DESCRIPTION

TWO-DIRECTIONALLY MOVABLE TABLE

Technical Field

[0001]

The present invention relates to a structure of a two-directionally movable table.

Background Art

[0002]

In bonding apparatuses such as wire-bonding apparatuses, an XY table is used as a two-directionally movable table on which a bonding target such as a semiconductor device is movable in X and Y directions that is two horizontal mutually-orthogonal directions. Such an XY table includes a lower table to be guided and moved by an X-direction motor in the X direction and an upper table to be guided by a guide on the upper surface of the lower table and moved by a Y-direction motor in the Y direction. The upper table is configured to move in the Y direction on the lower table, which is configured to move in the X direction, so as to be freely movable in the X and Y directions.

[0003]

There has been proposed a technique of using a moving-coil direct-current linear motor as a Y-direction motor in such an XY table and connecting and fixing a flat plate-like movable member on which a coil is mounted to an upper table for high-accuracy positioning (see Patent Document 1, for example).

[0004]

Also, such a moving-coil linear motor often employs an alternating-current linear motor. For example, there has been proposed a motor in which three coils corresponding to the respective U-, V-, and W-phases of three-phase alternating current are arranged in a plane with the front and back thereof being fixed by a support member and magnets are disposed above and below the coils (see Patent Document 2, for example).

[0005]

There has also been proposed a method for configuring a rectangular coil for use in a lithography projection apparatus in a manner that main current conductor zones in the long side direction are arranged on a common plane, while cross zones in the short side direction are overlapped (see Patent Document 3, for example).

Related Art Documents

Patent Documents

[0006]

Patent Document 1: Japanese Unexamined Patent Application Publication No. 2002-329772

Patent Document 2: Japanese Unexamined Patent Application Publication No. 2005-333799

Patent Document 3: Japanese Patent No. 4280248

Summary of the Invention

Problems to be Solved by the Invention

[0007]

Incidentally, lead frames and substrates used in assembling semiconductor devices and the like, its width have recently been widened to increase the area per substrate from the viewpoint of cost reduction. For bonding on semiconductor devices with wide substrates, XY tables in bonding apparatuses are required to have a larger stroke in both X and Y directions. However, in one-coil direct-current linear motors like the Y-direction motor described in Patent Document 1, the Y-direction stroke depends on the Y-direction size of the coil. Therefore, achieving a larger Y-direction stroke requires a larger movable member, resulting in an increase in the length and weight of the movable member. This in turn results in that an increased vibration can occur in the movable member and affect the bonding quality, suffering from a problem in that the increase in the Y-direction stroke should be limited.

[0008]

In the case of such an alternating-current linear motor

as described in Patent Document 2, the Y-direction stroke does not depend on the Y-direction size of the coils, so that the Y-direction stroke does not require increasing the Y-direction side of the coils, unlike increasing the Y-direction stroke, as in the case of direct-current linear motors. However, such an alternating-current linear motor with coils arranged in a plane as described in Patent Document 2 requires four magnets (two by two for N and S) to be arranged on one side with respect to the thrust-direction size of a set of three-phase coils, which makes the N and S poles close to each other to result in a reduction in the magnetic flux density at the center of each magnetic pole. As a result, the thrust per the unit volume of each coil decreases, and eventually achieving a larger Y-direction stroke leads to an increase in the weight of the movable member, which can affect the bonding quality. For this reason, even employing such an alternating-current linear motor as described in Patent Document 2 also suffers from a problem in that the increase in the Y-direction stroke should be limited. In addition, there is a need for XY tables in wire-bonding apparatuses to bring the center of gravity of the linear motor coil close to the mounting position of the XY table, however, thinning and widening a coil as in the related art described in Patent Document 2 suffers from a problem of a width increase in the thrust direction and therefore a large gap between the center of gravity of the coil and the mounting position of the XY table, a problem of difficulty in applying the related art described in Patent Document 2 to XY tables in wire-bonding apparatuses.

[0009]

In the related art described in Patent Document 3, the overlapping of the cross zones is thickened and thereby the spacing between the permanent magnets vertically sandwiching the Y-direction movable member therebetween increases to result in a reduction in the magnetic flux, requiring a larger coil and thus resulting in an increase in the weight of the movable member. As is the case with the related art described in Patent Document 1, this results in that an increased vibration can

occur in the movable member and affect the bonding quality, suffering from a problem in that the increase in the Y-direction stroke should be limited.

[0010]

It is hence an object of the present invention to provide a two-directionally movable table with an increased Y-direction stroke.

Means for Solving the Problems

[0011]

The present invention is directed to a two-directionally movable table movable in two directions, first and second directions, orthogonal to each other in the same plane, the table including: a first table for driving in a first direction by a first motor, the first table to be guided in the first direction; a second table for driving in the first direction together with the first table as well as in a second direction by a second motor, the second table to be guided in the second direction by a second directional guide provided on an upper surface of the first table; a movable arm for moving in the first and second directions together with the second table, the movable arm extending in the second direction with one end thereof being fixed to the second table; and a drive coil partially protruding in a width direction of the movable arm, the drive coil being attached within the movable arm, in which the drive coil is a lap-winding coil in which central portions of multiple coreless coils are arranged in parallel with the second direction within the movable arm and portions at which the coreless coils mutually intersect, are arranged in positions protruding from the movable arm.

[0012]

In the two-directionally movable table according to the present invention, it is also preferable that, the drive coil includes: a basic coreless coil; and at least two laminated coreless coils formed by laminating multiple unit coreless coils in a direction of the thickness of the basic coreless coil, in which the unit coreless coils in each laminated coreless coil

intersect with the basic coreless coil at different positions in the basic coreless coil, and portions at which the basic coreless coil and the unit coreless coils overlap, are located between two planes extending along the surface of the basic coreless coil at a predetermined distance on both sides in the lamination direction from the center in the direction of the thickness of the basic coreless coil, and in which the overlapping thickness of the portions at which the unit coreless coils mutually intersect, is equal to or smaller than the thickness of the portions at which the basic coreless coil and the unit coreless coils overlap.

[0013]

In the two-directionally movable table according to the present invention, it is also preferable that, the number of the unit coreless coils laminated in each laminated coreless coil is even, and each of the same number of the unit coreless coils are displaced with respect to each other in the first direction to be arranged symmetrically with respect to the center line of the movable arm running in the second direction. Further, it is also preferable that, the basic coreless coil includes multiple layers laminated in the thickness direction, and also preferable that the unit coreless coils run between the layers of the basic coreless coil.

[0014]

In the two-directionally movable table according to the present invention, it is also preferable that, each laminated coreless coil is formed by laminating two unit coreless coils and the thickness of each unit coreless coil is half the thickness of the basic coreless coil, in which the thickness of the portions at which the basic coreless coil and the unit coreless coils overlap, is one-and-a-half the thickness of the basic coreless coil, and in which the predetermined distance is one-and-a-half the thickness of the basic coreless coil.

Advantage

[0015]

The present invention offers the advantage of providing

a two-directionally movable table with an increased Y-direction stroke.

Brief Description of the Drawings

[0016]

FIG. 1 is a plan view of an XY table according to an exemplary embodiment of the present invention.

FIG. 2 is a front view of the XY table according to the exemplary embodiment of the present invention.

FIG. 3 is a side view of the XY table including a Y-direction movable member according to the exemplary embodiment of the present invention.

FIG. 4 is a perspective view of the Y-direction movable member in the XY table according to the exemplary embodiment of the present invention.

FIG. 5 is a plan view of a drive coil of the Y-direction movable member in the XY table according to the exemplary embodiment of the present invention.

FIG. 6 is an X-direction cross-sectional view of the drive coil taken along the lines A-A to F-F of FIG. 5.

FIG. 7 is a Y-direction cross-sectional view of the drive coil taken along the lines G-G to M-M of FIG. 5.

FIG. 8 is a plan view of an XY table according to another exemplary embodiment of the present invention.

Modes for Carrying Out the Invention

[0017]

Exemplary embodiments of the present invention will hereinafter be described with reference to the accompanying drawings. As shown in FIG. 1, an XY table 10 of a wire-bonding apparatus 100 is configured to include a lower table 13 and an upper table 21 that are arranged, respectively, in X-axis (along line X-X) and Y-axis (along line Y-Y) directions that is of coordinate axes orthogonal to each other in a plane. The lower and upper tables 13 and 21 are connected, respectively, with an X-direction motor 30 and a Y-direction motor 40, so that the tables 13 and 21 can be driven, respectively, in the X and Y

directions by the respective motors 30 and 40. On the upper table 21 is placed a bonding head 101 for vertically moving a capillary 103 attached at a leading end of a bonding arm 102. As shown in FIG. 1, the direction in which the bonding arm 102 extends is Y direction, and the direction orthogonal thereto is X direction.

[0018]

As shown in FIG. 2, the X-direction motor 30 is installed on the upper surface of a cabinet 11 via an X-direction guide rail 37. The X-direction motor 30, which is a voice coil motor, as is well known, is configured to include an X-direction motor stator 31 having a permanent magnet 32 and an X-direction movable member 33 having a coil 34. The X-direction movable member 33 is held inside the X-direction motor stator 31 by an X-direction guide not shown, which makes the X-direction movable member 33 to be movable only in the X direction. The X-direction guide is a well-known direct acting type one employing a cross roller guide or the like. The X-direction motor stator 31 is held by the X-direction guide rail 37 to be movable in the X direction, in which the X-direction movable member 33 is driven, but not movable in the Y direction.

[0019]

The X-direction movable member 33 is provided with a bracket 36 on the side of the lower table 13. The bracket 36 is fixedly coupled to a bracket 16 in the lower table 13 with a bolt. The lower table 13 is held on a table holder 12 via an X-direction guide rail 14 in a manner that is movable in the X direction, in which the X-direction movable member 33 is driven, but not movable in the Y direction. The table holder 12 is fixed to the cabinet 11. It is here assumed that the weight of the X-direction motor stator 31 is greater than the total weight of the X-direction movable member 33, the lower table 13, and additionally a Y-direction movable member 45, the upper table 21, and the bonding head 101 loaded on the lower table 13.

[0020]

As shown in FIG. 2, an X-direction motor stator speed

sensor 38 for detecting the travel speed of the X-direction motor stator 31 in the X direction is installed in the cabinet 11. A lower table sensor 18 for detecting the position and travel speed of the lower table 13 in the X direction is mounted on the upper surface of the table holder 12.

[0021]

As shown in FIG. 3, the Y-direction motor 40 is a moving-coil alternating-current linear motor held on the upper surface of the cabinet 11 via a Y-direction motor holder 17 and a Y-direction guide rail 47 in a manner that is movable in the Y direction. The Y-direction motor 40 is configured to include a Y-direction motor stator 41 having permanent magnets 42 and the Y-direction movable member 45 having a drive coil 44 and a movable arm 43 shown in FIG. 1.

[0022]

As shown in FIG. 3, the Y-direction movable member 45 is provided with a bracket 46 on the side of the upper table 21. The bracket 46 of the Y-direction movable member 45 is fixed to the upper surface of the upper table 21 with a bolt 23. The upper table 21 is held on the lower table 13 via a Y-direction guide rail 22 extending in the Y direction. The upper table 21 is thus configured to be movable in the X direction together with the lower table 13 as well as in the Y direction on the upper surface of the lower table 13, so that the upper table 21 is movable in both the X and Y directions. The Y-direction movable member 45, which is fixed to the upper table 21, is also configured to be movable in both the X and Y directions together with the upper table 21.

[0023]

As shown in FIG. 1, the permanent magnet 42, which serves as magnetic field forming means in the Y-direction motor stator 41, is provided extensively to the ends of the Y-direction motor stator 41, resulting in that the permanent magnets 42 cover the entire region of the movement of the drive coil 44 in the X direction, which serves as a magnetomotive section in the Y-direction movable member 45. In addition, the weight of the Y-direction motor stator 41 is greater than the total weight

of the Y-direction movable member 45, the upper table 21, and the bonding head 101.

[0024]

The lower table sensor 18 is mounted on the table holder 12 to detect the position and speed of the lower table 13. On the upper surface of the lower table 13, an upper table sensor 19 is mounted for detecting the position and travel speed of the upper table 21 in the Y direction. A Y-direction motor stator speed sensor 48 for detecting the travel speed of the Y-direction motor stator 41 is installed in the Y-direction motor holder 17. There is also provided with a nozzle 55 for blowing cooling air to cool the Y-direction movable member 45, so that the air outlet of the nozzle 55 faces toward the drive coil 44.

[0025]

The following gives a brief description of an operation of the thus configured XY table 10. When a position command signal for moving the lower table 13 to a predetermined position is output from a controller not shown, the X-direction movable member 33 is accelerated to move in the X direction, so that the lower table 13 is guided by the X-direction guide rail 14 to move also in the X direction. In contrast, Since the X-direction motor stator 31 is provided along the X-direction guide rail 37 in a manner that is movable in the X direction, the X-direction motor stator 31 is subject to a force of the same magnitude in the opposite direction as a reaction to the movement of the X-direction movable member 33 and the lower table 13, and then accelerated to move in the direction opposite to that of the movement of the lower table 13. Since the X-direction motor stator 31 thus moves in the direction opposite to that of the movement of the lower table 13, the cabinet 11 theoretically has no momentum and thereby hardly vibrates at all.

[0026]

The position and speed of the lower table 13 is then detected by the lower table sensor 18 and fed back to the controller, and thereafter a voltage is applied to the coil 34

in the X-direction motor 30 such that the lower table 13 is controlled to move to a predetermined position. The position and speed of the X-direction motor stator 31 is also detected by the X-direction motor stator speed sensor 38, and then compensation for the electric power consumed for the movement of the X-direction motor stator 31 is input to the coil 34.
[0027]

Similarly, when a position command signal for moving the upper table 21 to a predetermined position is output from the controller not shown, the Y-direction movable member 45 is accelerated to move in the Y direction, so that the upper table 21 is guided by the Y-direction guide rail 22 to move also in the Y direction. In contrast, since the Y-direction motor stator 41 is provided along the Y-direction guide rail 47 in a manner that is movable in the Y direction, the Y-direction motor stator 41 is subject to a force of the same magnitude in the opposite direction as a reaction to the movement of the Y-direction movable member 45 and the upper table 21, and then accelerated to move in the direction opposite to that of the movement of the upper table 21. Since the Y-direction motor stator 41 thus moves in the direction opposite to that of the movement of the upper table 21, the cabinet 11 and the table holder 12 theoretically have no momentum and thereby hardly vibrate at all.
[0028]

The position and speed of the upper table 21 is then detected by the upper table sensor 19 and fed back to the controller, and thereafter a voltage is applied to the coil 44 in the Y-direction motor 40 such that the upper table 21 is controlled to move to a predetermined position. The position and speed of the Y-direction motor stator 41 is also detected by the Y-direction motor stator speed sensor 48, and then compensation for the electric power consumed for the movement of the Y-direction motor stator 41 is input to the coil 44.
[0029]

As described heretofore, in the XY table 10, the lower table 13 is driven in the X direction by the X-direction motor

30, while the upper table 21, which is mounted on the lower table 13 slidably in the Y direction, is driven in the Y direction by the Y-direction motor 40, which causes the upper table 21 to be moved in the X and Y directions. With the movement of the upper table 21 in the X and Y directions, the Y-direction movable member 45, which is fixed to the upper table 21, is also moved in the X and Y directions.

[0030]

The Y-direction movable member 45 will next be described in detail with reference to FIG. 4. The Y-direction movable member 45 includes a flattened rectangular cylindrical movable arm 43 with a bracket 46 provided on one end thereof to be fixed to the upper table 21, a drive coil 44 attached to the movable arm 43, and a dynamic damper 50 provided at the end of the movable arm 43. The longitudinal direction, width direction, and thickness direction of the Y-direction movable member 45 correspond, respectively, to the Y, X, and Z directions. The width and thickness of the movable arm 43 are represented, respectively, by W1 and H1.

[0031]

The movable arm 43 is formed into a hollow by sandwiching glass epoxy web plates 43c arranged at the both ends in the width direction between carbon fiber-reinforced plastic upper and lower plates 43a and 43b, with central glass epoxy spacers 43d between the upper and lower plates 43a and 43b, and jointing the upper and lower plates 43a and 43b with bolts and adhesives. The web plates 43c are notched on the side of the end of the movable arm 43 to provide openings 43e on both sides of the movable arm 43. These openings 43e lead to the interior space of the movable arm 43. Also, the dynamic damper 50, which is attached to the end face of the movable arm 43 opposite the bracket 46, includes a flat plate 51 protruding from the movable arm 43 and a weight 52 mounted on the upper surface of the flat plate 51. The flat plate 51 includes a connection tightly fitting into the movable arm 43 to provide connection between the flat plate 51 and the movable arm 43, and the connection is fixed adhesively to the movable arm 43. Further, on the

surface of the flat plate 51 opposite the weight 52 is attached a damping member for vibration damping. The damping member can be attached with a double-sided adhesive tape. The dynamic damper 50 is dispersed the vibration peak of the Y-direction movable member 45 using the weight 52 and the damping member, thereby preventing the vibration occurring at the Y-direction movable member 45.

[0032]

The drive coil 44 is installed between the upper and lower plates 43a and 43b of the movable arm 43 and its partially protrudes in the width direction from the openings 43e on lateral side of the movable arm 43. The drive coil 44 is a lap-winding coil formed by lap-winding a basic coreless coil 441 and two laminated coreless coils 442 and 443 corresponding to the respective phases of three-phase alternating current. Portions at which each of the coreless coils 441, 442, and 443 mutually intersect that correspond to coil ends thereof, are configured in such a manner so as to be located at positions protruding from the movable arm 43 in the width direction with central windings the each coreless coil arranged approximately in parallel with the Y direction in a non-overlapped manner between the upper and lower plates 43a and 43b of the movable arm 43.

[0033]

For details, the drive coil 44 is configured to include the quadrangular basic coreless coil 441 and the two laminated coreless coils 442 and 443. The basic coreless coil 441 is formed by laminating two quadrangular upper and lower flat coreless coils 44a and 44b that is unit coreless coils having approximately the same shape in the XY plane. The upper and lower flat coreless coils 44a and 44b, which are, respectively, upper and lower positions in the Z direction in FIG. 4, are bent integrally up and down. The laminated coreless coils 442 and 443 are formed by laminating two upper and lower flat coreless coils 44c and 44d and two upper and lower flat coreless coils 44e and 44f, respectively, unit coreless coils having approximately the same shape in the XY plane. The laminated

coreless coil 442 is configured by the upper and lower flat coreless coils 44c and 44d, which are, respectively, upper and lower positions in the Z direction in FIG. 4 and displaced with respect to each other in the X direction so as to be symmetrical with respect to the center axis of the movable arm 43 running in the Y direction. Similarly, the laminated coreless coil 443 is arranged in the upper and lower flat coreless coils 44e and 44f, which are, respectively, upper and lower positions in the Z direction in FIG. 4 and displaced with respect to each other in the X direction so as to be symmetrical with respect to the center axis of the movable arm 43 running in the Y direction. That is, the flat coreless coils (44c and 44d) (44e and 44f) in the laminated coils 442 and 443 have approximately the same shape in the XY plane, and the upper flat coreless coils 44c and 44e as well as the lower flat coreless coils 44d and 44f are displaced in opposite directions with respect to each other in the X direction to be symmetrical with respect to the Y axis of the movable arm 43. Then, the center of the basic coreless coil 441 in the width direction is arranged on the center of the movable arm 43 in the Y direction, so that the windings of the drive coil 44 is symmetrical with respect to the Y axis of the movable arm 43, whereby the thrust center of the drive coil 44 is configured to align the center axis of the movable arm 43 running in the Y direction.

[0034]

The flat coreless coils (44c and 44d) (44e and 44f) that is unit coreless coils in the laminated coreless coils 442 and 443 intersect with the basic coreless coil 441 (44a and 44b) at different positions in the basic coreless coil 441. Then, portions at which the basic coreless coil 441 and the flat coreless coils 44c to 44f overlap, are within the same range in the direction of the thickness of the basic coreless coil 441. The overlapping thickness of the portions at which the flat coreless coils 44c to 44f mutually intersect, is equal to or smaller than the thickness of the basic coreless coil 441 and the flat coreless coils 44c to 44f, and arranged within the range of the thickness of the portions at which the basic

coreless coil 441 and the flat coreless coils 44c to 44f overlap.
[0035]

Next will be described how the portions at which the coreless coils 441, 442, and 443 mutually intersect, overlap with reference to FIGs. 4 to 7. FIG. 5 is a plan view of the drive coil 44. In FIG. 5, the lines A-A to F-F and the lines G-G to M-M indicate sectioning positions, respectively, in the Y and X directions. The cross-sections taken along the lines A-A to F-F are shown in FIGs. 6 (a) to 6 (f), while the cross-sections taken along the lines G-G to M-M are shown in FIGs. 7 (g) to 7 (m). It is noted that the arrows near the characters A to M in FIG. 5 indicate the directions to see the cross-sections shown in FIGs. 6 (a) to 6 (f) and FIGs. 7 (g) to 7 (m).
[0036]

As shown in FIGs. 4 and 5, the coreless coils 441, 442, and 443 are arranged in an order of the laminated coreless coil 442, basic coreless coil 441, and laminated coreless coil 443 in the Y direction. As shown in FIG. 5, the coreless coils 441, 442, and 443 have a four-sided annular shape with round corners. The upper and lower flat coreless coils 44a to 44f configuring the coreless coils 441, 442, and 443 have approximately the same shape in the XY plane and also have the same thickness of "t". Since the upper and lower flat coreless coils 44a and 44b in the basic coreless coil 441 are bent integrally up and down (in the Z direction) as shown in FIGs. 6(b), 6 (e), 7 (h), and 7 (l), the upper and lower flat coreless coils 44a and 44b appear as one four-sided ring in FIG. 5. One long side of the laminated coreless coil 442 is arranged in parallel with one long side of the basic coreless coil 441 at a Y coordinate smaller than that of the basic coreless coil 441. One long side of the laminated coreless coil 443 and the other long side of the laminated coreless coil 442 are arranged sequentially in the Y direction within the four-sided annular basic coreless coil 441. The other long side of the laminated coreless coil 443 is then arranged approximately in parallel with the other long side of the basic coreless coil 441 at a Y coordinate greater

than that of the long side of the basic coreless coil 441. The long sides of the coreless coils 441, 442, and 443 are connected to each other through their respective short sides running in the Y direction.

[0037]

As shown in FIGs. 5, 7 (j), and 6 (c), the short side at the smaller X coordinate of the upper flat coreless coil 44c in the laminated coreless coil 442 extends negatively in the Y direction from within the four-sided annular basic coreless coil 441 to intersect with the upper flat coreless coil 44a upward in the Z direction and extend to a Y coordinate smaller than that of the upper flat coreless coil 44a, and then is bent downward in the Z direction to become integrated with the corresponding lower flat coreless coil 44d. Given that the thickness of each unit coil (44a to 44f) is "t", the overlapping thickness H2 of the position at which the basic coreless coil 441 (44a and 44b) and the upper flat coreless coil 44c intersect, is represented by $3t = 1.5 \times 2t$ that is one-and-a-half the thickness of the basic coreless coil 441. As shown in FIG. 6 (f), the upper flat coreless coil 44c then extends positively in the X direction at a thickness of "2t" together with the lower flat coreless coil 44d. After reaching the greatest X coordinate, the upper flat coreless coil 44c extends positively in the Y direction. As shown in FIG. 6 (c), the upper flat coreless coil 44c then extends negatively in the X direction and is bent upward in the Z direction to intersect with the upper flat coreless coil 44a in the basic coreless coil 441 thereover, and then is bent downward to extend negatively in the X direction again together with the lower flat coreless coil 44d to return to the original position. The overlapping thickness H2 of the position at which the basic coreless coil 441 (44a and 44b) and the upper flat coreless coil 44c intersect, is represented by $3t = 1.5 \times 2t$ that is one-and-a-half the thickness of the basic coreless coil 441. The thickness of the central portion is "2t", which corresponds to the thickness of any two from the flat coreless coils 44a to 44f that is the thickness of the basic coreless coil 441 (flat coreless coils 44a and 44b).

[0038]

As shown in FIGs. 5, 6 (c), and 7 (g), the long side at the greater Y coordinate of the lower flat coreless coil 44d in the laminated coreless coil 442 extends negatively in the X direction from within the four-sided annular basic coreless coil 441 to be bent upward two times, and then intersects with the upper flat coreless coil 44a thereover to extend to an X coordinate smaller than that of the upper flat coreless coil 44a. The overlapping thickness of the position at which the basic coreless coil 441 (44a and 44b) and the lower flat coreless coil 44d intersect, is represented by $3t = 1.5 \times 2t$ that is one-and-a-half the thickness of the basic coreless coil 441. The lower flat coreless coil 44d is then bent downward in the Z direction to overlap on the lower flat coreless coil 44f in the laminated coreless coil 443 and reach the greatest X coordinate, and then extends horizontally and negatively in the Y direction, as shown in FIG. 7 (g). As shown in FIG. 6 (f), after reaching the smallest Y coordinate, the lower flat coreless coil 44d then extends positively in the X direction and is bent downward in the Z direction to intersect with the upper flat coreless coil 44a in the basic coreless coil 441 thereover, as shown in FIG. 7 (k), and then is bent downward to go under the upper flat coreless coil 44c and extend negatively in the X direction together with the upper flat coreless coil 44c to return to the original position.

[0039]

As shown in FIGs. 5, 7 (j), and 6 (b), the short side at the smaller X coordinate of the upper flat coreless coil 44e in the laminated coreless coil 443 extends positively in the Y direction from within the four-sided annular basic coreless coil 441 to intersect with the lower flat coreless coil 44b thereunder and extend to a Y coordinate greater than that of the lower flat coreless coil 44b, and then is bent upward in the Z direction to become integrated with the corresponding lower flat coreless coil 44f. The overlapping thickness H2 of the position at which the basic coreless coil 441 (44a and 44b) and the upper flat coreless coil 44e intersect, is represented

by 3t = 1.5 × 2t that is one-and-a-half the thickness of the basic coreless coil 441. As shown in FIG. 6 (a), the upper flat coreless coil 44e then extends positively in the X direction together with the lower flat coreless coil 44f. After being bent downward and reaching the greatest X coordinate, the upper flat coreless coil 44e extends negatively in the Y direction. As shown in FIG. 7 (m), the upper flat coreless coil 44e then extends horizontally and negatively in the Y direction. As shown in FIG. 6 (d), the upper flat coreless coil 44e is then bent downward to intersect with the lower flat coreless coil 44b in the basic coreless coil 441 thereunder and is bent upward two times to extend negatively in the X direction together with the lower flat coreless coil 44f, and then is bent downward to go under the upper flat coreless coil 44c in the laminated coreless coil 442 and extend positively in the Y direction to return to the original position. In this configuration, as shown in FIGs. 6 (d) and 7 (j), the overlapping thickness of the position at which the basic coreless coil 441 (44a and 44b) and the upper flat coreless coil 44e intersect, is represented by 3t = 1.5 × 2t that is one-and-a-half the thickness of the basic coreless coil 441. The thickness of the central portion is "2t", which corresponds to the thickness of any two from the flat coreless coils 44a to 44f that is the thickness of the basic coreless coil 441 (flat coreless coils 44a and 44b).

[0040]

As shown in FIGs. 5 and 6 (d), the long side at the smaller Y coordinate of the lower flat coreless coil 44f in the laminated coreless coil 443 extends negatively in the X direction from within the four-sided annular basic coreless coil 441 to be bent downward, and then intersects with the lower flat coreless coil 44b, downward in the Z direction, to extend to an X coordinate smaller than that of the lower flat coreless coil 44b. The overlapping thickness H2 of the position at which the basic coreless coil 441 (44a and 44b) and the lower flat coreless coil 44f intersect, is represented by 3t = 1.5 × 2t that is one-and-a-half the thickness of the basic coreless coil 441. The lower flat coreless coil 44f is then bent upward in the Z

direction to overlap under the upper flat coreless coil 44d in the laminated coreless coil 442 and reach the greatest Y coordinate, and then extends horizontally and negatively in the X direction, as shown in FIG. 6 (a). As shown in FIG. 7 (k), the lower flat coreless coil 44f then extends negatively in the X direction and is bent downward in the Z direction to intersect with the lower flat coreless coil 44b in the basic coreless coil 441 thereunder, and then goes under the upper flat coreless coil 44e to extend negatively in the X direction together with the upper flat coreless coil 44e to return to the original position. [0041]

As described heretofore, in the laminated coreless coils 442 and 443, the upper flat coreless coils 44c and 44e and the lower flat coreless coils 44d and 44f are displaced, respectively, with respect to each other in the X direction to have a halved thickness, intersecting with the basic coreless coil 441 thereover or thereunder. Therefore, the overlapping thickness H2 of the positions at which the basic coreless coil 441 (44a and 44b) and the upper and lower flat coreless coils 44c to 44f intersect, is represented by $3t = 1.5 \times 2t$. As shown in FIGs. 6 (b) and 6 (d), the thickness H2 is vertically symmetrical with respect to the center line of the drive coil 44 in the Z direction, which is protruding by 1.5t on either side. Therefore, attaching the upper and lower plates 43a and 43b of the movable arm 43 having the same thickness, respectively, on the upper and lower sides of the central portion allows the maximum thickness in the Z direction of the entire Y-direction movable member 45 to be minimized. In this case, if the thickness of the upper and lower plates 43a and 43b of the movable arm 43 is half the thickness "t" of the flat coreless coils that is 0.5t, the thickness of the central portion of the movable member 45 is the overlapping thickness "2t" of the flat coreless coils plus the total thickness "t" of the upper and lower plates 43a and 43b that is 3t. Thus, the thickness H1 of the movable arm 43 shown in FIG. 4 is equal to the overlapping thickness H2 of the portions at which the basic coreless coil 441 (44a and 44b) and the flat coreless coils

44c to 44f intersect.

[0042]

Further, since the positions at which the upper and lower flat coreless coils 44a to 44f overlap, are within the range of the thickness H2 as shown in FIGs. 6 (a) to 6 (f), the overlapping portions cannot protrude by 1.5t or more on one side from the center line of the drive coil 44 in the Z direction, whereby the overall thickness can be reduced. Accordingly, the Z-direction spacing between the permanent magnets 42 in the stator of the Y-direction motor 40 can be kept narrow even if the Y-direction movable member 45 moves in the X and Y directions as in the XY table, which can prevent the thrust of the alternating-current linear motor from decreasing.

[0043]

Moreover, in the exemplary embodiment above, since the coreless coils 441, 442, and 443 are lap-winding ones and overlapped to achieve a narrower magnetic pole pitch and therefore a higher magnetic flux density so that the thrust reduction can be prevented, the Y-direction stroke width can be increased while preventing the drive coil 44 from becoming heavier. In addition, since the lap-winding can reduce the Y-direction length of the drive coil 44, the natural frequency of the entire Y-direction movable member 45 can be kept high, which in turn can prevent the Y-direction movable member 45 from vibrating and the bonding quality from degrading. Furthermore, since the portions at which the coreless coils 441, 442, and 443 mutually intersect protrude in the width direction of the movable arm 43, and cooling air blown out of the nozzle 55 can be fed into the movable arm 43 through the openings 43e on the movable arm 43, whereby the coreless coils 441, 442, and 443 can be cooled easily.

[0044]

Although the basic coreless coil 441 is formed by laminating two quadrangular upper and lower flat coreless coils 44a and 44b having approximately the same shape in the XY plane and the upper and lower flat coreless coils 44a and 44b, which are, respectively, upper and lower positions in the Z direction

in FIG. 4, are bent integrally up and down in the above description of this exemplary embodiment, the upper and lower flat coreless coils 44a and 44b can be bent integrally up and down and the upper and lower flat coreless coils 44c to 44f in the laminated coreless coils 442 and 443 can run between the upper and lower flat coreless coils 44a and 44b in the basic coreless coil 441. Alternatively, not two but one plate can serve as the upper and lower flat coreless coils 44a and 44b. In addition, overlapping the portions at which the upper and lower flat coreless coils 44a to 44f mutually intersect that correspond to coil ends of the coreless coils, is not limited to what is described in this exemplary embodiment, but can overlap in various manners. Further, although the coreless coils 441, 442, and 443 each include two layers in the above description of this exemplary embodiment, the number of layers can be four or six as long as the number is even and the thrust center of the drive coil 44 is configured to be aligned with the center axis of the movable arm 43.

[0045]

Although this exemplary embodiment describes the case of applying the present invention to the Y-direction movable member 45, the X-direction motor 70 and the Y-direction motor 80 in the configuration shown in FIG. 1 can replace each other as in the XY table 10 shown in FIG. 8. In this case, the movable member in the X-direction motor 70 is configured to include such a lap-winding coil as shown in FIG. 4.

[0046]

The present invention is not limited to the above-described exemplary embodiments, and various variations and modifications can be made without departing from the technical scope and nature of the invention defined in the appended claims.

Description of Reference Numerals

[0047]

10	XY table
11	Cabinet

12	Table holder
13	Lower table
14, 37	X-direction guide rails
16, 36, 46	Brackets
17	Y-direction motor holder
18	Lower table sensor
19	Upper table sensor
21	Upper table
22, 47	Y-direction guide rails
23	Bolt
30, 70	X-direction motors
31	X-direction motor stator
32, 42	Permanent magnets
33	X-direction movable member
34	Coil
38	X-direction motor stator speed sensor
40, 80	Y-direction motors
41	Y-direction motor stator
43	Movable arm
43a	Upper plate
43b	Lower plate
43c	Web plate
43d	Spacer
43e	Opening
44	Drive coil
44a, 44c, 44e	Upper flat coreless coils
44b, 44d, 44f	Lower flat coreless coils
45	Y-direction movable member
47	Y-direction guide rail
48	Y-direction motor stator speed sensor
50	Dynamic damper
51	Flat plate
52	Weight
55	Nozzle
100	Wire-bonding apparatus
101	Bonding head
102	Bonding arm

103	Capillary
441	Basic coreless coil
442, 443	Laminated coreless coils

CLAIMS

[Claim 1]

A two-directionally movable table movable in two directions, first and second directions, orthogonal to each other in the same plane, the table comprising:

a first table for driving in a first direction by a first motor, the first table to be guided in the first direction;

a second table for driving in the first direction together with the first table as well as in a second direction by a second motor, the second table to be guided in the second direction by a second directional guide provided on an upper surface of the first table;

a movable arm for moving in the first and second directions together with the second table, the movable arm extending in the second direction with one end thereof being fixed to the second table; and

a drive coil partially protruding in a width direction of the movable arm, the drive coil being attached within the movable arm, wherein

the drive coil is a lap-winding coil in which central portions of a plurality of coreless coils are arranged in parallel with the second direction within the movable arm and portions at which the coreless coils mutually intersect, are arranged in positions protruding from the movable arm.

[Claim 2]

The two-directionally movable table according to claim 1, wherein

the drive coil comprises:

a basic coreless coil; and

at least two laminated coreless coils formed by laminating a plurality of unit coreless coils in a direction of the thickness of the basic coreless coil, wherein

the unit coreless coils in each laminated coreless coil intersect with the basic coreless coil at different portions in the basic coreless coil, and portions at which the basic

coreless coil and the unit coreless coils overlap, are located between two planes extending along the surface of the basic coreless coil at a predetermined distance on both sides in the lamination direction from the center in the direction of the thickness of the basic coreless coil, and wherein

the overlapping thickness of the portions at which the unit coreless coils mutually intersect, is equal to or smaller than the thickness of the portions at which the basic coreless coil and the unit coreless coils overlap.

[Claim 3]

The two-directionally movable table according to claim 2, wherein

the number of the unit coreless coils laminated in each laminated coreless coil is even, and each of the same number of the unit coreless coils are displaced with respect to each other in the first direction to be arranged symmetrically with respect to the center line of the movable arm running in the second direction.

[Claim 4]

The two-directionally movable table according to claim 2, wherein

the basic coreless coil comprises a plurality of layers laminated in the thickness direction.

[Claim 5]

The two-directionally movable table according to claim 3, wherein

the basic coreless coil comprises a plurality of layers laminated in the thickness direction.

[Claim 6]

The two-directionally movable table according to claim 4, wherein

the unit coreless coils runs between the layers of the basic coreless coil.

[Claim 7]

The two-directionally movable table according to claim 5, wherein

the unit coreless coils runs between the layers of the basic coreless coil.

[Claim 8]

The two-directionally movable table according to claim 2, wherein

each laminated coreless coil is formed by laminating two unit coreless coils and the thickness of each unit coreless coil is half the thickness of the basic coreless coil, and wherein

the thickness of the portions at which the basic coreless coil and the unit coreless coils overlap, is one-and-a-half the thickness of the basic coreless coil, and wherein

the predetermined distance is one-and-a-half the thickness of the basic coreless coil.