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Tobari et al.

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(54) **ROTARY TABLE**

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(73) Assignee: **NIPPON THOMPSON CO., LTD.**, Tokyo (JP)

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B23Q 16/06 (2006.01)
B23Q 17/00 (2006.01)

(52) **U.S. Cl.**
CPC ***B23Q 1/52*** (2013.01); ***B23Q 16/06*** (2013.01); ***B23Q 17/003*** (2013.01)

(58) **Field of Classification Search**
CPC B23Q 17/003
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,784,932 A * 7/1998 Gilberti B23Q 17/24 108/22
6,722,289 B2 * 4/2004 Kato B23Q 16/026 108/22
(Continued)

FOREIGN PATENT DOCUMENTS

JP H03-144151 A 6/1991
JP H03-167415 A 7/1991
(Continued)

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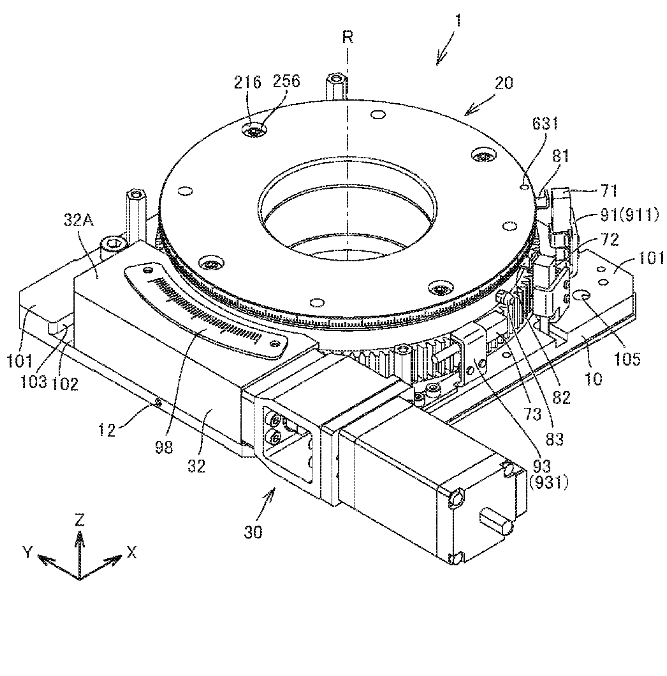
(57) **ABSTRACT**

A rotary table includes a base body, a movable ring rotatably arranged on the base body, a fixed ring arranged on an inner periphery side of the movable ring and fixed to the base body, and a plurality of rolling elements. The rotary table includes a sensor fixed to the base body and a dog fixed to the movable ring. The movable ring has a scale extending at least at a portion of an outer peripheral side surface, and a groove-shaped recess formed to be recessed inward from an outer periphery of the movable ring at a position corresponding to the scale on the outer periphery. The dog has a leg portion fitted to the recess, and a detected portion protruding outward from the leg portion and detectable by the sensor. The leg portion is able to be fixed to the movable ring at any position in the recess.

8 Claims, 15 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

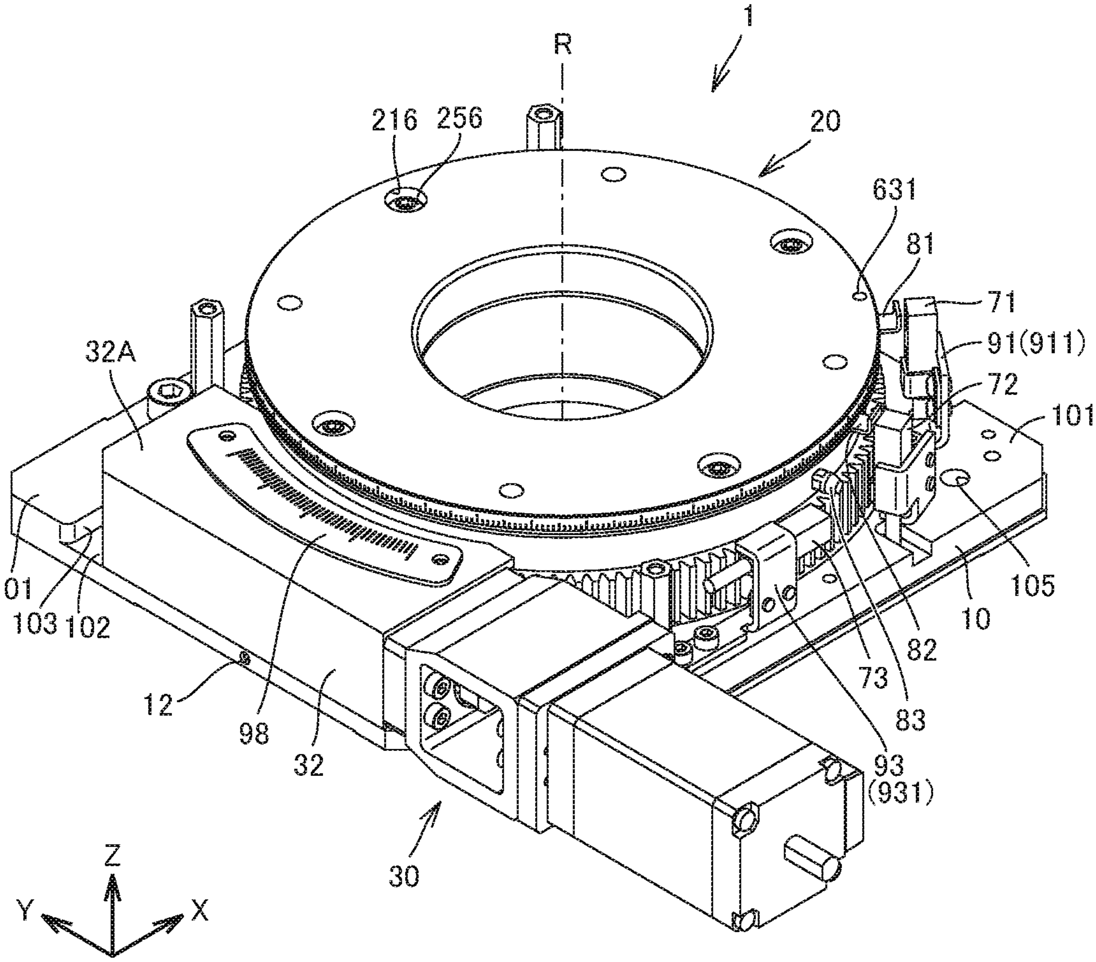
7,638,963	B2 *	12/2009	Amendolea	B23Q 16/02 318/560
2022/0347807	A1	11/2022	Takahashi	

FOREIGN PATENT DOCUMENTS

JP	2010-271098	A	12/2010
WO	2021/090551	A1	5/2021

* cited by examiner

FIG. 1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72
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(931)
30
Z
Y
X

FIG. 2

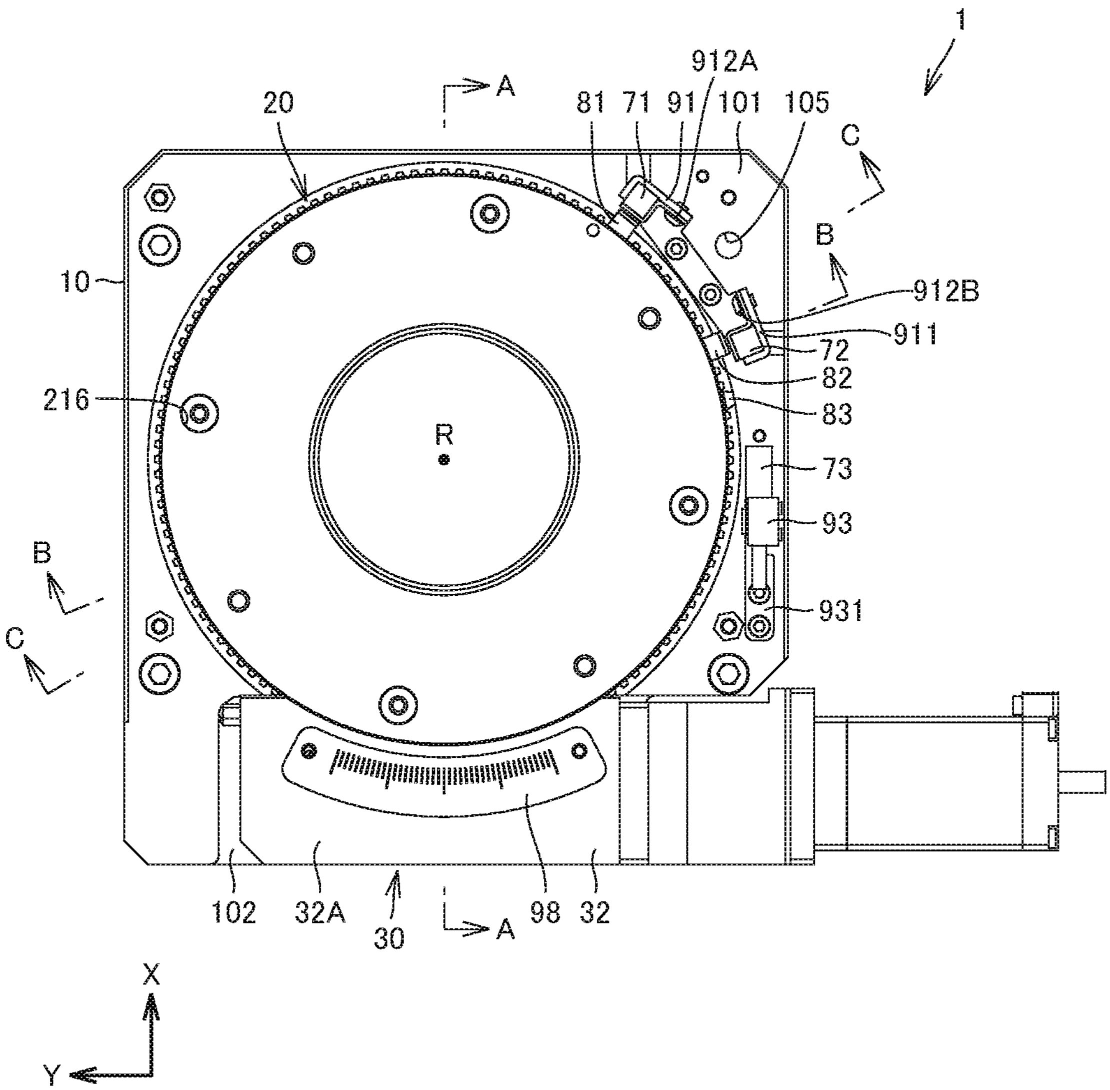
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FIG. 3

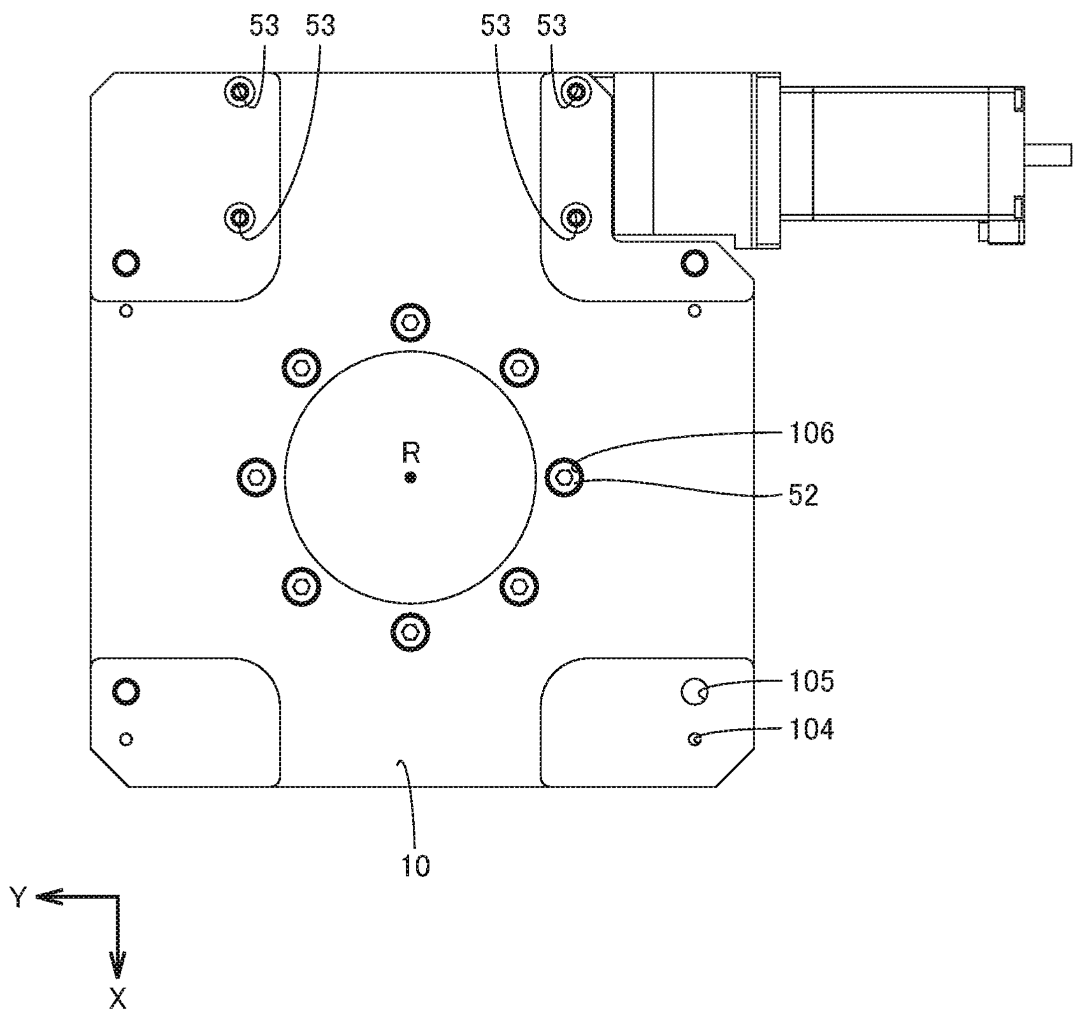
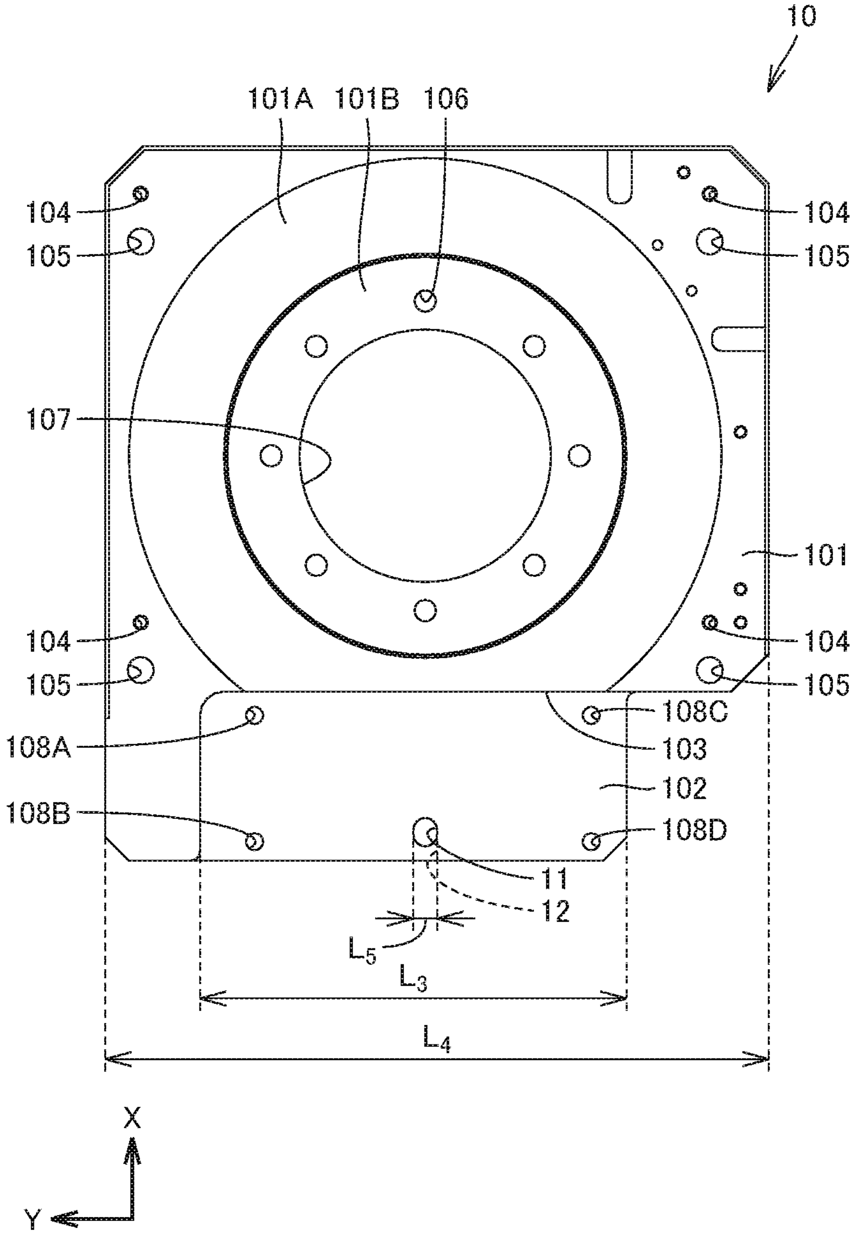


FIG. 4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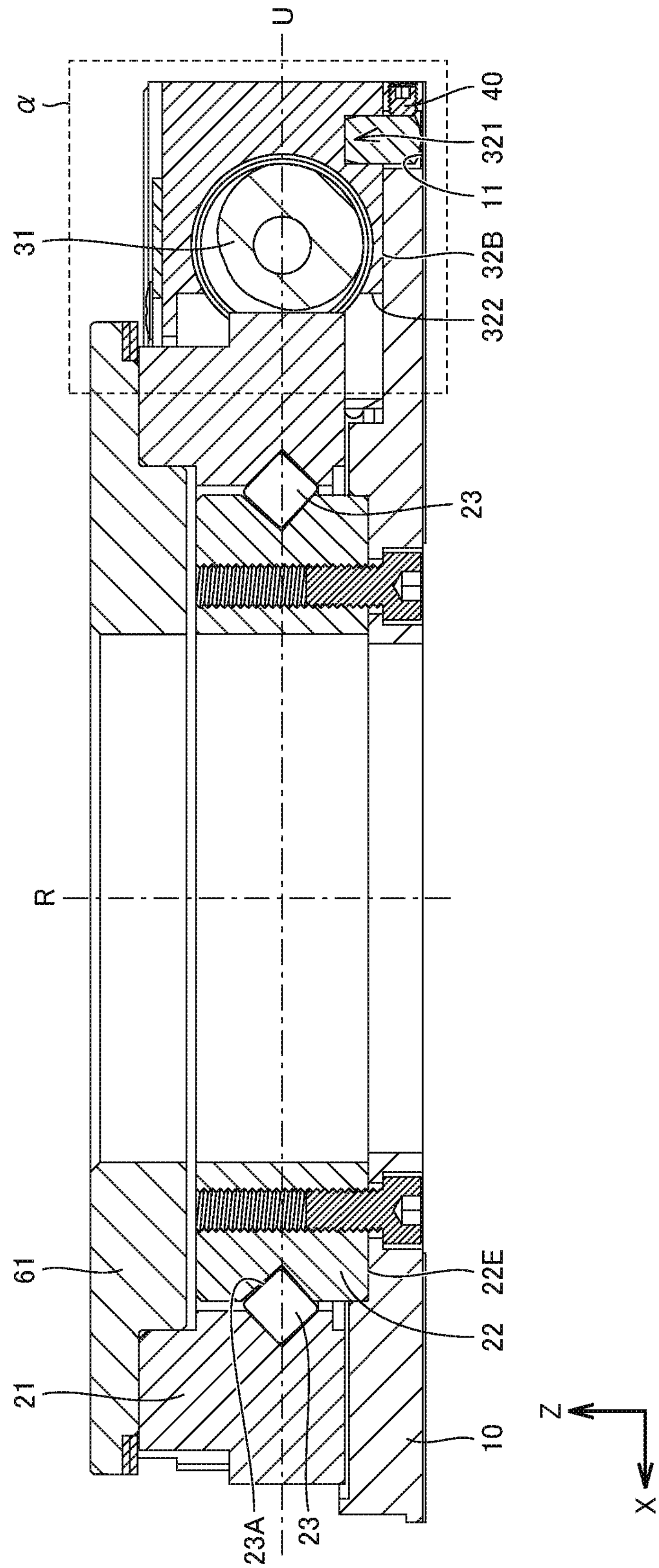
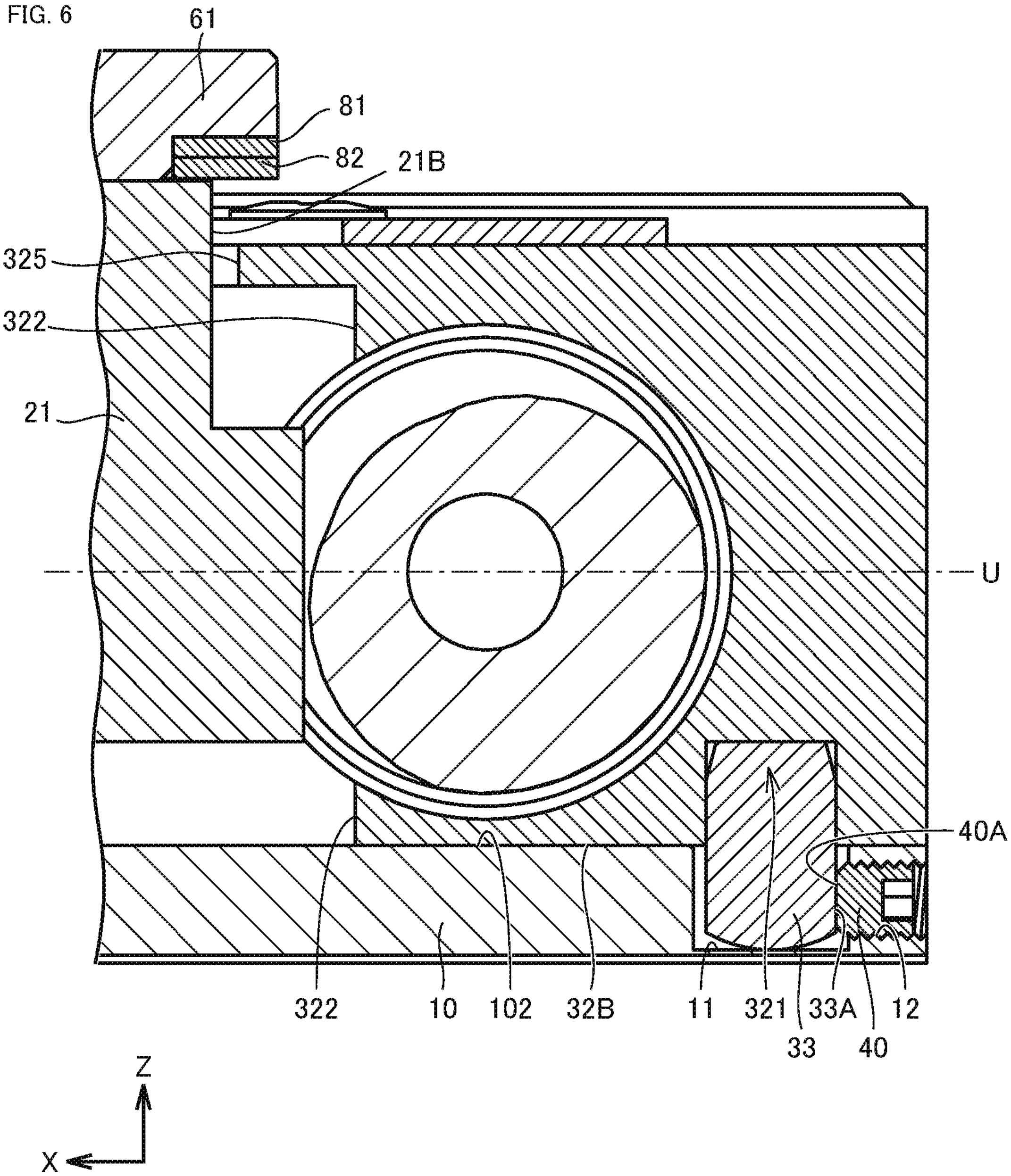
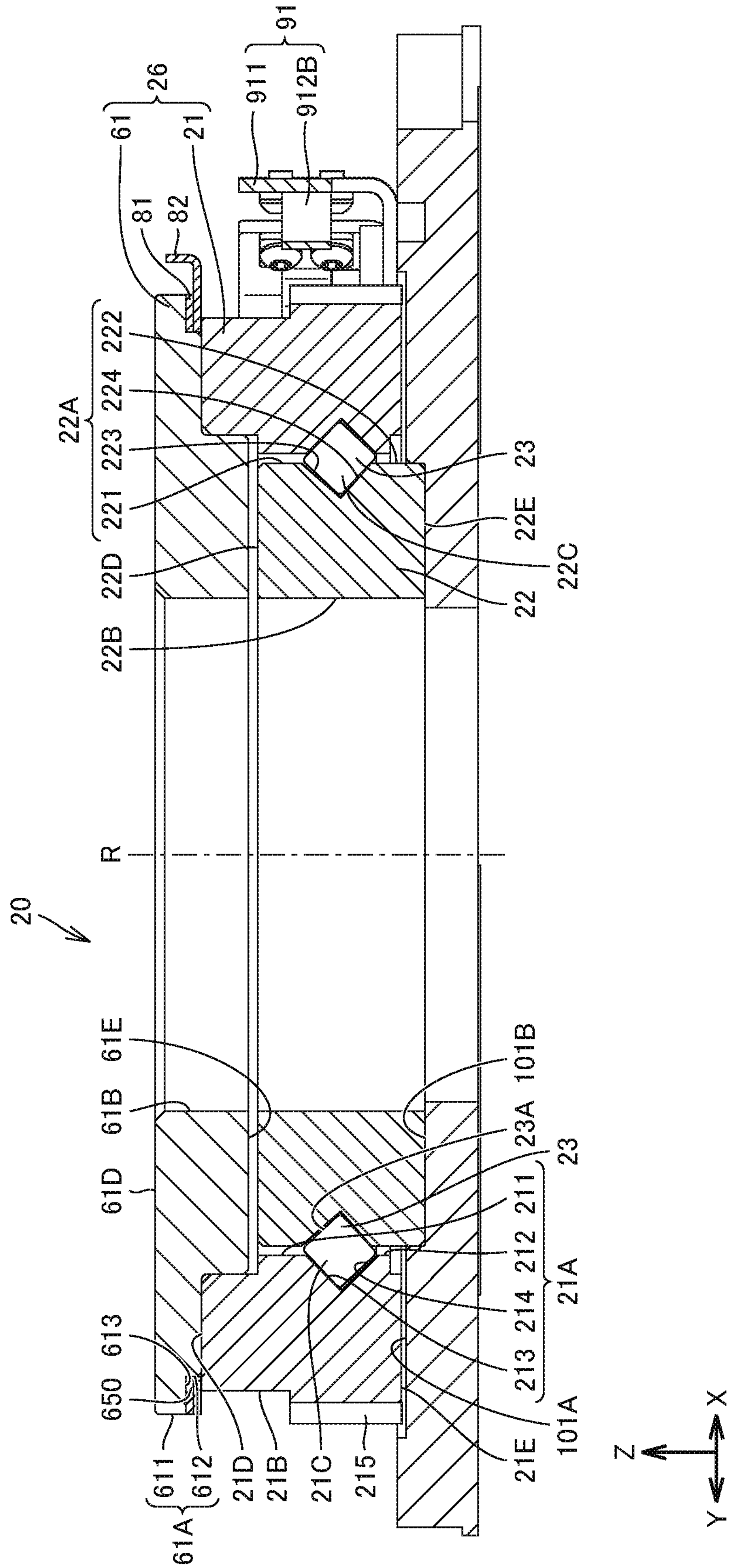


FIG. 5

FIG. 6

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61D
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21B
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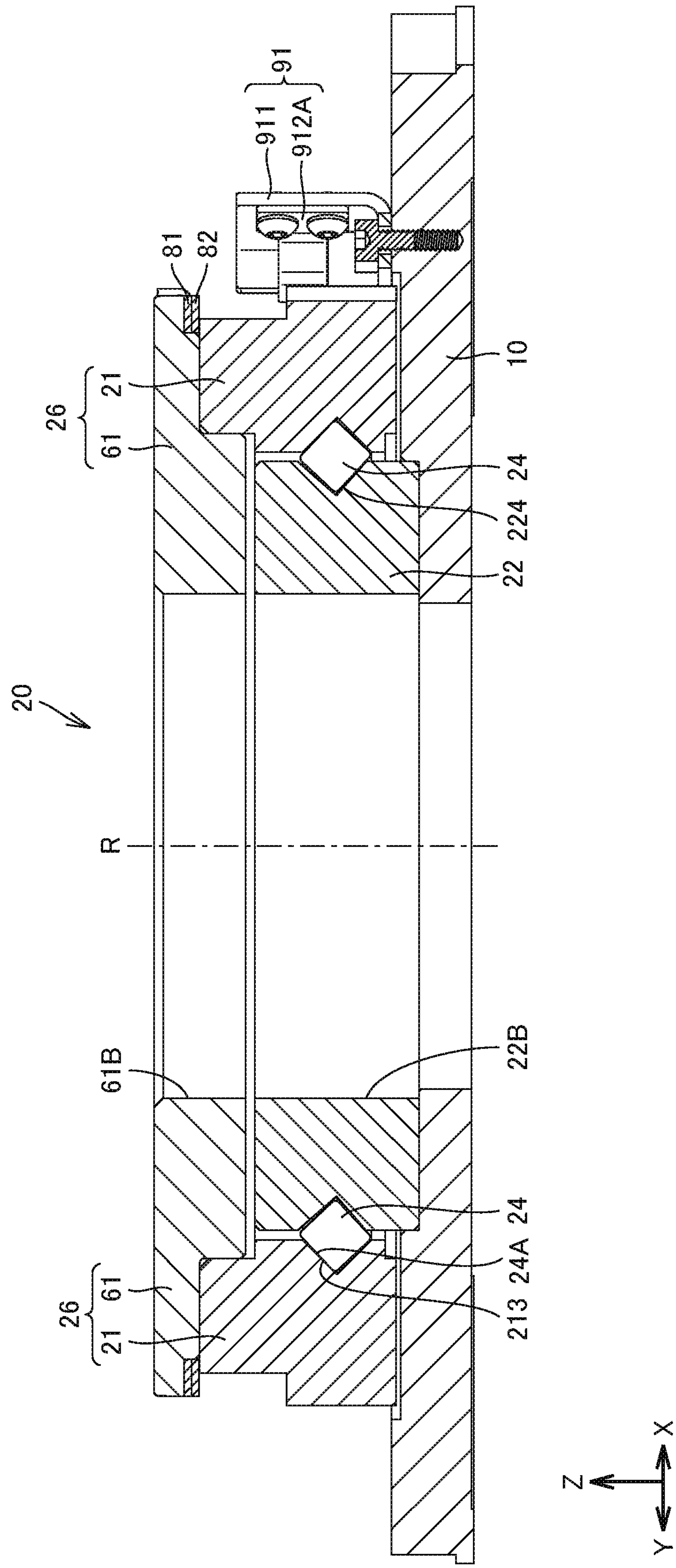
FIG. 7

FIG. 8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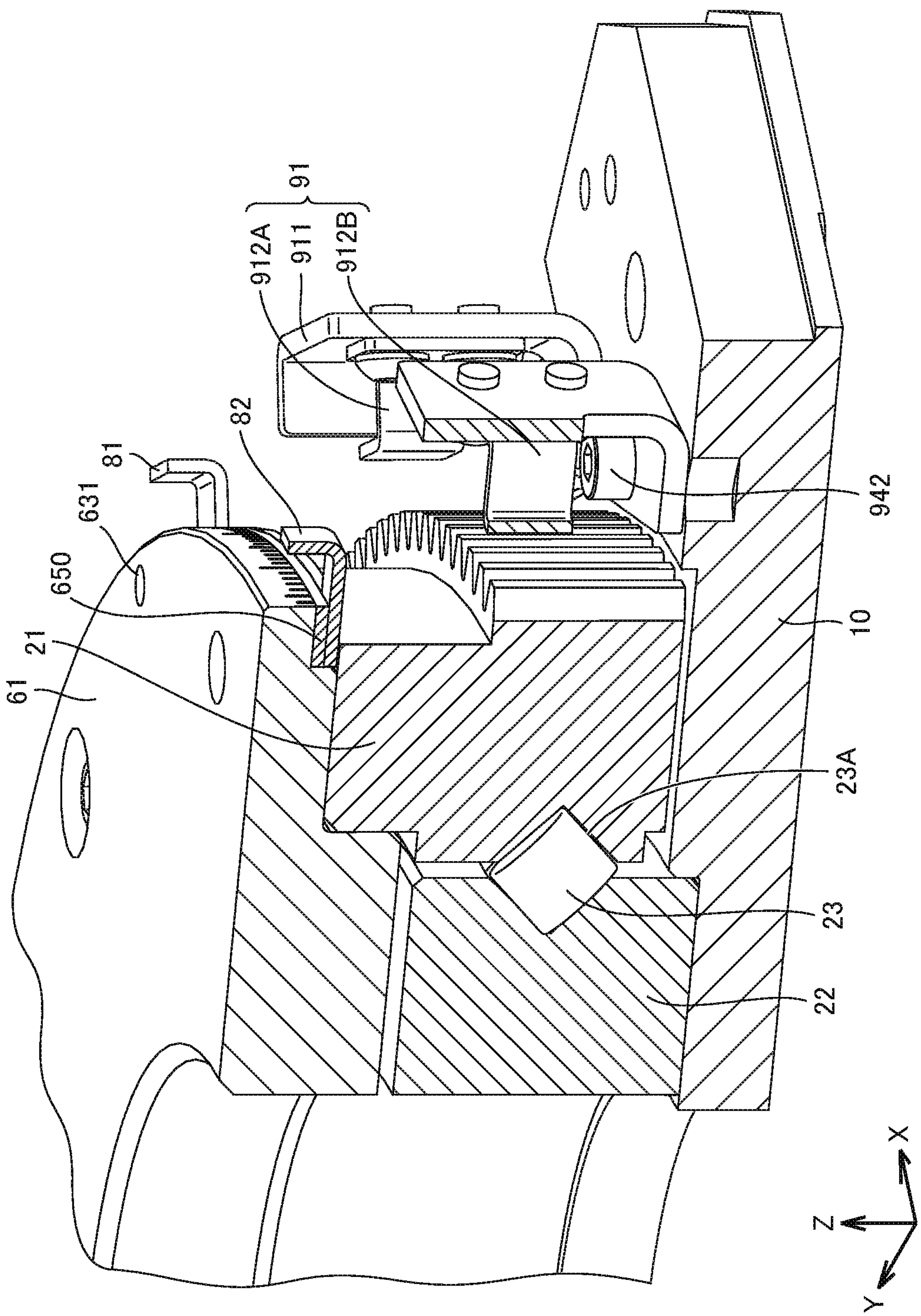
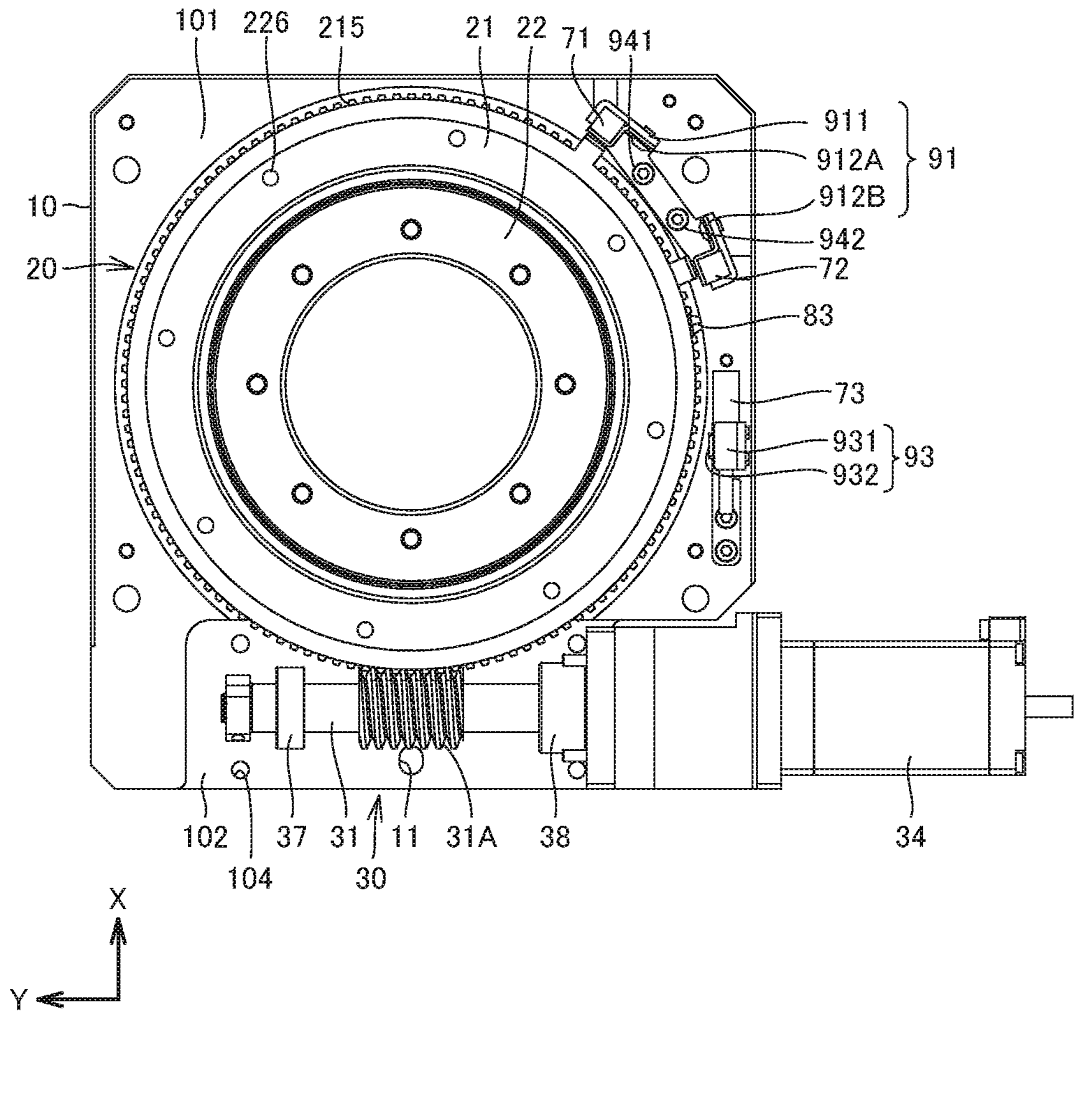


FIG. 9

FIG. 10



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912A
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942
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31A
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X
Y

FIG. 11

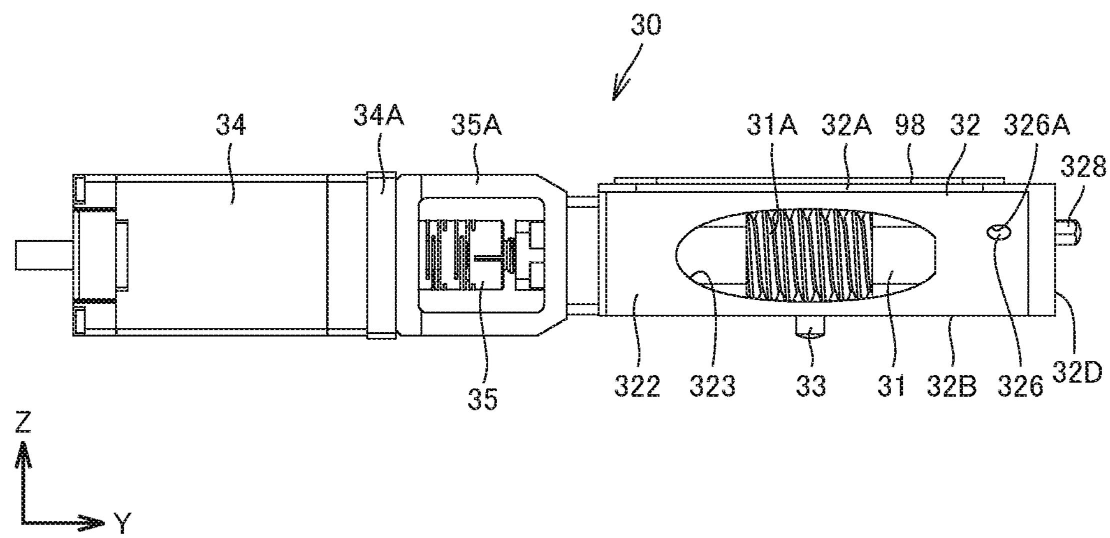
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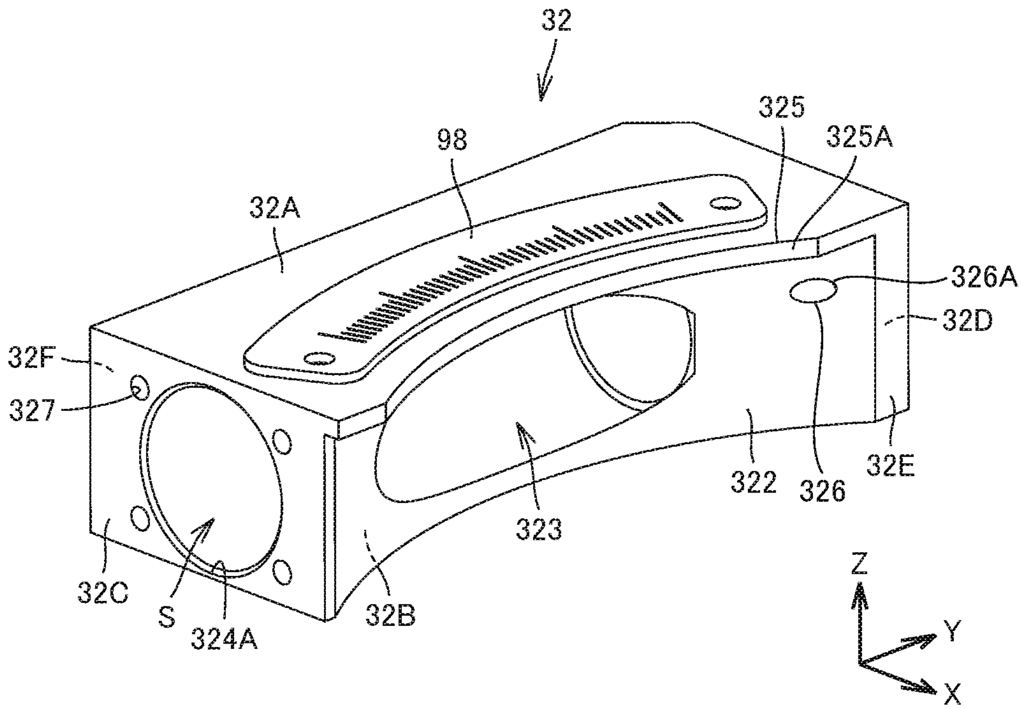
FIG. 12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32B
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FIG. 13

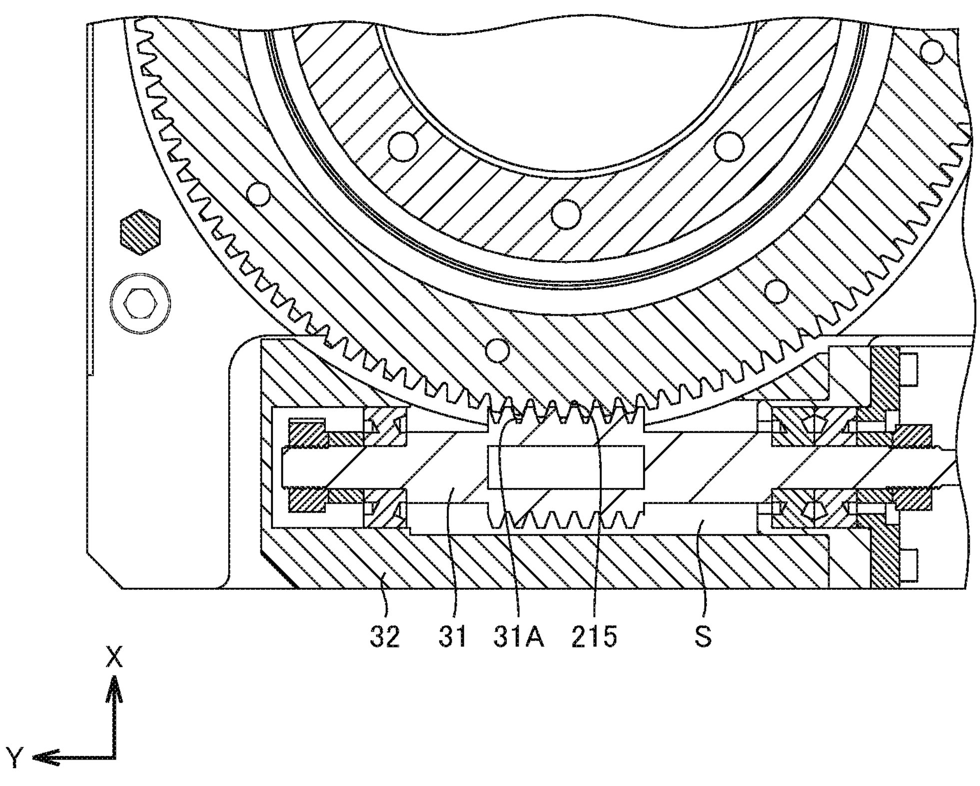
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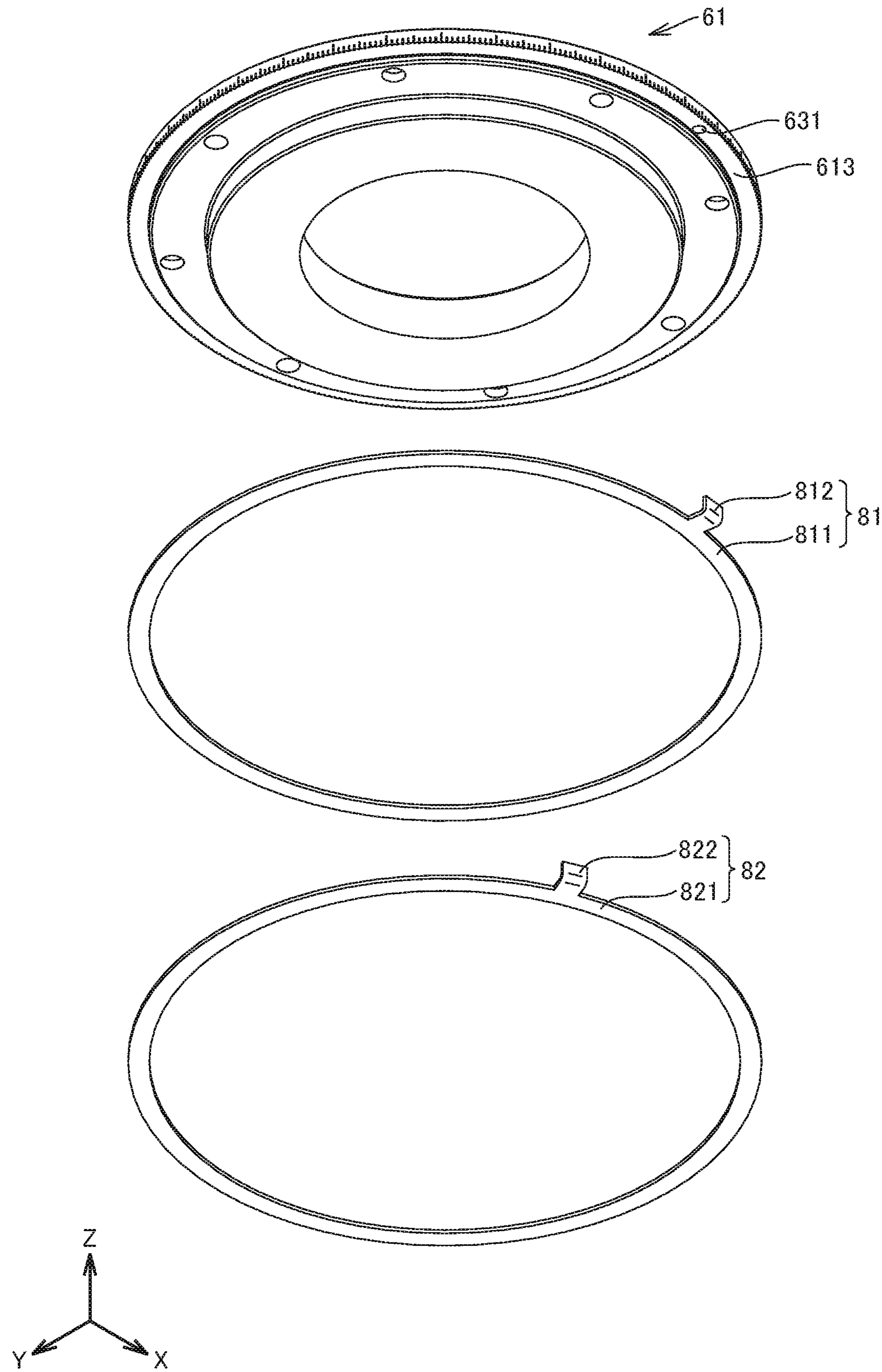
FIG. 14



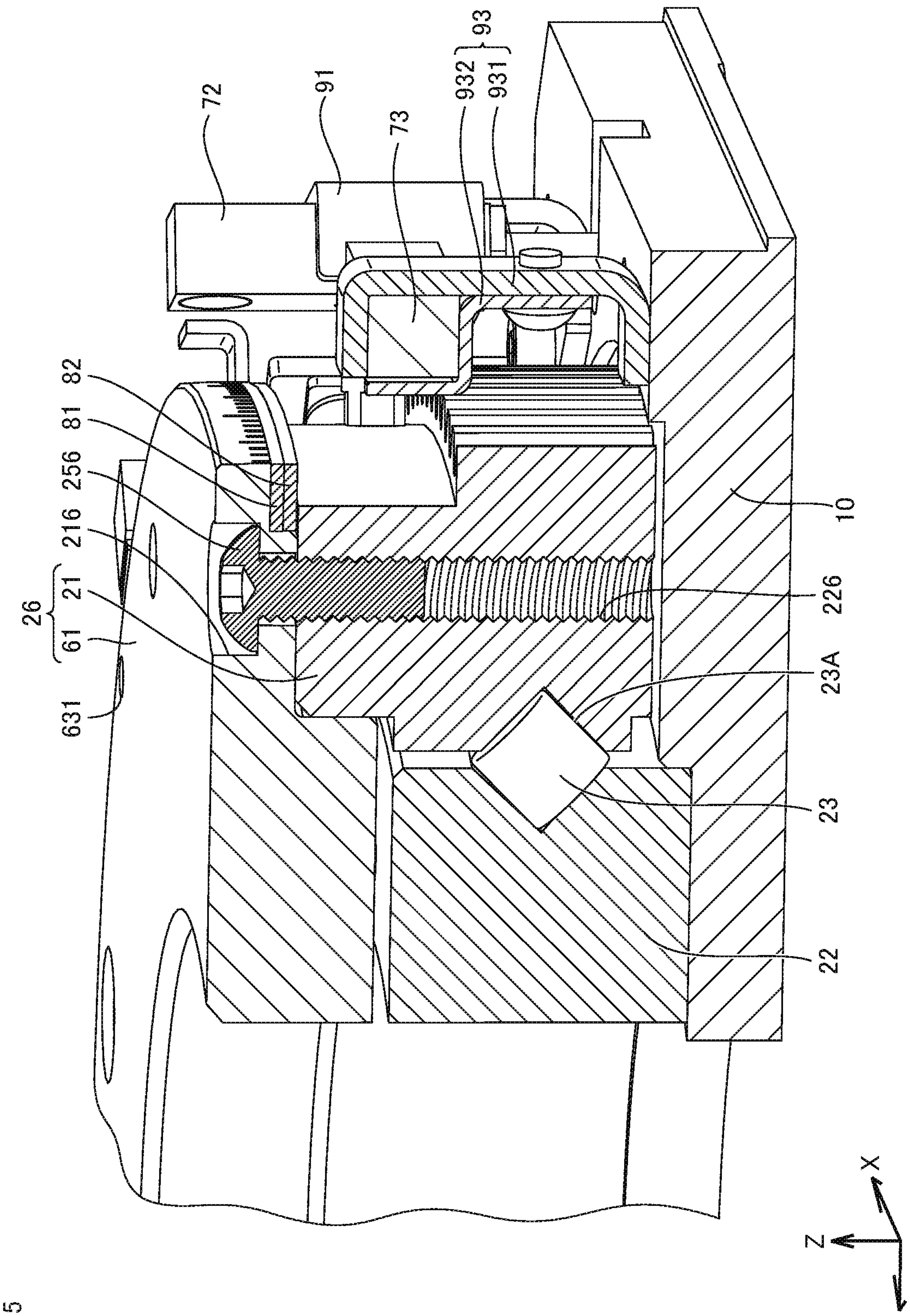
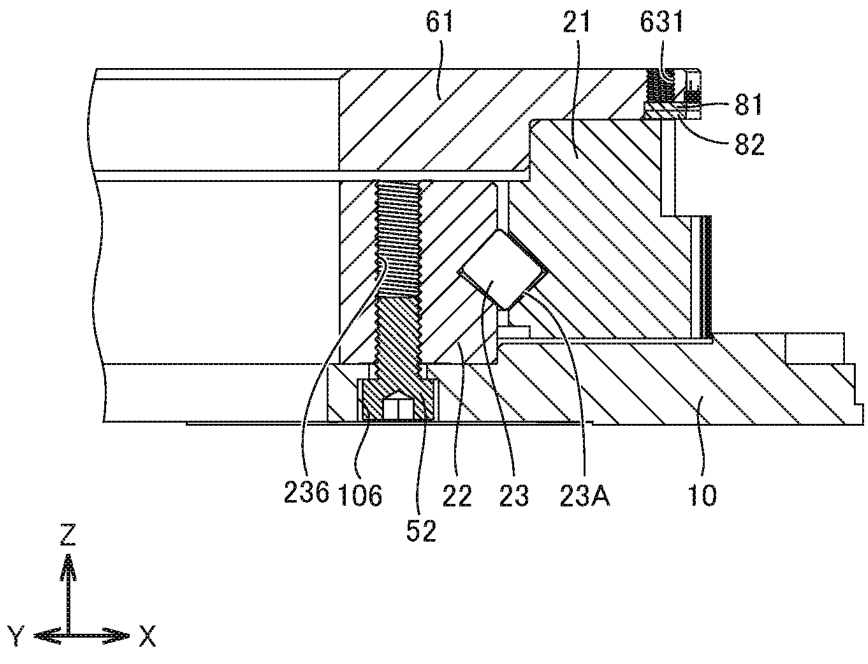


FIG. 15

FIG. 16



ROTARY TABLE

TECHNICAL FIELD

The present invention relates to a rotary table. The present application claims priority based on Japanese Patent Application No. 2021-089430 filed on May 27, 2021, the entire contents of which are incorporated herein by reference.

BACKGROUND ART

It is known in a rotary table to use a dog fixed to the rotary table and a sensor mounted on the base for the purpose of controlling the rotation operation of the table (see, for example, Patent Literature 1).

CITATION LIST

Patent Literature

Patent Literature 1: Japanese Patent Application Laid-Open No. H03-144151

SUMMARY OF INVENTION

Technical Problem

In a rotary table, it is preferable that the rotation angle can be easily set and also easily changed and adjusted. Therefore, one of the objects is to provide a rotary table that allows easy setting, and changing and adjustment of the rotation angle.

Solution to Problem

A rotary table according to the present disclosure includes: a base body having a planar holding surface; a movable ring arranged on the base body to be rotatable around an axis; a fixed ring arranged on an inner periphery side of the movable ring and fixed to the base body; and a plurality of rolling elements arranged to be rollable on an inner circumferential surface of the movable ring and an outer circumferential surface of the fixed ring. The rotary table includes a sensor fixed to the base body and a dog fixed to the movable ring. The movable ring has a scale extending at least at a portion of an outer peripheral side surface, and a groove-shaped recess formed to be recessed inward from an outer periphery of the movable ring at a position corresponding to the scale on the outer periphery. The dog has a leg portion fitted to the recess, and a detected portion protruding outward from the leg portion and detectable by the sensor. The leg portion is able to be fixed to the movable ring at any position in the recess.

Advantageous Effects of Invention

The rotary table described above allows easy setting, and changing and adjustment of the rotation angle.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a perspective view showing the structure of a rotary table in Embodiment 1.

FIG. **2** is a plan view showing the structure of the rotary table in Embodiment 1.

FIG. **3** is a plan view showing the structure of the rotary table in Embodiment 1.

FIG. **4** is a plan view showing the structure of a base body.

FIG. **5** is a cross-sectional view showing the structure of the rotary table in Embodiment 1.

FIG. **6** is an enlarged cross-sectional view of a portion of FIG. **5**.

FIG. **7** is a cross-sectional view showing the structure of the rotary table in Embodiment 1.

FIG. **8** is a cross-sectional view showing the structure of the rotary table in Embodiment 1.

FIG. **9** is a cross-sectional perspective view showing the structure of the rotary table in Embodiment 1.

FIG. **10** is a plan view of the rotary table in Embodiment 1, with its configuration partially excluded.

FIG. **11** is a side view showing the structure of a worm screw unit.

FIG. **12** is a schematic perspective view showing the structure of a worm screw housing.

FIG. **13** is a cross-sectional view showing the structure of the rotary table in Embodiment 1.

FIG. **14** is an exploded perspective view showing a table and dogs of the rotary table.

FIG. **15** is an enlarged cross-sectional perspective view of a portion of the structure of the rotary table in Embodiment 1.

FIG. **16** is an enlarged cross-sectional view of a portion of the structure of the rotary table in Embodiment 1.

DESCRIPTION OF EMBODIMENTS

Outline of Embodiments

First, embodiments of the present disclosure will be listed and described. A rotary table according to the present disclosure includes: a base body having a planar holding surface; a movable ring arranged on the base body to be rotatable around an axis; a fixed ring arranged on an inner periphery side of the movable ring and fixed to the base body; and a plurality of rolling elements arranged to be rollable on an inner circumferential surface of the movable ring and an outer circumferential surface of the fixed ring. The rotary table includes a sensor fixed to the base body and a dog fixed to the movable ring. The movable ring has a scale extending at least at a portion of an outer peripheral side surface, and a groove-shaped recess formed to be recessed inward from an outer periphery of the movable ring at a position corresponding to the scale on the outer periphery. The dog has a leg portion fitted to the recess, and a detected portion protruding outward from the leg portion and detectable by the sensor. The leg portion is able to be fixed to the movable ring at any position in the recess.

There is a desire for a rotary table in which the rotation angle can be easily set, changed, and adjusted. It is conventionally well known for a rotary table to use a dog fixed to the rotary table and a sensor fixed to the base for the purpose of controlling the rotation operation of the table. A conceivable way to change the rotation angle of the rotary table is to change the position of the sensor or the position of the dog. However, the sensor used in a rotary table is often provided together with a dedicated bracket. This would limit the position and direction for attachment of the sensor. It was also sometimes difficult to secure the space for attaching the bracket. Under these circumstances, there was a desire for a sensor attachment structure that could be used even in a small rotary table. It was also desired to be able to easily and reliably change the position of the dog.

The present inventors have thoroughly studied these problems and found that the rotary table according to the present disclosure can solve the problems. In the rotary table according to the present disclosure, a scale is applied on the outer peripheral side surface of the movable ring, a recess is also provided at a position corresponding to the scale on the outer peripheral side surface of the movable ring, and the dog is movably secured in this recess. This configuration facilitates confirmation of the dog attachment position. Accordingly, even in the case where a user should adjust the rotation angle by him/herself, the user can easily perform the rotation angle adjustment work while looking at the scale.

In the above rotary table, the recess in the movable ring may be formed entirely around the outer peripheral side surface, and the leg portion of the dog may have a flat annular shape. According to this configuration, the shape of the movable ring becomes uniform over the entire periphery. This further improves the stability in the control of the rotary table and durability in long term use. In addition, the dog can be secured more reliably.

In the above rotary table, the movable ring may include an outer ring including a raceway surface of the rolling elements and a table fixed to an upper surface of the outer ring, and the outer ring and the table in combination may form the recess. According to this configuration, the design of the outer ring in a conventional rotary table can be utilized to constitute a movable ring that has a scale on its outer peripheral side surface and a recess on the outer peripheral side surface. This allows a rotary table with stable quality to be achieved at a reasonable cost.

In the above rotary table, the dog may include a plurality of dogs, and the plurality of dogs may be able to be fixed to the movable ring at any positions independently of each other. According to this configuration, the range of setting of the rotation angle becomes flexible, and further, in combination with an origin sensor, a rotary table applicable to a wide range of uses can be obtained.

In the above rotary table, the outer ring may be a worm wheel having an outer circumferential surface with a first gear formed over an entire circumferential direction. The rotary table may further include a worm screw unit fixed on the holding surface, and the worm screw unit may include a worm screw held to be rotatable around an axis and having a second gear that meshes with the first gear, and a worm screw housing surrounding and holding the worm screw and fixed so as to contact the holding surface at a planar contacting surface thereof. According to this configuration, a rotary table that is driven by a so-called worm drive is obtained. This rotary table can realize stable rotation control even in the case where a large load is applied, and is particularly suitable for applications requiring small rotation angles.

In the above rotary table, the worm screw housing may have a scale formed on an upper surface in a shape following the outer periphery of the movable ring. According to this configuration, the scale as a reference for adjustment of the dog becomes more easily visible, which further facilitates the adjustment of the dog.

In the above rotary table, one of the holding surface and the contacting surface may have a cylindrical pin arranged to protrude therefrom, and the other of the holding surface and the contacting surface may have a first recess formed to receive the pin, the first recess having a width corresponding to the pin and being elongated in a radial direction of the worm wheel. This configuration facilitates adjustment of a backlash in the worm drive, and in combination with the above-described configuration, provides a rotary table that is easier to handle and has excellent operational stability.

In the above rotary table, the sensor may be clamped and fixed to a holding member that includes a first plate member fixed to the base body and composed of a bent metal plate, and a second plate member fixed to the first plate member and composed of a bent metal plate. According to this configuration, even when the space for attaching a sensor is small, the sensor can be held using a member of simple structure. The sensor attachment member using sheet metal widens the ranges for the sensor attachment position and orientation, and allows the sensor to be attached in a desired position and orientation.

SPECIFIC EMBODIMENTS

Specific embodiments of the rotary table of the present disclosure will be described below with reference to the drawings. In the drawings referenced below, the same or corresponding portions are denoted by the same reference numerals and the description thereof will not be repeated.

Embodiment 1

FIG. **1** is a perspective view showing the structure of a rotary table in Embodiment 1. In FIG. **1**, the Z axis direction is a direction (axial direction) along which a rotational axis R of a worm wheel extends. FIG. **2** is a plan view showing the structure of the rotary table. FIG. **3** is a plan view of the rotary table as seen from the viewpoint opposite to that of FIG. **2**. FIG. **4** shows a base body constituting the rotary table. FIG. **5** is a cross-sectional view of the rotary table taken along A-A in FIG. **2**. FIG. **6** is an enlarged cross-sectional view of a region a in FIG. **5**. FIG. **7** is a cross-sectional view of the rotary table taken along B-B in FIG. **2**. FIG. **8** is a cross-sectional view of the rotary table taken along C-C in FIG. **2**.

Referring to FIGS. **1** to **3**, the rotary table **1** in Embodiment 1 includes a base body **10**, a rolling bearing unit **20**, and a worm screw unit **30**.

The base body **10** is described.

Referring to FIG. **1**, the base body **10** has a plate shape. Referring to FIGS. **1** and **4**, the base body **10** has a first surface **101**, a second surface **102** serving as a holding surface of the worm screw unit **30**, and a third surface **103**. Referring to FIG. **1**, the region corresponding to the first surface **101** has a thickness greater than that of the region corresponding to the second surface **102**. In other words, the second surface **102** has a height in the Z axis direction lower than that of the first surface **101**. The first surface **101** and the second surface **102** are connected via the third surface **103**. Referring to FIG. **4**, the first surface **101** has a planar shape. The first surface **101** has fourth through holes **105** formed at its corners to penetrate in the thickness direction. The first surface **101** has an annular recess **101**B formed to surround a through hole **107**. The through hole **107** penetrating in the thickness direction is formed at the center of the recess **101**B. In plan view in the Z axis direction, the through hole **107** has a circular shape with the rotational axis R at its center. A ring-shaped recess **101**A is formed to surround the recess **101**B. Referring to FIG. **7**, a region of the first surface **101** corresponding to the recess **101**A has a thickness greater than that of a region of the first surface **101** corresponding to the recess **101**B. Referring to FIG. **4**, the recesses **101**A and **101**B have shapes corresponding to a worm wheel **21** and an inner ring **22** (FIG. **5**), respectively, which will be described later. The recess **101**B has a plurality of (in the present embodiment, eight) screw holes **106** formed at equal intervals in the circumferential direction. The first surface **101** has a plurality of (in the present embodiment, four) screw holes **104** formed on the outer periphery side from the recess **101**A.

Referring to FIG. **4**, the second surface **102** has a length L_3 in the Y axis direction shorter than a length La of the first surface **101** in the Y axis direction. The second surface **102** has a planar shape. The second surface **102** has fourth through holes **108**A, **108**B, **108**C, and **108**D formed to penetrate in the thickness direction. The through holes **108**A, **108**B, **108**C, and **108**D each have an inside diameter greater than an outside diameter of a threaded portion of a screw **53** (FIG. **3**), which will be described later. The second surface **102** has a first recess **11** formed between the through hole **108**B and the through hole **108**D. In plan view in the Z axis direction, the first recess **11** is formed in a region of the second surface **102** closer to its long side opposite to the first surface **101** with respect to the center of the second surface **102** in the X axis direction. Referring to FIGS. **4** and **6**, the base body **10** has a first screw hole **12** formed to communicate with the first recess **11**. The first screw hole **12** extends along the X axis direction.

The rolling bearing unit **20** is described.

Referring to FIGS. **7** and **8**, the rolling bearing unit **20** includes a worm wheel **21** as an outer ring, a table **61**, an inner ring **22** as a fixed ring, and a plurality of first rollers **23** and a plurality of second rollers **24** as a plurality of rolling elements. The worm wheel **21** and the table **61** are fixed to each other to constitute a movable ring **26**. The worm wheel **21** is disposed on the first surface **101** of the base body **10**. The worm wheel **21** is arranged so as to correspond to the position of the recess **101**A formed in the first surface **101**. The worm wheel **21** is arranged such that the direction along the rotational axis R of the worm wheel **21** coincides with the direction perpendicular to the first surface **101** (Z axis direction). The worm wheel **21** has an annular shape.

The worm wheel **21** includes an inner circumferential surface **21**A, an outer circumferential surface **21**B, an end surface **21**D in the axial direction, and an end surface **21**E opposite to the end surface **21**D in the axial direction. The outer circumferential surface **21**B has a first gear **215** formed over the entire circumferential direction. The inner circumferential surface **21**A includes a first region **211** and a second region **212**. The first region **211** is located on the end surface **21**D side with respect to the center of the inner circumferential surface **21**A in the axial direction. The second region **212** is located on the end surface **21**E side with respect to the center of the inner circumferential surface **21**A in the axial direction. In the Z axis direction, an annular recessed space **21**C is formed between the first region **211** and the second region **212**. The space **21**C is surrounded by a first rolling surface **213** of an annular shape and a second rolling surface **214** of an annular shape. The first rolling surface **213** and the second rolling surface **214** are crossing (orthogonal to) each other. The space **21**C is formed along a rolling path of the first rollers **23** and the second rollers **24**.

The table **61** is fixed to the worm wheel **21**. The table **61** and the worm wheel **21** constitute the movable ring **26**. The table **61** has an annular shape. The table **61** includes an outer circumferential surface **61**A, an inner circumferential surface **61**B, an end surface **61**D in the axial direction, and an end surface **61**E opposite to the end surface **61**D in the axial direction. The end surface **61**D of the table **61**, which is the upper surface of the rotary table **1**, has a planar shape. The outer circumferential surface **61**A includes a first portion **611** and a second portion **612**. The second portion **612** has a diameter smaller than that of the first portion **611**. The first portion **611** has a scale applied over the entire periphery (FIG. **1**). The first portion **611** and the second portion **612** are connected via an end surface **613**. The end surface **613** is a surface parallel to the end surface **21**D of the worm wheel **21**. The second portion **612** has a diameter smaller than that of the outer circumferential surface **21**B of the outer ring. As the worm wheel **21** and the table **61** are combined, a recess **650** is formed surrounded by the end surface **613**, the second portion **612** of the outer circumferential surface, and the end surface **21**D of the worm wheel **21**. The recess **650** is a groove-shaped recess that is formed to be recessed inward from an outer periphery of the movable ring **26**. The recess **650** is formed over the entire periphery of the movable ring **26**. The inner circumferential surface **61**B of the table **61** has a diameter approximately equal to that of an inner circumferential surface **22**B of the inner ring **22**. The table **61** has a plurality of (in the present embodiment, eight) screw holes **216** formed at equal intervals in the circumferential direction (FIG. **1**). The screw holes **216** are arranged such that their positions coincide with the positions of eight screw holes **226** (FIG. **10**) formed in the worm wheel **21**. Four of the eight screw holes **216**, **226** are utilized for fixing the table **61** to the worm wheel **21**. Screws **256** ([FIG. **15**]) are screwed into the screw holes **216** of the table **61** and the screw holes **226** of the worm wheel **21**. In this manner, the table **61** is fixed to the worm wheel **21**.

The inner ring **22** has an annular shape. The inner ring **22** is arranged on an inner periphery side of the worm wheel **21**. The inner ring **22** is arranged so as to correspond to the position of the recess **101**B (FIG. **4**) formed in the first surface **101** of the base body **10**. The inner ring **22** includes an outer circumferential surface **22**A, the inner circumferential surface **22**B, an end surface **22**D in the axial direction, and an end surface **22**E opposite to the end surface **22**D in the axial direction. The outer circumferential surface **22**A includes a third region **221** and a fourth region **222**. The third region **221** is located on the end surface **22**D side with respect to the center of the outer circumferential surface **22**A in the axial direction. The fourth region **222** is located on the end surface **22**E side with respect to the center of the outer circumferential surface **22**A in the axial direction. In the Z axis direction, an annular recessed space **22**C is formed between the third region **221** and the fourth region **222**. The space **22**C is surrounded by a third rolling surface **223** of an annular shape and a fourth rolling surface **224** of an annular shape. The third rolling surface **223** and the fourth rolling surface **224** are crossing (orthogonal to) each other. The space **22**C is formed along the rolling path of the first rollers **23** and the second rollers **24**. The first rolling surface **213** and the fourth rolling surface **224** face each other. In the present embodiment, in the cross section including the rotational axis R, the first rolling surface **213** and the fourth rolling surface **224** are arranged in parallel. The second rolling surface **214** and the third rolling surface **223** face each other. In the present embodiment, in the cross section including the rotational axis R, the second rolling surface **214** and the third rolling surface **223** are arranged in parallel.

The inner ring **22** has a plurality of screw holes **236** ([FIG. **16**]) formed at equal intervals in the circumferential direction. The screw holes **236** are arranged such that their positions coincide with the positions of the screw holes **106** ([FIG. **3**]) formed in the base body **10**, and screws **52** ([FIG. **3**]) are screwed into the screw holes **106** of the base body **10** and the screw holes **236** of the inner ring **22**. In this manner, the inner ring **22** is fixed to the base body **10**.

Referring to FIGS. **7** and **8**, the first rollers **23** and the second rollers **24** each have a cylindrical shape. The first rollers **23** and the second rollers **24** are arranged alternately in the circumferential direction. The first rollers **23** are arranged to be able to roll while contacting the second rolling surface **214** and the third rolling surface **223** at their outer circumferential surfaces **23**A. The second rollers **24** are arranged to be able to roll while contacting the first rolling surface **213** and the fourth rolling surface **224** at their outer circumferential surfaces **24**A. The central axis of a first roller **23** and the central axis of a second roller **24** are crossing (orthogonal to) each other. Here, the state in which the central axis of the first roller **23** and the central axis of the second roller **24** are crossing means that when the center of gravity of the first roller **23** and the center of gravity of the second roller **24** pass a certain point during the rotation of the worm wheel **21**, the central axis of the first roller **23** and the central axis of the second roller **24** intersect (orthogonally). In this manner, the worm wheel **21** is able to rotate around the rotational axis R with respect to the base body **10**.

The worm screw unit **30** is described.

FIG. **10** is a plan view of the rotary table **1**, with some components including the table **61** and a worm screw housing **32** removed therefrom. FIG. **11** is a side view of the worm screw unit **30**. FIG. **12** is a perspective view of the worm screw housing **32**. FIG. **13** is an enlarged cross-sectional view of an area around a region where the first gear **215** and a second gear **31**A contact each other.

Referring to FIG. **1**, the worm screw unit **30** is disposed on the second surface **102** of the base body **10**. Referring to FIGS. **10** and **11**, the worm screw unit **30** includes a worm screw **31**, a worm screw housing **32**, a pin **33**, a motor **34**, a coupling **35**, a first support bearing **37**, and a second support bearing **38**. The worm screw **31** has a columnar shape. The worm screw **31** has a second gear **31**A formed on its outer circumferential surface. The second gear **31**A meshes with the first gear **215**. The worm screw **31** has one end portion fixed to an inner ring of the first support bearing **37**. The first support bearing **37** has its outer ring fixed to the worm screw housing **32**. The first support bearing **37** supports the worm screw **31** so as to be rotatable with respect to the worm screw housing **32**. The coupling **35** is arranged at the other end portion of the worm screw **31**. The motor **34** is fixed by a motor attachment **34**A and attached to a motor bracket **35**A. For the motor **34** in the present embodiment, a stepping motor or an AC servo motor, for example, can be adopted. The second support bearing **38** supports the worm screw **31** so as to be rotatable with respect to the coupling **35**. The worm screw **31** is connected to the motor **34** via the coupling **35**. The motor **34** is electrically connected to an external power source (not shown).

Referring to FIG. **12**, the worm screw housing **32** has a rectangular parallelepiped shape with an internal space S formed therein. The worm screw housing **32** includes a first outer wall surface **32**A, a second outer wall surface **32**B as a contacting surface (bottom surface), a third outer wall surface **32**C, a fourth outer wall surface **32**D, a fifth outer wall surface **32**E, and a sixth outer wall surface **32**F. The first outer wall surface **32**A, the second outer wall surface **32**B, the third outer wall surface **32**C, the fourth outer wall surface **32**D, and the sixth outer wall surface **32**F each have a planar shape. The first outer wall surface **32**A and the second outer wall surface **32**B are arranged aligned in the Z axis direction. The first outer wall surface **32**A and the second outer wall surface **32**B are arranged in parallel. The third outer wall surface **32**C and the fourth outer wall surface **32**D are arranged aligned in the X axis direction. The third outer wall surface **32**C and the fourth outer wall surface **32**D are arranged in parallel. The fifth outer wall surface **32**E and the sixth outer wall surface **32**F are arranged aligned in the Y axis direction. On an upper surface of the first outer wall surface **32**A, a scale **98** is attached to follow the outer periphery of the movable ring **26**.

Referring to FIGS. **6** and **12**, the second outer wall surface **32**B, which is the bottom surface of the worm screw housing **32**, has a recess **321** formed therein. The third outer wall surface **32**C has an opening **324**A formed to communicate with the internal space S. Around the opening **324**A, four screw holes **327** are formed. The fifth outer wall surface **32**E has a curved (arc-shaped) opposing surface **322** that is recessed in the X axis direction. The opposing surface **322** has a first through hole **323** formed to communicate with the internal space S. The worm screw housing **32** includes a flange portion **325** that protrudes from the opposing surface **322** in the X axis direction. The flange portion **325** has, in its protruding direction, a curved (arc-shaped) tip end portion **325**A. The tip end portion **325**A constitutes a part of the fifth outer wall surface **32**E.

Referring to FIGS. **11** and **12**, the worm screw housing **32** has a lubrication hole **326** formed to penetrate from the fourth outer wall surface **32**D to the opposing surface **322**. The lubrication hole **326** has a first opening **326**A on the opposing surface **322** and a second opening on the fourth outer wall surface **32**D. The first opening **326**A is formed spaced apart from the first through hole **323** in the Y axis direction. A grease nipple **328** is attached to close the second opening. Attachment of the grease nipple **328** facilitates adjustment of the grease supply amount.

Referring to FIG. **6**, the pin **33** of a cylindrical shape is arranged to protrude from the second outer wall surface **32**B. The pin **33** is fitted in the recess **321** in the second outer wall surface **32**B. In the present embodiment, the pin **33** has an outside diameter slightly smaller than a width L_5 (FIG. **4**) in the X axis direction of the first recess **11** in the base body **10**.

Referring to FIGS. **11** and **13**, the worm screw housing **32** surrounds the worm screw **31**. The worm screw **31** is housed in the internal space S formed in the worm screw housing **32**. The second gear **31**A of the worm screw **31** is exposed from the first through hole **323** in the worm screw housing. Referring to FIG. **6**, the second outer wall surface **32**B, which is the bottom surface of the worm screw housing **32**, contacts the second surface **102** of the base body **10**. The opposing surface **322** of the worm screw housing **32** faces the outer circumferential surface **21**B of the worm wheel **21**. Referring to FIG. **13**, the second gear **31**A exposed from the first through hole **323** on the opposing surface **322** is in mesh with the first gear **215** of the worm wheel **21**.

Referring to FIG. **6**, the pin **33** is inserted into the long hole-shaped first recess **11** in the base body **10**. The rotary table **1** further includes a hexagon socket set screw **40** which is a first screw screwed into the first screw hole **12** of the base body **10**. The hexagon socket set screw **40** has its tip end portion **40**A coming into contact with an outer circumferential surface **33**A of the pin **33**. Referring to FIGS. **3** and **4**, the worm screw housing **32** is disposed such that the positions of the screw holes formed on the second outer wall surface **32**B as the bottom surface of the worm screw housing **32** coincide with the positions of the through holes **108**A, **108**B, **108**C, and **108**D formed in the base body **10**, and screws **53** are screwed thereinto. In this manner, the worm screw housing **32** is fixed to the base body **10**.

A description is made of how to fix the worm screw unit **30** to the base body **10**.

A structural body with the rolling bearing unit **20** attached to the base body **10** is first prepared. Next, as shown in FIG. **2**, the worm screw unit **30** is disposed on the base body **10**.

At this time, referring to FIG. **6**, the pin **33** being press-fitted in the recess **321** in the worm screw housing **32** is inserted into the first recess **11** in the base body **10**. Then, referring to FIGS. **2**, **3**, and **4**, the screws **53** are inserted into the through holes **108**A, **108**B, **108**C, and **108**D to temporarily secure the worm screw housing **32** to the base body **10**. Next, referring to FIG. **2**, the worm screw unit is brought closer to the first gear **215** along the radial direction of the worm screw, to make the first gear **215** and the second gear **31**A contact each other with appropriate force. Next, referring to FIG. **6**, the hexagon socket set screw **40** is screwed into the first screw hole **12**. Then, referring to FIGS. **2** and **3**, the screws **53** are further tightened to thereby make the worm screw housing **32** fixed to the base body **10**.

Here, in the rotary table **1** of the present embodiment, the first recess **11** has a width corresponding to the pin **33** (slightly greater than the outside diameter of the pin **33**) and has a shape elongated in the radial direction of the worm wheel **21**. Inserting the pin **33** into the first recess **11** allows the worm screw housing **32** to move in the radial direction, while restricting the movement of the worm screw housing **32** in the tangential direction of the worm wheel **21**. It further allows the worm screw housing **32** to rotate with respect to the base body **10** with the pin **33** as a pivot point. By making the worm screw unit **30** approach the first gear **215** along the radial direction of the worm screw and by making the first gear **215** and the second gear **31**A contact each other with appropriate force, the backlash between the first gear **215** and the second gear **31**A can be adjusted appropriately through the movement of the worm screw housing **32** in the radial direction and its rotation with the pin **33** as the pivot point as described above. The adjustment of the backlash between the first gear **215** and the second gear **31**A thus becomes easy. As such, the rotary table **1** in the present embodiment is able to easily adjust the backlash between the first gear **215** and the second gear **31**A.

In the above embodiment, the first screw hole **12** is formed which is in communication with the first recess **11** and has an opening facing the outer circumferential surface of the pin **33**. The rotary table **1** is equipped with the hexagon socket set screw **40** which is screwed into the first screw hole **12** and has its tip end portion **40**A coming into contact with the outer circumferential surface **33**A of the pin **33**. After adjustment of the relative position of the worm screw housing **32** with respect to the base body **10**, the hexagon socket set screw **40** is screwed into the first screw hole **12**. This can regulate the relative movement of the worm screw housing **32** with respect to the base body **10**. Accordingly, the changes over time of the backlash between the first gear **215** and the second gear **31**A can be suppressed.

In the above embodiment, the worm screw housing **32** has the opposing surface **322** which faces the outer circumferential surface **21**B of the worm wheel **21**. The worm screw housing **32** includes the flange portion **325** which protrudes from the opposing surface **322** to cover a side surface **215**A of the first gear **215** facing the opposing surface **322**. Adopting such a configuration can reduce the chances of foreign matters entering into the region where the first gear **215** and the second gear **31**A contact each other, and also reduce splattering of the grease to the outside of the rotary table **1**.

In the above embodiment, referring to FIGS. **5**, **7**, and **8**, the trajectory of a midpoint in the central axis of a first roller **23** and the trajectory of a midpoint in the central axis of a second roller **24** are included in a virtual plane U. In the present embodiment, the virtual plane U includes a region where the first gear **215** and the second gear **31**A contact each other. In the Z axis direction, the height of the center of the trajectory in the rolling bearing unit **20** coincides with the height of gear contact between the first gear **215** and the second gear **31**A in the worm screw unit **30**. Arranging the rolling bearing unit **20** and the worm screw unit **30** in this manner facilitates optimizing the gear contact between the first gear **215** and the second gear **31**A for the purpose of efficient transmission of force from the second gear **31**A to the first gear **215**.

The sensor and the dog for the rotary table are described.

Referring to FIG. **1**, the rotary table **1** has sensors **71**, **72**, and **73** as sensors fixed to the base body **10**. The sensors **71**, **72**, and **73** are, for example, proximity sensors. The sensors **71** and **72** are used as limit sensors. The sensor **73** is used as an origin sensor. The sensors **71** and **72** are attached to the base body **10** via a holder **91**, which is a holding member. The sensor **73** is attached to the base body **10** via a holder **93**.

The rotary table **1** has dogs **81**, **82**, and **83** fixed to the movable ring **26**. The dogs **81** and **82** are attached to the positions corresponding to the sensors **71** and **72** in the Z axis direction. The dog **83** is attached to the position corresponding to the sensor **73** in the Z axis direction.

Attachment structures of the dogs **81**, **82**, and **83** are described. Referring to FIGS. **1** and **10**, the dog **83**, which is an origin dog, is attached to an outer peripheral side surface of the worm wheel **21**. The dog **83** is a member provided to protrude outward from the outer peripheral side surface of the worm wheel **21**. The dog **83** is screwed into a screw hole provided on the outer peripheral side surface of the worm wheel **21**.

Referring to FIGS. **9**, **14**, and **16**, the dogs **81** and **82** are members identical in shape. The dogs **81** and **82** have flat and annular leg portions **811** and **821** and detected portions **812** and **822** protruding outward from the leg portions, respectively. The detected portions **812**, **822** have a portion extending in the Z axis direction. This shape facilitates detection by the sensors **71**, **72**. The dogs **81** and **82** are clamped in the recess **650** formed by the table **61** and the worm wheel **21**. The table **61** has a screw hole **631** formed therein. The screw hole **631** is a through hole that penetrates from the end surface **61**D, which is the upper surface of the table **61**, to the end surface **613** (FIG. **7**). Inserting a screw into the screw hole **631** and tightening it can press and fix the dogs **81** and **82**. Loosening the screw allows the dogs **81** and **82** to rotate in the circumferential direction of the movable ring **26** in the state of being held in the recess **650**. In other words, the dogs **81** and **82** can be fixed at any desired positions by loosening the screw and rotating the dogs **81** and **82** to desired positions and tightening the screw again. The dogs **81** and **82** are moved independently of each other.

Referring to FIGS. **15** and **16**, the table **61** and the worm wheel **21** are fixed to each other via the screws **256** inserted into the screw holes **216** and **226**. On the other hand, the dogs **81** and **82** are fixed to the movable ring **26** via the screw inserted into the screw hole **631**. This structure allows the positions of the dogs **81** and **82** to be changed without loosening the fixation between the table **61** and the worm wheel **21**. Further, the scale formed on the outer circumferential surface **61**A of the table **61** can be referred to when determining the positions of the dogs. This ensures easy positioning. In addition, by also utilizing the scale **98** (FIG. **12**) for positioning, the positions of the dogs can be easily set and changed on the user side.

Referring to FIGS. **9** and **10**, the holder **91**, which is the holding member for the sensors **71** and **72**, includes a base portion **911** as a first plate member, and holding portions

912A and 912B as second plate members. In FIG. 9, the sensors 71 and 72 are not shown for ease of understanding. The base portion 911 is composed of a bent metal plate. The base portion 911 is fixed to the base body 10 via screws 941 and 942. The base portion 911 has a first portion that is in contact with the first surface 101 as the upper surface of the base body 10 and extends in the circumferential direction corresponding to the outer periphery of the worm wheel 21, and a second portion that rises from the first portion in the Z axis direction. The holding portions 912A and 912B are fixed to the second portion of the base portion 911. The holding portions 912A and 912B are each composed of a bent metal plate. The sensor 71 is clamped between the base portion 911 and the holding portion 912A. The sensor 72 is clamped between the base portion 911 and the holding portion 912B. The sensor holding member configured in this manner allows the sensor to be held with the holding member that utilizes simple members. According to such a holding member, a plurality of sensors are easily installed even in a small rotary table having a limited space for installing the sensors.

The holder 93, which is the holding member for the sensor 73, includes a base portion 931 as a first plate member and a holding portion 932 as a second plate member. The base portion 931 and the holding portion 932 are each composed of a bent metal plate. The base portion 931 is screw-fastened to the first surface 101 as the upper surface of the base body 10. The holding portion 932 is screw-fastened to the base portion 931. The sensor 73 is clamped between the base portion 931 and the holding portion 932. Although the sensors 71, 72 and the sensor 73 differ in the installation direction from each other, in each installation direction, a sensor is held by a holder 91, 93 composed of a combination of two plate members.

(Variations)

The structure for fixing a dog to the movable ring is not limited to that of the above-described embodiment. For example, a dog and the table as one piece may be configured to rotate with respect to the worm wheel and to be fixed at any position. Alternatively, a dog and the worm wheel as one piece may be configured to rotate with respect to the table and to be fixed at any position. The number of dogs can also be changed depending on the desired rotation operation. Two dogs may be provided which are fixed to the outer ring, and one movable dog may be provided which is held movably with respect to the outer ring.

The scale and the recess provided on the outer periphery of the movable ring are not limited to those provided over the entire periphery of the movable ring. The scale and the recess may be formed on only a portion of the outer periphery of the movable ring, and a dog may be moved within the range of the recess extending in the circumferential direction.

It should be understood that the embodiments disclosed herein are illustrative and non-restrictive in every respect. The scope of the present invention is defined by the terms of the claims, rather than the description above, and is intended to include any modifications within the scope and meaning equivalent to the terms of the claims.

REFERENCE SIGNS LIST

1: rotary table; **10**: base body; **11**: first recess; **12**: first screw hole; **13**: second screw hole; **20**: unit; **21**: worm wheel; **21**A, **22**B: inner circumferential surface; **21**B, **22**A, **23**A, **24**A, **33**A: outer circumferential surface; **21**C, **22**C: space; **21**D, **21**E, **22**D, **22**E: end surface; **22**: inner ring; **23**: first roller; **24**: second roller; **26**: movable ring; **30**: worm screw unit; **31**: worm screw; **31**A: second gear; **32**: worm screw housing; **32**A: first outer wall surface; **32**B: second outer wall surface; **32**C: third outer wall surface; **32**D: fourth outer wall surface; **32**E: fifth outer wall surface; **32**F: sixth outer wall surface; **33**: pin; **34**: motor; **34**A: motor attachment **35**: coupling; **35**A: motor bracket; **37**: first support bearing; **38**: second support bearing; **40**: hexagon socket set screw; **40**A, **325**A: tip end portion; **52**, **53**: screw; **101**: first surface; **101**A, **101**B, **321**: recess; **102**: second surface; **103**: third surface; **104**, **106**, **216**, **226**, **236**, **327**: screw hole; **105**, **107**, **108**A, **108**B, **108**C, **108**D: through hole; **211**: first region; **212**: second region; **213**: first rolling surface; **214**: second rolling surface; **215**: first gear; **221**: third region; **222**: fourth region; **223**: third rolling surface; **224**: fourth rolling surface; **322**: opposing surface; **323**: first through hole; **324**A: opening; **325**: flange portion; **326**: lubrication hole; **326**A: first opening; **328**: grease nipple; **61**: table; **611**, **612**: portion; **613**: end surface; **61**A: outer circumferential surface; **61**B: inner circumferential surface; **61**D, **61**E: end surface; **631**: screw hole; **650**: recess; **71**, **72**, **73**: sensor; **81**, **82**, **83**: dog; **811**: leg portion; **812**: detected portion; **91**, **93**: holder; **911**, **931**: base portion; **912**A, **912**B, **932**; holding portion; and **98**: scale.

The invention claimed is:

1. A rotary table comprising:

a base body having a planar holding surface;

a movable ring arranged on the base body to be rotatable around an axis;

a fixed ring arranged on an inner periphery side of the movable ring and fixed to the base body; and

a plurality of rolling elements arranged to be rollable on an inner circumferential surface of the movable ring and an outer circumferential surface of the fixed ring;

the rotary table including a sensor fixed to the base body and a dog fixed to the movable ring,

the movable ring having

a scale extending at least at a portion of an outer peripheral side surface, and

a groove-shaped recess formed to be recessed inward from an outer periphery of the movable ring at a position corresponding to the scale on the outer periphery,

the dog having

a leg portion fitted to the recess, and

a detected portion protruding outward from the leg portion and detectable by the sensor,

the leg portion being able to be fixed to the movable ring at any position in the recess.

2. The rotary table according to claim **1**, wherein

the recess is formed entirely around the outer peripheral side surface of the movable ring, and

the leg portion of the dog has a flat annular shape.

3. The rotary table according to claim **1**, wherein the movable ring includes an outer ring including a raceway surface of the rolling elements and a table fixed to an upper surface of the outer ring, and the outer ring and the table in combination form the recess.

4. The rotary table according to claim **3**, wherein the outer ring is a worm wheel having an outer circumferential surface with a first gear formed over an entire circumferential direction,

the rotary table further comprising a worm screw unit fixed on the holding surface, the worm screw unit including a worm screw held to be rotatable around an axis and having a second gear that meshes with the first gear, and a worm screw housing surrounding and holding the worm screw and fixed so as to contact the holding surface at a planar contacting surface thereof.

5. The rotary table according to claim **4**, wherein the worm screw housing has a scale formed on an upper surface in a shape following a periphery of the outer ring.

6. The rotary table according to claim **4**, wherein one of the holding surface and the contacting surface has a cylindrical pin arranged to protrude therefrom, and the other of the holding surface and the contacting surface has a first recess formed to receive the pin, the first recess having a width corresponding to the pin and being elongated in a radial direction of the worm wheel.

7. The rotary table according to claim **1**, wherein the dog includes a plurality of dogs, and the plurality of dogs are able to be fixed to the movable ring at any positions independently of each other.

8. The rotary table according to claim **1**, wherein the sensor is clamped and fixed to a holding member, the holding member including

a first plate member fixed to the base body and composed of a bent metal plate, and

a second plate member fixed to the first plate member and composed of a bent metal plate.

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