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(54) **MOTOR COIL SUBSTRATE AND MOTOR**

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(57) **ABSTRACT**

A motor coil substrate includes a flexible substrate, and coils including wirings such that the wirings are formed on a first surface of the flexible substrate and a second surface on the opposite side with respect to the first surface. The flexible substrate is wound circumferentially from one end of a longitudinal direction of a flexible substrate around an axis extending in a direction perpendicular to the longitudinal direction of the flexible substrate such that the flexible substrate is formed into a cylindrical shape, and the coils are formed such that a space factor of the coils in a cross section of the motor coil substrate is in a range of 50% to 99%.

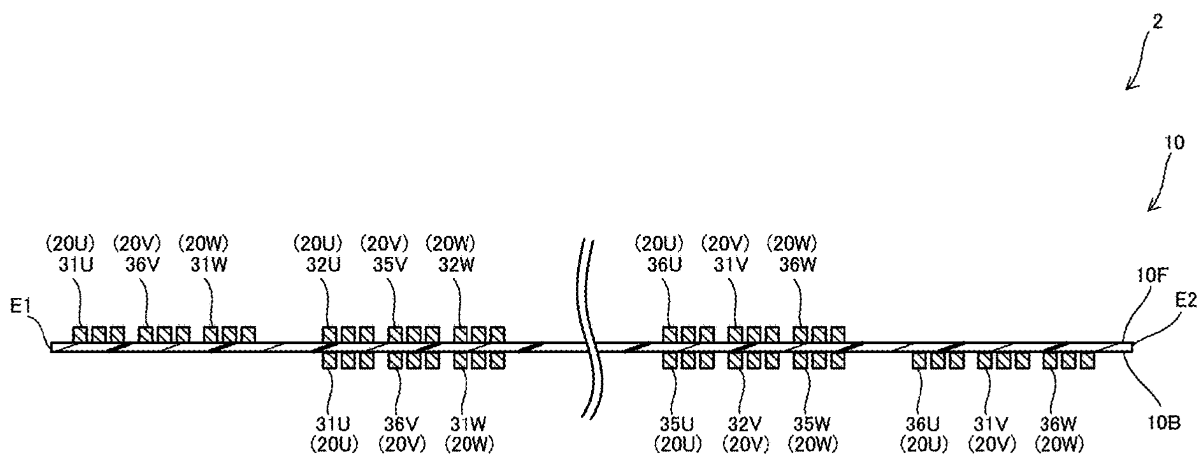


FIG. 1

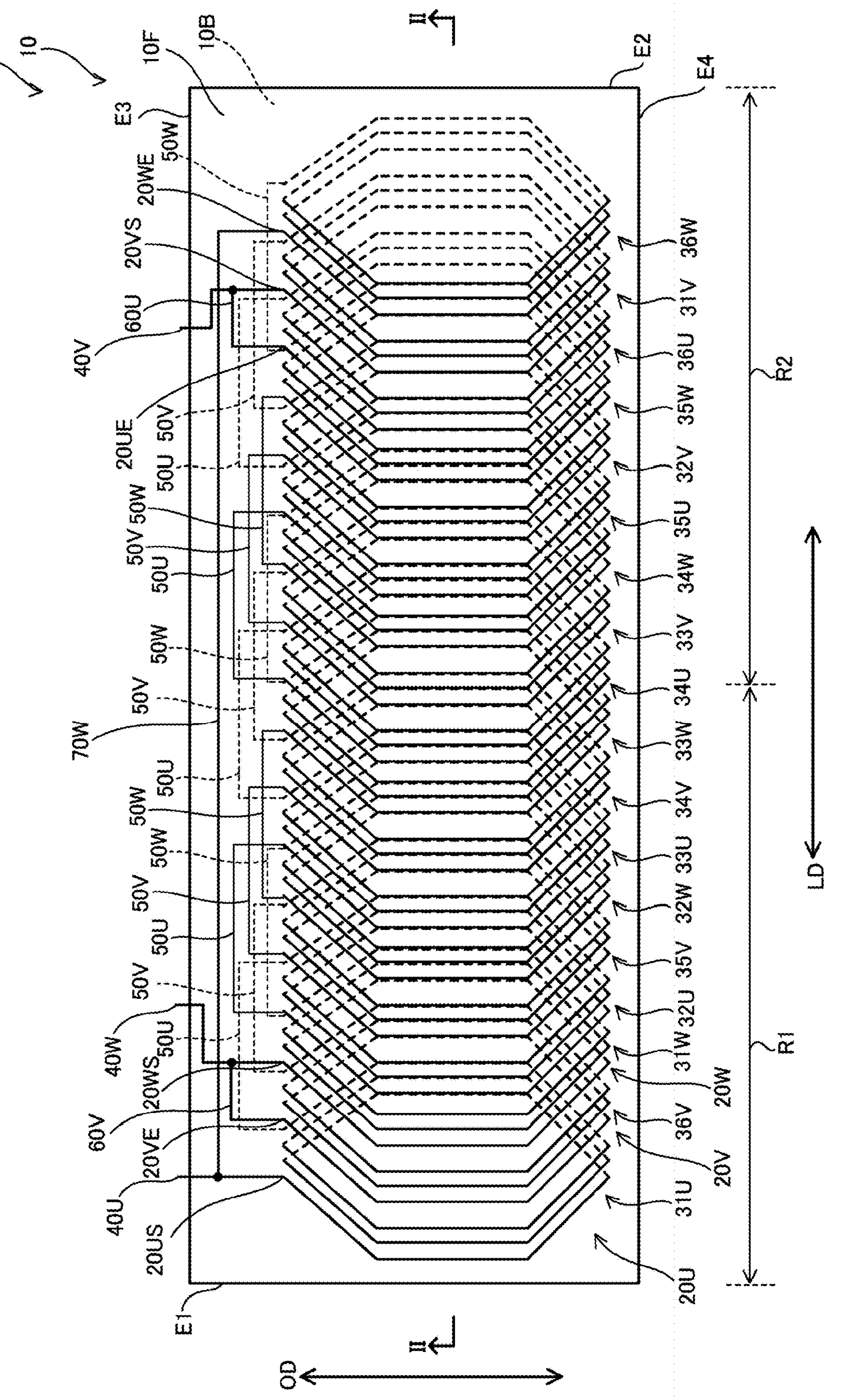

2
10
10F
10B
II
E2
E4
E3
50W
20WE
20VS
60U
40V
20UE
50V
50U
50W
50V
50U
50W
50V
70W
50U
50W
50W
50V
50U
50V
40W
50U
20WS
60V
20VE
40U
20US
E1
II
OD
36W
31V
36U
35W
32V
35U
34W
33V
34U
33W
34V
33U
32W
35V
32U
31W
20W
36V
20V
31U
20U
R2
R1
LD

FIG. 2

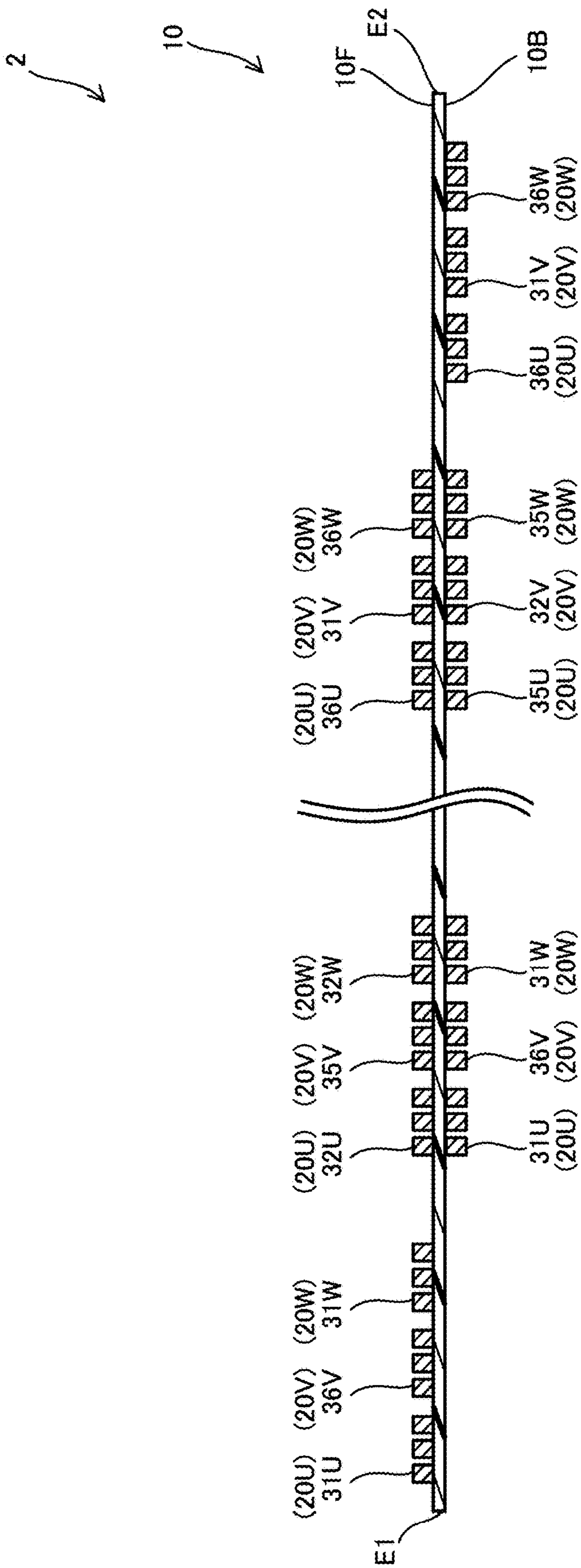

2
10
E2
10F
10B
36W (20W)
31V (20V)
36U (20U)
(20W) 36W
(20V) 31V
(20U) 36U
35W (20W)
32V (20V)
35U (20U)
(20W) 32W
(20V) 35V
(20U) 32U
31W (20W)
36V (20V)
31U (20U)
(20W) 31W
(20V) 36V
(20U) 31U
E1

FIG. 3A

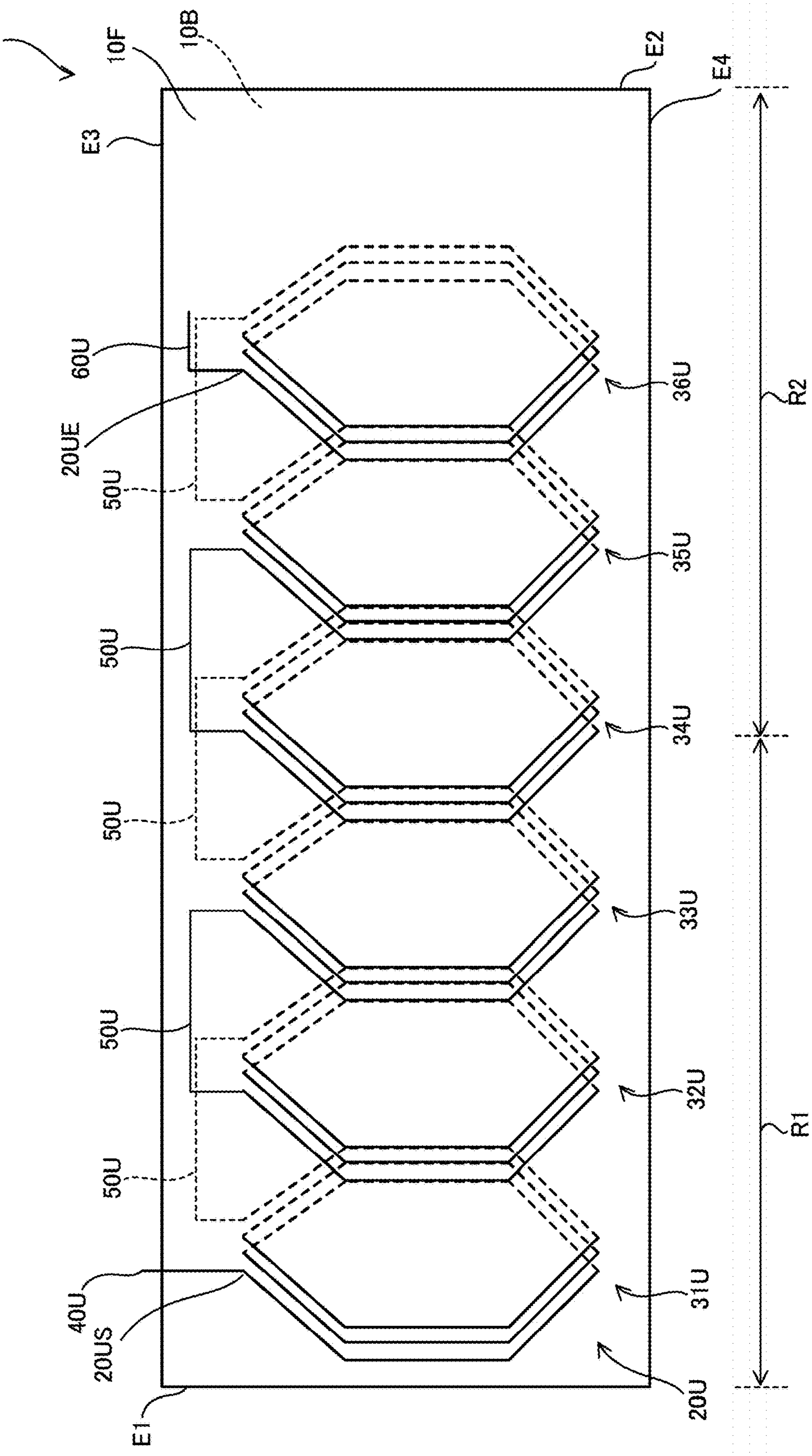
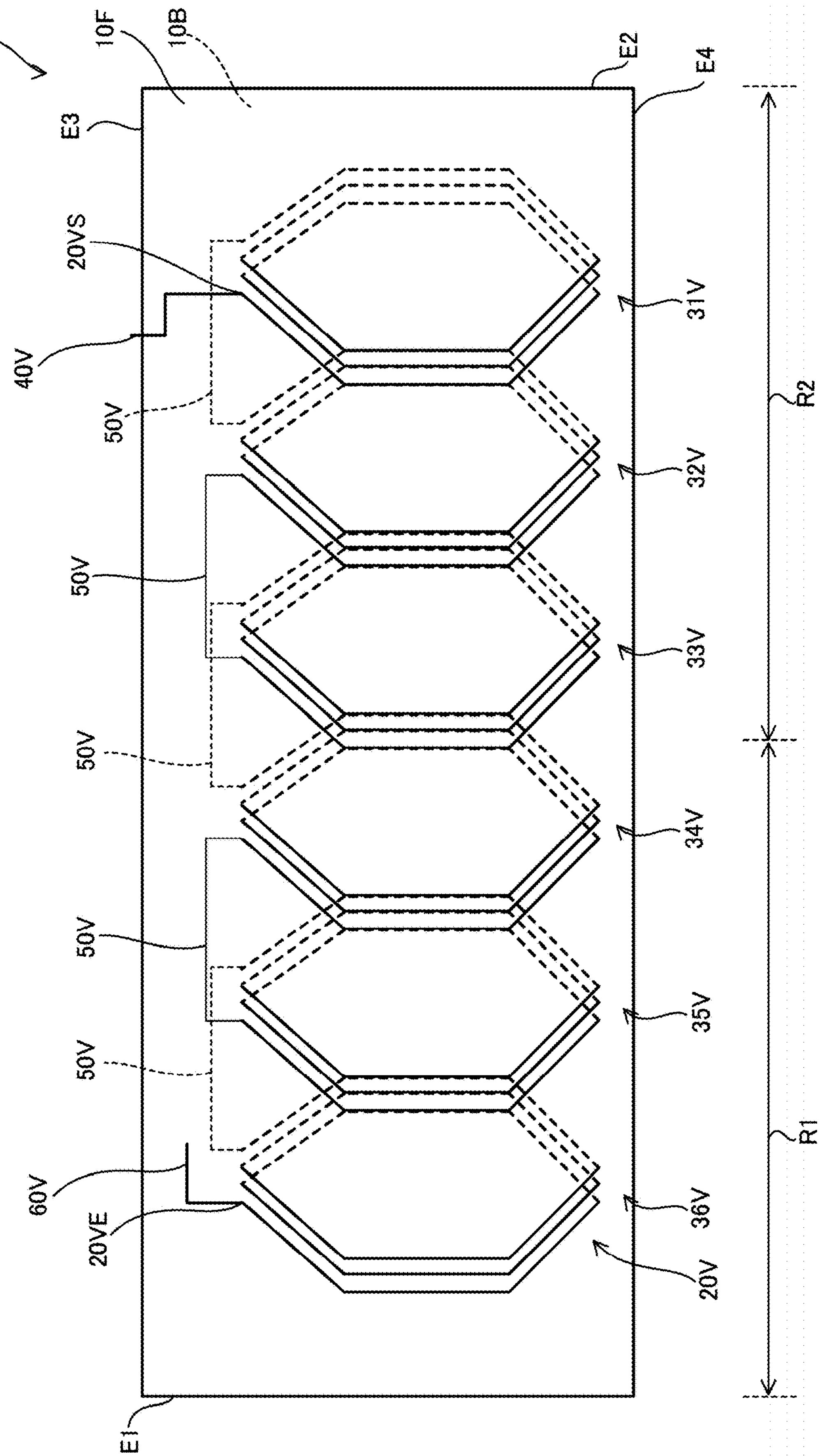

10
10F
10B
E2
E4
E3
60U
20UE
50U
50U
50U
50U
50U
36U
35U
34U
33U
32U
31U
R2
R1
40U
20US
20U
E1

FIG. 3B


10
10F
10B
E2
E4
E3
20VS
31V
40V
50V
R2
32V
50V
33V
50V
34V
50V
35V
50V
60V
36V
20VE
20V
R1
E1

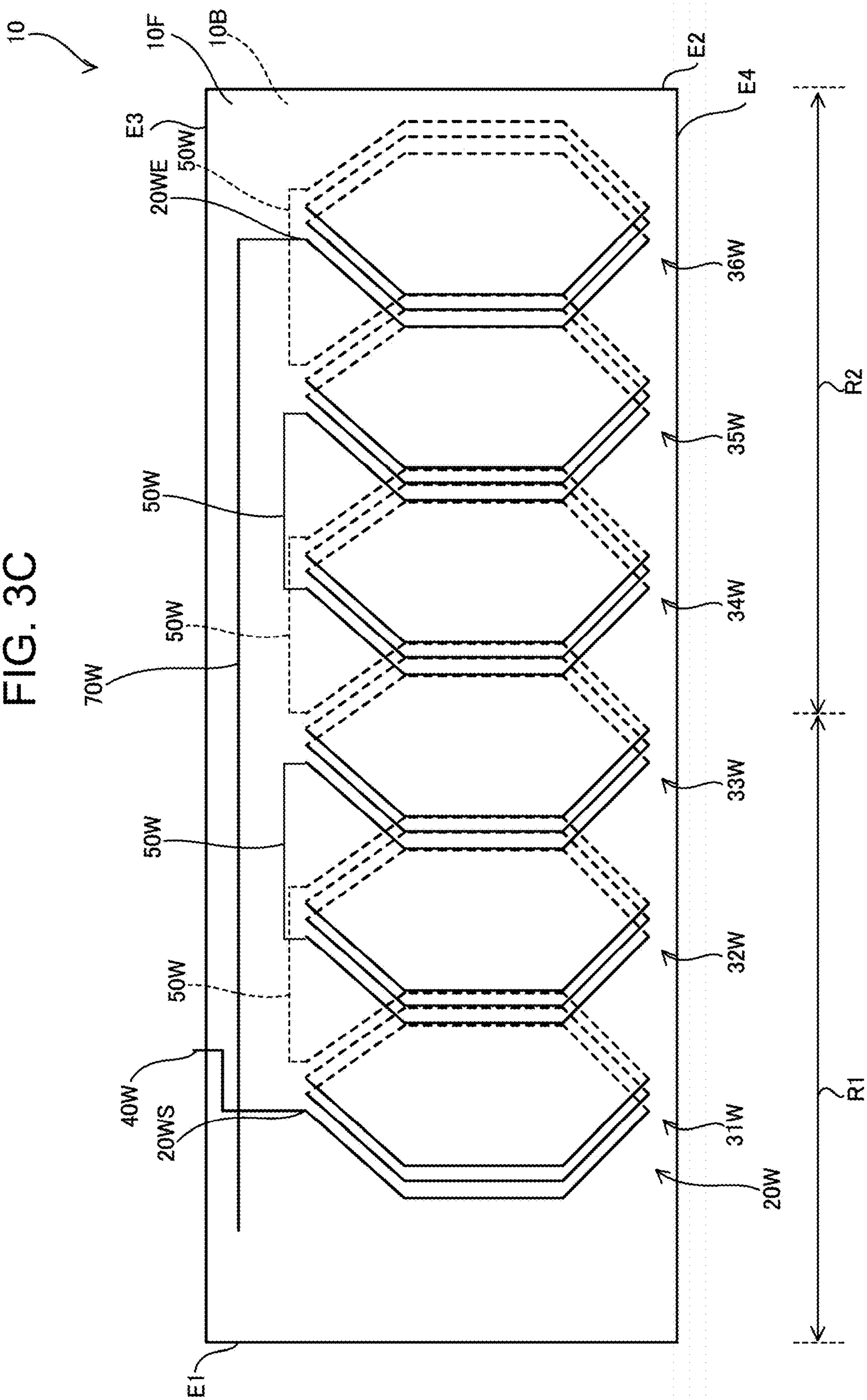
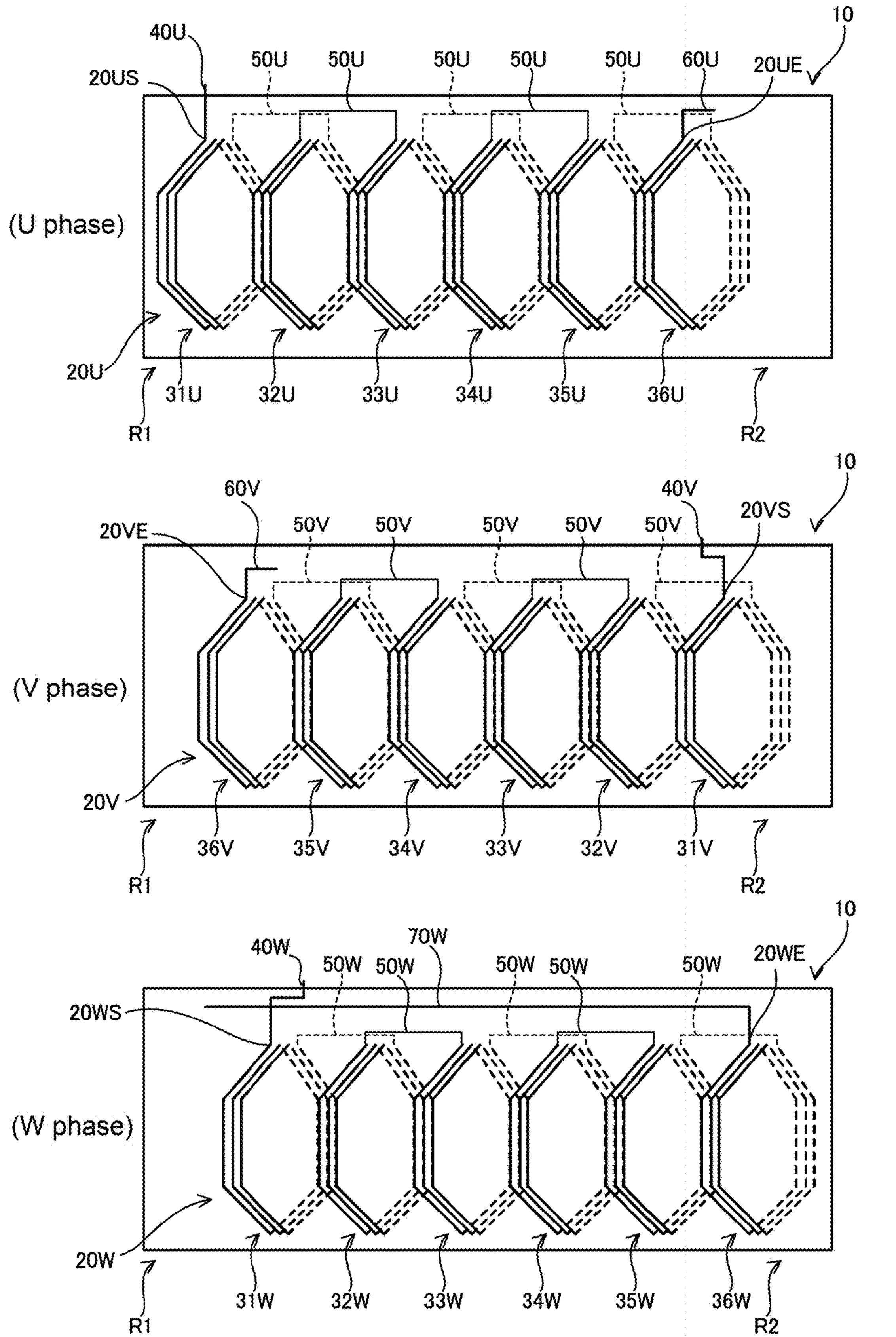

10
10F
10B
E2
E4
E3
50W
20WE
36W
35W
R2
50W
50W
70W
34W
33W
50W
32W
50W
40W
20WS
31W
20W
R1
E1

FIG. 3C

FIG. 4



10
40U
20US
50U
50U
50U
50U
50U
60U
20UE
(U phase)
20U
31U
32U
33U
34U
35U
36U
R1
R2
10
60V
20VE
50V
50V
50V
50V
50V
40V
20VS
(V phase)
20V
36V
35V
34V
33V
32V
31V
R1
R2
10
40W
70W
20WS
50W
50W
50W
50W
50W
20WE
(W phase)
20W
31W
32W
33W
34W
35W
36W
R1
R2

FIG. 5

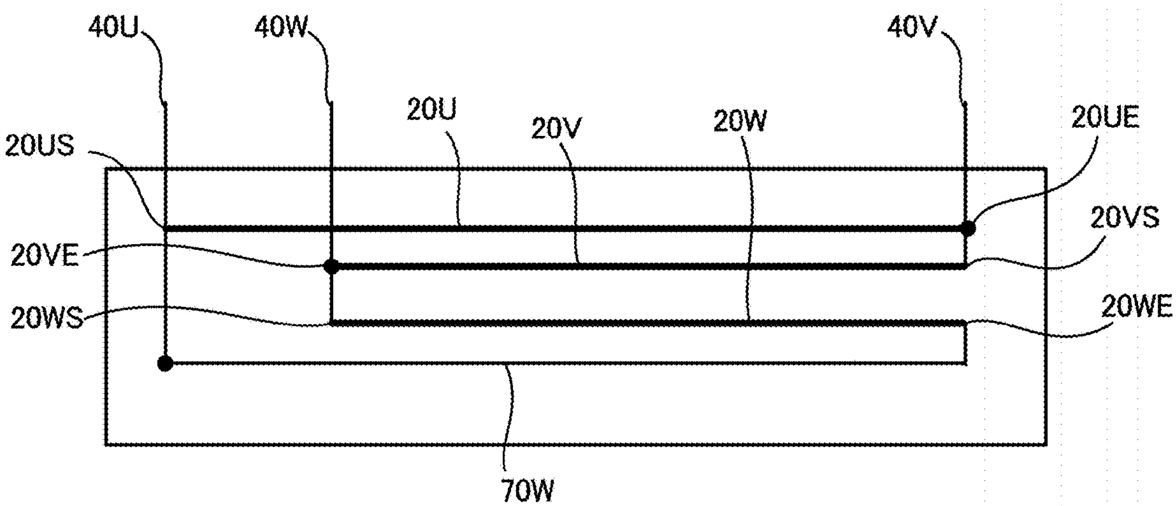

40U
40W
40V
20U
20V
20W
20US
20UE
20VE
20VS
20WS
20WE
70W

FIG. 6

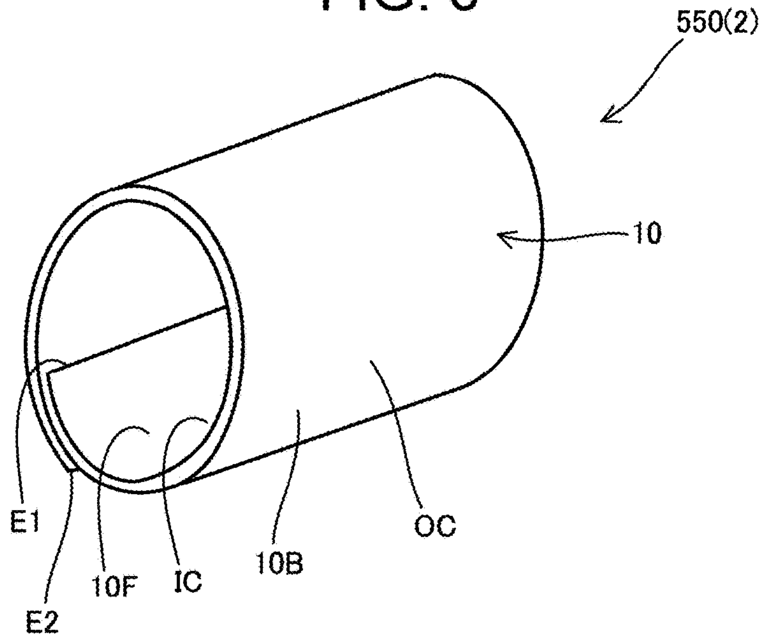

550(2)
10
E1
E2
10F
IC
10B
OC

FIG. 7

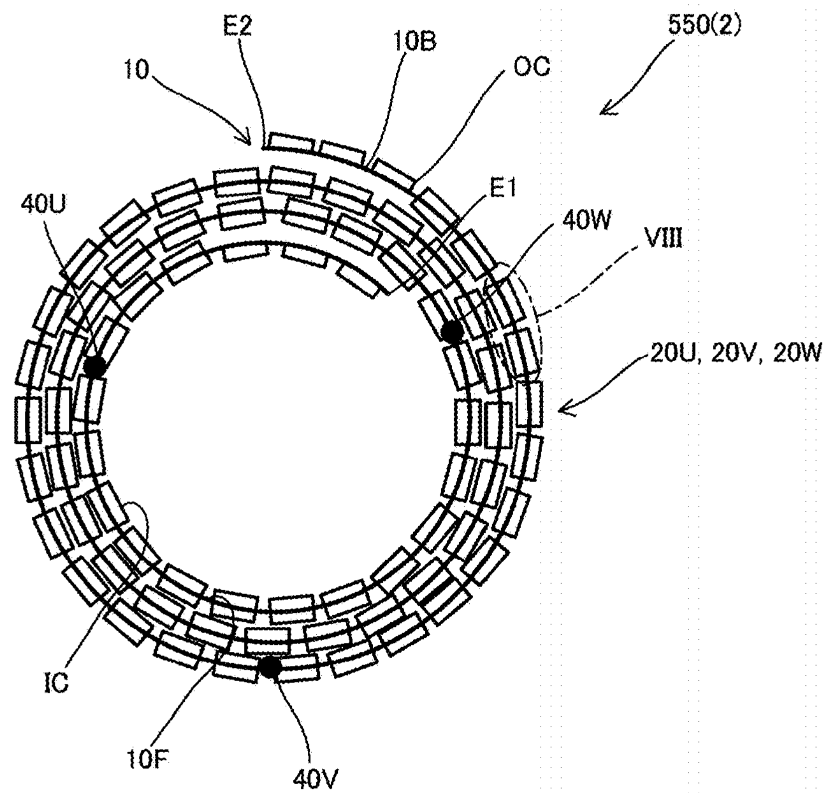

E2
10B
10
OC
550(2)
E1
40U
40W
VIII
20U, 20V, 20W
IC
10F
40V

FIG. 8

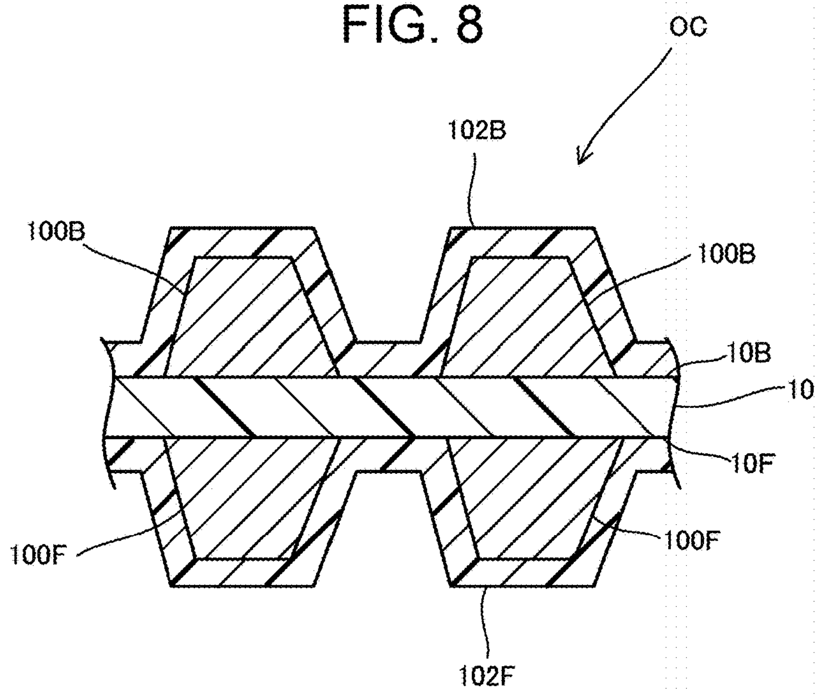

OC
102B
100B
100B
10B
10
10F
100F
100F
102F

FIG. 9

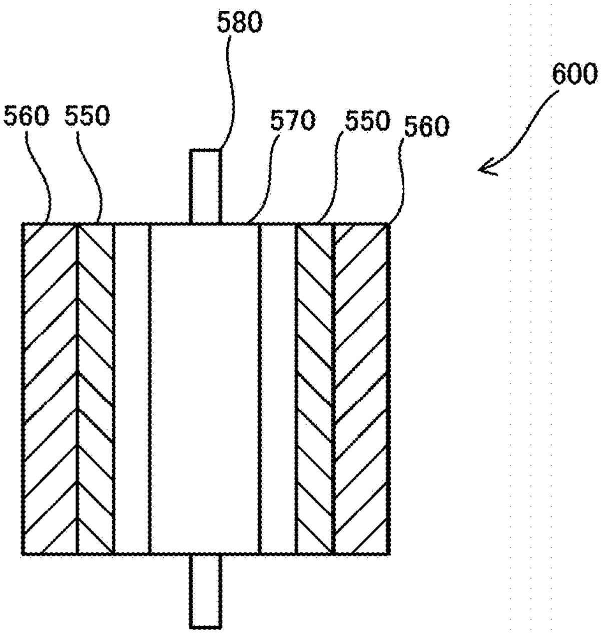

580
600
560 550
570 550 560

FIG. 10

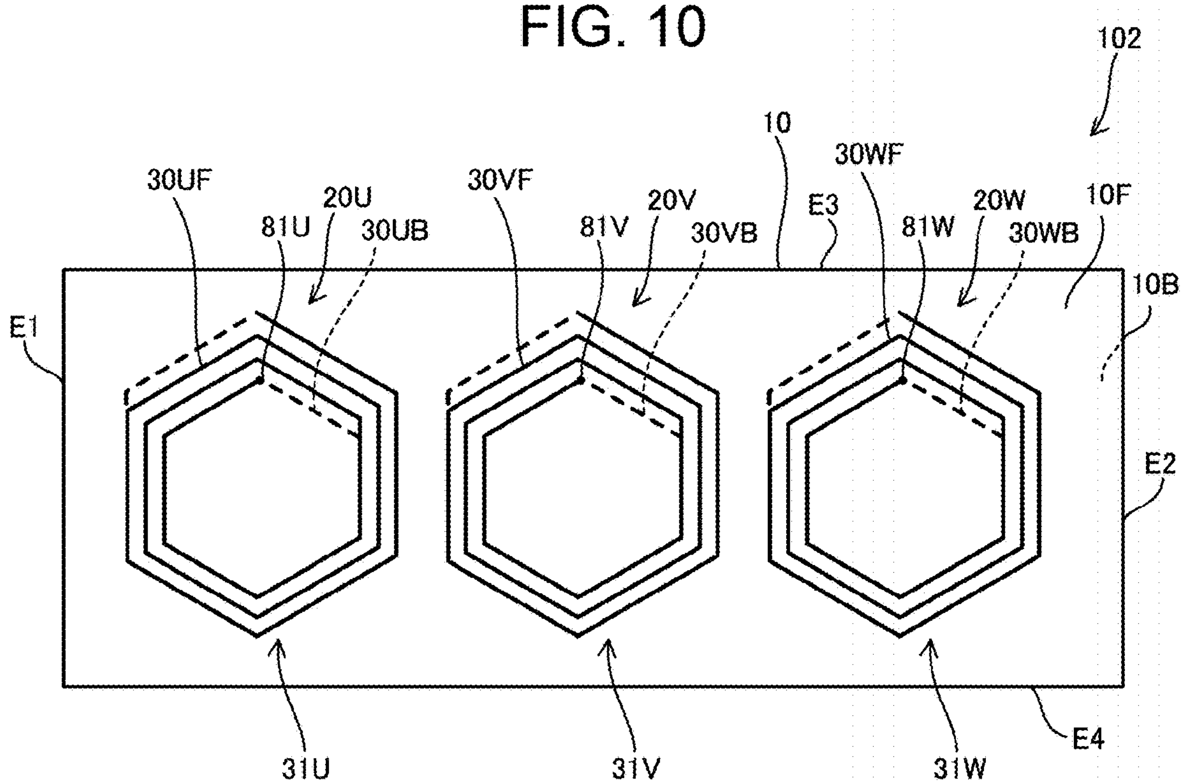
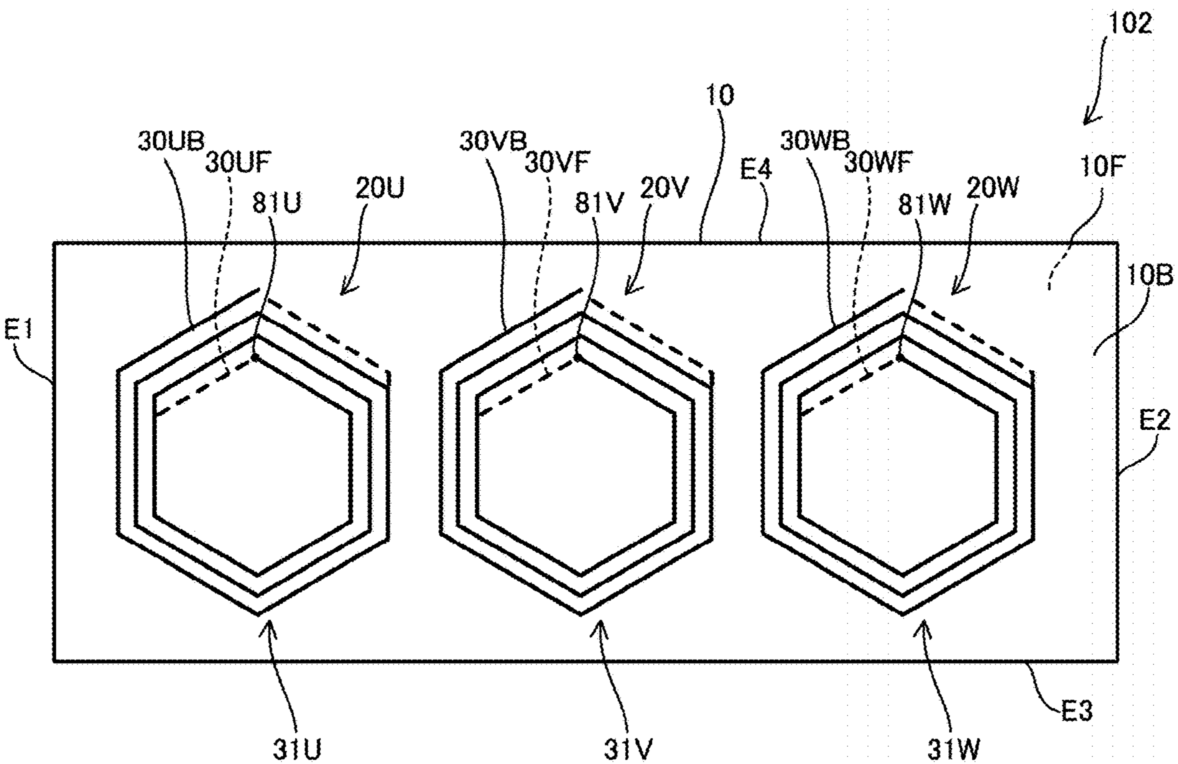

102
10
30WF
30UF
20U
81U
30UB
30VF
20V
81V
30VB
E3
81W
20W
30WB
10F
10B
E1
E2
E4
31U
31V
31W

FIG. 11


102
10
30UB
30UF
81U
20U
30VB
30VF
81V
20V
E4
30WB
30WF
81W
20W
10F
10B
E1
E2
E3
31U
31V
31W

MOTOR COIL SUBSTRATE AND MOTOR

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application is a continuation of and claims the benefit of priority to International Application No. PCT/JP2022/038928, filed Oct. 19, 2022, the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The present invention relates to a motor coil substrate, and a motor formed using the motor coil substrate.

Description of Background Art

[0003] Japanese Patent Application Laid-Open Publication No. 2022-65910 describes a coil substrate having a flexible substrate and spiral-shaped coils formed on both sides of the flexible substrate. The entire contents of this publication are incorporated herein by reference.

SUMMARY OF THE INVENTION

[0004] According to one aspect of the present invention, a motor coil substrate includes a flexible substrate, and coils including wirings such that the wirings are formed on a first surface of the flexible substrate and a second surface on the opposite side with respect to the first surface. The flexible substrate is wound circumferentially from one end of a longitudinal direction of a flexible substrate around an axis extending in a direction perpendicular to the longitudinal direction of the flexible substrate such that the flexible substrate is formed into a cylindrical shape, and the coils are formed such that a space factor of the coils in a cross section of the motor coil substrate is in a range of 50% to 99%.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

[0006] FIG. **1** is a plan view schematically illustrating a coil substrate according to an embodiment of the invention;

[0007] FIG. **2** is a cross-sectional view schematically illustrating a coil substrate according to an embodiment of the invention;

[0008] FIG. **3**A is a plan view schematically illustrating U-phase coils in a coil substrate according to an embodiment of the invention;

[0009] FIG. **3**B is a plan view schematically illustrating V-phase coils in a coil substrate according to an embodiment of the invention;

[0010] FIG. **3**C is a plan view schematically illustrating W-phase coils in a coil substrate according to an embodiment of the invention;

[0011] FIG. **4** is a plan view comparing the U phase, V phase, and W phase of a coil substrate according to an embodiment of the invention;

[0012] FIG. **5** is a plan view illustrating a simplified version of a coil substrate according to an embodiment of the invention;

[0013] FIG. **6** is a perspective view schematically illustrating a motor coil substrate according to an embodiment of the invention;

[0014] FIG. **7** is an explanatory diagram schematically illustrating positions of terminals on a motor coil substrate according to an embodiment of the invention;

[0015] FIG. **8** is an enlarged view of a portion of FIG. **7**;

[0016] FIG. **9** is a cross-sectional view schematically illustrating a motor according to an embodiment of the invention;

[0017] FIG. **10** is a plan view schematically illustrating a coil substrate of a modified example according to an embodiment of the invention; and

[0018] FIG. **11** is a bottom view schematically illustrating a coil substrate of the modified example.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0019] Embodiments will now be described with reference to the accompanying drawings, wherein like reference numerals designate corresponding or identical elements throughout the various drawings.

Embodiment

[0020] FIG. **1** is a plan view illustrating a coil substrate **2** according to an embodiment of the present invention. FIG. **2** is a cross-sectional view between II-II of FIG. **1**. FIGS. **3**A-**3**C are plan views illustrating a U-phase coil (**20**U), a V-phase coil (**20**V), and a W-phase coil (**20**W), respectively. FIG. **4** illustrates plan views comparing the U phase, the V phase, and the W phase of the coil substrate **2** of the embodiment. FIG. **5** is a plan view illustrating a simplified version of the coil substrate **2** of FIG. **1**.

[0021] As illustrated in FIG. **1**, the coil substrate **2** has a flexible substrate **10**, a U-phase coil (**20**U), a V-phase coil (**20**V), a W-phase coil (**20**W), a U-phase terminal (**40**U), a V-phase terminal (**40**V), a W-phase terminal (**40**W), multiple inter-coil connection wirings (**50**U, **50**V, **50**W), multiple interphase connection wirings (**60**U, **60**V), and a return wire (**70**W).

[0022] The flexible substrate **10** is a resin substrate having a first surface (**10**F) and a second surface (**10**B) on the opposite side with respect to the first surface (**10**F). The flexible substrate **10** is formed using an insulating resin such as polyimide or polyamide. The flexible substrate **10** is flexible. The flexible substrate **10** is formed in a rectangular shape having four sides, first side (E**1**)-fourth side (E**4**). The first side (E**1**) is a short side on one end side of the flexible substrate **10** in a longitudinal direction (arrow (LD) direction in FIG. **1**). The second side (E**2**) is a short side on the other end side in the longitudinal direction. The first side (E**1**) and the second side (E**2**) are short sides extending along an orthogonal direction (arrow (OD) direction in FIG. **1**) that is orthogonal to the longitudinal direction. The third side (E**3**) and the fourth side (E**4**) are long sides extending in the longitudinal direction. As will be described in detail later, when the coil substrate **2** is wound into a cylindrical shape to form a motor coil substrate **550** (see FIG. **6**), the first surface (**10**F) is positioned on an inner circumferential side and the second surface (**10**B) is positioned on an outer circumferential side.

[0023] The flexible substrate **10** has a first region (R**1**) on one end side (first side (E**1**) side) in the longitudinal direction, and a second region (R**2**) adjacent to the first region (R**1**). The second region (R**2**) includes the second side (E**2**).

[0024] The U-phase terminal (**40**U), the V-phase terminal (**40**V), and the W-phase terminal (**40**W) are all formed on the third side (E**3**) of the flexible substrate **10**. In the embodiment, the U-phase terminal (**40**U) and the W-phase terminal (**40**W) are formed in the first region (R**1**). The V-phase terminal (**40**V) is formed in the second region (R**2**). As illustrated in FIG. **1**, the U-phase terminal (**40**U) is connected to a starting end (**20**US) of the U-phase coil (**20**U). At the same time, the U-phase terminal (**40**U) is connected to an ending end (**20**WE) of the W-phase coil (**20**W) via the return wiring (**70**W). The V-phase terminal (**40**V) is connected to a starting end (**20**VS) of the V-phase coil (**20**V). At the same time, the V-phase terminal (**40**V) is connected to an ending end (**20**UE) of the U-phase coil (**20**U) via the inter-phase connection wiring (**60**U). The W-phase terminal (**40**W) is connected to a starting end (**20**WS) of the W-phase coil (**20**W). At the same time, the W-phase terminal (**40**W) is connected to an ending end (**20**VE) of the V-phase coil (**20**V) via the inter-phase connection wiring (**60**V). That is, in the embodiment, the U-phase coil (**20**U), the V-phase coil (**20**V), and the W-phase coil (**20**W) are A-connected (see FIG. **5**). In examples, the U-phase coil (**20**U), the V-phase coil (**20**V), and the W-phase coil (**20**W) may be Y-connected or may be otherwise connected.

[0025] The U-phase coil (**20**U), the V-phase coil (**20**V), and the W-phase coil (**20**W) respectively constitute the U phase, the V phase, and the W phase of a three-phase motor.

[0026] As illustrated in FIGS. **1**, **3**A, and **4**, the starting end (**20**US) of the U-phase coil (**20**U) is formed in the first region (R**1**). The ending end (**20**UE) of the U-phase coil (**20**U) is formed in the second region (R**2**). As illustrated in FIG. **3**A, the U-phase coil (**20**U) includes six coils (**31**U, **32**U, **33**U, **34**U, **35**U, **36**U). The six coils (**31**U-**36**U) are formed in this order from the starting end (**20**US) to the ending end (**20**UE) of the U-phase coil (**20**U) (from the first region (R**1**) to the second region (R**2**)). The six coils (**31**U-**36**U) are connected to each other by the inter-coil connection wirings (**50**U).

[0027] The six coils (**31**U-**36**U) are each formed by forming a first wiring, which forms a half turn of one turn, on the first surface (**10**F) side, forming a second wiring, which forms the remaining half turn of the one turn, on the second surface (**10**B) side, and forming adjacent turns in a staggered manner. The first wiring and the second wiring are electrically connected via a via conductor that penetrates the flexible substrate **10**.

[0028] Winding start positions (starting ends) of the first coil (**31**U), the third coil (**33**U), and the fifth coil (**35**U) from the starting end (**20**US) of the U-phase coil (**20**U) are formed on the first surface (**10**F), and winding end positions (terminating ends) thereof are formed on the second surface (**10**B). When the flexible substrate **10** is viewed from the first surface (**10**F) side, the coils (**31**U, **33**U, **35**U) are wound counterclockwise.

[0029] On the other hand, winding start positions (starting ends) of the second coil (**32**U), the fourth coil (**34**U), and the sixth coil (**36**U) from the starting end (**20**US) of the U-phase coil (**20**U) are formed on the second surface (**10**B), and winding end positions (terminating ends) thereof are formed on the first surface (**10**F). When the flexible substrate **10** is viewed from the first surface (**10**F) side, the coils (**32**U, **34**U, **36**U) are wound clockwise.

[0030] As illustrated in FIGS. **2**, **3**A, and **1**, a portion of the wiring (second wiring) of the coil (**31**U) overlaps a portion of the wiring (first wiring) of the adjacent coil (**32**U) via the flexible substrate **10**. Similarly, a portion of the wiring (second wiring) of the coil (**32**U) overlaps a portion of the wiring (first wiring) of the adjacent coil (**33**U). A portion of the wiring (second wiring) of the coil (**33**U) overlaps a portion of the wiring (first wiring) of the adjacent coil (**34**U). A portion of the wiring (second wiring) of the coil (**34**U) overlaps a portion of the wiring (first wiring) of the adjacent coil (**35**U). A portion of the wiring (second wiring) of the coil (**35**U) overlaps a portion of the wiring (first wiring) of the adjacent coil (**36**U).

[0031] As illustrated in FIGS. **3**A and **1**, the inter-coil connection wiring (**50**U) connecting the coil (**31**U) and the coil (**32**U), the inter-coil connection wiring (**50**U) connecting the coil (**33**U) and the coil (**34**U), and the inter-coil connection wiring (**50**U) connecting the coil (**35**U) and the coil (**36**U) are formed on the second surface (**10**B). On the other hand, the inter-coil connection wiring (**50**U) connecting the coil (**32**U) and the coil (**33**U) and the inter-coil connection wiring (**50**U) connecting the coil (**34**U) and the coil (**35**U) are formed on the first surface (**10**F). The U-phase terminal (**40**U) and the inter-phase connection wiring (**60**U) are formed on the first surface (**10**F).

[0032] As illustrated in FIGS. **1**, **3**B, and **4**, the starting end (**20**VS) of the V-phase coil (**20**V) is formed in the second region (R**2**). The ending end (**20**VE) of the V-phase coil (**20**V) is formed in the first region (R**1**). As illustrated in FIG. **3**B, the V-phase coil (**20**V) includes six coils (**31**V, **32**V, **33**V, **34**V, **35**V, **36**V). The six coils (**31**V-**36**V) are formed in this order from the starting end (**20**VS) to the ending end (**20**VE) of the V-phase coil (**20**V) (from the second region (R**2**) to the first region (R**1**)). The six coils (**31**V-**36**V) are connected to each other by the inter-coil connection wirings (**50**V).

[0033] The six coils (**31**V-**36**V) are each formed by forming a first wiring, which forms a half turn of one turn, on the first surface (**10**F) side, forming a second wiring, which forms the remaining half turn of the one turn, on the second surface (**10**B) side, and forming adjacent turns in a staggered manner. The first wiring and the second wiring are electrically connected via a via conductor that penetrates the flexible substrate **10**.

[0034] Winding start positions (starting ends) of the first coil (**31**V), the third coil (**33**V), and the fifth coil (**35**V) from the starting end (**20**VS) of the V-phase coil (**20**V) are formed on the first surface (**10**F), and winding end positions (terminating ends) thereof are formed on the second surface (**10**B). When the flexible substrate **10** is viewed from the first surface (**10**F) side, the coils (**31**V, **33**V, **35**V) are wound counterclockwise.

[0035] On the other hand, winding start positions (starting ends) of the second coil (**32**V), the fourth coil (**34**V), and the sixth coil (**36**V) from the starting end (**20**VS) of the V-phase coil (**20**V) are formed on the second surface (**10**B), and winding end positions (terminating ends) thereof are formed on the first surface (**10**F). When the flexible substrate **10** is viewed from the first surface (**10**F) side, the coils (**32**V, **34**V, **36**V) are wound clockwise.

[0036] As illustrated in FIGS. **2**, **3**B, and **1**, a portion of the wiring (first wiring) of the coil (**31**V) overlaps a portion of the wiring (second wiring) of the adjacent coil (**32**V) via the flexible substrate **10**. Similarly, a portion of the wiring (first wiring) of the coil (**32**V) overlaps a portion of the wiring (second wiring) of the adjacent coil (**33**V). A portion of the wiring (first wiring) of the coil (**33**V) overlaps a portion of the wiring (second wiring) of the adjacent coil (**34**V). A portion of the wiring (first wiring) of the coil (**34**V) overlaps a portion of the wiring (second wiring) of the adjacent coil (**35**V). A portion of the wiring (first wiring) of the coil (**35**V) overlaps a portion of the wiring (second wiring) of the adjacent coil (**36**V).

[0037] As illustrated in FIGS. **3**B and **1**, the inter-coil connection wiring (**50**V) connecting the coil (**31**V) and the coil (**32**V), the inter-coil connection wiring (**50**V) connecting the coil (**33**V) and the coil (**34**V), and the inter-coil connection wiring (**50**V) connecting the coil (**35**V) and the coil (**36**V) are formed on the second surface (**10**B). On the other hand, the inter-coil connection wiring (**50**V) connecting the coil (**32**V) and the coil (**33**V) and the inter-coil connection wiring (**50**V) connecting the coil (**34**V) and the coil (**35**V) are formed on the first surface (**10**F). The V-phase terminal (**40**V) and the inter-phase connection wiring (**60**V) are formed on the first surface (**10**F).

[0038] As illustrated in FIGS. **1**, **3**C, and **4**, the starting end (**20**WS) of the W-phase coil (**20**W) is formed in the first region (R**1**). The ending end (**20**WE) of the W-phase coil (**20**W) is formed in the second region (R**2**). As illustrated in FIG. **3**C, the W-phase coil (**20**W) includes six coils (**31**W, **32**W, **33**W, **34**W, **35**W, **36**W). The six coils (**31**W-**36**W) are formed in this order from the starting end (**20**WS) to the ending end (**20**WE) of the W-phase coil (**20**W) (from the first region (R**1**) to the second region (R**2**)). The six coils (**31**W-**36**W) are connected to each other by the inter-coil connection wirings (**50**W).

[0039] The six coils (**31**W-**36**W) are each formed by forming a first wiring, which forms a half turn of one turn, on the first surface (**10**F) side, forming a second wiring, which forms the remaining half turn of the one turn, on the second surface (**10**B) side, and forming adjacent turns in a staggered manner. The first wiring and the second wiring are electrically connected via a via conductor that penetrates the flexible substrate **10**.

[0040] Winding start positions (starting ends) of the first coil (**31**W), the third coil (**33**W), and the fifth coil (**35**W) from the starting end (**20**WS) of the W-phase coil (**20**W) are formed on the first surface (**10**F), and winding end positions (terminating ends) thereof are formed on the second surface (**10**B). When the flexible substrate **10** is viewed from the first surface (**10**F) side, the coils (**31**W, **33**W, **35**W) are wound counterclockwise.

[0041] On the other hand, winding start positions (starting ends) of the second coil (**32**W), the fourth coil (**34**W), and the sixth coil (**36**W) from the starting end (**20**WS) of the W-phase coil (**20**W) are formed on the second surface (**10**B), and winding end positions (terminating ends) thereof are formed on the first surface (**10**F). When the flexible substrate **10** is viewed from the first surface (**10**F) side, the coils (**32**W, **34**W, **36**W) are wound clockwise.

[0042] As illustrated in FIGS. **2**, **3**C, and **1**, a portion of the wiring (second wiring) of the coil (**31**W) overlaps a portion of the wiring (first wiring) of the adjacent coil (**32**W) via the flexible substrate **10**. Similarly, a portion of the wiring (second wiring) of the coil (**32**W) overlaps a portion of the wiring (first wiring) of the adjacent coil (**33**W). A portion of the wiring (second wiring) of the coil (**33**W) overlaps a portion of the wiring (first wiring) of the adjacent coil (**34**W). A portion of the wiring (second wiring) of the coil (**34**W) overlaps a portion of the wiring (first wiring) of the adjacent coil (**35**W). A portion of the wiring (second wiring) of the coil (**35**W) overlaps a portion of the wiring (first wiring) of the adjacent coil (**36**W).

[0043] As illustrated in FIGS. **3**C and **1**, the inter-coil connection wiring (**50**W) connecting the coil (**31**W) and the coil (**32**W), the inter-coil connection wiring (**50**W) connecting the coil (**33**W) and the coil (**34**W), and the inter-coil connection wiring (**50**W) connecting the coil (**35**W) and the coil (**36**W) are formed on the second surface (**10**B). On the other hand, the inter-coil connection wiring (**50**W) connecting the coil (**32**W) and the coil (**33**W) and the inter-coil connection wiring (**50**W) connecting the coil (**34**W) and the coil (**35**W) are formed on the first surface (**10**F). W-phase terminal (**40**W) and the return wiring (**70**W) are formed on the first surface (**10**F).

[0044] As illustrate in FIGS. **3**C, **5**, and **1**, the return wiring (**70**W) connects between the ending end (**20**WE) of the W-phase coil (**20**W) and the U-phase terminal (**40**U). The return wiring (**70**W) extends from the second region (R**2**) to the first region (R**1**).

[0045] Although not illustrated, the first surface (**10**F), and the wirings of the coils (**20**U, **20**V, **20**W), the inter-coil connection wirings (**50**U, **50**V, **50**W), the inter-phase connection wirings (**60**U, **60**V), and the return wiring (**70**W), which are formed on the first surface (**10**F), are covered by a resin insulation layer. Similarly, the second surface (**10**B), and the wirings of the coils (**20**U, **20**V, **20**W) and the inter-coil connection wirings (**50**U, **50**V, **50**W), which are formed on the second surface (**10**B), are covered by a resin insulation layer.

[0046] As illustrated in FIGS. **1** and **3**A-**3**C, in the embodiment, the wirings of the coils (**20**U, **20**V, **20**W) are each formed in a hexagonal shape. In other examples, the wirings of the coils (**20**U, **20**V, **20**W) may be formed in any shape, such as a circle (perfect circle, ellipse), a triangle, a quadrangle (square, rectangle, rhombus), a pentagon, or a polygon with seven or more sides. Further, it is not limited to having identical wiring formation shapes for all the coils; the wiring formation shapes may differ between the coils. The number of turns in one coil wiring may be one or more, and is preferably 3 or more and 7 or less. A coil wiring is formed by forming a half turn on the first surface, forming a half turn on the second surface, and connecting them via a through hole. Further, it is also possible to form a half turn on the second surface and form a half turn on the first surface. In this case, a half turn refers to half of a coil wiring. Further, it is possible to form a ¼ turn on the first surface and a ¼ turn on the second surface, connect them via a through hole, and form a total of a half turn on either the first surface or the second surface. Further, a coil wiring may be formed on either the first surface or the second surface. In this case, it is possible that a coil wiring on the first surface and a coil wiring on the second surface fully or partially overlap, or do not overlap.

[0047] The coil substrate **2** of the embodiment can be manufactured using any method. For example, the coil substrate **2** may be formed using a tenting method using a flexible substrate having a conductor layer (metal foil) as a starting material. In another example, the coil substrate **2** may be obtained by forming a metal layer on a flexible substrate using a printing or dispensing method. In yet another example, the coil substrate **2** may be obtained by forming a flexible material and a metal layer using a **3**D printer.

[0048] FIG. **6** is a perspective view schematically illustrating a motor coil substrate **550** formed using the coil substrate **2** of the embodiment (FIGS. **1**-**5**). As illustrated in FIG. **6**, the motor coil substrate **550** for a motor is formed by winding the coil substrate **2** of the embodiment (FIGS. **1**-**5**) into a cylindrical shape. When the coil substrate **2** is wound into a cylindrical shape, the coil substrate **2** is wound multiple turns around an axis extending in the orthogonal direction (an axis extending parallel to the first side (E**1**)) with the first side (E**1**) (FIG. **1**) as a starting point. Further, the number of turns the coil substrate is wound is not particularly limited. When the coil substrate **2** is wound into a cylindrical shape, the first surface (**10**F) of the flexible substrate **10** is positioned on the inner circumferential side, and the second surface (**10**B) is positioned on the outer circumferential side.

[0049] FIG. **7** schematically illustrates positions of the terminals when the motor coil substrate **550** is viewed along an axial direction. As illustrated in FIG. **7**, the U-phase terminal (**40**U), the V-phase terminal (**40**V), and the W-phase terminal (**40**W) are formed at substantially **120**-degree intervals in a circumferential direction. The U-phase terminal (**40**U) and the W-phase terminal (**40**W) are formed on an inner circumferential surface.

[0050] The V-phase terminal (**40**V) is formed on an outer circumferential surface. FIG. **7** illustrates that a conductor layer in a wound state overlaps with a conductor layer on an outer side thereof. However, it is also possible that a conductor layer partially overlaps with a conductor layer on an outer side thereof, or a conductor layer does not overlap with a conductor layer on an outer side thereof.

[0051] FIG. **8** is an enlarged view of a portion (VIII) in FIG. **7**, illustrating an example of a structure of a terminal. As illustrated in FIG. **8**, conductor layers (**100**F, **100**B) of the coils (**20**U, **20**V, **20**W) are respectively formed on both sides of the flexible substrate **10**, and insulating films (**102**F, **102**B) are respectively formed on the conductor layers (**100**F, **100**B) of the coils (**20**U, **20**V, **20**W). By forming the insulating films (**102**F, **102**B), the conductor layers (**100**F, **100**B) are not exposed, and there is no contact between adjacent conductor layers (**100**F, **100**B) or between adjacent conductor layers (**100**F, **100**B) in a cross section when the coil substrate **2** is wound, and thus, insulation is maintained. The insulating films (**102**F, **102**B) can be formed by printing a liquid resin. An example of the resin is polyimide. In FIG. **8**, the insulating films (**102**F, **102**B) are formed so as to follow the conductor layers (**100**F, **100**B), but may also be formed so as to cover upper surfaces of the conductor layers (**100**F, **100**B) and fill spaces between the conductor layers (**100**F, **100**B). The insulating layers (**102**F, **102**B) are not particularly limited in thickness, but are preferably formed to each have a thickness of about **1** um or more and **30** um or less. In FIG. **8**, the conductor layers (**100**F, **100**B) are symmetrically formed with the flexible substrate **10** sandwiched in between. However, it is also possible that the conductor layers (**100**F, **100**B) partially overlap each other with the flexible substrate **10** sandwiched in between, or do not overlap each other with the flexible substrate **10** sandwiched in between. Further, in FIG. **8**, a cross-sectional shape of each of the conductor layers (**100**F, **100**B) is a trapezoid. However, it is also possible that the cross-sectional shape of each of the conductor layers (**100**F, **100**B) is a square, a rectangle, or a quadrangle. The conductor layers (**100**F, **100**B) may have the same cross-sectional shape, or may have different cross-sectional shapes.

[0052] In this case, a cross section of the motor coil substrate **550** is composed of the flexible substrate **10**, the conductor layers, which are the wirings of the phases, and the insulating layers, which cover the conductor layers. In this case, a result obtained by calculating a cross-sectional area of all the conductor layers in a cross-sectional area of the motor coil substrate **550** is a space factor of the coils. In this case, the space factor of the coils in the cross section of the motor coil substrate **550** is 50% or more and 99% or less. A high space factor of the coil conductors is ensured. Therefore, when a motor is formed using the motor coil substrate **550** of the embodiment, high torque can be obtained. A high-performance motor can be obtained. In this case, a method for calculating the space factor of the coils is: Space factor=((sum of cross-sectional areas of conductor parts)/(coil cross-sectional area))×100.

[0053] FIG. **7** illustrates an outer circumferential surface (OC) and an inner circumferential surface (IC) of the motor coil substrate **550**. In the embodiment, a cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.3 mm. When the cylindricity of the outer circumferential surface (OC) is greater than 0.0 mm and equal to or less than 0.3 mm, the motor coil substrate **550** does not roll evenly on a flat surface. When the cylindricity of the outer circumferential surface (OC) is greater than 0.0 mm and equal to or less than 0.3 mm, adhesion strength with a yoke during motor formation is increased. A motor with stable performance can be obtained. Further, the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is preferably greater than 0.0 mm and equal to or less than 0.2 mm. When the cylindricity of the outer circumferential surface (OC) is greater than 0.0 mm and equal to or less than 0.2 mm, the adhesion strength with the yoke during motor formation can be increased and stability can be improved. Therefore, even when it is operated as a motor, the motor coil substrate **550** is not positionally displaced, and a motor with stable performance can be obtained.

[0054] The cylindricity of the outer circumferential surface (OC) is measured using a V-block measurement method. That is, the cylindricity of the outer circumferential surface (OC) is measured by placing the motor coil substrate **550** on a V-block, rotating it one turn, measuring a deviation in a direction perpendicular to the axis at five different locations, and calculating an average value thereof.

[0055] The combined coil space factor of the coils (**20**U, **20**V, **20**W) in a cross section of the motor coil substrate 550 is 50% or more and 99% or less. By using a motor coil substrate **550** with a space factor of 50% or more and 99% or less, a high-torque motor can be obtained. Further, when the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained. In the present specification, a small motor refers to a motor with an outer diameter of 50 mm or less.

[0056] Further, the space factor of the coils in a cross section of the motor coil substrate **550** is preferably 55% or more and 90% or less. By using a motor coil substrate **550** with a coil space factor of 55% or more and 90% or less, a high-torque motor can be obtained. Further, when the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained.

[0057] Further, the space factor of the coils in a cross section of the motor coil substrate **550** is more preferably 60% or more and 80% or less. A high space factor of the coil conductors can be ensured, and when it is wound into a cylindrical shape, a predetermined cylindrical shape can be achieved. Further, a high space factor of the coil conductors can be ensured even in a small motor, and when it is wound into a cylindrical shape, a predetermined cylindrical shape can be achieved, torque can be increased, and a high-performance motor can be obtained.

[0058] A ratio of the wirings (that is, the wirings of the coils (**20**U, **20**V, **20**W)) in a total weight of the motor coil substrate **550** is 80.0% or more and 99.9% or less. A high-torque motor can be obtained by using a motor coil substrate **550** with the ratio of the wirings in the total weight being 80.0% or more and 99.9% or less. In this case, a method for calculating the ratio of the wirings in the total weight of the motor coil substrate **550** is: Wiring ratio=((total weight of conductor part)/(weight of coil substrate))×100.

[0059] Further, the ratio of the wirings in the total weight of the motor coil substrate **550** is preferably 85.0% or more and 96.0% or less. Since the wiring ratio is 85.0% or more and 96.0% or less, a high space factor of the coil conductors can be ensured, and when it is wound into a cylindrical shape, a predetermined cylindrical shape can be achieved. Further, a high space factor of the coil conductors can be ensured even in a small motor, and when it is wound into a cylindrical shape, a predetermined cylindrical shape can be achieved, torque can be increased, and a high-performance motor can be obtained.

[0060] The outer circumferential surface (OC) of the motor coil substrate **550** is formed of the flexible substrate **10**, and the wirings of the coils (**20**U, **20**V, **20**W) are not exposed. That is, an insulating layer that covers the wirings is formed on the outermost circumference of the motor coil substrate **550**. The outer circumferential surface (OC) of the motor coil substrate **550** is insulated from the outside.

[0061] When the motor coil substrate **550** is formed, the number of turns of the coil substrate **2** is arbitrary. The number of turns of the coil substrate **2** is preferably 2 or more and 10 or less. By setting the number of turns to 2 or more and 10 or less, the cylindricity of the outer circumferential surface (OC) of the formed motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.3 mm, as described above. As a result, deterioration in motor performance can be suppressed.

[0062] The space factor of the coils in a cross section of the motor coil substrate **550** is 50% or more and 99% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.3 mm. In the motor coil substrate **550** of the embodiment of the present invention, the space factor of the coils is 50% or more and 99% or less, and the cylindricity of the outer circumferential surface (OC) is greater than 0.0 mm and equal to or less than 0.3 mm. When a motor is formed using the motor coil substrate **550**, the adhesion strength with the yoke during motor formation can be increased, and high torque can be obtained. A high-performance motor can be obtained. Further, when the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained.

[0063] It is preferable that the space factor of the coils in a cross section of the motor coil substrate **550** is 55% or more and 90% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.3 mm. By using a motor coil substrate **550** in which the space factor of the coils is 55% or more and 90% or less and the cylindricity of the outer circumferential surface (OC) is greater than 0.0 mm and equal to or less than 0.3 mm, the adhesion strength with the yoke during motor formation can be increased, and a high-torque motor can be obtained. A high-performance motor can be obtained. Further, when the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained.

[0064] Further, it is preferable that the space factor of the coils in a cross section of the motor coil substrate **550** is 60% or more and 80% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.3 mm. Since the space factor of the coils in a cross section of the motor coil substrate **550** is 60% or more and 80% or less and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.3 mm, a high space factor of the coil conductors can be ensured, and when it is wound into a cylindrical shape, a predetermined cylindrical shape can be achieved. The adhesion strength with the yoke during motor formation can be increased, and high torque can be obtained. A high-performance motor can be obtained. Further, a high space factor of the coil conductors can be ensured even in a small motor, and when it is wound into a cylindrical shape, a predetermined cylindrical shape can be achieved, the adhesion strength with the yoke during motor formation can be increased, torque can be increased, and a high-performance motor can be obtained. Further, when the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained.

[0065] It is preferable that the space factor of the coils in a cross section of the motor coil substrate **550** is 50% or more and 99% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.2 mm. Since the space factor of the coils in a cross section of the motor coil substrate **550** is 50% or more and 99% or less and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.2 mm, a high space factor of the coil conductors can be ensured, and when it is wound into a cylindrical shape, a predetermined cylindrical shape can be achieved. The adhesion strength with the yoke during motor formation can be increased, and high torque can be obtained. A high-performance motor can be obtained. Further, a high space factor of the coil conductors can be ensured even in a small motor, and when it is wound into a cylindrical shape, a predetermined cylindrical shape can be achieved, the adhesion strength with the yoke during motor formation can be increased, and stability can be improved. Therefore, even when it is operated as a motor, the motor coil substrate **550** is not positionally displaced, torque can be increased, and a high-performance motor can be obtained. Further, when the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained.

[0066] It is preferable that the space factor of the coils in a cross section of the motor coil substrate **550** is 55% or more and 90% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.2 mm. Since the space factor of the coils in a cross section of the motor coil substrate **550** is 55% or more and 90% or less and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.2 mm, a high space factor of the coil conductors can be ensured, and when it is wound into a cylindrical shape, a predetermined cylindrical shape can be achieved. The adhesion strength with the yoke during motor formation can be increased, and high torque can be obtained. A high-performance motor can be obtained. Further, a high space factor of the coil conductors can be ensured even in a small motor, and when it is wound into a cylindrical shape, a predetermined cylindrical shape can be achieved, the adhesion strength with the yoke during motor formation can be increased, and stability can be improved. Therefore, even when it is operated as a motor, the motor coil substrate **550** is not positionally displaced, torque can be increased, and a high-performance motor can be obtained. Further, when the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained.

[0067] It is preferable that the space factor of the coils in a cross section of the motor coil substrate **550** is 60% or more and 80% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.2 mm. Since the space factor of the coils in a cross section of the motor coil substrate **550** is 60% or more and 80% or less and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.2 mm, a high space factor of the coil conductors can be ensured, and when it is wound into a cylindrical shape, a predetermined cylindrical shape can be achieved. The adhesion strength with the yoke during motor formation can be increased, and high torque can be obtained. A high-performance motor can be obtained. Further, a high space factor of the coil conductors can be ensured even in a small motor, and when it is wound into a cylindrical shape, a predetermined cylindrical shape can be achieved, the adhesion strength with the yoke during motor formation can be increased, and stability can be improved. Therefore, even when it is operated as a motor, the motor coil substrate **550** is not positionally displaced, torque can be increased, and a high-performance motor can be obtained. Further, when the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained.

[0068] The ratio of the wirings in the total weight of the motor coil substrate **550** is 80.0% or more and 99.9% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.3 mm. When a motor is formed using the motor coil substrate **550** in which the ratio of the wirings in the total weight of the motor coil substrate **550** of the embodiment is 80.0% or more and 99.9% or less and the cylindricity of the outer circumferential surface (OC) is greater than 0.0 mm and equal to or less than 0.3 mm, the space factor of the coils can be increased and high torque can be obtained. A high-performance motor can be obtained. Further, when the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained.

[0069] Further, the ratio of the wirings in the total weight of the motor coil substrate **550** is 85.0% or more and 96.0% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.3 mm. When a motor is formed using the motor coil substrate **550** in which the ratio of the wirings in the total weight of the motor coil substrate **550** of the embodiment is 85.0% or more and 96.0% or less and the cylindricity of the outer circumferential surface (OC) is greater than 0.0 mm and equal to or less than 0.3 mm, the ratio of the wirings can be increased, and a predetermined cylindrical shape can be obtained. As a result, the adhesion strength with the yoke during motor formation can be increased, the space factor of the coils can be increased, and high torque can be obtained. A high-performance motor can be obtained. Further, when the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained.

[0070] The ratio of the wirings in the total weight of the motor coil substrate **550** is 80.0% or more and 99.9% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.2 mm. When a motor is formed using the motor coil substrate **550** in which the ratio of the wirings in the total weight of the motor coil substrate **550** of the embodiment is 80.0% or more and 99.9% or less and the cylindricity of the outer circumferential surface (OC) is greater than 0.0 mm and equal to or less than 0.2 mm, the ratio of the wirings can be increased, and a predetermined cylindrical shape can be obtained. As a result, the adhesion strength with the yoke during motor formation can be increased, the space factor of the coils can be increased, and high torque can be obtained. A high-performance motor can be obtained. Further, when the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained.

[0071] Further, the ratio of the wirings in the total weight of the motor coil substrate **550** is 85.0% or more and 96.0% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.2 mm. When a motor is formed using the motor coil substrate **550** in which the ratio of the wirings in the total weight of the motor coil substrate **550** of the embodiment is 85.0% or more and 96.0% or less and the cylindricity of the outer circumferential surface (OC) is greater than 0.0 mm and equal to or less than 0.2 mm, the ratio of the wirings can be increased, the space factor of the coils can be increased, a predetermined cylindrical shape can be achieved, and high torque can be obtained. As a result, the adhesion strength with the yoke during motor formation can be increased, and stability can be improved. Therefore, even when it is operated as a motor, the motor coil substrate **550** is not positionally displaced, and a motor with stable performance can be obtained.

Further, when the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained.

[0072] The space factor of the coils in a cross section of the motor coil substrate **550** is 50% or more and 99% or less, and the ratio of the wirings in the total weight of the motor coil substrate **550** is 80.0% or more and 99.9% or less. In the motor coil substrate **550** of the embodiment, the space factor of the coils is 50% or more and 99% or less, and the ratio of the wirings in the total weight of the motor coil substrate **550** is 80.0% or more and 99.9% or less. By using the motor coil substrate, the space factor of the coils can be increased and high torque can be obtained. A high-performance motor can be obtained. Further, when the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained.

[0073] The space factor of the coils in a cross section of the motor coil substrate **550** is 50% or more and 99% or less, and the ratio of the wirings in the total weight of the motor coil substrate **550** is 85.0% or more and 96.0% or less. In the motor coil substrate **550** of the embodiment, the space factor of the coils is 50% or more and 99% or less, and the ratio of the wirings in the total weight of the motor coil substrate **550** is 85.0% or more and 96.0% or less. By using the motor coil substrate, the space factor of the coils can be increased and high torque can be obtained. A high-performance motor can be obtained. Further, when the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained.

[0074] The space factor of the coils in a cross section of the motor coil substrate **550** is 55% or more and 90% or less, and the ratio of the wirings in the total weight of the motor coil substrate **550** is 80.0% or more and 99.9% or less. In the motor coil substrate **550** of the embodiment, the space factor of the coils is 55% or more and 90% or less, and the ratio of the wirings in the total weight of the motor coil substrate **550** is 80.0% or more and 99.9% or less. By using the motor coil substrate, the space factor of the coils can be increased and high torque can be obtained. A high-performance motor can be obtained. Further, when the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained.

[0075] It is preferable that the space factor of the coils in a cross section of the motor coil substrate **550** is 55% or more and 90% or less, and the ratio of the wirings in the total weight of the motor coil substrate **550** is 85.0% or more and 96.0% or less. By using the motor coil substrate **550** in which the space factor of the coils is 55% or more and 90% or less and the ratio of the wirings in the total weight of the motor coil substrate **550** is 85.0% or more and 96.0% or less, the space factor of the coils can be increased and a high-torque motor can be obtained. A high-performance motor can be obtained. Further, when the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained.

[0076] The space factor of the coils in a cross section of the motor coil substrate **550** is 60% or more and 80% or less, and the ratio of the wirings in the total weight of the motor coil substrate **550** is 80.0% or more and 99.9% or less. In the motor coil substrate **550** of the embodiment, the space factor of the coils is 60% or more and 80% or less, and the ratio of the wirings in the total weight of the motor coil substrate **550** is 80.0% or more and 99.9% or less. By using the motor coil substrate, the space factor of the coils can be increased and high torque can be obtained. A high-performance motor can be obtained. Further, when the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained.

[0077] Further, it is preferable that the space factor of the coils in a cross section of the motor coil substrate **550** is 60% or more and 80% or less, and the ratio of the wirings in the total weight of the motor coil substrate **550** is 85.0% or more and 96.0% or less. Since the space factor of the coils is 60% or more and 80% or less, and the ratio of the wirings in the total weight of the motor coil substrate **550** is 85.0% or more and 96.0% or less, a high space factor of the coil conductors can be ensured, and when it is wound into a cylindrical shape, a predetermined cylindrical shape can be achieved. High torque can be obtained. A high-performance motor can be obtained. Further, a high space factor of the coil conductors can be ensured even in a small motor, and when it is wound into a cylindrical shape, a predetermined cylindrical shape can be achieved, torque can be increased, and a high-performance motor can be obtained. Further, when the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained.

[0078] The space factor of the coils in a cross section of the motor coil substrate **550** is 50% or more and 99% or less, the ratio of the wirings in the total weight of the motor coil substrate **550** is 80.0% or more and 99.9% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.3 mm. In the motor coil substrate **550** of the embodiment, the space factor of the coils is 50% or more and 99% or less, the ratio of the wirings in the total weight of the motor coil substrate **550** is 80.0% or more and 99.9% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.3 mm. When a motor is formed using the motor coil substrate, the space factor of the coils can be increased and high torque can be obtained. The adhesion strength with the yoke during motor formation can be increased, and high torque can be obtained. A high-performance motor can be obtained. Further, when the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained.

[0079] The space factor of the coils in a cross section of the motor coil substrate **550** is 50% or more and 99% or less, the ratio of the wirings in the total weight of the motor coil substrate **550** is 85.0% or more and 96.0% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.3 mm. In the motor coil substrate **550** of the embodiment, the space factor of the coils is 50% or more and 99% or less, the ratio of the wirings in the total weight of the motor coil substrate **550** is 85.0% or more and 96.0% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.3 mm. When a motor is formed using the motor coil substrate, the space factor of the coils can be increased and high torque can be obtained. The adhesion strength with the yoke during motor formation can be increased, and high torque can be obtained. A high-performance motor can be obtained. Further, when the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained.

[0080] The space factor of the coils in a cross section of the motor coil substrate **550** is 50% or more and 99% or less, the ratio of the wirings in the total weight of the motor coil substrate **550** is 80.0% or more and 99.9% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.2 mm. In the motor coil substrate **550** of the embodiment, the space factor of the coils is 50% or more and 99% or less, the ratio of the wirings in the total weight of the motor coil substrate **550** is 80.0% or more and 99.9% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.2 mm. When a motor is formed using the motor coil substrate, the space factor of the coils can be increased and high torque can be obtained. The adhesion strength with the yoke during motor formation can be increased, and high torque can be obtained. A high-performance motor can be obtained. Further, when the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained.

[0081] The space factor of the coils in a cross section of the motor coil substrate **550** is 50% or more and 99% or less, the ratio of the wirings in the total weight of the motor coil substrate **550** is 85.0% or more and 96.0% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.2 mm. In the motor coil substrate **550** of the embodiment, the space factor of the coils is 50% or more and 99% or less, the ratio of the wirings in the total weight of the motor coil substrate **550** is 85.0% or more and 96.0% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.2 mm. When a motor is formed using the motor coil substrate, the space factor of the coils can be increased and high torque can be obtained. The adhesion strength with the yoke during motor formation can be increased, and high torque can be obtained. A high-performance motor can be obtained. Further, when the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained.

[0082] Further, it is preferable that the space factor of the coils in a cross section of the motor coil substrate **550** is 55% or more and 90% or less, the ratio of the wirings in the total weight of the motor coil substrate **550** is 80.0% or more and 99.9% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.3 mm. By using the motor coil substrate **550** in which the space factor of the coils is 55% or more and 90% or less, the ratio of the wirings in the total weight of the motor coil substrate **550** is 80.0% or more and 99.9% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.3 mm, the space factor of the coils can be increased, a predetermined cylindrical shape can be achieved, and a high-torque motor can be obtained. Therefore, even when it is operated as a motor, a motor with stable performance can be obtained. Further, when the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained.

[0083] Further, it is preferable that the space factor of the coils in a cross section of the motor coil substrate **550** is 55% or more and 90% or less, the ratio of the wirings in the total weight of the motor coil substrate **550** is 85.0% or more and 96.0% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.3 mm. By using the motor coil substrate **550** in which the space factor of the coils is 55% or more and 90% or less, the ratio of the wirings in the total weight of the motor coil substrate **550** is 85.0% or more and 96.0% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.3 mm, the space factor of the coils can be increased, a predetermined cylindrical shape can be achieved, and a high-torque motor can be obtained. Therefore, even when it is operated as a motor, a motor with stable performance can be obtained. Further, when the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained.

[0084] Further, it is preferable that the space factor of the coils in a cross section of the motor coil substrate **550** is 55% or more and 90% or less, the ratio of the wirings in the total weight of the motor coil substrate **550** is 80.0% or more and 99.9% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.2 mm. By using the motor coil substrate **550** in which the space factor of the coils is 55% or more and 90% or less, the ratio of the wirings in the total weight of the motor coil substrate **550** is 80.0% or more and 99.9% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.2 mm, the space factor of the coils can be increased, a predetermined cylindrical shape can be achieved, and a high-torque motor can be obtained. Therefore, even when it is operated as a motor, a motor with stable performance can be obtained. Further, when the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained.

[0085] Further, it is preferable that the space factor of the coils in a cross section of the motor coil substrate **550** is 55% or more and 90% or less, the ratio of the wirings in the total weight of the motor coil substrate **550** is 85.0% or more and 96.0% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.2 mm. By using the motor coil substrate **550** in which the space factor of the coils is 55% or more and 90% or less, the ratio of the wirings in the total weight of the motor coil substrate **550** is 85.0% or more and 96.0% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.2 mm, the space factor of the coils can be increased, a predetermined cylindrical shape can be achieved, and a high-torque motor can be obtained. Therefore, even when it is operated as a motor, a motor with stable performance can be obtained. Further, when the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained.

[0086] It is preferable that the space factor of the coils in a cross section of the motor coil substrate **550** is 60% or more and 80% or less, the ratio of the wirings in the total weight of the motor coil substrate **550** is 80.0% or more and 99.0% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0mm and equal to or less than 0.3 mm. By using the motor coil substrate **550** in which the space factor of the coils is 60% or more and 80% or less, the ratio of the wirings in the total weight of the motor coil substrate **550** is 80.0% or more and 99.9% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.3 mm, the space factor of the coils can be increased, a predetermined cylindrical shape can be achieved, and a high-torque motor can be obtained. Therefore, even when it is operated as a motor, a motor with stable performance can be obtained. Further, when the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained.

[0087] It is preferable that the space factor of the coils in a cross section of the motor coil substrate **550** is 60% or more and 80% or less, the ratio of the wirings in the total weight of the motor coil substrate **550** is 85.0% or more and 96.0% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.3 mm. Since the space factor of the coils is 60% or more and 80% or less, the ratio of the wirings in the total weight of the motor coil substrate **550** is 85.0% or more and 96.0% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.3 mm, a high space factor of the coil conductors can be ensured, and when it is wound into a cylindrical shape, a predetermined cylindrical shape can be achieved. High torque can be obtained. As a result, the adhesion strength with the yoke during motor formation can be increased. Therefore, even when it is operated as a motor, a motor with stable performance can be obtained. When the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained.

[0088] It is preferable that the space factor of the coils in a cross section of the motor coil substrate **550** is 60% or more and 80% or less, the ratio of the wirings in the total weight of the motor coil substrate **550** is 80.0% or more and 99.0% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.2 mm. By using the motor coil substrate **550** in which the space factor of the coils is 60% or more and 80% or less, the ratio of the wirings in the total weight of the motor coil substrate **550** is 80.0% or more and 99.9% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.2 mm, the space factor of the coils can be increased, a predetermined cylindrical shape can be achieved, and a high-torque motor can be obtained. Therefore, even when it is operated as a motor, a motor with stable performance can be obtained. Further, when the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained.

[0089] It is preferable that the space factor of the coils in a cross section of the motor coil substrate **550** is 60% or more and 80% or less, the ratio of the wirings in the total weight of the motor coil substrate **550** is 85.0% or more and 96.0% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.2 mm. Since the space factor of the coils is 60% or more and 80% or less, the ratio of the wirings in the total weight of the motor coil substrate **550** is 85.0% or more and 96.0% or less, and the cylindricity of the outer circumferential surface (OC) of the motor coil substrate **550** is greater than 0.0 mm and equal to or less than 0.2 mm, a high space factor of the coil conductors can be ensured, and when it is wound into a cylindrical shape, a predetermined cylindrical shape can be achieved. High torque can be obtained. As a result, the adhesion strength with the yoke during motor formation can be increased, and stability can be improved. Therefore, even when it is operated as a motor, the motor coil substrate **550** is not positionally displaced, and a motor with stable performance can be obtained. When the motor coil substrate **550** of the embodiment is applied to a small motor, torque can be increased, and a high-performance motor can be obtained.

[0090] The motor coil substrate **550** of the embodiment is used in a slotless motor. In another example, the motor coil substrate **550** may be used in a motor other than a slotless motor.

[0091] A diameter of the outer circumferential surface (OC) (outer diameter of a cross section) of the motor coil substrate **550** is 50 mm or less. The diameter of the outer circumferential surface (OC) (outer diameter of a cross section) of the motor coil substrate **550** is preferably 30 mm or less. By forming a small motor using a motor coil substrate **550** with a diameter of 50 mm or less, degradation in motor performance can be effectively suppressed. The diameter of the outer circumferential surface (OC) of the motor coil substrate **550** is measured using a caliper. In the embodiment illustrated in FIG. **1**, the space factor of the coils in a cross-sectional area of the motor coil substrate **550** is 70%. The ratio of the wirings in the total weight of the motor coil substrate **550** is 93%.

[0092] The cylindricity of the outer circumferential surface (OC) is 0.1 mm. The diameter of the outer circumferential surface (OC) (outer diameter of a cross section) of the motor coil substrate **550** is 16 mm.

[0093] FIG. **9** is a cross-sectional view schematically illustrating a motor **600** formed using the motor coil substrate **550** of the embodiment (FIGS. **6-8**). The motor **600** is formed by positioning the motor coil substrate **550** on an inner side of a yoke **560**, and positioning a rotation shaft **580** and a magnet **570** fixed to the rotation shaft **580** on an inner side of the motor coil substrate **550**. The motor **600** of the embodiment is a slotless motor.

[0094] In the above, the structures of the coil substrate **2** (FIGS. **1-5**), the motor coil substrate **550** (FIGS. **6-8**), and the motor **600** (FIG. **9**) of the embodiment have been described. As described above, the space factor of the coils (**20**U, **20**V, **20**W) in a cross section of the motor coil substrate **550** of the embodiment is 50% or more and 99% or less. A high space factor is ensured. Therefore, when the motor **600** is formed using the motor coil substrate **550** of the embodiment, high torque can be obtained. A high-performance motor **600** can be obtained.

Modified Example

[0095] FIGS. **10** and **11** illustrate a modified example of the embodiment. FIG. **10** is a plan view illustrating a coil substrate **102** of the modified example. FIG. **11** is a bottom view illustrating the coil substrate **102** of the modified example. As illustrated in FIGS. **10** and **11**, in the modified example, the formation of the wirings of the coils (**31**U, **31**V, **31**W) that form the U-phase coil (**20**U), the V-phase coil (**20**V), and the W-phase coil (**20**W) is different from that of the embodiment.

[0096] In FIGS. **10** and **11**, only the coils (**31**U, **31**V, **31**W) are illustrated as the coils forming the U-phase coil (**20**U), the V-phase coil (**20**V), and the W-phase coil (**20**W). However, in reality, the U-phase coil (**20**U), the V-phase coil (**20**V), and the W-phase coil (**20**W) may be formed of multiple coils including the coils (**31**U, **31**V, **31**W). Further, in FIGS. **10** and **11**, the U-phase terminal (**40**U), the V-phase terminal (**40**V), the W-phase terminal (**40**W), the inter-coil connection wirings (**50**U, **50**V, **50**W), the multiple inter-phase connection wirings (**60**U, **60**V), and the return wiring (**70**W) are omitted from the illustration.

[0097] The coil (**31**U) forming the U-phase coil (**20**U) is formed of a coil-shaped first wiring (**30**UF) provided on the first surface (**10**F) (FIG. **10**) and a coil-shaped second wiring (**30**UB) provided on the second surface (**10**B) (FIG. **11**). The first wiring (**30**UF) and the second wiring (**30**UB) are electrically connected via a via conductor (**81**U) penetrating the flexible substrate **10**. Similarly, the coil (**20**V) forming the V phase is formed of a first wiring (**30**VF) and a second wiring (**30**VB). The first wiring (**30**VF) and the second wiring (**30**VB) are electrically connected via a via conductor (**81**V). The coil (**20**W) forming the W phase is formed of a first wiring (**30**WF) and a second wiring (**30**WB). The first wiring (**30**WF) and the second wiring (**30**WB) are electrically connected via a via conductor (**81**W).

[0098] As illustrated in FIG. **10**, the first wiring (**30**UF) is formed in a clockwise spiral shape (hexagonal spiral shape) from an outer circumference toward an inner circumference. The via conductor (**81**U) is formed at an inner circumference side end of the first wiring (**30**UF). As illustrated in FIG. **11**, the second wiring (**30**UB) is formed in a counterclockwise spiral shape (hexagonal spiral shape) from an outer circumference toward an inner circumference. The via conductor (**81**U) is formed at an inner circumference side end of the second wiring (**30**UB). The first wiring (**30**UF) and the second wiring (**30**UB) are formed in spiral shapes wound in the same direction when viewed from the same surface. The first wiring (**30**UF) and the second wiring (**30**UB) overlap via the flexible substrate **10**. The first wiring (**30**UF) and the second wiring (**30**UB) are electrically connected in series and function as one coil (**31**U).

[0099] The first wiring (**30**VF) and the second wiring (**30**VB), as well as the first wiring (**30**WF) and the second wiring (**30**WB), have the same relationship as the first wiring (**30**UF) and the second wiring (**30**UB) described above. The first wiring (**30**VF) and the second wiring (**30**VB) are formed in spiral shapes wound in the same direction when viewed from the same surface. The first wiring (**30**VF) and the second wiring (**30**VB) overlap via the flexible substrate **10**. The first wiring (**30**VF) and the second wiring (**30**VB) are electrically connected in series and function as one coil (**31**V). The first wiring (**30**WF) and the second wiring (**30**WB) are formed in spiral shapes wound in the same direction when viewed from the same surface. The first wiring (**30**WF) and the second wiring (**30**WB) overlap via the flexible substrate **10**. The first wiring (**30**WF) and the second wiring (**30**WB) are electrically connected in series and function as one coil (**31**W).

[0100] Although not illustrated, the first surface (**10**F) and the first wirings (**30**UF, **30**VF, **30**WF) are covered with a resin insulation layer. Similarly, the second surface (**10**B) and the second wirings (**30**UB, **30**VB, **30**WB) are covered with a resin insulation layer. In the present specification, a small motor refers to a motor with an outer diameter of 50 mm or less.

[0101] As illustrated in FIGS. **10** and **11**, in the modified example, the wirings of the coils (**20**U, **20**V, **20**W) are each formed in a hexagonal shape. In other examples, the wirings of the coils (**20**U, **20**V, **20**W) may be formed in any shape, such as a circle (perfect circle, ellipse), a triangle, a quadrangle (square, rectangle, rhombus), a pentagon, or a polygon with seven or more sides. Further, it is not limited to having identical wiring formation shapes for all the coils; the wiring formation shapes may differ between the coils.

[0102] The coil substrate **102** of the modified example can be manufactured using any method. For example, the coil substrate **2** may be formed using a tenting method using a flexible substrate having a conductor layer (metal foil) as a starting material. In another example, the coil substrate **102** may be obtained by forming a metal layer on a flexible substrate using a printing or dispensing method. In yet another example, the coil substrate **102** may be obtained by forming a flexible material and a metal layer using a 3D printer.

[0103] A motor coil substrate **550** for a motor is formed by winding the coil substrate **102** of the modified example into a cylindrical shape (see FIGS. **6**-**8**). The motor coil substrate **550** formed using the coil substrate **102** of the modified example has the same characteristics as the motor coil substrate **550** of the embodiment. Therefore, the motor coil substrate **550** of the modified example can achieve the same effect as the motor coil substrate **550** of the embodiment. In the modified example illustrated in FIGS. **10** and **11**, the space factor of the coils in a cross-sectional area of the motor coil substrate **550** is 65%. The ratio of the wirings in the total weight of the motor coil substrate **550** is 91%. The cylindricity of the outer circumferential surface (OC) (see FIG. **7**) is 0.1 mm. The diameter of the outer circumferential surface (OC) (outer diameter of a cross section) of the motor coil substrate **550** is 16 mm.

[0104] Japanese Patent Application Laid-Open Publication No. 2022-65910 describes a coil substrate having a flexible substrate and spiral-shaped coils formed on both sides of the flexible substrate. A motor coil substrate is formed by winding the coil substrate into a cylindrical shape. A motor is formed by positioning the formed motor coil substrate on an inner side of a cylindrical yoke, and positioning a rotation shaft and a magnet on an inner side of the motor coil substrate.

[0105] A motor coil substrate according to an embodiment of the present invention includes: a flexible substrate having a first surface and a second surface on the opposite side with respect to the first surface; and multiple coils formed by wirings provided on the first surface and the second surface. The motor coil substrate is formed into a cylindrical shape by being wound circumferentially around an axis extending in a direction perpendicular to a longitudinal direction of the flexible substrate, starting from a first end of the longitudinal direction of the flexible substrate. A space factor of the coils in a cross section of the motor coil substrate is 50% or more and 99% or less.

[0106] In a motor coil substrate according to an embodiment of the present invention, the space factor of the coils in the cross section of the motor coil substrate is 50% or more and 99% or less. A high space factor is ensured. Therefore, when a motor is formed using a motor coil substrate according to an embodiment of the present invention, high torque can be obtained. A high-performance motor can be obtained. Further, torque can be increased even in a small motor, and a high-performance motor can be obtained.

[0107] In a motor coil substrate according to an embodiment of the present invention, the space factor of the coils in a cross section of the motor coil substrate may be 55% or more and 90% or less. By using a motor coil substrate with a coil space factor of 55% or more and 90% or less, a high-torque motor can be obtained.

[0108] In a motor coil substrate according to an embodiment of the present invention, the space factor of the coils in a cross section of the motor coil substrate may be 60% or more and 80% or less. A high space factor of the coil conductors can be ensured, and when it is wound into a cylindrical shape, a predetermined cylindrical shape can be achieved.

[0109] In a motor coil substrate according to an embodiment of the present invention, the space factor of the coils in a cross section of the motor coil substrate may be 50% or more and 99% or less, and the cylindricity of the outer circumferential surface of the motor coil substrate may be greater than 0.0 mm and equal to or less than 0.3 mm. The adhesion strength with the yoke during motor formation can be increased, and high torque can be obtained.

[0110] In a motor coil substrate according to an embodiment of the present invention, the space factor of the coils in a cross section of the motor coil substrate may be 55% or more and 90% or less, and the cylindricity of the outer circumferential surface of the motor coil substrate may be greater than 0.0 mm and equal to or less than 0.3 mm. The adhesion strength with the yoke during motor formation can be increased, and a high-torque motor can be obtained. A high-performance motor can be obtained.

[0111] In a motor coil substrate according to an embodiment of the present invention, the space factor of the coils in a cross section of the motor coil substrate may be 60% or more and 80% or less, and the cylindricity of the outer circumferential surface of the motor coil substrate may be greater than 0.0 mm and equal to or less than 0.3 mm. A high space factor of the coil conductors can be ensured, and when it is wound into a cylindrical shape, a predetermined cylindrical shape can be achieved. The adhesion strength with the yoke during motor formation can be increased, and high torque can be obtained. A high-performance motor can be obtained.

[0112] In a motor coil substrate according to an embodiment of the present invention, the space factor of the coils in a cross section of the motor coil substrate may be 50% or more and 99% or less, and the cylindricity of the outer circumferential surface of the motor coil substrate may be greater than 0.0 mm and equal to or less than 0.2 mm. When the cylindricity of the outer circumferential surface of the motor coil substrate during motor formation is greater than 0.0 mm and equal to or less than 0.2 mm, the adhesion strength with the yoke can be increased, and since the space factor of the coils of the motor coil substrate is high at 50% or more and 99% or less, high torque can be obtained. Further, even when it is operated as a motor, the motor coil substrate is not positionally displaced, and a motor with stable performance can be obtained.

[0113] In a motor coil substrate according to an embodiment of the present invention, the space factor of the coils in a cross section of the motor coil substrate may be 55% or more and 90% or less, and the cylindricity of the outer circumferential surface of the motor coil substrate may be greater than 0.0 mm and equal to or less than 0.2 mm. When the cylindricity of the outer circumferential surface of the motor coil substrate during motor formation is greater than 0.0 mm and equal to or less than 0.2 mm, the adhesion strength with the yoke can be increased, and since the space factor of the coils of the motor coil substrate is high at 55% or more and 90% or less, high torque can be obtained. Further, even when it is operated as a motor, the motor coil substrate is not positionally displaced, and a motor with stable performance can be obtained.

[0114] In a motor coil substrate according to an embodiment of the present invention, the space factor of the coils in a cross section of the motor coil substrate may be 60% or more and 80% or less, and the cylindricity of the outer circumferential surface of the motor coil substrate may be greater than 0.0 mm and equal to or less than 0.2 mm. When the cylindricity of the outer circumferential surface of the motor coil substrate during motor formation is greater than 0.0 mm and equal to or less than 0.2 mm, adhesion strength with a yoke can be increased, and since the space factor of the coils of the motor coil substrate is high at 60% or more and 80% or less, high torque can be obtained. Further, when it is wound into a cylinder, a predetermined cylindrical shape can be achieved. Further, even when it is operated as a motor, the motor coil substrate is not positionally displaced, and a motor with stable performance can be obtained.

[0115] In a motor coil substrate according to an embodiment of the present invention, the space factor of the coils in a cross section of the motor coil substrate may be 50% or more and 99% or less, and a ratio of the wirings in a total weight of the motor coil substrate may be 80.0% or more and 99.9% or less. The space factor of the coils can be increased, and high torque can be obtained. A high-performance motor can be obtained.

[0116] In a motor coil substrate according to an embodiment of the present invention, the space factor of the coils in a cross section of the motor coil substrate may be 50% or more and 99% or less, and the ratio of the wirings in the total weight of the motor coil substrate may be 85.0% or more and 96.0% or less. Since the space factor of the coils is 50% or more and 99% or less and the ratio of the wirings in the total weight of the motor coil substrate is 85.0% or more and 96.0% or less, the space factor of the coils in the motor coil substrate can be increased and a high-torque motor can be obtained. A high-performance motor can be obtained. Further, when it is wound into a cylinder, a predetermined cylindrical shape can be achieved.

[0117] In a motor coil substrate according to an embodiment of the present invention, the space factor of the coils in a cross section of the motor coil substrate may be 55% or more and 90% or less, and the ratio of the wirings in the total weight of the motor coil substrate may be 80.0% or more and 99.9% or less. Since the space factor of the coils is 55% or more and 90% or less and the ratio of the wirings in the total weight of the motor coil substrate is 80.0% or more and 99.9% or less, the space factor of the coils in the motor coil substrate can be increased and a high-torque motor can be obtained. A high-performance motor can be obtained.

[0118] In a motor coil substrate according to an embodiment of the present invention, the space factor of the coils in a cross section of the motor coil substrate may be 55% or more and 90% or less, and the ratio of the wirings in the total weight of the motor coil substrate may be 85.0% or more and 96.0% or less. The space factor of the coils can be increased, and a high-torque motor can be obtained. A high-performance motor can be obtained. Further, when it is wound into a cylinder, a predetermined cylindrical shape can be achieved.

[0119] In a motor coil substrate according to an embodiment of the present invention, the space factor of the coils in a cross section of the motor coil substrate may be 60% or more and 80% or less, and the ratio of the wirings in the total weight of the motor coil substrate may be 80.0% or more and 99.9% or less. A high space factor of the coil conductors can be ensured, and when it is wound into a cylindrical shape, a predetermined cylindrical shape can be achieved. High torque can be obtained. A high-performance motor can be obtained.

[0120] In a motor coil substrate according to an embodiment of the present invention, the space factor of the coils in a cross section of the motor coil substrate may be 60% or more and 80% or less, and the ratio of the wirings in the total weight of the motor coil substrate may be 85.0% or more and 96.0% or less. A high space factor of the coil conductors can be ensured, and when it is wound into a cylindrical shape, a predetermined cylindrical shape can be achieved. High torque can be obtained. A high-performance motor can be obtained.

[0121] In a motor coil substrate according to an embodiment of the present invention, the space factor of the coils in a cross section of the motor coil substrate may be 50% or more and 99% or less, the ratio of the wirings in the total weight of the motor coil substrate may be 80.0% or more and 99.9% or less, and the cylindricity of the outer circumferential surface of the motor coil substrate may be greater than 0.0 mm and less than 0.3 mm. The space factor of the coils can be increased, and high torque can be obtained. The adhesion strength with the yoke during motor formation can be increased, and high torque can be obtained. A high-performance motor can be obtained.

[0122] In a motor coil substrate according to an embodiment of the present invention, the space factor of the coils in a cross section of the motor coil substrate may be 50% or more and 99% or less, the ratio of the wirings in the total weight of the motor coil substrate may be 85.0% or more and 96.0% or less, and the cylindricity of the outer circumferential surface of the motor coil substrate may be greater than 0.0 mm and less than 0.3 mm. The space factor of the coils can be increased, and high torque can be obtained. The adhesion strength with the yoke during motor formation can be increased, and high torque can be obtained. A high-performance motor can be obtained. Further, when it is wound into a cylinder, a predetermined cylindrical shape can be achieved.

[0123] In a motor coil substrate according to an embodiment of the present invention, the space factor of the coils in a cross section of the motor coil substrate may be 50% or more and 99% or less, the ratio of the wirings in the total weight of the motor coil substrate may be 80.0% or more and 99.9% or less, and the cylindricity of the outer circumferential surface of the motor coil substrate may be greater than 0.0 mm and less than 0.2 mm. The space factor of the coils can be increased, and high torque can be obtained. The adhesion strength with the yoke during motor formation can be increased, and high torque can be obtained. A high-performance motor can be obtained. Further, even when it is operated as a motor, the motor coil substrate is not positionally displaced, and a motor with stable performance can be obtained.

[0124] In a motor coil substrate according to an embodiment of the present invention, the space factor of the coils in a cross section of the motor coil substrate may be 50% or more and 99% or less, the ratio of the wirings in the total weight of the motor coil substrate may be 85.0% or more and 96.0% or less, and the cylindricity of the outer circumferential surface of the motor coil substrate may be greater than 0.0 mm and less than 0.2 mm. The space factor of the coils can be increased, and high torque can be obtained. The adhesion strength with the yoke during motor formation can be increased, and high torque can be obtained. A high-performance motor can be obtained. Further, even when it is operated as a motor, the motor coil substrate is not positionally displaced, and a motor with stable performance can be obtained.

[0125] In a motor coil substrate according to an embodiment of the present invention, the space factor of the coils in a cross section of the motor coil substrate may be 55% or more and 90% or less, the ratio of the wirings in the total weight of the motor coil substrate may be 80.0% or more and 99.9% or less, and the cylindricity of the outer circumferential surface of the motor coil substrate may be greater than 0.0 mm and less than 0.3 mm. The space factor of the coils can be increased, a specified cylindrical shape can be achieved, and a high-torque motor can be obtained. Therefore, even when it is operated as a motor, a motor with stable performance can be obtained.

[0126] In a motor coil substrate according to an embodiment of the present invention, the space factor of the coils in a cross section of the motor coil substrate may be 55% or more and 90% or less, the ratio of the wirings in the total weight of the motor coil substrate may be 85.0% or more and 96.0% or less, and the cylindricity of the outer circumferential surface of the motor coil substrate may be greater than 0.0 mm and less than 0.3 mm. The space factor of the coils can be increased, a specified cylindrical shape can be achieved, and a high-torque motor can be obtained. Therefore, even when it is operated as a motor, a motor with stable performance can be obtained.

[0127] In a motor coil substrate according to an embodiment of the present invention, the space factor of the coils in a cross section of the motor coil substrate may be 55% or more and 90% or less, the ratio of the wirings in the total weight of the motor coil substrate may be 80.0% or more and 99.9% or less, and the cylindricity of the outer circumferential surface of the motor coil substrate may be greater than 0.0 mm and less than 0.2 mm. The space factor of the coils can be increased, a specified cylindrical shape can be achieved, and a high-torque motor can be obtained. Therefore, even when it is operated as a motor, a motor with stable performance can be obtained.

[0128] In a motor coil substrate according to an embodiment of the present invention, the space factor of the coils in a cross section of the motor coil substrate may be 55% or more and 90% or less, the ratio of the wirings in the total weight of the motor coil substrate may be 85.0% or more and 96.0% or less, and the cylindricity of the outer circumferential surface of the motor coil substrate may be greater than 0.0 mm and less than 0.2 mm. The space factor of the coils can be increased, a specified cylindrical shape can be achieved, and a high-torque motor can be obtained. Therefore, even when it is operated as a motor, a motor with stable performance can be obtained.

[0129] In a motor coil substrate according to an embodiment of the present invention, the space factor of the coils in a cross section of the motor coil substrate may be 60% or more and 80% or less, the ratio of the wirings in the total weight of the motor coil substrate may be 80.0% or more and 99.9% or less, and the cylindricity of the outer circumferential surface of the motor coil substrate may be greater than 0.0 mm and less than 0.3 mm. A high space factor of the coil conductors can be ensured, and when it is wound into a cylindrical shape, a predetermined cylindrical shape can be achieved. High torque can be obtained.

[0130] In a motor coil substrate according to an embodiment of the present invention, the space factor of the coils in a cross section of the motor coil substrate may be 60% or more and 80% or less, the ratio of the wirings in the total weight of the motor coil substrate may be 85.0% or more and 96.0% or less, and the cylindricity of the outer circumferential surface of the motor coil substrate may be greater than 0.0 mm and less than 0.3 mm. A high space factor of the coil conductors can be ensured, and when it is wound into a cylindrical shape, a predetermined cylindrical shape can be achieved. High torque can be obtained.

[0131] In a motor coil substrate according to an embodiment of the present invention, the space factor of the coils in a cross section of the motor coil substrate may be 60% or more and 80% or less, the ratio of the wirings in the total weight of the motor coil substrate may be 80.0% or more and 99.9% or less, and the cylindricity of the outer circumferential surface of the motor coil substrate may be greater than 0.0 mm and less than 0.2 mm. A high space factor of the coil conductors can be ensured, and when it is wound into a cylindrical shape, a predetermined cylindrical shape can be achieved. High torque can be obtained.

[0132] In a motor coil substrate according to an embodiment of the present invention, the space factor of the coils in a cross section of the motor coil substrate may be 60% or more and 80% or less, the ratio of the wirings in the total weight of the motor coil substrate may be 85.0% or more and 96.0% or less, and the cylindricity of the outer circumferential surface of the motor coil substrate may be greater than 0.0 mm and less than 0.2 mm. A high space factor of the coil conductors can be ensured, and when it is wound into a cylindrical shape, a predetermined cylindrical shape can be achieved. High torque can be obtained. As a result, the adhesion strength with the yoke during motor formation can be increased, and stability can be improved.

[0133] In a motor coil substrate according to an embodiment of the present invention, it is also possible that the outer circumferential surface of the motor coil substrate is formed by the flexible substrate, and the wirings are not exposed.

[0134] In a motor coil substrate according to an embodiment of the present invention, an insulating layer that covers the wirings may be formed on an outermost circumference of the motor coil substrate.

[0135] In a motor coil substrate according to an embodiment of the present invention, the coils may each have a half-turn first wiring formed on the first surface, a half-turn second wiring formed on the second surface, and a via conductor connecting the first wiring and the second wiring.

[0136] In a motor coil substrate according to an embodiment of the present invention, the coils may each have a first wiring formed in a spiral shape on the first surface, a second wiring formed in a spiral shape on the second surface, and a via conductor connecting the first wiring and the second wiring.

[0137] In a motor coil substrate according to an embodiment of the present invention, the motor coil substrate may have an outer diameter of 50 mm or less.

[0138] In a motor coil substrate according to an embodiment of the present invention, the motor coil substrate may have an outer diameter of 30 mm or less.

[0139] In a motor coil substrate according to an embodiment of the present invention, the motor coil substrate may be used in a slotless motor.

[0140] A motor according to an embodiment of the present invention is formed by positioning an above motor coil substrate according to an embodiment of the present invention on an inner side of a cylindrical yoke, and positioning a rotation shaft and a magnet on an inner side of the motor coil substrate.

[0141] In a motor according to an embodiment of the present invention, the space factor of the coils in the cross section of the motor coil substrate is 50% or more and 99% or less. A high space factor of the coil conductors is ensured. Therefore, high torque can be obtained. A high-performance motor can be obtained. Further, torque can be increased even in a small motor, and a high-performance motor can be obtained.

[0142] Obviously, numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

1. A motor coil substrate, comprising:

a flexible substrate; and

a plurality of coils comprising a plurality of wirings such that the wirings are formed on a first surface of the flexible substrate and a second surface on an opposite side with respect to the first surface,

wherein the flexible substrate is configured to be wound circumferentially from one end of a longitudinal direction of a flexible substrate around an axis extending in a direction perpendicular to the longitudinal direction of the flexible substrate such that the flexible substrate is formed into a cylindrical shape, and the plurality of coils is formed such that a space factor of the coils in a cross section of the motor coil substrate is in a range of 50% to 99%.

2. The motor coil substrate according to claim **1**, wherein the plurality of coils is formed such that the space factor of the coils is in a range of 55% to 90%.

3. The motor coil substrate according to claim **1**, wherein the plurality of coils is formed such that the space factor of the coils is in a range of 60% to 80%.

4. The motor coil substrate according to claim **1**, wherein the plurality of coils is formed such that the space factor of the coils is in a range of 50% to 99%, and the flexible substrate is configured to be wound circumferentially around the axis extending in the direction perpendicular to the longitudinal direction of the flexible substrate such that a cylindricity of an outer circumferential surface of the motor coil substrate is greater than 0.0 mm and equal to or less than 0.3 mm.

5. The motor coil substrate of claim **1**, wherein the plurality of coils is formed such that the space factor of the coils is in a range of 50% to 99% and that a ratio of the wirings in a total weight of the motor coil substrate is in a range of 80.0% to 99.9%.

6. The motor coil substrate according to claim **1**, wherein the plurality of coils is formed such that the space factor of the coils is in a range of 50% to 99% and that a ratio of the wirings in a total weight of the motor coil substrate is in a range of 80.0% to 99.9%, and the flexible substrate is configured to be wound circumferentially around the axis extending in the direction perpendicular to the longitudinal direction of the flexible substrate such that a cylindricity of an outer circumferential surface of the motor coil substrate is greater than 0.0 mm and equal to or less than 0.3 mm.

7. The motor coil substrate according to claim **1**, wherein the flexible substrate is configured to be wound circumferentially around the axis extending in the direction perpendicular to the longitudinal direction of the flexible substrate such that the outer circumferential surface is formed by the flexible substrate and that the wirings are not exposed.

8. The motor coil substrate according to claim **1**, further comprising:

an insulating layer covering the plurality of wirings such that the insulating layer is formed on an outermost circumference of the motor coil substrate.

9. The motor coil substrate according to claim **1**, wherein the plurality of coils is formed such that each of the coils has a half-turn first wiring formed on the first surface, a half-turn second wiring formed on the second surface, and a via conductor connecting the first wiring and the second wiring.

10. The motor coil substrate according to claim **1**, wherein the plurality of coils is formed such that each of the coils has a first wiring formed in a spiral shape on the first surface of the flexible substrate, a second wiring formed in a spiral shape on the second surface of the flexible substrate, and a via conductor connecting the first wiring and the second wiring through the flexible substrate.

11. A slotless motor, comprising:

the motor coil substrate of claim **1**.

12. The motor coil substrate according to claim **1**, wherein the flexible substrate is configured to be wound circumferentially around the axis extending in the direction perpendicular to the longitudinal direction of the flexible substrate such that the motor coil substrate has a cross section having an outer diameter of 50 mm or less.

13. The motor coil substrate according to claim **1**, wherein the flexible substrate is configured to be wound circumferentially around the axis extending in the direction perpendicular to the longitudinal direction of the flexible substrate such that the motor coil substrate has a cross section having an outer diameter of 30 mm or less.

14. A motor, comprising:

a cylindrical yoke;

a motor coil substrate positioned on an inner side of the cylindrical yoke;

a magnet positioned on an inner side of the motor coil substrate; and

a rotation shaft positioned on the inner side of the motor coil substrate,

wherein the motor coil substrate is the motor coil substrate of claim **1**.

15. The motor coil substrate according to claim **7**, further comprising:

an insulating layer covering the plurality of wirings such that the insulating layer is formed on an outermost circumference of the motor coil substrate.

16. The motor coil substrate according to claim **7**, wherein the plurality of coils is formed such that each of the coils has a half-turn first wiring formed on the first surface, a half-turn second wiring formed on the second surface, and a via conductor connecting the first wiring and the second wiring.

17. The motor coil substrate according to claim **7**, wherein the plurality of coils is formed such that each of the coils has a first wiring formed in a spiral shape on the first surface of the flexible substrate, a second wiring formed in a spiral shape on the second surface of the flexible substrate, and a via conductor connecting the first wiring and the second wiring through the flexible substrate.

18. The motor coil substrate according to claim **8**, wherein the plurality of coils is formed such that each of the coils has a half-turn first wiring formed on the first surface, a half-turn second wiring formed on the second surface, and a via conductor connecting the first wiring and the second wiring.

19. The motor coil substrate according to claim **8**, wherein the plurality of coils is formed such that each of the coils has a first wiring formed in a spiral shape on the first surface of the flexible substrate, a second wiring formed in a spiral shape on the second surface of the flexible substrate, and a via conductor connecting the first wiring and the second wiring through the flexible substrate.

20. The motor coil substrate according to claim **9**, wherein the plurality of coils is formed such that each of the coils has a first wiring formed in a spiral shape on the first surface of the flexible substrate, a second wiring formed in a spiral shape on the second surface of the flexible substrate, and a via conductor connecting the first wiring and the second wiring through the flexible substrate.

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