



(11)

EP 4 742 286 A1

(12)

EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
13.05.2026 Bulletin 2026/20

(51) International Patent Classification (IPC):
H01F 41/06 (2016.01)

(21) Application number: **24899334.7**

(52) Cooperative Patent Classification (CPC):
H01F 41/06

(22) Date of filing: **20.08.2024**

(86) International application number:
PCT/CN2024/113231

(87) International publication number:
WO 2025/118686 (12.06.2025 Gazette 2025/24)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
GE KH MA MD TN

(72) Inventors:
• **WANG, Shaojian**
Jinhua, Zhejiang 321109 (CN)
• **SONG, Bo**
Jinhua, Zhejiang 321109 (CN)
• **PAN, Lu**
Jinhua, Zhejiang 321109 (CN)
• **SU, Zhengjun**
Jinhua, Zhejiang 321109 (CN)

(30) Priority: **05.12.2023 CN 202311653633**
05.12.2023 CN 202311670449
05.12.2023 CN 202311653950

(74) Representative: **advotec.**
Patent- und Rechtsanwaltspartnerschaft mbB
Widenmayerstraße 4
80538 München (DE)

(71) Applicant: **Zhejiang Pangood Power Technology Co., Ltd.**
Jinhua, Zhejiang 321109 (CN)

(54) **COIL WINDING DEVICE AND WINDING METHOD**

(57) The present invention provides a coil winding device and a winding method. The device comprises a bending mechanism, a winding support, and an adjustment mechanism. The bending mechanism is used for bending a wire so as to obtain a coil forming a winding, and a discharge port of the bending mechanism is arranged facing downward. The winding support is used for bearing the winding bent by the bending mechanism, and the winding support comprises a winding plate and a winding fixed base. The adjustment mechanism is used for adjusting the position of the wire in the winding support, and the adjustment mechanism comprises a clamping arm and a clamping member fixed to the clamping arm and used for gripping the winding. The bending mechanism can sequentially bend a wire according to a predetermined path, thereby forming each layer of coil of the winding. Once the bending mechanism has completed winding of a coil, the adjustment mechanism can adjust the position of the wire in the winding support, so that when a coil of the next winding is wound, the previously wound winding does not interfere with same, ensuring the winding quality of each winding while achieving automated winding.

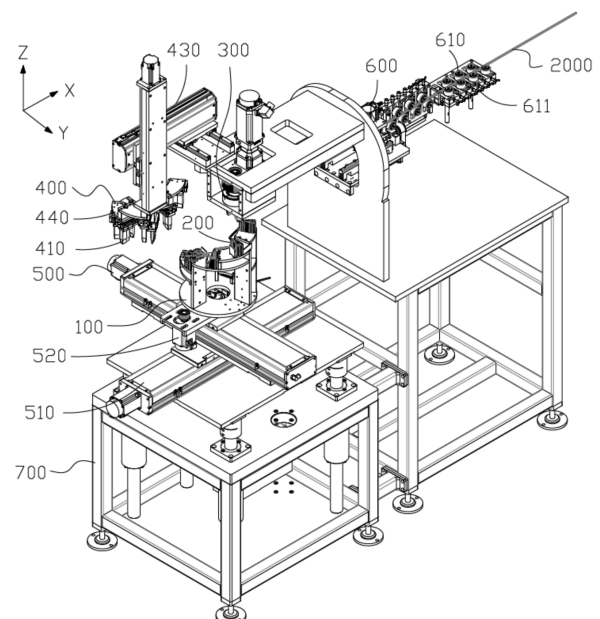


FIG. 1

EP 4 742 286 A1

Description

FIELD

- 5 [0001] The present application relates to the technical field of winding, and in particular, to a coil winding apparatus and a coil winding method.

BACKGROUND

- 10 [0002] CN211830375U provides a winding structure including multiple winding coils arranged in a circumferential direction, where adjacent winding coils are connected by a jumper wire. The winding structure is integrally formed by winding copper wire and requires that each of the winding coils be kept at the same horizontal position so as to fit and be mounted on a stator core of a motor.

- 15 [0003] In order to ensure that each of the winding coils is located at the same horizontal position, a certain length of the copper wire is reserved as a jumper wire after the winding of the previous winding coil is completed, and then the next winding coil is wound at the current horizontal position. Due to the limited space between adjacent winding coils, winding interference is inevitable, which may affect the winding quality of a winding.

SUMMARY

- 20 [0004] Based on this, an object of the present application to provide a coil winding apparatus and a coil winding method for addressing the technical issues mentioned in the above background technology.

- [0005] In one aspect of the present application, a coil winding apparatus is provided, which includes:

- 25 a bending mechanism configured for bending a wire to obtain a coil forming a winding and having a discharge port that faces downwards;

a winding carrier configured for supporting the winding bent by the bending mechanism and including a winding tray and a winding fixing seat; and

- 30 an adjustment mechanism configured for adjusting a position of the wire in the winding carrier and including a clamping arm and a clamping member that is fixed to the clamping arm and configured for gripping the winding.

- 35 [0006] In an embodiment, the coil winding apparatus further includes: a carrier movement assembly for installing the winding carrier and driving the winding carrier to translate and rotate. The carrier movement assembly includes a translation assembly and a rotation assembly, the translation assembly is configured for driving the winding carrier to translate in X, Y and Z directions, and the rotation assembly is configured for driving the winding carrier to rotate around the Z axis.

- 40 [0007] In an embodiment, in the coil winding apparatus, the winding tray is provided with a wire supporting plane, and the overall height of the winding fixing seat is lower than the wire supporting plane.

- [0008] In an embodiment, in the coil winding apparatus, multiple winding fixing seats are provided, horizontal heights of the multiple winding fixing seats decrease stepwise from a first of the winding fixing seats to a last of the winding fixing seats, and the first of the winding fixing seats is adjacent to the winding tray.

- 45 [0009] In an embodiment, in the coil winding apparatus, the winding carrier further includes a baseplate for mounting and fixing the winding tray and the winding fixing seat, and the winding tray and the winding fixing seat are circumferentially arranged around a virtual center line and fixed on the baseplate.

- [0010] In an embodiment, in the coil winding apparatus, the winding tray and multiple fixing seat bottom plates are sequentially arranged from top to bottom and circumferentially arranged around the virtual center line, and spirally arranged in a stepped manner.

- 50 [0011] In an embodiment, in the coil winding apparatus, the winding tray includes a tray horizontal plate. The winding fixing seat includes a fixing seat bottom plate, a circumferential stopper and a radial stopper. The circumferential stopper is arranged on a side surface of the fixing seat bottom plate along a circumferential direction around the virtual center line, and the radial stopper is arranged on an outer side surface of the fixing seat bottom plate along a radial direction about the virtual center line. Any point of the fixing seat bottom plate, the circumferential stopper and the radial stopper is lower than a horizontal height of an upper end plane of the tray horizontal plate.

- 55 [0012] In an embodiment, in the coil winding apparatus, the winding tray further includes a tray vertical plate that supports and connects the tray horizontal plate. The winding fixing seat further includes a fixing vertical plate that supports and connects the fixing seat bottom plate.

[0013] In an embodiment, in the coil winding apparatus, the winding fixing seat is provided with an adjusting hole, and the circumferential stopper is slidable in the adjusting hole.

[0014] In an embodiment, in the coil winding apparatus, the clamping member is configured to be insertable into the coil and capable of performing expansion and contraction actions. The clamping member closely abuts against an inner side of the coil when the clamping member is expanded.

[0015] In an embodiment, in the coil winding apparatus, the adjustment mechanism further includes a clamping member mounting disc. The number of clamping members is more than one. The more than one clamping members are mounted on the clamping member mounting disc. Horizontal heights of bottom surfaces of the clamping members decrease stepwise from a first of the clamping members to a last of the clamping members, so that heights of the clamping members correspond to heights of the winding tray and the winding fixing seat.

[0016] In an embodiment, in the coil winding apparatus, the clamping members are circumferentially arranged and correspond to the circumferential arrangement of the winding tray and multiple windings.

[0017] In an embodiment, in the coil winding apparatus, the translation assembly includes a carrier X-direction moving part, a carrier Y-direction moving part and a carrier Z-direction moving part. The carrier Z-direction moving part is connected to the carrier X-direction moving part and is capable of driving the carrier X-direction moving part to move in the Z-direction, the carrier X-direction moving part is connected to the carrier Y-direction moving part and is capable of driving the carrier Y-direction moving part to move in the X-direction, the carrier Y-direction moving part is connected to the winding carrier and is capable of driving the winding carrier to move in the Y-direction.

[0018] In an embodiment, in the coil winding apparatus, the rotation assembly includes a base, a rotation seat and a rotation motor. The rotation seat is rotatably mounted on the base, the rotation motor drives the rotation seat to rotate, the base is mounted on the translation assembly, and the winding carrier is mounted on the rotation seat.

[0019] In an embodiment, in the coil winding apparatus, the clamping arm includes a clamping X-direction moving part, a clamping Y-direction moving part and a clamping Z-direction moving part. The clamping Y-direction moving part is connected to the clamping X-direction moving part and is capable of driving the clamping X-direction moving part to move in the Y-direction, and the clamping X-direction moving part is connected to the clamping Z-direction moving part and is capable of driving the clamping Z-direction moving part to move in the X-direction, and the clamping Z-direction moving part is connected to the clamping member and is capable of driving the clamping member to move in the Z-direction.

[0020] In an embodiment, the coil winding apparatus further includes: a wire feeding mechanism which is arranged on one side of the bending mechanism and configured for feeding the wire to the bending mechanism.

[0021] In another aspect of the present application, a coil winding method is provided, which includes the following steps:

step 10) for winding a coil: bending a wire through a bending mechanism to obtain the coil;

step 20) for reserving a jumper-wire intermediate body: reserving the jumper-wire intermediate body on one side of the coil that has been wound, through the bending mechanism;

step 30): repeating the steps 10) and 20) to obtain a structure in which multiple coils are connected with each other through the jumper-wire intermediate body; and

step 40) for shaping a jumper wire: deforming the jumper-wire intermediate body such that end faces of two sides of the multiple coils are flush.

[0022] In an embodiment, the coil winding method further includes: step 25) for adjusting positions of the coil and the jumper-wire intermediate body. The positions of the coil and the jumper-wire intermediate body on the winding carrier are adjusted by an adjustment mechanism before repeating the step 10).

[0023] Compared with the conventional technology, the present application has the following beneficial effects.

[0024] The bending mechanism can sequentially bend the wire according to a predetermined trajectory, so as to form each layer of the coil of the winding. After the bending mechanism completes the winding of one coil, the adjustment mechanism can adjust the position of the wire in the winding carrier, so that during the winding of the next coil of the winding, the previously wound winding does not interfere with the process, thus ensuring the winding quality of each winding and realizing automatic winding.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025]

FIG. 1 is a schematic structural diagram of a coil winding apparatus according to the present application;

FIG. 2 is a schematic structural diagram of a winding carrier according to a first embodiment of the present application;

FIG. 3 is a schematic diagram of the winding carrier according to the first embodiment of the present application during winding;

FIG. 4 is a schematic structural diagram of a winding carrier according to a second embodiment of the present application;

FIG. 5 is a schematic diagram of the winding carrier according to the second embodiment of the present application during winding;

FIG. 6 is a schematic diagram showing an assembly of a bending mechanism and an adjustment mechanism according to the present application; and

FIG. 7 is a schematic diagram showing an assembly of a winding carrier and a carrier movement assembly according to the present application.

[0026] Reference signs in the figures are listed as follows:

100	winding carrier,	110	winding tray,
110a	wire supporting plane,	111	tray horizontal plate,
112	tray vertical plate,	121	winding fixing seat,
122	fixing seat bottom plate,	1202	fixing vertical plate,
130	limiting assembly,	131	circumferential stopper,
132	radial stopper,	140	baseplate,
200	winding,	210	coil,
220	jumper wire,	1000	virtual center line,
1300	winding placement area,	300	bending mechanism,
310	bending fixture,	320	bending motor,
400	adjustment mechanism,	410	clamping member,
411	clamping block,	420	air cylinder,
430	clamping arm,	431	clamping X-direction moving part,
432	clamping Y-direction moving part,	433	clamping Z-direction moving part,
440	clamping member mounting disc,	500	carrier movement assembly,
510	translation assembly,	511	carrier X-direction moving part,
512	carrier Y-direction moving part,	513	carrier Z-direction moving part,
520	rotation assembly,	521	base,
522	rotation seat,	523	rotation motor,
600	wire feeding mechanism,	610	roller set,
611	roller,	700	workbench,
710	sheet metal,	720	profile,
730	foot,	1200	adjusting hole,
2000	wire,	221	jumper-wire intermediate body,
211	right leg,	212	right corner,
213	lower base,	214	left corner,
215	left leg		

[0027] The present application is further illustrated by the following specific embodiments combined with the above drawings.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0028] In order to facilitate the understanding of the present application, the present application is described more fully below with reference to the relevant drawings. Several embodiments of the present application are shown in the drawings.

However, the present application can be implemented in many different forms and is not limited to the embodiments described herein. Rather, these embodiments are provided to make the disclosure of the present application more thorough and comprehensive.

[0029] It should be noted that, when an element is referred to as being "fixed to" another element, it may be directly on the another element or there may be an intervening element; when an element is considered to be "connected to" another element, it may be directly connected to the another element or there may be an intervening element. The terms "vertical", "horizontal", "left" and "right" and similar expressions used herein are for illustration purposes only.

[0030] Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by those skilled in the art of the present application. The terms used in the description of the present application is only for the purpose of describing specific embodiments, and is not intended to limit the present application. The term "and/or" as used herein includes any and all combinations of one or more of the associated listed items.

First Embodiment

[0031] Referring to FIGS. 1 and 2, a coil winding apparatus is provided according to a first embodiment of the present application, which includes:

a bending mechanism 300 configured for bending a wire 2000 to obtain a coil 210 constituting a winding 200 and having a discharge port that faces downwards;

a winding carrier 100 configured for supporting the winding 200 bent by the bending mechanism 300 and including a winding tray 110 and a winding fixing seat 121; and

an adjustment mechanism 400 configured for adjusting a position of the wire 2000 in the winding carrier 100 and including a clamping arm 430 and a clamping member 410 that is fixed to the clamping arm 430 and configured for clamping the winding 200.

[0032] The bending mechanism 300 is configured to sequentially bend the wire 2000 according to a predetermined trajectory, so as to form each layer of the coil 210 of the winding 200. After the bending mechanism 300 completes the winding of one coil 210, the adjustment mechanism 400 can adjust the position of the wire 2000 in the winding carrier 100, so that when winding the next coil of the winding 200, the previously wound winding 200 does not interfere with the winding process, ensuring the winding quality of each winding 200 while enabling automated winding.

[0033] Specifically, the coil winding apparatus further includes a carrier movement assembly 500 for mounting the winding carrier 100 and driving the winding carrier 100 to translate and rotate. The carrier movement assembly 500 includes a translation assembly 510 and a rotation assembly 520. The translation assembly 510 can drive the winding carrier 100 to translate in the X, Y, and Z directions, and the rotation assembly 520 can drive the winding carrier 100 to rotate around the Z-axis.

[0034] As shown in FIGS. 2 and 3, the winding tray 110 is provided with a wire supporting plane 110a, and an overall height of the winding fixing seat 121 is lower than a height of the wire supporting plane 110a.

[0035] The winding tray 110 includes a tray horizontal plate 111 and a tray vertical plate 112. The tray vertical plate 112 is configured for supporting a lower surface of the tray horizontal plate 111 to form the wire supporting plane 110a at an upper surface of the tray horizontal plate 111. The overall height of the winding fixing seat 121 is lower than the wire supporting plane 110a. Therefore, when the bending mechanism 300 is bending the wire 2000 to form the coil 210, the coil 210 formed by bending can be directly supported on the wire supporting plane 110a without being affected by the winding fixing seat 121 and the like, thereby improving the winding quality of the winding 200.

[0036] In a preferred embodiment, the tray horizontal plate 111 of the winding tray 110 is unobstructed circumferentially, so as to prevent any obstruction from affecting the winding that is being wound and supported by the tray horizontal plate 111, which further improves the winding quality of the winding 200.

[0037] As shown in FIG. 2 and FIG. 3, there are multiple winding fixing seats 121, and horizontal heights of the multiple winding fixing seats 121 decreases stepwise from a first of the multiple winding fixing seats 121 to a last of the multiple winding fixing seats 121, and the first of the multiple winding fixing seats 121 is adjacent to the winding tray 110. The winding tray 110 and the first to the last of the winding fixing seats may be sequentially connected end-to-end and arranged in an annular shape, which makes the structure compact and improves the stability of the structure.

[0038] Further, the winding carrier 100 further includes a baseplate 140 for mounting and fixing the winding tray 110 and the winding fixing seats 121. The winding tray 110 and the winding fixing seats 121 are circumferentially arranged about a virtual center line 1000 and fixed on the baseplate 140. Specifically, the baseplate 140 may be annular, and the virtual center line 1000 may be located at a center line of the baseplate 140. That is, the multiple winding fixing seats 121 are arranged along a circumferential direction around the center line of the baseplate 140 to arrange multiple coils 210 of the

winding 200 that are arranged along the circumferential direction.

[0039] Referring specifically to FIG. 3, the winding 200 includes multiple coils 210 and a jumper wire 220 connected between two adjacent coils 210 of the multiple coils 210, and the multiple coils 210 are circumferentially arranged. The winding tray 110 is configured for supporting a coil 210 of the winding 200 that is being wound, and the multiple winding

fixing seats 121 are configured for arranging the coils 210 of the winding 200 that have been wound, and each of the winding fixing seats 121 may correspond to one of the coils 210.

[0040] Furthermore, the winding tray 110 and multiple fixing seat bottom plates 122 of the winding fixing seats 121 are sequentially arranged from top to bottom and circumferentially arranged around the virtual center line 1000, and spirally arranged in a stepped manner.

[0041] In the winding carrier 100, a horizontal height of the tray horizontal plate 111 of the winding tray 110 is the highest, so as to support the coil 210 being wound on the tray horizontal plate 111. The horizontal heights of the fixing seat bottom plates 122 of the multiple winding fixing seats 121 successively decreases along the circumferential direction about the virtual center line 1000, so as to arrange the coils 210 of the winding 200 that have been wound.

[0042] The multiple winding fixing seats 121 are respectively the first to Nth of the winding fixing seats, and the horizontal heights of the first to Nth of the winding fixing seats decreases successively along the circumferential direction about the virtual center line 1000. The winding tray 110 and the first to Nth of the winding fixing seats may be sequentially connected end to end in an annular arrangement, so that the structure is compact and the stability of the structure is improved.

[0043] The horizontal height of the first of the winding fixing seats is lower than that of the tray horizontal plate 111 of the winding tray 110, and a height difference between them is not less than a height of the coil 210. Due to the height difference between the first of the winding fixing seats 121 and the tray horizontal plate 111, the horizontal heights of the coils 210 of the winding 200 that have been wound decreases successively, so as to be placed on the fixing seat bottom plates 122 of the first to Nth of the winding fixing seats with the horizontal heights decreasing successively.

[0044] As shown in FIG. 2, the winding fixing seat 121 includes the fixing seat bottom plate 122 and a fixing vertical plate 1202. The coil 122 that has been wound is supported on an upper surface of the fixing seat bottom plate 122, and the fixing vertical plate 1202 may support and connect a lower surface of the fixing seat bottom plate 122. The fixing seat bottom plate 122 may be directly fixed to the baseplate 140 or fixed to the fixing seat bottom plate 1222 of the next winding fixing seat 121.

[0045] As shown in FIG. 2 and FIG. 3, the fixing seat bottom plate 122 of the winding fixing seat 121 is provided with a limiting assembly 130 for positioning the coil 210, which prevents the coil 210 that has been wound and arranged on the winding fixing seat 121 from interfering with the coil 210 that is being wound and supported by the winding tray 110, and also prevents the coil 210 from disengaging from the winding carrier 100 due to centrifugal force caused by the rotation of the winding carrier 100.

[0046] Specifically, the limiting assembly 130 includes a circumferential stopper 131 and a radial stopper 132. The circumferential stopper 131 is arranged on a side surface of the fixing seat bottom plate 122 along the circumferential direction about the virtual center line 1000, and the radial stopper 132 is arranged on an outer side surface of the fixing seat bottom plate 122 along a radial direction about the virtual center line 1000.

[0047] Any point of the fixing seat bottom plate 122, the circumferential stopper 131 and the radial stopper 132 is lower than a horizontal height of an upper end plane of the tray horizontal plate 111.

[0048] The winding tray 110 is configured for supporting the winding 200 being wound, and the winding fixing seat 121 is configured for fixing the winding 200 that has been wound. The winding fixing seat 121 includes the fixing seat bottom plate 122, the circumferential stopper 131 and the radial stopper 132, which improves the stability of fixation to the winding 200 that has been wound. Moreover, any point of the fixing seat bottom plate 122, the circumferential stopper 131 and the radial stopper 132 is lower than the horizontal height of the upper end plane of the tray horizontal plate 111, thus not affecting winding of the winding 200 on the winding tray 110, thereby improving the winding quality of the winding 200.

[0049] As shown in FIG. 2, the winding fixing seat 121 is provided with an adjusting hole 1200, and the circumferential stopper 131 is slidable in the adjusting hole 1200.

[0050] The adjusting holes 1200 is arranged along the circumferential direction, so that the position of the circumferential stopper 131 is adjustable in the circumferential direction, thereby adjusting an accommodating space for the coil 210. A screw may pass through the adjusting hole 1200 to connect the circumferential stopper 131, so that the circumferential stopper 131 is slidable in the adjusting hole 1200, and the position of the circumferential stopper 131 can be fixed by tightening the screw.

[0051] Referring to FIG. 2, a top side surface of the circumferential stopper 131 facing the coil 210 is a chamfered surface to facilitate the passage and insertion of a transfer mechanism into the coil 210, as well as to facilitate the movement of the coil 210. A top side surface of the radial stopper 132 facing the coil 210 may also be a chamfered surface.

[0052] As shown in FIG. 2, the winding tray 110 and the multiple fixing seat bottom plates 122 are sequentially arranged from top to bottom and circumferentially arranged around the virtual center line 1000, and spirally arranged in a stepped manner. A last of the fixing seat bottom plates 122 may be integrally connected with the baseplate 140, and the circumferential stopper 131 and the radial stopper 132 are arranged on the last of the fixing seat bottom plates 122.

[0053] Referring to FIG. 6, the bending mechanism 300 includes a bending motor 320 and a bending fixture 310. The bending motor 320 is in transmission connection with the bending fixture 310 through a gear and the like, and the bending motor 320 drives the bending fixture 310 to rotate. The shape of the bending fixture 310 defines the shape of the coil 210. The coil 210 may be trapezoidal or fan-shaped. The wire 2000 is conveyed to the bending fixture 310 of the bending mechanism 300 by a wire feeding mechanism 600, and the winding carrier 100 is driven to move by the translation assembly 510, so that the bending fixture 310 is located directly above the winding tray 110 of the winding carrier 100. Then, the bending motor 320 drives the bending fixture 310 to rotate once, that is, the bending fixture 310 performs one bending operation on the wire 2000 to form a first layer of the coil 210. Subsequently, a carrier Z-direction moving part 513 of the carrier movement assembly 510 drives the winding carrier 100 to move downwards. The discharge port of the bending mechanism 300 faces downwards, so that the first layer of the coil 210 falls onto the winding tray 110 under the action of gravity. This cycle is repeated to form second to final layers of the coil 210. In this way, the coil 210 is wound from bottom to top.

[0054] Referring to FIG. 1, further, a tail end of the wire 2000 is located at the wire feeding mechanism 600, and a head end of the wire 2000 may be clamped by a robotic arm or the like. The robotic arm and the wire feeding mechanism 600 are located on two sides of the bending fixture 310, and the wire 2000 is located on one side of the bending fixture 310. The bending fixture 310 rotates once to bend the wire 2000 to wind one layer of the coil 210. Then, the robotic arm releases the wire 2000, and the carrier Z-direction moving part 513 of the carrier movement assembly 510 drives the winding carrier 100 to move downwards, so that the first layer of the coil 210 that has been wound falls onto the winding tray 110 under the action of gravity. Subsequently, the position of the bending fixture 310 remains unchanged to wind the second layer of the coil 210, and then the carrier Z-direction moving part 513 of the carrier movement assembly 510 drives the winding carrier 100 to move downwards again until the winding of the coil 210 is completed.

[0055] As shown in FIG. 1, the wire feeding mechanism 600 includes at least one roller set 610, and the roller set 610 includes multiple rollers 611 which are arranged on two sides of the wire 2000. The rollers 611 on the two sides of the wire 2000 may be staggered. By arranging the rollers 611, the conveying stability of the wire 2000 is improved, and the feeding direction of the wire 2000 is limited. For example, the wire 2000 is transported to a side of the bending fixture 310 along the X-axis direction.

[0056] In a case that there are two roller sets 610, the two roller sets 610 are arranged perpendicular to each other, for example, rollers 611 of one of the two roller sets 610 are perpendicular to rollers 611 of the other of the two roller sets 610.

[0057] As shown in FIG. 1 and FIG. 6, the adjustment mechanism 400 includes at least one clamping member 410 which is configured to be inserted into the coil 210 and perform expansion and contraction actions. When the clamping member 410 is expanded, the clamping member 410 closely abuts against an inner side of the coil 210.

[0058] The shape of the clamping member 410 is adapted to the shape of the coil 210 and can be inserted into the coil 210. A chamfered surface may be formed at the bottom of the clamping member 410 to facilitate the insertion of the clamping member 410 into the coil 210 and the withdrawal of the clamping member 410 from the interior of the coil 210.

[0059] The clamping member 410 includes two clamping blocks 411. One of the two clamping blocks 411 is driven by an air cylinder 420. When the air cylinder moves one of the two clamping blocks 411 away from the other, the clamping member 410 performs the expansion action. When the air cylinder moves one of the two clamping blocks 411 toward the other, the clamping member 410 performs the contraction action.

[0060] Therefore, when the clamping member 410 is inserted into the coil 210 and performs the expansion action to tightly abut against the inner side of the coil 210, the coil 210 can be moved to prevent the coil 210 from falling off during the movement. When the clamping member 410 is inserted into the coil 210 and performs the contraction action to release tight abutment between the clamping member 410 and the inner side of the coil 210, the clamping member 410 can be detached from the coil 210.

[0061] Referring to FIG. 6, the clamping member 410 moves the coil 210 on the winding tray 110 to the first of the winding fixing seats 121, and moves the coil 210 on a current winding fixing seat 121 to the next winding fixing seat 121.

[0062] As shown in FIG. 6, the adjustment mechanism 400 further includes a clamping member mounting disc 440. Multiple clamping members 410 are mounted on the clamping member mounting disc 440. Horizontal heights of bottom surfaces of the multiple clamping members 410 decrease stepwise from the first of the clamping members to the last of the clamping members, so that heights of the clamping members 410 correspond to the heights of the winding tray 110 and the winding fixing seat 121.

[0063] The arrangement of the clamping members 410 is influenced by the arrangement of the winding tray 110 and the winding fixing seat 121. The multiple clamping members 410 are circumferentially arranged and correspond to the circumferential arrangement of the winding tray 110 and the multiple windings 200. That is, the horizontal heights of the bottom surfaces of the clamping members 410 decrease stepwise from the first to the last of the clamping members.

[0064] As shown in FIG. 1, FIG. 6 and FIG. 7, the translation assembly 510 includes a carrier X-direction moving part 511, a carrier Y-direction moving part 512 and a carrier Z-direction moving part 513.

[0065] The carrier Z-direction moving part 513 is connected to the carrier X-direction moving part 511 and can drive the carrier X-direction moving part 511 to move in the Z direction. The carrier X-direction moving part 511 is connected to the

carrier Y-direction moving part 512 and can drive the carrier Y-direction moving part 512 to move in the X direction. The carrier Y-direction moving part 512 is connected to the winding carrier 100 and can drive the winding carrier 100 to move in the Y direction. The carrier X-direction moving part 511, the carrier Y-direction moving part 512 and the carrier Z-direction moving part 513 may have the same shape, for example, each of them includes a motor, a lead screw, a guide rail and so on. The carrier Z-direction moving part 513 may be raised and lowered by hydraulic pressure. In addition, positions of the carrier X-direction moving part 511, the carrier Y-direction moving part 512 and the carrier Z-direction moving part 513 may be interchangeable, for example, the carrier Z-direction moving part 513 is arranged between the winding carrier 100 and the carrier Y-direction moving part 512.

[0066] As shown in FIG. 7, the rotation assembly 520 includes a base 521, a rotation seat 522 and a rotation motor 523. The rotation seat 522 is rotatably mounted on the base 521, and the rotation motor 523 drives the rotation seat 522 to rotate. The base 521 is mounted on the translation assembly 510, and the winding carrier 100 is mounted on the rotation seat 522.

[0067] The rotation motor 523 may be connected to the rotation seat 522 through a pulley, a gear and the like, so that the rotation motor 523 drives the winding carrier 100 connected to the rotation seat 522 to rotate. The rotation assembly 520 drives the winding carrier 100 to rotate eccentrically relative to the virtual center line 1000, or the rotation assembly 520 drives the winding carrier 100 to rotate around the virtual center line 1000, which may be determined according to design requirements.

[0068] Referring to FIG. 1 and FIG. 7, the coil winding apparatus further includes a workbench 700. The carrier movement assembly 510 and the bending mechanism 300 may be fixed to the workbench 700. The workbench 700 may be constructed by sheet metal 710, profiles 720, foot bases 730, etc. The number of the workbenches 700 may be two, and the horizontal heights of the two workbenches 700 may be different. The carrier movement assembly 510 is fixed on one of the workbenches 700 with a lower horizontal height, and the bending mechanism 300 may be fixed on the other of the workbenches 700 with a higher horizontal height, so that the bending mechanism 300 connected to the carrier movement assembly 510 is located above the winding carrier 100.

[0069] As shown in FIG. 1 and FIG. 6, the clamping arm 430 includes a clamping X-direction moving part 431, a clamping Y-direction moving part 432 and a clamping Z-direction moving part 433.

[0070] The clamping Y-direction moving part 432 is connected to the clamping X-direction moving part 431 and can drive the clamping X-direction moving part 431 to move in the Y-direction. The clamping X-direction moving part 431 is connected to the clamping Z-direction moving part 433 and can drive the clamping Z-direction moving part 433 to move in the X-direction. The clamping Z-direction moving part 433 is connected to the clamping member 410 and can drive the clamping member 410 to move in the Z-direction. The clamping X-direction moving part 431, the clamping Y-direction moving part 432 and the clamping Z-direction moving part 433 may have the same shape, for example, each of them includes a motor, a lead screw, a guide rail and the like, and positions of the three may be interchangeable. Referring to FIG. 6, the clamping Y-direction moving part 432 is fixed to the bending mechanism 300, so that the adjustment mechanism 400 connected to the clamping movement assembly 520 can be kept above the winding carrier 100.

[0071] To sum up, the bending mechanism 300 can sequentially wind the wire 2000 to form the coils 210 of the winding 200, and reserve a jumper wire 220 between two adjacent coils 210. The wire 2000 may be a flat copper wire, a round copper wire or the like, preferably a flat copper wire. After the bending mechanism 300 has wound one coil 210 and the wound coil 210 is supported by the winding tray 110 of the winding carrier 100, the carrier movement assembly 500 drives the winding carrier 100 to move, and the clamping arm 430 drives the clamping member 410 to move, so that the clamping member 410 moves the wound coil 210 on the winding tray 110 to the winding fixing seat 121, thereby enabling the bending mechanism 300 to wind the next coil 210 of the winding 200 on the winding tray 110. Moreover, the coil fixed on the winding fixing seat 121 does not affect the winding of the next coil 210 on the winding tray 110, thus ensuring the winding quality of the winding 200 and realizing automatic winding.

Second Embodiment

[0072] As shown in FIGS. 4 and 5, a winding carrier according to a second embodiment differs from the winding carrier according to the first embodiment in that: the winding carrier further includes a winding placement area 1300 for placing a winding 200 that has been wound, and at least one winding fixing seat 121 is adjacent to the winding tray 110.

[0073] The number of the winding fixing seat 121 may be one. The winding tray 110 is located on one side of the winding fixing seat 121 along a circumferential direction around the virtual center line 1000, and the winding tray 110 is adjacent to the winding fixing seat 121. The winding placement area 1300 is located on the other side of the winding fixing seat 121 along the circumferential direction around the virtual center line 1000. Only a coil 210 adjacent to the winding machine is fixed by the winding fixing seat 121, while the remaining coils 210 are freely arranged on the winding placement area 1300, as shown in FIG. 4. The winding fixing seat 121 fixes the coil 210, preventing the coil 210 from affecting the winding of the winding 200 on the winding tray 110, and further preventing the freely placed and swinging coil from affecting the winding quality.

Third Embodiment

[0074] As shown in FIG. 1 to FIG. 3, a coil winding method according to a third embodiment of the present application includes the following steps 10) to 40).

[0075] In step 10) for winding a coil 210, a wire 2000 is bent by a bending mechanism 300 to obtain the coil 210.

[0076] In step 20) for reserving a jumper-wire intermediate body 221, the jumper-wire intermediate body 221 is reserved on one side of the wound coil 210 by the bending mechanism 300.

[0077] In step 30), the above steps 10) and 20) are repeated to obtain a structure in which multiple coils 210 are connected to each other through the jumper-wire intermediate body 221.

[0078] In step 40) for shaping a jumper wire 220, the jumper-wire intermediate body 221 is deformed such that two side end faces of the multiple coils 210 are flush.

[0079] The winding 200 includes the coils 210 and the jumper wire 220 including multiple jumper-wire intermediate bodies 221. The jumper-wire intermediate body 221 is connected between two adjacent coils 210. From the steps 10) to 30), it can be seen that the winding 200 is continuously and integrally wound and formed by automatic winding. In the step 40), the jumper wire 220 is shaped such that the two side end faces of the coils 210 of the winding 200 are flush, thus meeting assembly requirements for a stator of an axial flux motor, that is, each coil 210 is sleeved on one tooth block of the stator.

[0080] Referring to FIG. 3, the coil 210 has a spiral shape and is divided into multiple layers or multiple turns from a lower side end face to an upper side end face thereof. Each layer of the coil 210 has the same shape, and is trapezoidal, fan-shaped or the like. The trapezoidal or fan shape has four corners, so the bending mechanism 300 needs to bend the wire 2000 four times to complete the winding of each layer of the coil 210, and a bending angle is determined by the shape and size of each layer of the coil 210.

[0081] As shown in FIG. 1, the bending mechanism 300 bends the wire 2000 to obtain the coil 210. The wire 2000 may be a flat copper wire, a round copper wire or the like, preferably a flat copper wire. The coil 210 is wound from bottom to top, and a discharge port of the bending mechanism 300 faces downward. Thus, in the step 10), the bottom of the coil 210 is formed first, and the coil 210 is formed by spiraling upward sequentially from the bottom to the top of the coil 210. The coil 210 is discharged vertically downward, and is supported by the winding tray 110 of the winding carrier 100 located below the bending mechanism 300.

[0082] Referring to FIG. 1, the wire 2000 is conveyed to the bending mechanism 300 by the wire feeding mechanism 600. Since each layer of the coil 210 is trapezoidal with four sides and four corners, the wire feeding mechanism 600 continuously feeds the wire 2000 for four times at intervals during the winding process of each layer of the coil 210, corresponding respectively to the four sides of the trapezoid of each layer of the coil 210. During the intervals between the four wire feeding processes of the wire feeding mechanism 600, the bending mechanism 300 bends the wire 2000 to form the four corners of the trapezoid. That is, each time the wire feeding mechanism 600 feeds the wire 2000 once, the bending mechanism 300 immediately bends the wire 2000 once. This process is repeated until the winding of each layer of the coil 210 is completed.

[0083] During the winding of each layer of the coil 210, parameters such as a feeding length of the wire feeding mechanism 600 and the bending angle of the bending mechanism 300, are determined based on the shape and size of each layer of the coil 210.

[0084] Referring to FIGS. 1 to 3, in the step 10), the winding tray 110 of the winding carrier 100 supports the coil 210 that is being wound. The lower side end face of the coil 210 abuts against the winding tray 110.

[0085] It should be noted that, before winding each layer of the coil 210, the winding carrier 100 is moved downwards by a distance required for winding each layer of the coil 210, and the distance required for winding each layer of the coil 210 is a height of each layer of the coil 210, so that the next layer of the coil 210 can be wound on the layer of the coil 210 that has been wound, and the coil 210 can always be supported by the winding tray 110 during the winding process. It can be seen that the coil 210 is wound from bottom to top.

[0086] Referring to FIGS. 1 and 7, the winding carrier 100 is mounted on the carrier movement assembly 500, and the carrier movement assembly 500 drives the winding carrier 100 to move along the vertical, left-right, and front-back directions and rotate about the vertical axis, so that the winding carrier 100 moves relative to the bending mechanism 300 along the vertical, left-right, and front-back directions and rotates about the vertical direction, so as to facilitate the execution of the step 10).

[0087] Taking the trapezoidal coil 210 as an example, referring to FIG. 3, a right corner 212 is formed between a lower base 213 and a right leg 211 of each layer of the coil 210, and a left corner 214 is formed between the lower base 213 and a left leg 215. While the bending mechanism 300 bends the wire 2000 to form the right corner 212, the carrier movement assembly 500 drives the winding carrier 100 to rotate, so that the wire 2000 subsequently fed by the wire feeding mechanism 600 can correspond to the direction of the lower base 213. Then, the wire feeding mechanism 600 feeds the wire 2000 with a required length for the lower base 213, while the carrier movement assembly 500 drives the winding carrier 100 to move in the horizontal direction, so that the wire 2000 fed by the wire feeding mechanism 600 falls onto the

position where the lower base 213 is formed, until the bending mechanism 300 performs the bending for forming the left corner 214.

[0088] As can be seen from the above, the wire feeding movement of the wire feeding mechanism 600 and the movement of the winding carrier 100 are synchronous, and the rotation of the winding carrier 100 and the bending movement of the bending mechanism 300 are also synchronous, so that the wire feeding and the wound coil 210 follow the bending movement to complete the winding of the winding 200. Compared with manual lifting or hand-carrying in the conventional technology, the present application avoids drawbacks such as the inability to ensure synchronized movements, failure to ensure the correct shape of the coil 210, even deformation of the coil 210 that has been wound, high operational intensity, and susceptibility to fatigue. The winding carrier 100 is driven to move and rotate by the carrier movement assembly 500, so that the wound coil 210 can synchronously follow the wire feeding movement of the wire feeding mechanism 600 and the bending movement of the bending mechanism 300, thus ensuring the quality consistency of the winding 200 and production efficiency.

[0089] In the step 20), the wire feeding mechanism 600 feeds the wire 2000 with a required length for the jumper-wire intermediate body 221. In this process, the bending mechanism 300 does not perform bending, but the winding carrier 100 can be driven to move by the carrier movement assembly 500 and be opposite to the adjustment mechanism 400, so that in the step 25), the adjustment mechanism 400 moves the coil 210 that has been wound and is arranged on the winding tray 110 to the winding fixing seat 121 of the winding carrier 100, thereby freeing up space on the winding tray 110 for winding the next coil 210.

[0090] As shown in FIGS. 1 to 3, the winding method further includes: step 25) for adjusting positions of the coil 210 and the jumper-wire intermediate body 221. In the step 25), the positions of the coil 210 and the jumper-wire intermediate body 221 on the winding carrier 100 are adjusted by the adjustment mechanism 400 before repeating the step 10).

[0091] Furthermore, the winding carrier 100 moves and rotates under the drive of the carrier movement assembly 500, so the wound coil 210 is subjected to centrifugal force and inertial force during the continuous movement of the winding carrier 100. The wound coil 210 is moved downwards and fixed to the winding fixing seat 121 to ensure that the wound coil 210 is not moved under these forces, for example, without being thrown, thus avoiding the deformation of the winding 200 and further ensuring the quality of the winding 200.

[0092] As shown in FIG. 1 to FIG. 3, the horizontal heights of the winding tray 110 and the winding fixing seat 121 decrease in a stepped manner, the winding 200 on the winding carrier 100 may be driven to move by the adjustment mechanism 400, and the adjustment mechanism 400 may be a clamping member. Further, the step 25) includes the following steps 251) and 252).

[0093] In step 251), the winding 200 on the winding carrier 100 is clamped by the adjustment mechanism 400.

[0094] In step 252), the entire winding 200 clamped by the adjustment mechanism 400 is lowered by one step, thereby moving and fixing the coil 210 that has been wound and is arranged on the winding tray 110 to the winding fixing seat 121 of the winding carrier 100, and the coil 210 previously fixed to the winding fixing seat 121 is moved out of the winding fixing seat 121 and moved to the next winding fixing seat 121 or another location.

[0095] Referring to FIGS. 4 and 5, another location refers to a winding placement area 1300. The number of the winding fixing seat 121 may be one. The winding tray 110 is located on one side of the winding fixing seat 121 along the circumferential direction around the virtual center line 1000, and the winding tray 110 is adjacent to the winding fixing seat 121. The winding placement area 1300 is located on the other side of the winding fixing seat 121 along the circumferential direction around the virtual center line 1000. Only the coil 210 adjacent to the winding machine is fixed by the winding fixing seat 121, and the remaining coils 210 are freely placed on the winding placement area 1300, as shown in FIG. 5. The winding fixing seat 121 fixes the coil 210 to prevent the coil 210 from affecting the winding of the winding 200 on the winding tray 110 and also prevent the freely placed and swinging coils from affecting the winding quality.

[0096] In the step 251), the adjustment mechanism 400 includes a clamping arm 430 and a clamping member 410 fixed to the clamping arm 430 for clamping the winding. The clamping arm 430 is configured for driving the clamping member 410 to translate in the X, Y, and Z directions, and the winding carrier 100 is driven by the translation assembly 510 of the carrier movement assembly 500 and translates in the X, Y, and Z directions, so that the adjustment mechanism 400 can correspond to the winding carrier 100.

[0097] As shown in FIGS. 1 and 6, the adjustment mechanism 400 includes multiple clamping members 410, and horizontal heights of bottom surfaces of the multiple clamping members 410 decrease stepwise from a first to a last of the clamping members 410. Therefore, the step 251) includes:

causing the multiple clamping members 410 arranged in a stepped manner to correspond to the winding tray 110 and the winding fixing seat 121 arranged in a stepped manner, where the first of the clamping members 410 corresponds to the winding tray 110; and

clamping, by the multiple clamping members 410, the coils 210 on the winding tray 110 and the winding fixing seat 121 corresponding to the multiple clamping members 410.

[0098] The clamping members 410 are driven to move by the clamping arm 430, and the winding carrier 100 consisting of the winding tray 110 and the winding fixing seat 121 is driven to move by the translation assembly 510. The multiple clamping members 410 arranged in a stepped manner correspond to the winding tray 110 and the winding fixing seat 121 that are arranged in a stepped manner, that is, the first of the clamping members 410 corresponds to the winding tray 110, and the second of the clamping members 410 corresponds to the first of the winding fixing seat 121. In this case, the first of the clamping members 410 clamps the coil 210 on the winding tray 110, the second of the clamping members 410 clamps the coil on the first of the winding fixing seat 121, and so on.

[0099] Referring to FIG. 5, the two clamping blocks 411 are driven by an air cylinder 420 to move toward or away from each other. Therefore, in the step 251), the two clamping blocks 411 that are close to each other are inserted into the coil 210; and the air cylinder 420 drives the two clamping blocks 411 to move away from each other, so that the clamping member 410 tightly abuts against an inner side of the coil 210, thereby performing the clamping operation on the coil 210 by the clamping member 410.

[0100] As shown in FIGS. 1 and 7, the step 252) includes:

moving the winding carrier 100 downwards along the Z-direction, so that the winding carrier 100 is disengaged from the winding 200 clamped by the adjustment mechanism 400 in a height direction;

moving the winding carrier 100 in the X and Y directions and rotating the winding carrier 100 around the Z direction, so that the multiple the clamping members 410 are staggered by one step from the winding tray 110 and the winding fixing seat 121 that are arranged in a stepped manner, where the first of the clamping members 410 is opposite to the winding fixing seat 121; and

releasing the winding 200 clamped by the clamping members 410 onto the winding tray 110 and the winding fixing seat 121.

[0101] The horizontal heights of the first to the last of the clamping members 410 decrease in a counterclockwise direction when viewed from below, and the horizontal heights of the winding tray 110 and the winding fixing seat 121 decrease in a clockwise direction when viewed from above. The winding carrier 100 can be rotated in the counterclockwise direction by a circumferential angle corresponding to one step, so that the multiple the clamping members 410 are staggered by one step from the winding tray 110 and the winding fixing seat 121 that are arranged in a stepped manner. Moreover, the first of the clamping members 410, which was originally opposite to the winding tray 110, becomes opposite to the first of the winding fixing seats 121, and the second of the clamping members 410 becomes opposite to the second of the winding fixing seats 121.

[0102] As shown in FIGS. 2 and 3, the winding fixing seat 121 includes a fixing seat bottom plate 122, and a circumferential stopper 131 and a radial stopper 132 that are arranged on the fixing seat bottom plate 122. In the step 252), the coil 210 is placed on the fixing seat bottom plate 122 and confined between the circumferential stopper 131 and the radial stopper 132.

[0103] The circumferential stopper 131 and the radial stopper 132 are provided for positioning the coil 210, preventing the coil 210 that has been wound and is arranged on the winding fixing seat 121 from interfering with the coil 210 that is being wound and supported by the winding tray 110, and further preventing the coil 210 from being detached from the winding carrier 100 due to centrifugal force caused by the rotation of the winding carrier 100.

[0104] As shown in FIGS. 2 and 3, the circumferential stopper 131 is fixed on one side of the winding fixing seat 121 along the circumferential direction around the virtual center line 1000, and the tray vertical plate 112 or the fixing vertical plate 1202 is fixed on the other side of the winding fixing seat 121 along the circumferential direction around the virtual center line. Therefore, the coil 210 on the first winding fixing seat is circumferentially limited between the circumferential stopper 131 on the first winding fixing seat and the tray vertical plate 112 of the winding tray 110, and the coil 210 on each of the second to the last winding fixing seats is circumferentially limited between the circumferential stopper 131 on the current winding fixing seat and the fixing vertical plate 1202 of the previous winding fixing seat.

[0105] Referring to FIG. 6, during the process in which the clamping members 410 release the winding onto the winding tray 110 and the winding fixing seat 121, the air cylinder 420 drives the two clamping blocks 411 to approach each other, thereby releasing the tight contact between the clamping member 410 and the inner side of the coil. In this case, the clamping Z-direction moving part 433 of the clamping arm 430 drives the clamping member 410 to move upward, thereby releasing the winding 200.

[0106] After that, the clamping member 410 and the winding carrier 100 are reset to perform the winding of the next coil 210 of the winding 200.

[0107] Referring to FIG. 3, in the step 20), the jumper-wire intermediate body 221 is reserved at the top of the coil 210 that has been wound. In the step 10), the coil 210 is bent and formed above the formed jumper-wire intermediate body 221.

[0108] In the step 20), the coil 210 that has been wound and the jumper-wire intermediate body 221 are supported by the

winding carrier 100. Referring to FIG. 3, taking the coil 210 on the winding tray 110 as an example, the jumper-wire intermediate body 221 connected to the bottom of the coil 210 is directly supported by the winding tray 110.

[0109] In the step 30), the multiple coils 210 are staggered from each other in a stepped manner in the vertical and horizontal directions. The coils 210 of the winding 200 are circumferentially arranged and spaced apart from each other, and the horizontal heights of the coils 210 decrease in a stepped manner. Further, in the step 40), the jumper-wire intermediate body 221 is deformed so that end faces of two sides of the coils are flush. In this case, the jumper wire 220 are obliquely arranged, that is, the jumper wire 220 is connected to an upper end of one of two adjacent coils 210 and a lower end of the other of the two adjacent coils 210. Depending on the winding direction, the jumper wire 220 may be located on a radial inner side or a radial outer side of the coil 210.

[0110] The winding method further includes: step 5) for reserving a lead-out terminal intermediate body. In the step 10), the coil 210 is wound at an upper end of the lead-out terminal intermediate body or the jumper-wire intermediate body 221.

[0111] In the description of the specification, descriptions of the terms "one embodiment", "some embodiments", "example", "specific example" or "some examples" mean that a specific feature, structure, material or characteristic described in connection with the embodiment or example is included in at least one embodiment or example of the present application. In this specification, the schematic expressions of the above terms do not necessarily refer to the same embodiment or example. Moreover, the specific feature, structure, material or characteristic described may be combined in a suitable manner in any one or more embodiments or examples.

[0112] The above embodiments merely illustrate several implementations of the present application, and their descriptions are relatively specific and detailed, but they should not be construed as limiting the scope of the present application. It should be pointed out that those skilled in the art can make several variations and improvements without departing from the concept of the present application, and these variations and improvements all fall within the protection scope of the present application. Therefore, the protection scope of the present application should be determined by the appended claims.

Claims

1. A coil winding apparatus, **characterized by** comprising:

a bending mechanism (300) configured for bending a wire (2000) to obtain a coil (210) forming a winding (200) and having a discharge port that faces downwards;
a winding carrier (100) configured for supporting the winding (200) bent by the bending mechanism (300) and comprising a winding tray (110) and a winding fixing seat (121); and
an adjustment mechanism (400) configured for adjusting a position of the wire (2000) in the winding carrier (100) and comprising a clamping arm (430) and a clamping member (410) that is fixed to the clamping arm (430) and configured for gripping the winding (200).

2. The coil winding apparatus according to claim 1, further comprising:

a carrier movement assembly (500) for installing the winding carrier (100) and driving the winding carrier (100) to translate and rotate, wherein the carrier movement assembly (500) comprises a translation assembly (510) and a rotation assembly (520), the translation assembly (510) is configured for driving the winding carrier (100) to move in X, Y, and Z directions, and the rotation assembly (520) is configured for driving the winding carrier (100) to rotate about the Z-axis.

3. The coil winding apparatus according to claim 1, wherein the winding tray (110) is provided with a wire supporting plane (110a), and the overall height of the winding fixing seat (121) is lower than the wire supporting plane (110a).

4. The coil winding apparatus according to claim 1, wherein the number of winding fixing seats (121) is more than one, and horizontal heights of the more than one winding fixing seats (121) decrease stepwise from a first of the winding fixing seats (121) to a last of the winding fixing seats (121), and the first of the winding fixing seats (121) is adjacent to the winding tray (110).

5. The coil winding apparatus according to claim 1 or claim 4, wherein the winding carrier (100) further comprises a baseplate (140) for mounting and fixing the winding tray (110) and the winding fixing seat (121), and the winding tray (110) and the winding fixing seat (121) are circumferentially arranged around a virtual center line (1000) and are fixed on the baseplate (140).

6. The coil winding apparatus according to claim 5, wherein the winding tray (110) and a plurality of fixing seat bottom

plates (122) are sequentially arranged from top to bottom and circumferentially arranged around the virtual center line (1000), and spirally arranged in a stepped manner.

7. The coil winding apparatus according to claim 5, wherein

the winding tray (110) comprises a tray horizontal plate (111);
the winding fixing seat (121) comprises a fixing seat bottom plate (122), a circumferential stopper (131) and a radial stopper (132);
the circumferential stopper (131) is arranged on a side surface of the fixing seat bottom plate (122) along a circumferential direction around the virtual center line (1000), and the radial stopper (132) is arranged on an outer side surface of the fixing seat bottom plate (122) along a radial direction about the virtual center line (1000); and any point of the fixing seat bottom plate (122), the circumferential stopper (131) and the radial stopper (132) is lower than a horizontal height of an upper end plane of the tray horizontal plate (111).

8. The coil winding apparatus according to claim 7, wherein

the winding tray (110) further comprises a tray vertical plate (112) that supports and connects the tray horizontal plate (111); and
the winding fixing seat (121) further comprises a fixing vertical plate (1202) that supports and connects the fixing seat bottom plate (122).

9. The coil winding apparatus according to claim 7, wherein the winding fixing seat (121) is provided with an adjusting hole (1200), and the circumferential stopper (131) is slidable in the adjusting hole (1200).

10. The coil winding apparatus according to claim 5, wherein the clamping member (410) is configured to be insertable into the coil (210) and capable of performing expansion and contraction actions, wherein the clamping member (410) closely abuts against an inner side of the coil (210) when the clamping member (410) expands.

11. The coil winding apparatus according to claim 10, wherein

the adjustment mechanism (400) further comprises a clamping member mounting disc (440), the number of clamping members (410) is more than one, and the more than one clamping members (410) are mounted on the clamping member mounting disc (440); and
horizontal heights of bottom surfaces of the clamping members (410) decrease stepwise from a first of the clamping members (410) to a last of the clamping members (410), so that heights of the clamping members (410) correspond to heights of the winding tray (110) and the winding fixing seat (121).

12. The coil winding apparatus according to claim 11, wherein the clamping members (410) are circumferentially arranged and correspond to a circumferential arrangement of the winding tray (110) and a plurality of windings (200).

13. The coil winding apparatus according to claim 2, wherein

the translation assembly (510) comprises a carrier X-direction moving part (511), a carrier Y-direction moving part (512) and a carrier Z-direction moving part (513); and
the carrier Z-direction moving part (513) is connected to the carrier X-direction moving part (511) and is capable of driving the carrier X-direction moving part (511) to move in the Z-direction, the carrier X-direction moving part (511) is connected to the carrier Y-direction moving part (512) and is capable of driving the carrier Y-direction moving part (512) to move in the X-direction, and the carrier Y-direction moving part (512) is connected to the winding carrier (100) and is capable of driving the winding carrier (100) to move in the Y-direction.

14. The coil winding apparatus according to claim 2, wherein the rotation assembly (520) comprises a base (521), a rotation seat (522) and a rotation motor (523), the rotation seat (522) is rotatably mounted on the base (521), the rotation motor (523) drives the rotation seat (523) to rotate, the base (521) is mounted on the translation assembly (510), and the winding carrier (100) is mounted on the rotation seat (522).

15. The coil winding apparatus according to claim 1, wherein

the clamping arm (430) comprises a clamping X-direction moving part (431), a clamping Y-direction moving part

(432) and a clamping Z-direction moving part (433); and
 the clamping Y-direction moving part (432) is connected to the clamping X-direction moving part (431) and is
 capable of driving the clamping X-direction moving part to move in the Y direction, the clamping X-direction
 moving part (431) is connected to the clamping Z-direction moving part (433) and is capable of driving the
 clamping Z-direction moving part (433) to move in the X-direction, and the clamping Z-direction moving part (433)
 is connected to the clamping member (410) and is capable of driving the clamping member (410) to move in the Z-
 direction.

16. The coil winding apparatus according to claim 1, further comprising:
 a wire feeding mechanism (600), which is arranged on one side of the bending mechanism (300) and configured for
 feeding the wire (2000) to the bending mechanism (300).

17. A coil winding method, **characterized by** comprising:

step 10) for winding a coil (210): bending a wire (2000) through a bending mechanism (300) to obtain the coil
 (210);
 step 20) for reserving a jumper-wire intermediate body (221): reserving the jumper-wire intermediate body (221)
 on one side of the coil (210) that has been wound, through the bending mechanism (300);
 step 30) repeating the steps 10) and 20) to obtain a structure in which a plurality of coils (210) are connected to
 each other through the jumper-wire intermediate body (221); and
 step 40) for shaping a jumper-wire (220): deforming the jumper-wire intermediate body (221) such that end faces
 of two sides of the plurality of coils (210) are flush.

18. The coil winding method according to claim 17, further comprising:
 step 25) for adjusting positions of the coil (210) and the jumper-wire intermediate body (221): adjusting the positions of
 the coil (210) and the jumper-wire intermediate body (221) on the winding carrier (100) through an adjustment
 mechanism (400) before repeating the step 10).

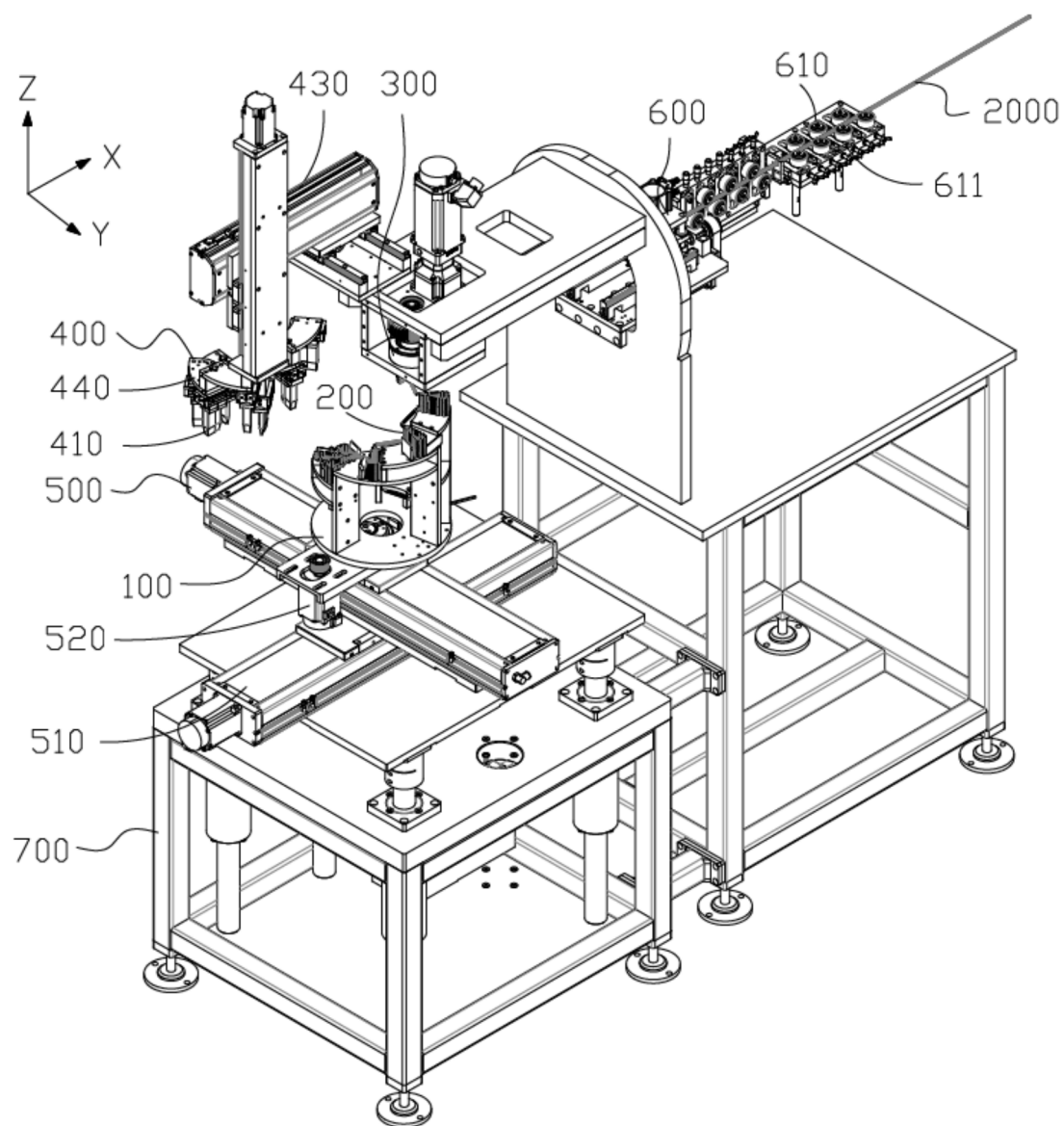


FIG. 1

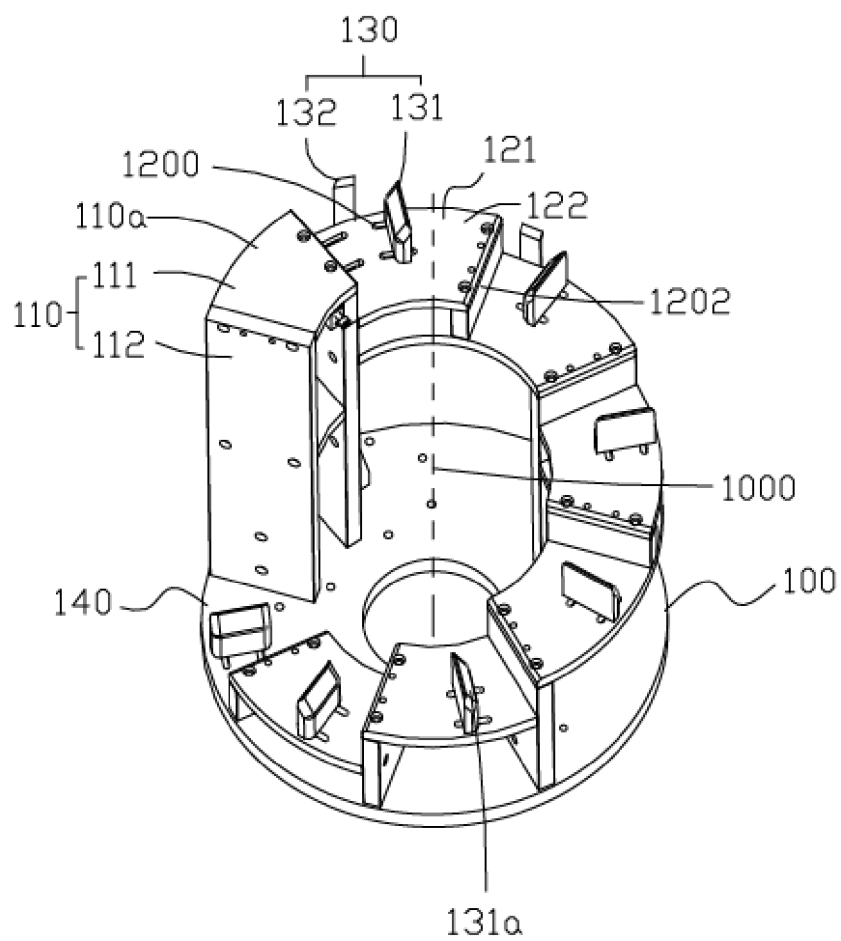


FIG. 2

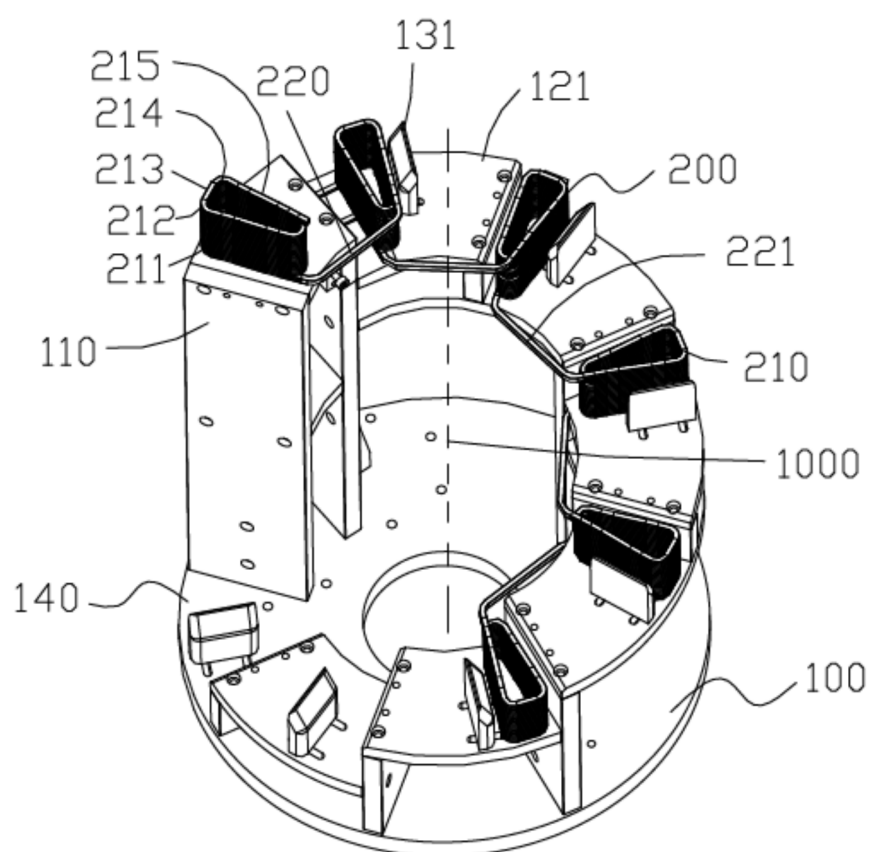


FIG. 3

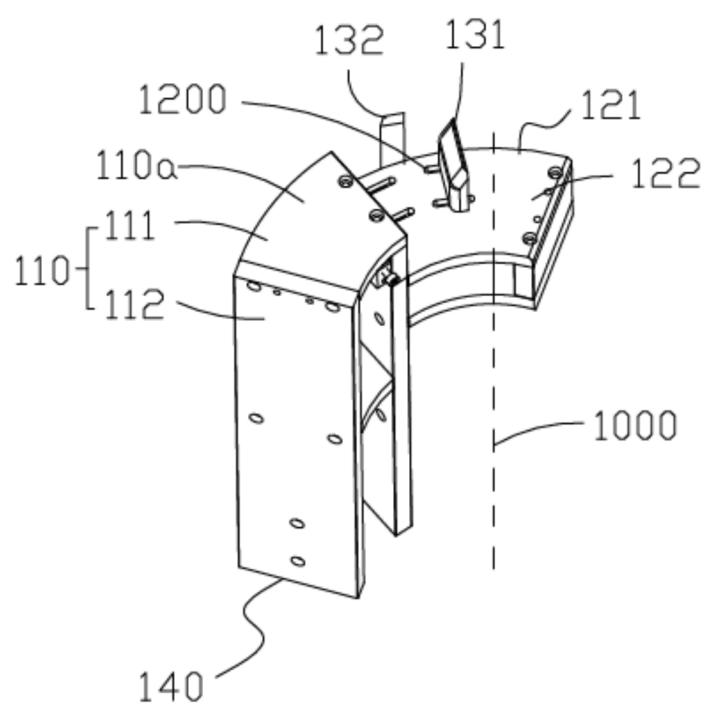


FIG. 4

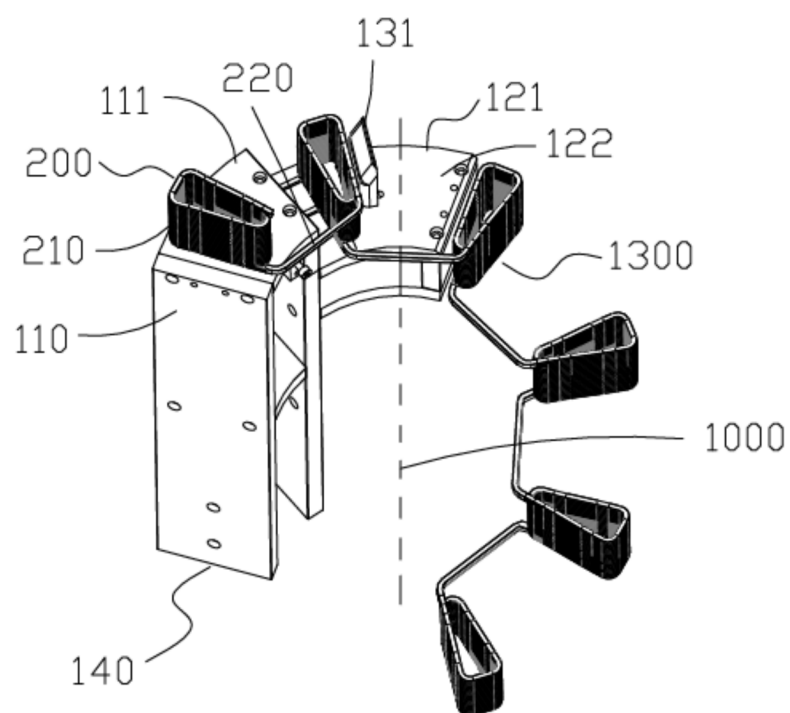


FIG. 5

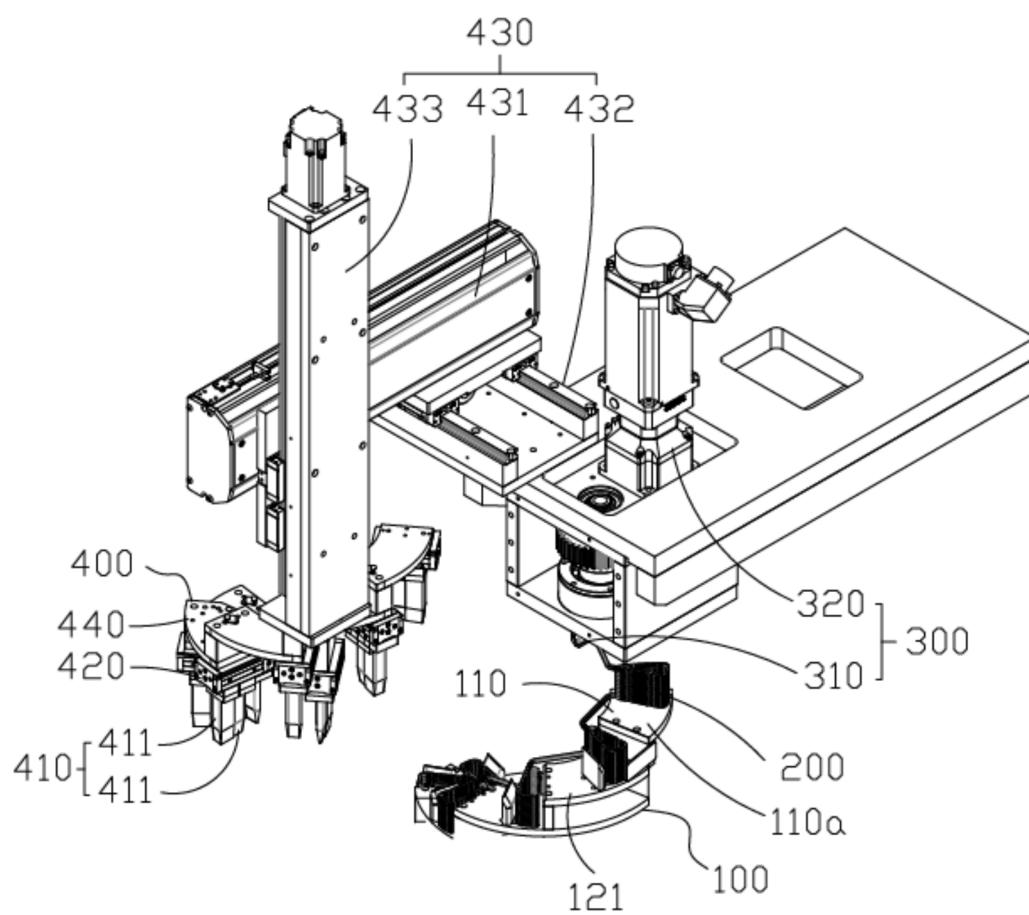


FIG. 6

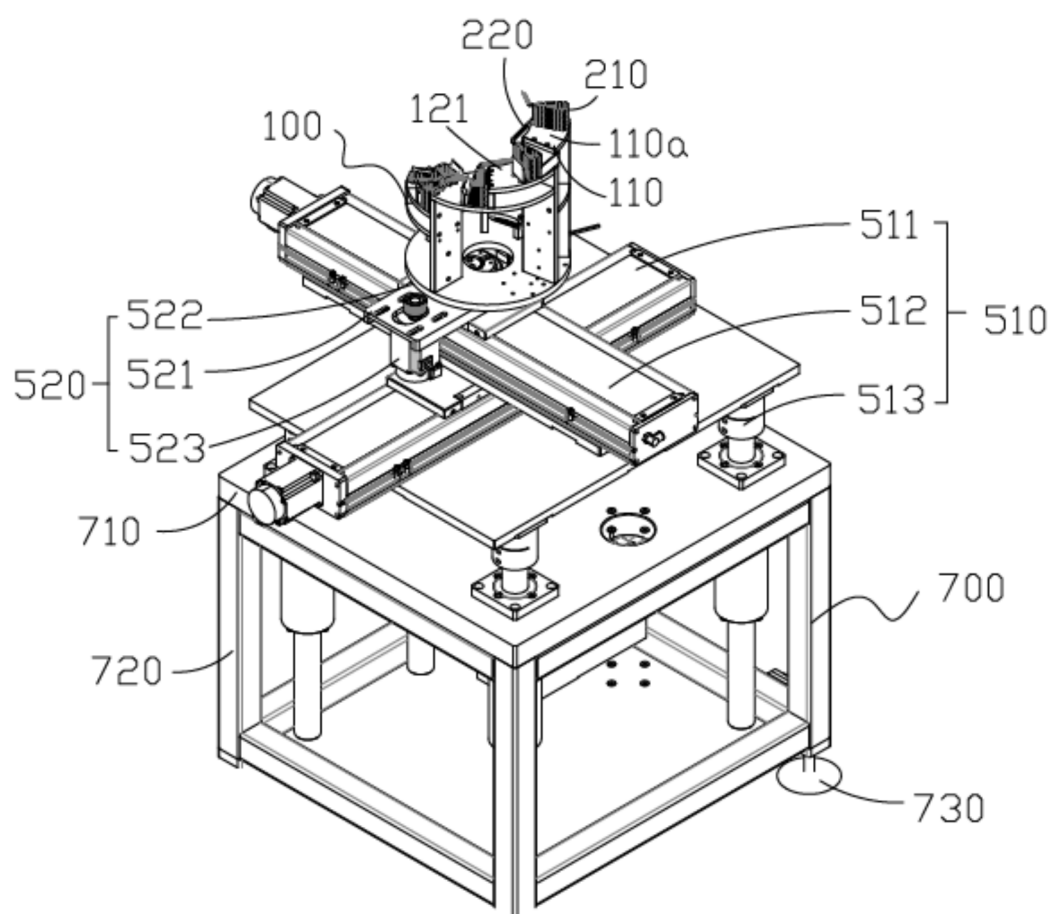


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2024/113231

A. CLASSIFICATION OF SUBJECT MATTER

H01F41/06(2016.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H01F, H02K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

VEN, CNABS, CNTXT, WOTXT, EPTXT, USTXT, CNKI, IEEE: 线圈, 绕组, 电机, 电动机, 绕制, 缠绕, 折弯, 弯折, 调整, 调节, 整形, coil, winding, motor, bend, adjust

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 102104301 A (NITTOKU ENGINEERING CO., LTD.) 22 June 2011 (2011-06-22) description, paragraphs 0008-0082, and figures 1-21	1-3, 13-16
Y	US 6223784 B1 (ROBERT BOSCH GMBH) 01 May 2001 (2001-05-01) description, column 3, line 31 to column 5, line 67, and figures 1-11	1-3, 13-16
X	JP 2002247812 A (FUJI ELECTRIC CO., LTD.) 30 August 2002 (2002-08-30) description, paragraphs 0010-0064, and figures 1-22	17-18
A	CN 211830375 U (ZHEJIANG PANGOOD POWER TECHNOLOGY CO., LTD.) 30 October 2020 (2020-10-30) entire document	1-18

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"D" document cited by the applicant in the international application	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"E" earlier application or patent but published on or after the international filing date	"&" document member of the same patent family
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 04 November 2024	Date of mailing of the international search report 14 November 2024
Name and mailing address of the ISA/CN China National Intellectual Property Administration (ISA/CN) China No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088	Authorized officer Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2024/113231

5

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report			Publication date (day/month/year)		Patent family member(s)			Publication date (day/month/year)	
CN	102104301	A	22 June 2011	JP	2011130554	A		30 June 2011	
US	6223784	B1	01 May 2001	AU	1659999	A		19 July 1999	
				AU	731628	B2		05 April 2001	
				CZ	9902919	A3		11 October 2000	
				CZ	300076	B6		21 January 2009	
				BR	9807599	A		22 February 2000	
				BR	9807599	B1		21 September 2010	
				WO	9934499	A1		08 July 1999	
				JP	2001513320	A		28 August 2001	
				JP	3904613	B2		11 April 2007	
				EP	0968563	A1		05 January 2000	
				EP	0968563	B1		02 April 2003	
				ES	2196631	T3		16 December 2003	
				KR	20000075535	A		15 December 2000	
JP	2002247812	A	30 August 2002	None					
CN	211830375	U	30 October 2020	CN	113113977	A		13 July 2021	
				WO	2021139079	A1		15 July 2021	

Form PCT/ISA/210 (patent family annex) (July 2022)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- CN 211830375 U [0002]