the transfer means transfers the object of measurement to face the measuring means, the object of measurement is transferred in parallel with the measurement reference surface. With this configuration, a large number of objects of measurement can be effectively transferred without generation of excess stress on the object of measurement, and a large number of objects of measurement can be rapidly measured.

[0021]

In accordance with the measurement device according to the present invention of (4), the measuring means includes a first measuring means and a second measuring means that are disposed to face each other. Thus, the arrangement space for the components of the measurement device can be reduced, and the measurement device may be downsized.

[0022]

In accordance with the measurement device according to the present invention of (5), the transfer means includes a first transfer means that transfers the object of measurement to face the first measuring means and a second transfer means that transfers the object of measurement to face the second measuring means, and a transfer direction by the first transfer means and a transfer direction by the second transfer means are opposite to each other. With this configuration, the arrangement space for the first transfer means and the first measuring means and the arrangement space for the second transfer means and the second measuring means may be reduced, and the measurement device may be downsized.

[0023]

In accordance with the measurement device according to the present

invention of (6), the measurement device includes a delivery portion that converts a vertical posture and an inclined posture between the vertical posture in which the object of measurement is located along a vertical direction and the inclined posture in which the object of measurement is located to be inclined by a predetermined angle with respect to the vertical direction. With this configuration, the delivery portion can smoothly convert the vertical posture of the transferred object of measurement into the inclined posture, and the delivery portion can smoothly convert the inclined posture of the transferred object of measurement into the vertical posture. Thus, the measurement device does not require the process of conversion into the inclined posture by the transfer portion, and can suppress generation of excess stress on the object of measurement during transfer and stabilize the posture of the object of measurement when placed in the measurement device.

[0024]

In accordance with the measurement device according to the present invention of (7), the measurement device includes a drive means that drives the transfer means, the drive means being disposed below the measuring means in the vertical direction. With this configuration, fine dust materials generated from the drive means are less likely to adhere to the components of the measuring means, such as a substrate, and the components, such as a substrate, are less likely to be contaminated.

[0025]

In accordance with the measurement device according to the present invention of (8), since the transfer means is configured to be able to reciprocate in a horizontal direction and in a direction perpendicular to the measurement reference surface, the object of measurement can be effectively and rapidly transferred. In addition, since the transfer means transfers the object of measurement from the entry side to the exit side of the measurement device while maintaining the primary surface of the object of measurement directed toward the measurement reference

surface, a large number of objects of measurement can be rapidly measured and transferred without wasted movement.

[0026]

In accordance with the measurement device according to the present invention of (9), since the object of measurement has a through hole that penetrates in a thickness direction, and the holding portion holds an inner wall portion of the through hole, the object of measurement can be stably held without generation of excess stress on the inclined object of measurement.

[0027]

In accordance with the measurement device according to the present invention of (10), since the measurement reference surface includes a support that supports the object of measurement and a steady rest, it is possible to suppress deflection of the object of measurement, maintain and stabilize the posture of the object of measurement, thus increasing the accuracy of measuring the flatness.

Advantageous Effects of Invention

[0028]

According to the present invention, it is possible to provide a measurement device capable of more precisely measuring the flatness of an object of measurement even if the object of measurement is relatively thin in shape.

Brief Description of Drawings

[0029]

Fig. 1 is a view of a disk that is measured by measurement devices according to a first embodiment to a third embodiment of the present invention, wherein Fig. 1(a) is a perspective view of the disk, and Fig. 1(b) is a cross-sectional view of the disk.

Fig. 2 is a process chart showing a process of producing the disk according to the first embodiment to the third embodiment of the present invention.

Fig. 3 is a schematic diagram schematically showing a configuration of the measurement device according to the first embodiment of the present invention.

Fig. 4 is a schematic diagram schematically showing the front of the measurement device according to the first embodiment of the present invention.

Fig. 5 is a schematic diagram of the measurement device according to the first embodiment of the present invention, wherein Fig. 5(a) is an enlarged front view of the measurement device, and Fig. 5(b) is an enlarged side view of the measurement device.

Fig. 6 is a schematic diagram of the measurement device according to the first embodiment of the present invention, wherein Fig. 6(a) is a front view of a disk holding portion of a robot transfer portion and a disk, Fig. 6(b) is a side view of the disk holding portion of the robot transfer portion and the disk, Fig. 6(c) is a front view of a support and a steady rest for a disk provided on a measurement reference surface side of an A-surface measuring portion, and the disk, Fig. 6(d) is a side view of the support provided on the measurement reference surface side of the A-surface measuring portion and the disk, Fig. 6(e) is a front view of a holding portion of an attachment transfer mechanism or a detachment transfer mechanism and the disk, and Fig. 6(f) is a side view of the holding portion of the attachment transfer mechanism or the detachment transfer mechanism and the disk.

Fig. 7 is a schematic diagram showing the operation of the measurement device according to the first embodiment of the present invention, wherein Fig. 7(1) shows a state where the holding portion is waiting in a position separated from the disk, Fig. 7(2) shows a state where the holding portion has approached the disk, Fig. 7(3) shows a state where the holding portion is moving up, and Fig. 7(4) shows a state where the holding portion is holding the disk.

Fig. 8 is a schematic diagram showing the operation of the measurement device according to the first embodiment of the present invention, wherein Fig. 8(a) shows a state where the disk holding portion of the robot transfer portion is passing the disk to an entry-side delivery portion, Fig. 8(b) shows a state where the

entry-side delivery portion is passing the disk to the attachment transfer mechanism of a first transfer portion, and Fig. 8(c) shows a state where the attachment transfer mechanism is attaching the disk to the disk holding portion of the A-surface measuring portion.

Fig. 9 is a schematic diagram showing the operation of the measurement device according to the first embodiment of the present invention, wherein Fig. 9(a) is a state where the attachment transfer mechanism of the first transfer portion is spaced from the A-surface measuring portion, and Fig. 9(b) shows a state where the attachment transfer mechanism of the first transfer portion has come closer to the A-surface measuring portion and has attached the disk to the disk holding portion of the A-surface measuring portion.

Fig. 10 is a schematic diagram showing the operation of the measurement device according to the first embodiment of the present invention, wherein Fig. 10(a) shows a state where the sensor of the A-surface measuring portion has moved closer to the entry-side delivery portion and has measured the A surface of the disk, Fig. 10(b) shows a state where the detachment transfer mechanism of the first transfer portion is passing the disk to the exit-side delivery portion, and Fig. 10(c) shows a state where the exit-side delivery portion is passing the disk to the disk holding portion of a third transfer portion.

Fig. 11 is a schematic diagram schematically showing a configuration of a measurement device according to a second embodiment of the present invention.

Fig. 12 is a schematic diagram schematically showing a configuration of a measurement device according to a third embodiment of the present invention.

Fig. 13 is a view of the conventional measurement device, wherein Fig. 13(a) is a perspective view of the measurement device, and Fig. 13(b) is a plan view of the measurement device.

Description of Embodiments

[0030]

Referring to the drawings, measurement devices 20, 20A, 20B according to the first embodiment, the second embodiment, and the third embodiment to which the measurement device according to the present invention is applied will be described.

[0031]

First, a disk 10 that is an object to be measured by the measurement devices 20, 20A, 20B according to the first embodiment, the second embodiment, and the third embodiment will be described. As shown in Fig. 1(a) and Fig. 1(b), the disk 10 has a disk-like shape with a thickness th , an outside diameter D , and a central through hole h having an inside diameter d . Note that the shape of the disk 10 is not limited to a disk, and may be other than the disk-like shape, for example, a rectangular shape or an elliptical shape. Although the disk 10 in the present embodiment, the second embodiment, and the third embodiment is a disk for a hard disk, it may be a disk used for other purposes.

[0032]

The disk 10 has a thickness th of about 0.3 mm to 2 mm, an outside diameter D of about 30 mm to 270 mm, and an inside diameter d of about 10 mm to 70 mm. Specifically, the disk 10 has a disk-like shape having a dimension selected from a thickness th of 1.75 mm, 1.6 mm, 1.27 mm, 1.0 mm, 0.8 mm, 0.635 mm, 0.6 mm, 0.5 mm, 0.38 mm, or 0.3 mm, an outside diameter D of 3.5 inches, 2.8 inches, or 2.5 inches, and an inside diameter d of 20 mm or 25 mm.

[0033]

The disk 10 is configured by an aluminum substrate made of an aluminum plate or an aluminum alloy plate. The disk 10 has smoothness and surface hardness, as well as rigidity and impact resistance that allow suppressing occurrence of vibrations caused by high-speed rotation. In addition, the disk 10 has rigidity that allows maintaining the posture state by itself when the disk 10 is supported vertically by a support member inserted into the through hole h , for example. In order to have such characteristics, the disk 10 is made of a hard

material and may be a glass substrate made of a glass plate.

[0034]

Next, one example of the process of producing the disk 10 will be briefly described with reference to Fig. 2.

First, an aluminum blank as a substrate is subjected to lathe machining including chamfering (step S1) to form a disk having a disk-like shape. The formed disk is subjected to annealing (step S2).

[0035]

Next, first grinding (step S3) and second grinding (step S4) are performed successively on the disk to grind the front and back surfaces of the disk, and then annealing is performed on the disk (step S5). After annealing, the front and back surfaces of the disk are subjected to pre-treatment and electroless nickel-phosphorus plating (NiP) to form a coating of nickel-phosphorus plating on the disk (step S6), and then annealing is performed on the disk (step S7).

[0036]

Next, first polishing (step S8) and second polishing (step S9) are performed successively on the disk using a polishing pad to precisely polish the front and back surfaces of the disk. After finish-polishing, final washing is performed on the disk, and the disk is dried after washing, and the disk 10 is completed (step S10). Examples of the final washing include precise washing by ultrasound using a detergent.

[0037]

After final washing, the flatness is measured for all of the disks 10 by the measurement device 20 according to the first embodiment. The flatness is a rate representing a degree of flatness of the front and back surfaces of the disk 10, and may be a degree similar to the planeness defined by Japanese Industrial Standard (JIS) (JIS B 0621-1984), for example.

[0038]

After the total measurement of the flatness, surface inspection of the disk

10 is performed using a surface inspection machine (step S11). The disk 10 identified as a defective product by the surface inspection (step S11) is processed as a defective product, and the disk 10 identified as a conforming product is vacuum packed (step S12), then packed in a carton box (step S13), and shipped to a predetermined destination.

[0039]

Meanwhile, depending on the specification of the disk 10, the disk 10 identified as a conforming product by the surface inspection is subjected to delivery inspection (step S14). The disk 10 identified as a defective product by the delivery inspection is processed as a defective product, and the disk 10 identified as a conforming product is shipped to a predetermined destination in a predetermined packing.

[0040]

Next, the measurement device 20 according to the present embodiment will be described with reference to the drawings.

As shown in Fig. 3 , Fig. 4 , Fig. 5(a), and Fig. 5(b), the measurement device 20 includes a first robot transfer portion 21, a first delivery portion 22, an A-surface measuring portion 23, a first transfer portion 24, and a first drive portion 25.

[0041]

In addition, the measurement device 20 includes a third transfer portion 36, a second delivery portion 32, a second transfer portion 34, a second drive portion 35, a B-surface measuring portion 33, a second robot transfer portion 31, and a controller (not shown) that controls operation of each component.

[0042]

The measurement device 20 imports the disk 10 from a predetermined location using the first robot transfer portion 21, and measures the shape of the front surface of the disk 10, that is, the flatness of the A surface, using the A-surface measuring portion 23. Then, the measurement device 20 transfers the disk 10 from the A-surface measuring portion 23 to the B-surface measuring portion 33, and

measures the shape of the back surface of the disk 10, that is, the flatness of the B surface, using the B-surface measuring portion 33. Then, the measurement device 20 is configured to export the measured disk 10 to a predetermined location using the second robot transfer portion 31. The measurement device 20 can operate fully automatically, while importing the disk 10 from a predetermined location, measuring the flatness of the A surface and the B surface, and exporting the measured disk 10 to a predetermined location.

[0043]

Note that the first transfer portion 24 and the second transfer portion 34 of the measurement device 20 according to the present embodiment correspond to the first transfer means and the second transfer means, respectively, that form the transfer means of a transfer device according to the present invention. The first delivery portion 22 and the second delivery portion 32 correspond to the delivery portion of the transfer device according to the present invention, the A-surface measuring portion 23 and the B-surface measuring portion 33 correspond to the first measuring means and the second measuring means, respectively, that form the measuring means of the transfer device according to the present invention, and the first drive portion 25 and the second drive portion 35 correspond to the drive means of the transfer device according to the present invention.

[0044]

As shown in Fig. 4, the first robot transfer portion 21 includes arms 41, 42 and a disk holding portion 43. The first robot transfer portion 21 is configured to transfer the disk 10 from a predetermined location and pass it to an entry-side delivery portion 51.

[0045]

The first robot transfer portion 21 is configured by a small articulated robot. The articulated robot may be a vertical articulated robot capable of taking various postures and operating within a wide range in the direction of gravity or may be a horizontal articulated robot having arms operating in a horizontal direction, for

example.

[0046]

As shown in Fig. 6(a) and Fig. 6(b), the disk holding portion 43 of the first robot transfer portion 21 includes an upper disk receiver 43a and a grooved hook 43b, and is configured to hold the disk 10 along a vertical direction, that is, to vertically hold the disk 10. The grooved hook 43b of the disk holding portion 43 can move up and down and the disk holding portion 43 grips the disk 10 between the upper disk receiver 43a and the grooved hook 43b.

[0047]

As shown in Fig. 3, the first delivery portion 22 includes an entry-side delivery portion 51 and an exit-side delivery portion 52. The entry-side delivery portion 51 is disposed on the entry side of the first drive portion 25, and is configured to receive the disk 10 from the disk holding portion 43 of the first robot transfer portion 21, move along the X direction, and pass the disk 10 to an attachment transfer mechanism 71 of the first transfer portion 24.

[0048]

When holding the disk 10 received from the disk holding portion 43, the entry-side delivery portion 51 is configured to hold the disk 10 by converting the vertical posture in which the disk 10 is vertically held by the disk holding portion 43 into the inclined posture in which the disk 10 is inclined at an inclination angle θ with respect to the vertical direction as Fig. 5(b) and Fig. 6(c) to Fig. 6(f). That is, when receiving the disk 10 held in the vertical posture by the disk holding portion 43, the entry-side delivery portion 51 causes the disk 10 held in the vertical posture to be inclined and holds the disk 10 in the inclined posture in which the disk 10 is inclined at an inclination angle θ . Note that the inclination angle θ according to the present embodiment corresponds to a predetermined angle according to the measurement device of the present invention, and the inclination angle θ is, for example, in a range of larger than 0° and smaller than 15° , and is set preferably to an angle of about 5° to 10° .

[0049]

The exit-side delivery portion 52 is disposed on the exit side of the first drive portion 25, and is configured to receive the disk 10 from the first transfer portion 24 and move in the X direction while maintaining the inclined posture in which the disk 10 is inclined at an inclination angle θ . Then, the exit-side delivery portion 52 is configured to convert the posture of the disk 10 inclined at an inclination angle θ into the vertical posture and pass the disk 10 to the third transfer portion 36.

[0050]

The entry-side delivery portion 51 and the exit-side delivery portion 52 have a function of converting the posture of the disk 10 into the vertical posture and the inclined posture, separately from a transfer mechanism, which will be described later. Thus, it is possible to suppress generation of excess stress on the disk 10 when transferred by the transfer mechanism, and to stabilize the posture including a disk angle of the disk 10 when placed in the measurement device 20, and also to increase the accuracy of measuring the flatness.

[0051]

For example, when the disk has a thickness having rigidity with which the disk is self-supported in the vertical posture but is sagged due to its own weight in the horizontal posture, stress may act on the disk 10 when the posture of the disk is converted from the vertical posture into the inclined posture, and the posture of the disk 10 may become unstable. In contrast, in the present embodiment, the entry-side delivery portion 51 and the exit-side delivery portion 52 convert the posture of the disk 10 in advance, and pass the disk held in the same posture to the A-surface measuring portion 23 and the B-surface measuring portion 33. Thus, it is possible to suppress influence of the sag due to its own weight and stabilize the posture of the object of measurement when attached to the A-surface measuring portion 23 and the B-surface measuring portion 33, thus allowing more precise measurement.

[0052]

In addition, in the present embodiment, the entry-side delivery portion 51 and the exit-side delivery portion 52 are configured to move in the X direction. However, the entry-side delivery portion 51 and the exit-side delivery portion 52 may not be configured to move in the X direction and may only have a function of converting the posture of the disk 10 into the vertical posture and the inclined posture. Transferring the disk 10 in the X direction by the drive portion of the delivery portion allows improvement of the operation efficiency in the transfer operation, particularly when there is a long distance from the first robot transfer portion 21 and the second robot transfer portion 31 to the transfer mechanism.

[0053]

As shown in Fig. 5(a) and Fig. 5(b), the A-surface measuring portion 23 includes a measuring portion body 61, a support 62, a sensor 63, a steady rest 64, and a sensor moving mechanism (not shown). The A-surface measuring portion 23 is configured to hold the disk 10 on the measurement reference surface 61a of the measuring portion body 61 and move the sensor 63 disposed to face the measurement reference surface 61a along the measurement reference surface 61a so as to measure the flatness of the A surface that is a front surface of the disk 10.

[0054]

The measuring portion body 61 is provided with a sensor moving mechanism that supports and moves the sensor 63 along the measurement reference surface 61a. The measurement reference surface 61a is a surface that serves as a reference when measuring the flatness of the front surface of the disk 10 by the A-surface measuring portion 23, and the flatness of the measurement reference surface 61a has a value that is substantially zero. The disk 10 is supported by the support 62 such that the B surface faces the measurement reference surface 61a and the A surface is exposed.

[0055]

The support 62 is inserted into the through hole h of the disk 10 to hang the

disk 10 thereon to support the disk 10 facing the measurement reference surface 61a in a suspended state. In the present embodiment, the support 62 is configured by a pair of hooks. As shown in Fig. 6(c) and Fig. 6(d), the support 62 includes a chamfered portion at an upper corner in the vertical direction, and the chamfered portion is in contact with the inner wall portion of the through hole h of the disk 10 (a part of the through hole except for the primary surface of the disk). That is, the disk 10 is hung on the chamfered portion of the support 62.

[0056]

The steady rest 64 prevents deflection of the disk 10 and supports it at a preset inclination angle θ when the disk 10 is supported by the support 62 on the measurement reference surface 61a. The steady rest 64 is provided on the measurement reference surface 61a. As shown in Fig. 6(c) and Fig. 6(d), the steady rest 64 includes a chamfered portion at an upper corner in the vertical direction, and the chamfered portion is in contact with the outer wall portion of the disk (a part of the peripheral end face except for the primary surface of the disk). As shown in Fig. 6(c), the steady rests 64 are provided in pair so as to contact the right and left sides of the lower part of the disk. The steady rest 64 can maintain and stabilize the posture of the disk 10 when the disk 10 is supported by the support 62, and has a function of increasing the accuracy of measuring the flatness by the sensor 63. The distance between the pair of steady rests 64 is set such that a lower disk receiver 81b of a holding portion 80 provided for each of an attachment transfer mechanism 71 and a detachment transfer mechanism 72, which will be described later, can vertically pass through the space between the pair of steady rests 64.

[0057]

The sensor 63 is configured by a known sensor capable of measuring the flatness of the A surface of the disk 10. The sensor 63 is moved in parallel along the measurement reference surface 61a of the measuring portion body 61 by the sensor moving mechanism, and during that time, measures the flatness of the A

surface of the disk 10 that is being hung on the support 62 and being held on the measurement reference surface 61a.

[0058]

Examples of the sensor include a laser displacement sensor capable of measuring the flatness with high accuracy by detecting a displacement amount of the A surface of the disk 10 in the height direction while moving the sensor in a non-contact fashion, and an eddy current displacement sensor capable of measuring the flatness with high accuracy by detecting an intensity of induced current flowing through a coil by electromagnetic induction while moving the sensor in a non-contact fashion.

[0059]

The sensor moving mechanism includes a known drive mechanism, for example, a linear motor (not shown) that produces power in a linear direction. Note that the drive mechanism is not limited to the one that produces power in a linear direction, and may include a moving mechanism including a rotating electric machine such as a motor, and a converting mechanism such as a timing pulley and a timing belt, a ball screw, and the like that convert rotational motion of the rotating electric machine into linear motion.

[0060]

The first transfer portion 24 is configured to transfer the disk 10 in parallel with the measurement reference surface 61a when transferring the disk 10 to face the A-surface measuring portion 23. As shown in Fig. 3 and Fig. 4, the first transfer portion 24 is configured to reciprocate along the X direction between the entry-side delivery portion 51 and the exit-side delivery portion 52 and to be able to shuttle transfer the disk 10. The attachment transfer mechanism 71 and the detachment transfer mechanism 72 are attached to the first transfer portion 24. The attachment transfer mechanism 71 and the detachment transfer mechanism 72 each include a holding portion 81 that holds the disk 10. The attachment transfer mechanism 71 performs the operation of receiving the disk 10 from the entry-side

delivery portion 51 and setting the disk 10 on the measurement reference surface 61a of the measuring portion body 61, and the detachment transfer mechanism 72 performs the operation of detaching the disk 10 from the measurement reference surface 61a of the measuring portion body 61 and passing the disk 10 to the exit-side delivery portion 52. The attachment transfer mechanism 71 and the detachment transfer mechanism 72 hold and transfer the disk 10 such that the A surface of the disk 10 is exposed on the side remote from the measuring portion body 61 and the B surface of the disk 10 faces the measuring portion body 61 on the side close to the measuring portion body 61.

[0061]

As shown in Fig. 5(a), Fig. 6(e), and Fig. 6(f), the holding portion 81 includes a hook portion 81a, a lower disk receiver 81b, an upper disk receiver 81c, and a frame 81d. The hook portion 81a is configured to be inserted into the through hole h of the disk 10 to hang thereon the inner wall portion of the through hole h to hold the disk 10, and the lower disk receiver 81b is configured to hold the disk 10 with the lower part of the disk 10 placed thereon. The upper disk receiver 81c is fixed to the frame 81d, and is configured to contact the upper part of the disk 10 to limit the upward movement of the disk 10. The hook portion 81a and the lower disk receiver 81b are integrally provided to be movable with respect to the frame 81d. The hook portion 81a and the lower disk receiver 81b, working together with the upper disk receiver 81c, hold or release the disk 10 by being moved in the Z direction and the Y direction by a moving means (not shown).

[0062]

The attachment transfer mechanism 71 and the detachment transfer mechanism 72 are fixed integrally to the first transfer portion 24 of the first drive portion 25, and are reciprocated along the horizontal direction, that is, the X direction shown in Fig. 4, by the first transfer portion 24 being moved by the horizontal moving portion 91 of the first drive portion 25. In addition, the first drive portion 25 includes a width-direction moving portion 92 between the first

transfer portion 24 and the horizontal moving portion 91. Moving the first transfer portion 24 by the width-direction moving portion 92 allows reciprocating the attachment transfer mechanism 71 and the detachment transfer mechanism 72 in a direction perpendicular to the measurement reference surface 61a to be close to or spaced from the measurement reference surface 61a, that is, in the Y direction shown in Fig. 5(b).

[0063]

The attachment transfer mechanism 71 can place the holding portion 81 in a position where the holding portion 81 faces the entry-side delivery portion 51 by the horizontal moving portion 91 of the first drive portion 25 (see Fig. 7(1)). Also, the attachment transfer mechanism 71 can move the holding portion 81 in the Y direction by the width-direction moving portion 92 of the first drive portion 25, insert the hook portion 81a into the through hole h of the disk 10 and place the lower disk receiver 81b below the disk 10, and place the upper disk receiver 81c to face the upper part of the disk 10 (see Fig. 7(2)). Then, the attachment transfer mechanism 71 can raise the hook portion 81a and the lower disk receiver 81b along the Z direction (see Fig. 7(3)), sandwich and lift the disk 10 with the upper disk receiver 81c, thereby receiving the disk 10 from the entry-side delivery portion 51 and holding it in the holding portion 81 (see Fig. 7(4)).

[0064]

Then, the attachment transfer mechanism 71 is moved in the X direction by the horizontal moving portion 91 of the first drive portion 25, places the holding portion 81 in a position where the holding portion 81 faces the measurement reference surface 61a, and moves the holding portion 81 along the Y direction to be close to the measurement reference surface 61a of the measuring portion body 61. Accordingly, the attachment transfer mechanism 71 can insert the support 62 of the measuring portion body 61 into the through hole h of the disk 10. Then, the attachment transfer mechanism 71 lowers the hook portion 81a and the lower disk receiver 81b along the Z direction and releases the disk 10 held by the holding

portion 81. Accordingly, the disk 10 is held on the measurement reference surface 61a with the support 62 hung on the through hole h and the steady rest 64 contacting the lower part of the disk 10 (see Fig. 6(c), Fig. 6(d)).

[0065]

When the attachment transfer mechanism 71 causes the disk 10 having been held by the holding portion 81 to be held on the measurement reference surface 61a of the measuring portion body 61, the first transfer portion 24 is moved from the exit-side delivery portion 52 toward the entry-side delivery portion 51 by the horizontal moving portion 91 of the first drive portion 25, and the holding portion 81 is placed in a position where the holding portion 81 faces the entry-side delivery portion 51. Note that at this timing when the first transfer portion 24 is moved from the exit-side delivery portion 52 toward the entry-side delivery portion 51, the sensor 63 is moved from the entry-side delivery portion 51 side toward the exit-side delivery portion 52 side or from the exit-side delivery portion 52 side toward the entry-side delivery portion 51 side, and the flatness of the A surface of the disk 10 being held on the measurement reference surface 61a is measured.

[0066]

In the same manner as the attachment transfer mechanism 71, the detachment transfer mechanism 72 includes a holding portion 81. When the detachment transfer mechanism 72 is moved in the X direction by the horizontal moving portion 91 of the first drive portion 25 and the holding portion 81 of the attachment transfer mechanism 71 is placed in a position where the holding portion 81 faces the entry-side delivery portion 51, the holding portion 81 of the detachment transfer mechanism 72 is placed in a position where the holding portion 81 faces the measurement reference surface 61a.

[0067]

In a state where the holding portion 81 is placed in a position where the holding portion 81 faces the measurement reference surface 61a, the detachment transfer mechanism 72 moves the holding portion 81 in the Y direction by the

width-direction moving portion 92 of the first drive portion 25. Then, the detachment transfer mechanism 72 inserts the hook portion 81a into the through hole h of the disk 10 being held on the measurement reference surface 61a and places the lower disk receiver 81b below the disk 10, and places the upper disk receiver 81c to face the upper part of the disk 10. Then, the detachment transfer mechanism 72 raises the hook portion 81a and the lower disk receiver 81b along the Z direction, sandwiches and lifts the disk 10 with the upper disk receiver 81c, thereby detaching the disk 10 from the measurement reference surface 61a and holding it in the holding portion 81.

[0068]

Then, the detachment transfer mechanism 72 is moved in the X direction by the horizontal moving portion 91 of the first drive portion 25, and places the holding portion 81 in a position where the holding portion 81 faces the exit-side delivery portion 52. Then, the detachment transfer mechanism 72 lowers the hook portion 81a and the lower disk receiver 81b in the Z direction, and releases the holding of the disk 10 by the holding portion 81 working together with the upper disk receiver 81c. Accordingly, the disk 10 is held by the exit-side delivery portion 52.

[0069]

As shown in Fig. 9, the first drive portion 25 includes the horizontal moving portion 91 and the width-direction moving portion 92. The horizontal moving portion 91 includes a known drive mechanism, for example, a linear motor (not shown) that produces power in a linear direction. Note that the drive mechanism is not limited to the one that produces power in a linear direction, and may include a mechanism including a rotating electric machine such as a motor, and a converting mechanism such as a timing pulley and a timing belt, a ball screw, and the like that convert rotational motion of the rotating electric machine into linear motion.

[0070]

The horizontal moving portion 91 is configured to reciprocate the first

transfer portion 24 in the X direction. The width-direction moving portion 92 is configured to reciprocate the holding portion 81 in a direction perpendicular to the measurement reference surface 61a, that is, in the Y direction shown in Fig. 4.

[0071]

As shown in Fig. 3, the disk 10 is passed from the exit-side delivery portion 52 to the third transfer portion 36, and transferred to the opposite second delivery portion 32, and then passed to the entry-side delivery portion 51 of the second delivery portion 32.

[0072]

In the same manner as the first delivery portion 22, the second delivery portion 32 includes an entry-side delivery portion 51 and an exit-side delivery portion 52, and is configured to receive the disk 10 from the third transfer portion 36 via the entry-side delivery portion 51, and pass the disk 10 to the second robot transfer portion 31 via the exit-side delivery portion 52.

[0073]

As shown in Fig. 3, the B-surface measuring portion 33 is disposed to face the A-surface measuring portion 23. In the same manner as the A-surface measuring portion 23, the B-surface measuring portion 33 includes a measuring portion body 61, a support 62, a sensor 63, a steady rest 64, and a sensor moving mechanism (not shown). The B-surface measuring portion 33 holds the disk 10 on the measurement reference surface 61a of the measuring portion body 61, moves the sensor 63 disposed to face the measurement reference surface 61a along the measurement reference surface 61a, thereby measuring the flatness of the B surface that is a back surface of the disk 10.

[0074]

The second transfer portion 34 is configured to transfer the disk 10 in parallel with the measurement reference surface 61a when transferring the disk 10 to face the B-surface measuring portion 33. In the same manner as the first transfer portion 24, the second transfer portion 34 is configured to reciprocate in

the X direction between the entry-side delivery portion 51 and the exit-side delivery portion 52 and to be able to shuttle transfer the disk 10. The attachment transfer mechanism 71 and the detachment transfer mechanism 72 are attached to the second transfer portion 34.

[0075]

The attachment transfer mechanism 71 and the detachment transfer mechanism 72 are fixed integrally to the second transfer portion 34 of the second drive portion 35, and are reciprocated in the X direction by the second transfer portion 34 being moved by the horizontal moving portion 91 of the second drive portion 35. In addition, the second drive portion 35 includes a width-direction moving portion 92 between the second transfer portion 34 and the horizontal moving portion 91. Moving the second transfer portion 34 by the width-direction moving portion 92 allows reciprocating the attachment transfer mechanism 71 and the detachment transfer mechanism 72 in a direction perpendicular to the measurement reference surface 61a of the B-surface measuring portion 33 to be close to or spaced from the measurement reference surface 61a, that is, in the Y direction.

[0076]

The third transfer portion 36 includes a disk holding portion (not shown) and a transfer drive portion (not shown). The disk holding portion is configured in the same manner as the disk holding portion 43 of the first robot transfer portion 21. The third transfer portion 36 is configured to receive the disk 10 in the vertical posture from the exit-side delivery portion 52, hold the disk 10 while maintaining the vertical posture by the disk holding portion, and pass the disk 10 to the entry-side delivery portion 51 of the second delivery portion 32.

[0077]

As shown in Fig. 3, the transfer drive portion of the third transfer portion 36 is configured to reciprocate the disk holding portion of the third transfer portion 36 in the Y direction.

[0078]

The controller includes a central processing unit performing operation processing and a memory storing a control program, and is configured to control operations of various components of the measurement device 20, that is, the operation of receiving the disk 10 from the first robot transfer portion 21, the operation of measuring the flatness of the A surface and the B surface of the disk 10, and the operation of passing the disk 10 after measurement to the second robot transfer portion 31.

[0079]

Next, the operation of the measurement device 20 according to the present embodiment will be described with reference to the drawings.

Note that since the operations of the components of the measurement device 20 are controlled by the controller, the following mainly describes the operations of the components, and omits description of the control of the operations of the components by the controller. All of the operations of the components of the measurement device 20 are performed automatically.

[0080]

First, the measurement device 20 measures the flatness of the A surface of the disk 10 by the A-surface measuring portion 23, and then measures the flatness of the B surface of the disk 10 by the B-surface measuring portion 33.

[0081] (Measuring the flatness of the A surface)

In the measurement device 20, first, the disk 10 at a predetermined location is held in the vertical posture shown in Fig. 6(a) and Fig. 6(b) by the disk holding portion 43 of the first robot transfer portion 21 shown in Fig. 3, moved in the X, Y, and Z directions from the predetermined location, and transferred to the entry-side delivery portion 51 of the first delivery portion 22.

[0082]

As shown in Fig. 8(a), the transferred disk 10 is passed from the disk holding portion 43 to the entry-side delivery portion 51 of the first delivery portion

22, and the disk 10 when passed is converted into the inclined posture in which the disk 10 is inclined 5° with respect to the vertical direction, for example, and held by the entry-side delivery portion 51 of the first delivery portion 22.

[0083]

Next, as shown in Fig. 8(b), the entry-side delivery portion 51 is moved in the X direction by the horizontal moving portion 91 and reaches the attachment transfer mechanism 71 of the first transfer portion 24, and then the disk 10 is passed from the entry-side delivery portion 51 to the holding portion 81 of the attachment transfer mechanism 71. At this time, the passed disk 10 is maintained in the inclined posture.

[0084]

Next, the first transfer portion 24 is moved in the X direction by the horizontal moving portion 91, and as shown in Fig. 8(c) and Fig. 9(a), the holding portion 81 of the attachment transfer mechanism 71 is placed in a position where the holding portion 81 faces the measurement reference surface 61a of the A-surface measuring portion 23. Then, the holding portion 81 of the attachment transfer mechanism 71 temporarily moves up in the Z direction shown by the arrow a from the position shown in Fig. 9(a) and keeps moving in a direction to come closer to the measurement reference surface 61a along the Y direction as shown in Fig. 9(b), and places the disk 10 in a position where the support 62 is inserted into the through hole h of the disk 10.

[0085]

After stopping, the holding portion 81 of the attachment transfer mechanism 71 moves down along the Z direction, and by hanging the disk 10 on the support 62, causes the disk 10 to be held on the measurement reference surface 61a. Next, the first transfer portion 24 is moved in the Y direction by the width-direction moving portion 92 and is spaced from the measurement reference surface 61a, and the attachment transfer mechanism 71 returns to the position shown in Fig. 9(a). Then, as shown in Fig. 10(a), the first transfer portion 24 is moved in the X

direction by the horizontal moving portion 91, and the holding portion 81 of the detachment transfer mechanism 72 is placed in a position where the holding portion 81 faces the measurement reference surface 61a of the A-surface measuring portion 23.

[0086]

When the attachment transfer mechanism 71 returns to the position shown in Fig. 10(a), the sensor 63 of the A-surface measuring portion 23 is moved by the sensor moving mechanism in the arrow a direction shown in Fig. 5(a), and scans the A surface of the disk 10. The flatness of the A surface is measured by the sensor 63 while scanning the A surface of the disk 10. Note that in the description of the example shown in Fig. 5(a), the sensor 63 moves in the arrow a direction from the state where the sensor 63 is waiting in a position where the sensor 63 is closer to the entry-side delivery portion 51 than to the holding portion 81. However, when the sensor 63 is waiting in a position where the sensor 63 is closer to the exit-side delivery portion 52 than to the holding portion 81, the sensor 63 is moved in a direction opposite to the arrow a direction to measure the flatness.

[0087]

When the holding portion 81 of the detachment transfer mechanism 72 is placed by the first drive portion 25 in a position where the holding portion 81 faces the support 62 on the measurement reference surface 61a of the A-surface measuring portion 23 and the measurement of the flatness of the A surface by the sensor 63 is completed, in the same manner as the attachment transfer mechanism 71 shown in Fig. 9(a) and Fig. 9(b), the holding portion 81 of the detachment transfer mechanism 72 is moved in a direction to be closer to the measurement reference surface 61a along the Y direction by the width-direction moving portion 92. Then, the hook portion 81a is inserted into the through hole h of the disk 10, the lower disk receiver 81b is placed below the disk 10, and the upper disk receiver 81c is placed in a position where the upper disk receiver 81c faces the upper part of the disk 10.

[0088]

Then, the holding portion 81 of the detachment transfer mechanism 72 raises the hook portion 81a and the lower disk receiver 81b along the Z direction, sandwiches and lifts the disk 10 with the upper disk receiver 81c, thereby detaching the disk 10 from the measurement reference surface 61a and holding it. Then, by raising the holding portion 81 in the Z direction, the detachment transfer mechanism 72 detaches the disk 10 from the support 62 and moves in a direction to be spaced from the measurement reference surface 61a along the Y direction, and further lowers the holding portion 81 in the Z direction, returns and stops in the position shown in Fig. 9(a) in the same manner as the holding portion 81 of the attachment transfer mechanism 71.

[0089]

In this state, the disk 10 is held in the inclined posture in the holding portion 81 of the detachment transfer mechanism 72. Furthermore, the holding portion 81 of the attachment transfer mechanism 71 and the holding portion 81 of the detachment transfer mechanism 72 have a function of improving transfer efficiency when continuously measuring a large number of disks 10, by simultaneously performing the attachment preparation for the next disk 10 to be measured and the detachment of the measured disk 10.

[0090]

Next, the attachment transfer mechanism 71 and the detachment transfer mechanism 72 of the first transfer portion 24 are moved in a direction to be closer to the exit-side delivery portion 52 along the X direction by the horizontal moving portion 91, and as shown in Fig. 10(b), the holding portion 81 of the detachment transfer mechanism 72 of the first transfer portion 24 is stopped in a position where the holding portion 81 faces the exit-side delivery portion 52. Then, the disk 10 is passed from the holding portion 81 of the detachment transfer mechanism 72 to the exit-side delivery portion 52. In this state as well, the disk 10 is held in the inclined posture by the exit-side delivery portion 52.

[0091]

Subsequently, as shown in Fig. 10(c), the exit-side delivery portion 52 moves in a direction to be spaced from the detachment transfer mechanism 72 and stops. At this time, the inclined posture of the disk 10 is converted into the vertical posture. Then, as shown in Fig. 3, the disk 10 is passed from the exit-side delivery portion 52 to the disk holding portion (not shown) of the third transfer portion 36.

[0092]

The third transfer portion 36 is moved in a direction to be spaced from the exit-side delivery portion 52 in the Y direction by the transfer drive portion (not shown) and reaches the entry-side delivery portion 51 on the B-surface measuring portion 33 side that measures the B surface. Then, the disk 10 is passed from the disk holding portion of the third transfer portion 36 to the entry-side delivery portion 51 on the B-surface measuring portion 33 side.

[0093] (Measuring the flatness of the B surface)

The measurement of the B surface is performed in the same manner as the measurement of the A surface. Since the A-surface measuring portion 23 and the B-surface measuring portion 33 are disposed to face each other, the direction of transfer of the disk 10 by the first transfer portion 24 and the direction of transfer of the disk 10 by the second transfer portion 34 are opposite to each other. However, throughout the transfer, i.e., after start of transfer by the first robot transfer portion 21, through the first transfer portion 24, the third transfer portion, and the second transfer portion 34, to completion of transfer by the second robot transfer portion 31, the disk 10 itself is transferred and then delivered with its constantly directed in the fixed direction transferring the disk 10 in their respective transfer directions.

[0094]

In the measurement of the B surface, first, as shown in Fig. 3, when the disk 10 is received from the second transfer portion 34, the entry-side delivery portion 51 on the B-surface measuring portion 33 side converts the posture of the

disk 10 into the inclined posture in which the disk 10 is inclined 5° with respect to the vertical direction, for example. Then, the entry-side delivery portion 51 moves in the X direction toward the exit side of the second drive portion 35 and passes the disk 10 to the attachment transfer mechanism 71 of the second transfer portion 34. The disk 10 is maintained in the inclined posture in which the disk 10 is inclined 5° with respect to the vertical direction, and is passed from the entry-side delivery portion 51 to the holding portion 81 of the attachment transfer mechanism 71 of the second transfer portion 34.

[0095]

Next, the second transfer portion 34 is moved in the X direction toward the exit side of the second drive portion 35, and the holding portion 81 of the attachment transfer mechanism 71 stops in a position where the holding portion 81 faces the support 62 provided on the measurement reference surface 61a of the B-surface measuring portion 33. Then, the holding portion 81 of the attachment transfer mechanism 71 temporarily moves up in the Z direction and keeps moving in a direction to come closer to the support 62 along the Y direction, and stops in a position where the support 62 is inserted into the through hole h of the disk 10.

[0096]

After stopping, the holding portion 81 of the attachment transfer mechanism 71 moves down, and by hanging the disk 10 on the support 62, attaches the disk 10 to the support 62. Next, the attachment transfer mechanism 71 moves in a direction to be spaced from the measurement reference surface 61a along the Y direction, and returns to the original position. Then, the second transfer portion 34 is moved in the X direction toward the entry side of the second drive portion 35 and the holding portion 81 of the detachment transfer mechanism 72 returns to the original position where the holding portion 81 faces the measurement reference surface 61a of the B-surface measuring portion 33.

[0097]

When the attachment transfer mechanism 71 returns to the original position,

the sensor 63 of the B-surface measuring portion 33 is moved by the sensor moving mechanism, and scans the B surface of the disk 10. The flatness of the B surface is measured by the sensor 63 while scanning the B surface of the disk 10.

[0098]

When the holding portion 81 of the detachment transfer mechanism 72 is placed by the second drive portion 35 in a position where the holding portion 81 faces the support 62 on the measurement reference surface 61a of the B-surface measuring portion 33 and the measurement of the flatness of the B surface by the sensor 63 is completed, the holding portion 81 of the attachment transfer mechanism 71 is moved in a direction to be closer to the measurement reference surface 61a along the Y direction by the width-direction moving portion 92. Then, the hook portion 81a is inserted into the through hole h of the disk 10, the lower disk receiver 81b is placed below the disk 10, and the upper disk receiver 81c is placed in a position where the upper disk receiver 81c faces the upper part of the disk 10.

[0099]

Then, the detachment transfer mechanism 72 raises the holding portion 81 in the Z direction, thereby detaching the disk 10 from the support 62, and moves in a direction to be spaced from the measurement reference surface 61a along the Y direction, and further lowers the holding portion 81 in the Z direction, returns and stops in the original position. In this state, the disk 10 is held in the inclined posture in the holding portion 81 of the detachment transfer mechanism 72.

[0100]

Next, the second transfer portion 34 is moved in the X direction toward the exit side of the second drive portion 35, and the holding portion 81 of the detachment transfer mechanism 72 is stopped in a position where the holding portion 81 faces the exit-side delivery portion 52. Then, the disk 10 is passed from the holding portion 81 of the detachment transfer mechanism 72 to the exit-side delivery portion 52. In this state, the disk 10 is held in the inclined posture

by the exit-side delivery portion 52.

[0101]

Subsequently, the exit-side delivery portion 52 moves in a direction to be spaced from the detachment transfer mechanism 72 and stops. Then, as shown in Fig. 3, the disk 10 is passed from the exit-side delivery portion 52 to the disk holding portion 43 of the second robot transfer portion 31.

[0102]

At this time, the inclined posture of the disk 10 is converted into the vertical posture, and the second robot transfer portion 31 transfers the disk 10 to a predetermined location. Subsequently, the operation from start of transfer by the first robot transfer portion 21 to the end of transfer by the second robot transfer portion 31 is repeated, and when the measurement of the flatness of the A surface and the B surface of all of the disks 10 is completed, the operation of the measurement device 20 ends.

[0103]

Hereinafter, the effects of the measurement device 20 according to the present embodiment will be described.

(1) The measurement device 20 according to the present embodiment includes the A-surface measuring portion 23 and the B-surface measuring portion 33 for measuring the disk 10, the first transfer portion 24, and the second transfer portion 34. The A-surface measuring portion 23 and the B-surface measuring portion 33 each include the measurement reference surface 61a that is inclined at an inclination angle θ° with respect to the vertical direction, and the first transfer portion 24 and the second transfer portion 34 each include the holding portion 81 that holds the disk 10 such that the disk 10 is in parallel with the measurement reference surface 61a. The holding portion 81 is configured to attach and detach the disk 10 to and from the A-surface measuring portion 23 or the B-surface measuring portion 33 while maintaining the inclined posture in which the disk 10 is inclined at an inclination angle θ° .

[0104]

In the measurement device 20 according to the present embodiment, the A-surface measuring portion 23 and the B-surface measuring portion 33 each include the measurement reference surface 61a that is inclined at an inclination angle θ° with respect to the vertical direction, and the disk 10 is supported along the measurement reference surface 61a. Consequently, it is possible to solve the issue of the conventional measurement device, that is, to obtain the effect that the sag of the disk by being horizontally held on the measuring table can be effectively suppressed and the flatness can be more precisely measured.

[0105]

In addition, the holding portion 81 is configured to attach and detach the disk 10 to and from the A-surface measuring portion 23 or the B-surface measuring portion 33 while maintaining the inclined posture in which the disk 10 is inclined at an inclination angle θ° . Consequently, it is possible to obtain the effect that the inclined posture can be maintained at high accuracy and the attachment and detachment of the disk 10 to and from the A-surface measuring portion 23 or the B-surface measuring portion 33 can be smoothly performed. Furthermore, it is possible to suppress influence of the sag due to its own weight and stabilize the posture of the object of measurement when placed in the measurement device.

[0106]

In addition, the measurement device 20 according to the first embodiment is configured to include the first robot transfer portion 21 and the second robot transfer portion 31, and automatically measures the disk 10 while the disk 10 is transferred from the first robot transfer portion 21 to the second robot transfer portion 31, and thus produces the effect that a large number of disks 10 can be measured at a relatively high speed.

[0107]

(2) In the measurement device 20 according to the present embodiment, the first transfer portion 24 includes the attachment transfer mechanism 71 and the

detachment transfer mechanism 72. The disk 10 is attached to the A-surface measuring portion 23 or the B-surface measuring portion 33 by the attachment transfer mechanism 71, and detached from the A-surface measuring portion 23 or the B-surface measuring portion 33 by the detachment transfer mechanism 72. Consequently, it is possible to obtain the effect that the measurement device 20 can rapidly transfer the disk 10 and smoothly perform the attachment and detachment of the disk 10 to and from the A-surface measuring portion 23 or the B-surface measuring portion 33, and effectively transfer the disk 10.

[0108]

(3) In the measurement device 20 according to the present embodiment, when the first transfer portion 24 transfers the disk 10 facing the A-surface measuring portion 23, and when the second transfer portion 34 transfers the disk 10 facing the B-surface measuring portion 33, the disk 10 is configured to be transferred in parallel with the measurement reference surface 61a. Consequently, it is possible to obtain the effect that a large number of disks 10 can be effectively transferred without generation of excess stress on the disk 10.

[0109]

(4) In the measurement device 20 according to the present embodiment, since the A-surface measuring portion 23 and the B-surface measuring portion 33 are disposed to face each other, it is possible to obtain the effect that the arrangement space for the components of the measurement device 20 can be reduced, and the measurement device 20 may be downsized.

[0110]

(5) In the measurement device 20 according to the present embodiment, the first transfer portion 24 is disposed to face the A-surface measuring portion 23 and the second transfer portion 34 is disposed to face the B-surface measuring portion 33, and a transfer direction by the first transfer portion 24 and a transfer direction by the second transfer portion 34 are configured to be opposite to each other. Consequently, it is possible to obtain the effect that the arrangement space for the

first transfer portion 24 and the A-surface measuring portion 23 and the arrangement space for of the second transfer portion 34 and the B-surface measuring portion 33 can be reduced, and the measurement device 20 may be downsized.

[0111]

(6) The measurement device 20 according to the present embodiment includes the first delivery portion 22 and the second delivery portion 32 that convert a vertical posture and an inclined posture between the vertical posture in which the disk 10 is located along the vertical direction and the inclined posture in which the disk 10 is located to be inclined at an inclination angle with respect to the vertical direction. Consequently, the first delivery portion 22 can smoothly convert the vertical posture of the disk 10 transferred from the first robot transfer portion 21 into the inclined posture, and the second delivery portion 32 can smoothly convert the inclined posture of the transferred disk 10 into the vertical posture. That is, it is possible to obtain the effect that the process of conversion into the inclined posture by the transfer portion is not required, excess stress on the disk 10 can be suppressed, and the posture of the object of measurement when placed in the measurement device can be stabilized.

[0112]

(7) The measurement device 20 according to the present embodiment includes the horizontal moving portion 91 that drives the first transfer portion 24, and the first drive portion 25 is disposed below the measuring portion body 61 in the vertical direction. With this configuration, fine dust materials generated from the first drive portion 25 directly drop downward and are less likely to adhere to the measuring portion body 61 disposed above the first drive portion 25. Accordingly, the measuring portion body 61 may be less likely to be contaminated by the generated dust materials.

[0113]

(8) In the measurement device 20 according to the present embodiment,

since the first transfer portion 24 is configured to be able to reciprocate in a horizontal direction and in a direction perpendicular to the measurement reference surface, it is possible to obtain the effect that the disk 10 can be effectively and rapidly transferred and be hung on the support 62 of the A-surface measuring portion 23. In addition, since the first transfer portion 24 transfers the disk 10 from the entry side to the exit side of the measurement device while maintaining the primary surface of the disk 10 directed toward the measurement reference surface, it is possible to obtain the effect that a large number of disks 10 can be rapidly measured and transferred without wasted movement.

[0114]

(9) In the measurement device 20 according to the present embodiment, since the disk 10 has a through hole that penetrates in a thickness direction, and the holding portion 81 of the attachment transfer mechanism 71 and the holding portion 81 of the detachment transfer mechanism 72 hold an inner wall portion of the through hole, it is possible to obtain the effect that the disk 10 in the inclined posture can be stably held without generation of excess stress.

[0115]

(10) In the measurement device 20 according to the present embodiment, the measurement reference surface 61a includes the support 62 that supports the disk 10 and the steady rest 64 that contacts the disk 10 supported by the support 62. Consequently, it is possible to obtain the effect that by suppressing deflection of the disk 10 supported by the support 62, maintaining and stabilizing the posture of the disk 10, the accuracy of measuring the flatness by the sensor 63 can be increased.

[0116]

It should be noted that the above describes the measurement device 20 according to the first embodiment configured to have a structure in which the A-surface measuring portion 23 and the B-surface measuring portion 33 are disposed to face each other. However, the measurement device according to the present

invention may be configured to have a structure other than the structure in which the A-surface measuring portion 23 and the B-surface measuring portion 33 are disposed to face each other.

[0117]

For example, the measurement device according to the present invention may be a measurement device 20A configured to have a structure in which the A-surface measuring portion 23 and the B-surface measuring portion 33 are disposed side by side in the same direction, or a measurement device 20B configured to have a structure in which the A-surface measuring portion 23 and the B-surface measuring portion 33 are disposed side by side in different directions.

[0118]

In addition, in the present embodiment, although the above describes the example of the measurement device 20 configured to include both the A-surface measuring portion 23 and the B-surface measuring portion 33, the measurement device 20 may include either the A-surface measuring portion 23 or the B-surface measuring portion 33 or may include at least one of the A-surface measuring portion 23 or the B-surface measuring portion 33.

[0119] (Second embodiment)

Hereinafter, the measurement device 20A according to the second embodiment will be described with reference to the drawings.

As shown in Fig. 11, the measurement device 20A according to the second embodiment is different from the measurement device 20 according to the first embodiment in that the A-surface measuring portion 23 and the B-surface measuring portion 33 are disposed side by side in the same direction. Note that the same components as those of the measurement device 20 according to the first embodiment are denoted by the same reference numerals as those of the measurement device 20 according to the first embodiment, and detailed description thereof is omitted.

[0120]

The measurement device 20A according to the second embodiment includes an A-surface measuring unit 11, a B-surface measuring unit 12, and a front/back inverting mechanism 13. The measurement device 20A is configured to measure the flatness of the A surface of the disk 10 by the A-surface measuring unit 11, invert the front and back surfaces of the disk 10 by the front/back inverting mechanism 13, and measure the flatness of the B surface of the disk 10 by the B-surface measuring unit 12.

[0121]

The A-surface measuring unit 11 includes an entry-side delivery portion 51, a first transfer portion 24, an A-surface measuring portion 23, and a horizontal moving portion 91. The B-surface measuring unit 12 includes a B-surface measuring portion 33, a second transfer portion 34, and an exit-side delivery portion 52.

[0122]

The front/back inverting mechanism 13 is configured by a known inverting mechanism (not shown). The front/back inverting mechanism 13 is configured such that when it receives, from the A-surface measuring unit 11, the disk 10 in a posture in which the A surface of the disk 10 faces the measurement reference surface 61a of the A-surface measuring portion 23, it maintains the posture of the disk 10 such that the B surface of the disk 10 faces the measurement reference surface 61a of the B-surface measuring portion 33 and passes the disk 10 to the B-surface measuring unit 12. The A surface and the B surface of the disk 10 are inverted by the front/back inverting mechanism 13.

[0123]

Next, the operation of the measurement device 20A according to the second embodiment will be described with reference to the drawings. The components denoted by the same reference numerals as those of the measurement device 20 according to the first embodiment operate in the same manner as the components of the measurement device 20, and thus the operation will be briefly described.

[0124]

In the measurement device 20A, first, when the entry-side delivery portion 51 shown in Fig. 11 receives the disk 10, the posture of the disk 10 is converted into the inclined posture, and moves in a direction to come closer to the first transfer portion 24 in the X direction by the horizontal moving portion 91 while maintaining the disk 10 in the inclined posture and stops in a position where the disk 10 is passed to the first transfer portion 24.

[0125]

After the disk 10 is stopped, the disk 10 maintained in the inclined posture is passed to the holding portion 81 of the attachment transfer mechanism 71 of the first transfer portion 24, the attachment transfer mechanism 71 is moved by the horizontal moving portion 91, and the disk 10 is hung on the support 62 of the A-surface measuring portion 23. Subsequently, the sensor 63 is moved and the flatness of the A surface of the disk 10 is measured. Then, the disk 10 is detached from the support 62 by the detachment transfer mechanism 72, the detachment transfer mechanism 72 is moved by the horizontal moving portion 91 and is stopped in a position where the disk 10 is passed to the front/back inverting mechanism 13.

[0126]

After the disk 10 is stopped, the disk 10 is passed to the front/back inverting mechanism 13, and the front and back surfaces of the disk 10 are inverted. When the disk 10 is inverted, the front/back inverting mechanism 13 changes the inclined posture of the disk 10 to a posture in which the disk 10 is inclined toward the B-surface measuring portion 33. Accordingly, the inclined posture of the disk 10 is maintained in a posture in which the disk 10 is inclined in the same direction as that before being passed to the front/back inverting mechanism 13.

[0127]

The disk 10 after conversion of the front and back surfaces is passed to the holding portion 81 of the attachment transfer mechanism 71 of the second transfer portion 34 while the disk 10 is maintained in the inclined posture. The disk 10 is

hung on the support 62 of the B-surface measuring portion 33 by the attachment transfer mechanism 71.

[0128]

Subsequently, the sensor 63 is moved and the flatness of the B surface of the disk 10 is measured. Then, the disk 10 is detached from the support 62 by the detachment transfer mechanism 72, and the detachment transfer mechanism 72 is moved by the horizontal moving portion 91 and is stopped in a position where the disk 10 is passed to the next transfer process.

[0129]

Hereinafter, the effect of the measurement device 20A according to the second embodiment will be described. The measurement device 20A is configured in the same manner as the measurement device 20 according to the first embodiment and its operation is the same as that of the measurement device 20, and thus the measurement device 20A can produce the same effect as that of the measurement device 20.

[0130]

That is, the measurement device 20A according to the second embodiment can produce the effect that the issue of generation of a sag of the disk in the conventional measurement device can be solved. In addition, since there is no likelihood of generation of a sag of the disk 10, it is possible to more precisely measure the flatness.

[0131]

In addition, the holding portion 81 of the first transfer portion 24 of the measurement device 20A according to the second embodiment is configured to hold the disk 10 and move in the vertical direction while maintaining the inclined posture in which the disk 10 is inclined at an inclination angle θ° , and perform the attachment and detachment of the disk 10 to and from the A-surface measuring portion 23 or the B-surface measuring portion 33. Consequently, it is possible to obtain the effect that the attachment and detachment of the disk 10 to and from the

A-surface measuring portion 23 or the B-surface measuring portion 33 can be smoothly performed. Furthermore, it is possible to suppress influence of the sag due to its own weight and stabilize the posture of the object of measurement when placed in the measurement device.

[0132]

It should be noted that in the measurement device 20A according to the second embodiment, the front/back inverting mechanism 13 may be configured to invert the front and back surfaces of the disk 10, and without converting the inclined posture of the disk 10, direct the disk 10 to the A-surface measuring portion 23, and pass the disk 10 to the first transfer portion 24 of the A-surface measuring unit 11 so as to measure the flatness of the B surface of the disk 10 by the A-surface measuring portion 23. With this configuration, it is possible to obtain the effect that the B-surface measuring unit 12 for measuring the B surface is not required, and the configuration can be simplified.

[0133] (Third embodiment)

As shown in Fig. 12, the measurement device 20B according to the third embodiment is different from the measurement device 20 according to the first embodiment and the measurement device 20A according to the second embodiment in that the A-surface measuring portion 23 and the B-surface measuring portion 33 are disposed side by side in different directions. The same components as those of the measurement device 20 according to the first embodiment are denoted by the same reference numerals as those of the measurement device 20 according to the first embodiment, and detailed description thereof is omitted.

[0134]

As shown in Fig. 12, the measurement device 20B according to the third embodiment includes an A-surface measuring unit 11, a B-surface measuring unit 12, and an inclination conversion mechanism 14. The measurement device 20B is configured to measure the flatness of the A surface of the disk 10 by the A-surface measuring unit 11, convert the inclined posture of the disk 10 by the inclination

conversion mechanism 14, and measure the flatness of the B surface of the disk 10 by the B-surface measuring unit 12.

[0135]

The A-surface measuring unit 11 includes an entry-side delivery portion 51, a first transfer portion 24, an A-surface measuring portion 23, and a horizontal moving portion 91. The B-surface measuring unit 12 includes a B-surface measuring portion 33, a second transfer portion 34, and an exit-side delivery portion 52. The A-surface measuring portion 23 and the B-surface measuring portion 33 are disposed on the opposite sides with respect to the direction of movement of the horizontal moving portion 91, i.e., on the right side that is one side in the width direction and on the left side that is the other side in the width direction.

[0136]

The inclination conversion mechanism 14 includes an entry-side delivery portion 14a, an exit-side delivery portion 14b, and a known conversion mechanism (not shown). The conversion mechanism receives the disk 10 from the A-surface measuring unit 11 in a posture in which the A surface of the disk 10 faces in parallel with the measurement reference surface of the A-surface measuring portion 23. Then, the conversion mechanism is configured to convert the posture of the disk 10 into a posture in which the B surface of the disk 10 faces in parallel with the B-surface measuring portion 33 and pass the disk 10 to the B-surface measuring unit 12.

[0137]

Next, the operation of the measurement device 20B according to the third embodiment will be described with reference to the drawings. The components denoted by the same reference numerals as those of the measurement device 20 according to the first embodiment operate in the same manner as the components of the measurement device 20, and thus the operation will be briefly described.

[0138]

In the measurement device 20B, first, when the entry-side delivery portion 51 receives the disk 10, the posture of the disk 10 is converted into the inclined posture in which the disk 10 is inclined toward the A-surface measuring portion 23. Then, the entry-side delivery portion 51 moves in a direction to come closer to the first transfer portion 24 along the X direction while maintaining the disk 10 in the inclined posture and stops in a position where the disk 10 is passed to the first transfer portion 24.

[0139]

After the disk 10 is stopped, the disk 10 maintained in the inclined posture is passed to the holding portion 81 of the attachment transfer mechanism 71 of the first transfer portion 24, the attachment transfer mechanism 71 is moved by the horizontal moving portion 91, and the disk 10 is hung on the support 62 of the A-surface measuring portion 23. Subsequently, the sensor 63 is moved and the flatness of the A surface of the disk 10 is measured. Then, the disk 10 is detached from the support 62 by the detachment transfer mechanism 72, the detachment transfer mechanism 72 is moved by the horizontal moving portion 91, and is stopped in a position where the disk 10 is passed to the entry-side delivery portion 14a of the inclination conversion mechanism 14.

[0140]

After the disk 10 is stopped, the disk 10 is passed to the entry-side delivery portion 14a of the inclination conversion mechanism 14, and the inclination of the disk 10 is converted into the inclination toward the opposite side. That is, the inclined posture in which the disk 10 is inclined toward the A-surface measuring portion 23 is converted into the inclined posture in which the disk 10 is inclined toward the B-surface measuring portion 33. Then, the disk 10 is transferred to the exit-side delivery portion 14b of the inclination conversion mechanism 14. The disk 10 is passed to the attachment transfer mechanism 71 by the exit-side delivery portion 14b and hung on the support 62 of the B-surface measuring portion 33 by the attachment transfer mechanism 71.

[0141]

Subsequently, the sensor 63 is moved and the flatness of the B surface of the disk 10 is measured. Then, the disk 10 is detached from the support 62 by the detachment transfer mechanism 72, and the detachment transfer mechanism 72 is moved by the horizontal moving portion 91 and is stopped in a position where the disk 10 is passed to the next transfer process.

[0142]

Hereinafter, the effect of the measurement device 20B according to the third embodiment will be described.

The measurement device 20B is configured in the same manner as the measurement device 20A and the measurement device 20 according to the first embodiment and its operation is the same as that of the measurement device 20, and thus the measurement device 20B can produce the same effect as that of the measurement device 20.

[0143]

That is, the measurement device 20B according to the third embodiment can produce the effect that the issue of generation of a sag of the disk in the conventional measurement device can be solved. In addition, since there is no likelihood of generation of a sag of the disk 10, it is possible to more precisely measure the flatness.

[0144]

In addition, the holding portion 81 of the first transfer portion 24 of the measurement device 20B according to the third embodiment is configured to hold the disk 10 and move in the vertical direction while maintaining the inclined posture in which the disk 10 is inclined at an inclination angle θ° , and perform the attachment and detachment of the disk 10 to and from the A-surface measuring portion 23 or the B-surface measuring portion 33. Consequently, it is possible to obtain the effect that the attachment and detachment of the disk 10 to and from the A-surface measuring portion 23 or the B-surface measuring portion 33 can be

smoothly performed. Furthermore, it is possible to suppress influence of the sag due to its own weight and stabilize the posture of the object of measurement when placed in the measurement device.

[0145]

Although the first embodiment to the third embodiment of the present invention have been described in detail above, the present invention is not limited to the foregoing first to third embodiments, and various design changes are possible in so far as they are within the spirit of the present invention in the scope of the claims.

In particular, in each of the foregoing embodiments, the measurement device according to the present invention is exemplified by use in the measurement device that measures the object of measurement. However, the measurement device according to the present invention is not limited thereto, and may be used, for example, as an inspection device that inspects the object of measurement or a sorting device that sorts the objects of measurement into conforming products and defective products after inspection.

Reference Signs List

[0146]

- 10 Disk (object of measurement)
- 11 A-surface measuring unit
- 12 B-surface measuring unit
- 13 Front/back inverting mechanism
- 14 Inclination conversion mechanism
- 14a, 51 Entry-side delivery portion (delivery portion)
- 14b, 52 Exit-side delivery portion (delivery portion)
- 20, 20A, 20B Measurement device
- 21 First robot transfer portion
- 22 First delivery portion (delivery portion)

- 23 A-surface measuring portion (measuring means, first measuring means)
- 24 First transfer portion (transfer means, first transfer means)
- 25 First drive portion (drive means)
- 31 Second robot transfer portion
- 32 Second delivery portion (delivery portion)
- 33 B-surface measuring portion (measuring means, second measuring means)
- 34 Second transfer portion (transfer means, second transfer means)
- 35 Second drive portion (drive means)
- 36 Third transfer portion
- 41, 42 Arm
- 43 Disk holding portion
- 43a Upper disk receiver
- 43b Grooved hook
- 61 Measuring portion body
- 61a Measurement reference surface
- 61b Support portion
- 62 Support
- 63 Sensor
- 64 Steady rest
- 71 Attachment transfer mechanism (first attachment transfer portion)
- 72 Detachment transfer mechanism (second detachment transfer portion)
- 81 Holding portion
- 81a Hook portion (holding portion)
- 81b Lower disk receiver (holding portion)
- 81c Upper disk receiver (holding portion)
- 81d Frame
- 91 Horizontal moving portion (transfer drive portion)
- 92 Width-direction moving portion
- θ Inclination angle (predetermined angle)

Claims

[Claim 1]

A measurement device that measures an object of measurement, comprising:

a measuring means that measures a shape of at least one of a front surface or a back surface of the object of measurement; and

a transfer means that transfers the object of measurement,

wherein:

the measuring means includes a measurement reference surface that is inclined by a predetermined angle with respect to a vertical direction;

the transfer means includes a holding portion that holds the object of measurement such that the object of measurement is in parallel with the measurement reference surface; and

the holding portion attaches and detaches the object of measurement to and from the measuring means while maintaining a posture in which the object of measurement is inclined by the predetermined angle.

[Claim 2]

The measurement device according to claim 1, wherein the transfer means includes an attachment holding portion that attaches the object of measurement to the measuring means and a detachment holding portion that detaches the object of measurement from the measuring means.

[Claim 3]

The measurement device according to claim 1 or 2, wherein when the transfer means transfers the object of measurement to face the measuring means, the object of measurement is transferred in parallel with the measurement reference surface.

[Claim 4]

The measurement device according to claim 1, wherein the measuring means includes a first measuring means and a second measuring means that are disposed to face each other.

[Claim 5]

The measurement device according to claim 4, wherein the transfer means includes a first transfer means that transfers the object of measurement to face the first measuring means and a second transfer means that transfers the object of measurement to face the second measuring means, and a transfer direction by the first transfer means and a transfer direction by the second transfer means are opposite to each other.

[Claim 6]

The measurement device according to any one of claims 1 to 5, comprising a delivery portion that converts a vertical posture and an inclined posture between the vertical posture in which the object of measurement is located along a vertical direction and the inclined posture in which the object of measurement is located to be inclined by a predetermined angle with respect to the vertical direction.

[Claim 7]

The measurement device according to claim 1, comprising a drive means that drives the transfer means, the drive means being disposed below the measuring means in the vertical direction.

[Claim 8]

The measurement device according to claim 1, wherein the transfer means is configured to be able to reciprocate in a horizontal direction and in a direction

perpendicular to the measurement reference surface, and the object of measurement is transferred by the transfer means from an entry side to an exit side of the measurement device while maintaining a primary surface of the object of measurement directed toward the measurement reference surface.

[Claim 9]

The measurement device according to claim 1, wherein the object of measurement has a through hole that penetrates in a thickness direction, and the holding portion holds an inner wall portion of the through hole.

[Claim 10]

The measurement device according to claim 1, wherein the measurement reference surface includes a support that supports the object of measurement and a steady rest that contacts the object of measurement supported by the support.