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(54) **OPTICAL ELEMENT DRIVING MECHANISM**

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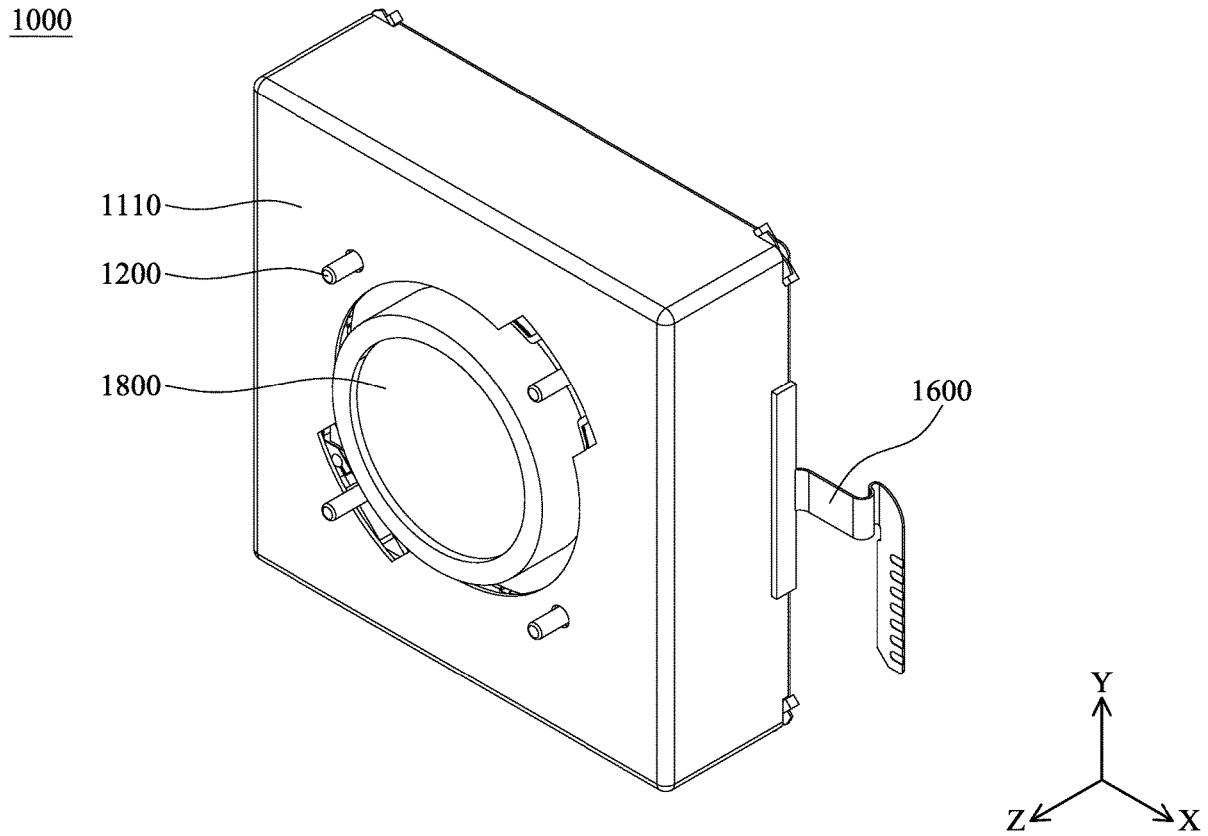
(52) **U.S. Cl.**

CPC ***H04N 23/687*** (2023.01); ***H04N 23/40*** (2023.01); ***H04N 23/55*** (2023.01)

(57) **ABSTRACT**

An optical element driving mechanism is provided. The optical element driving mechanism includes a movable portion, a fixed portion, and a driving assembly. The movable portion is used to connect the optical element. The movable portion may move relative to the fixed portion. The driving assembly is used to drive the movable portion to move relative to the fixed portion.



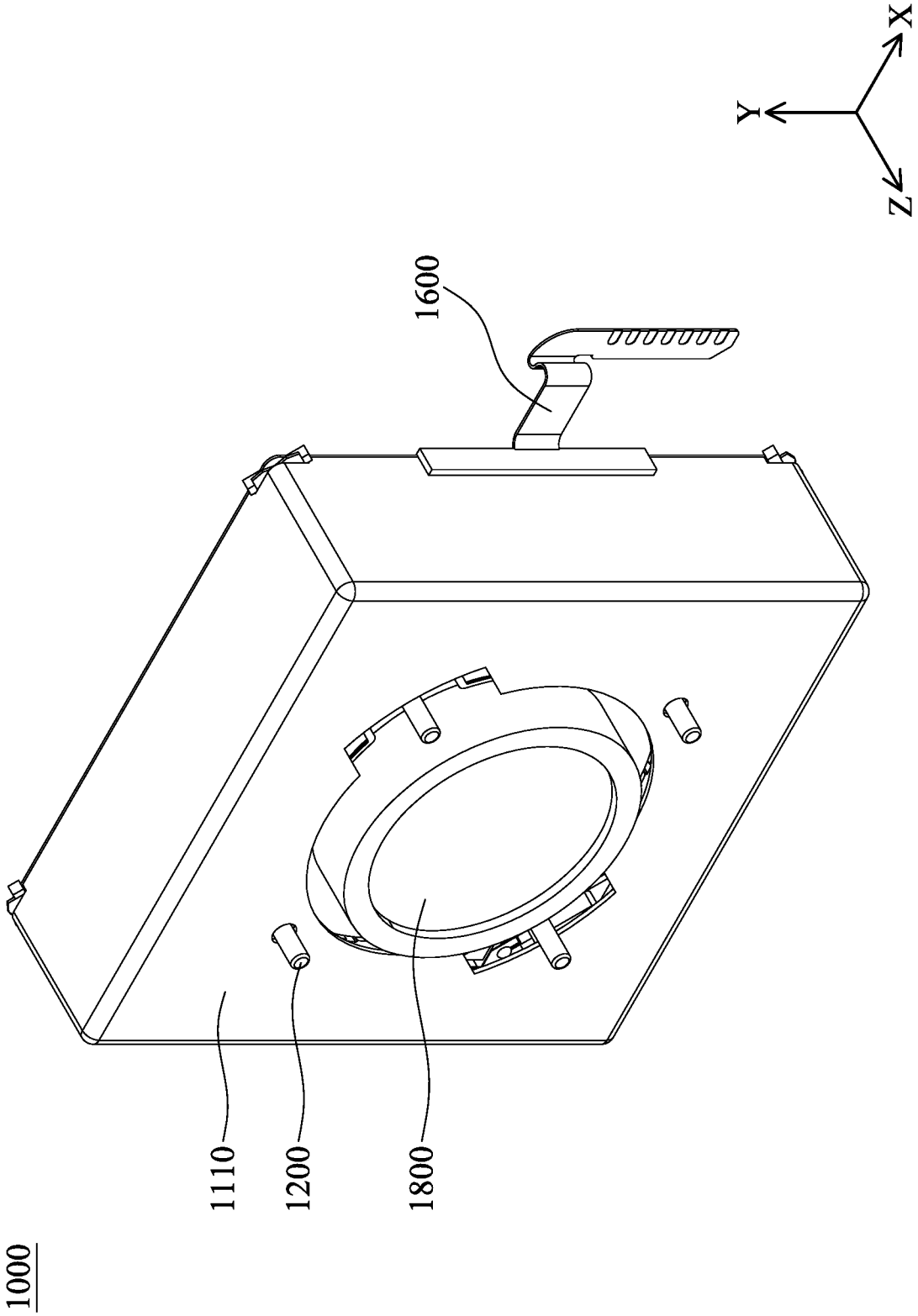
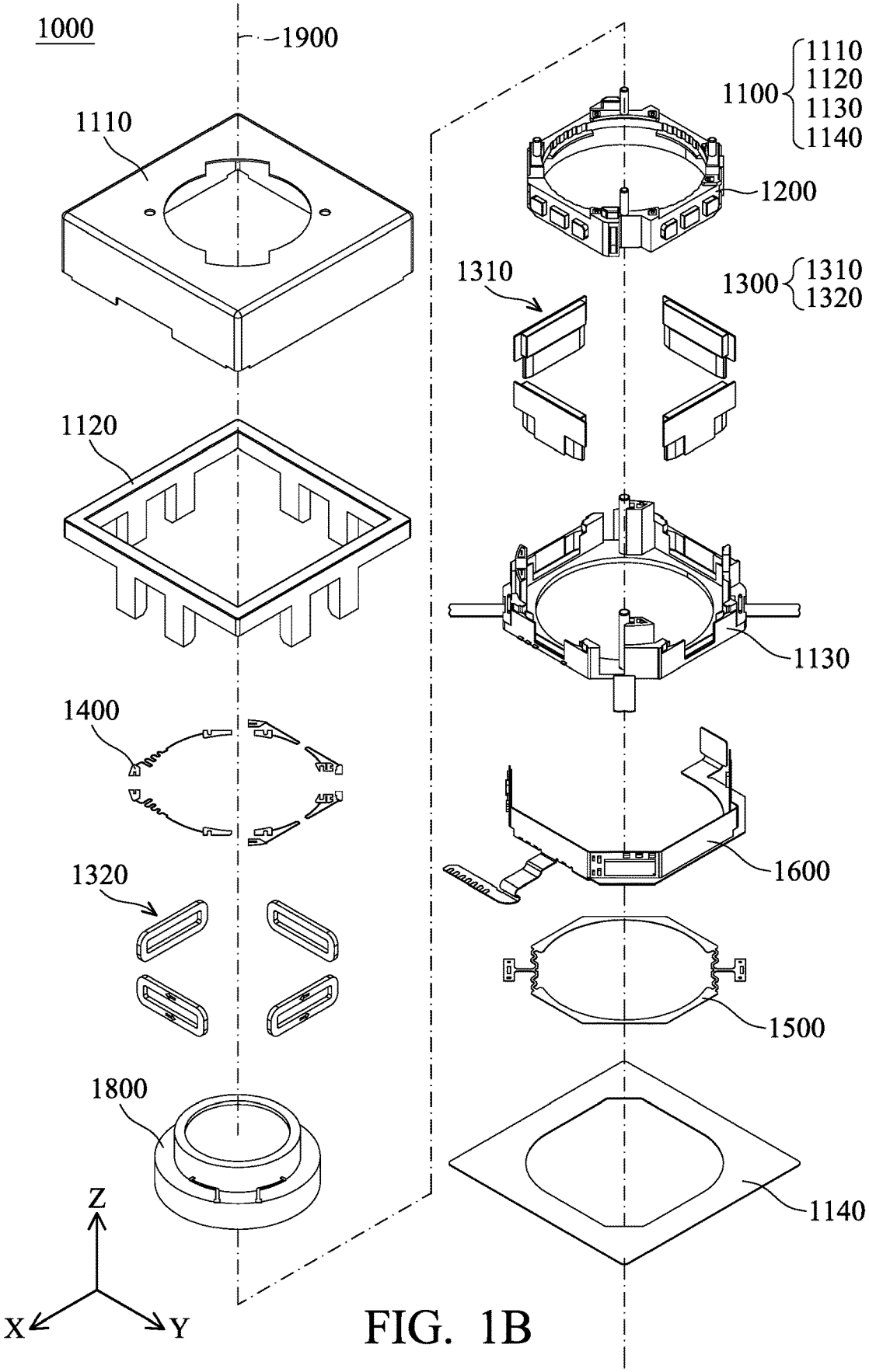


FIG. 1A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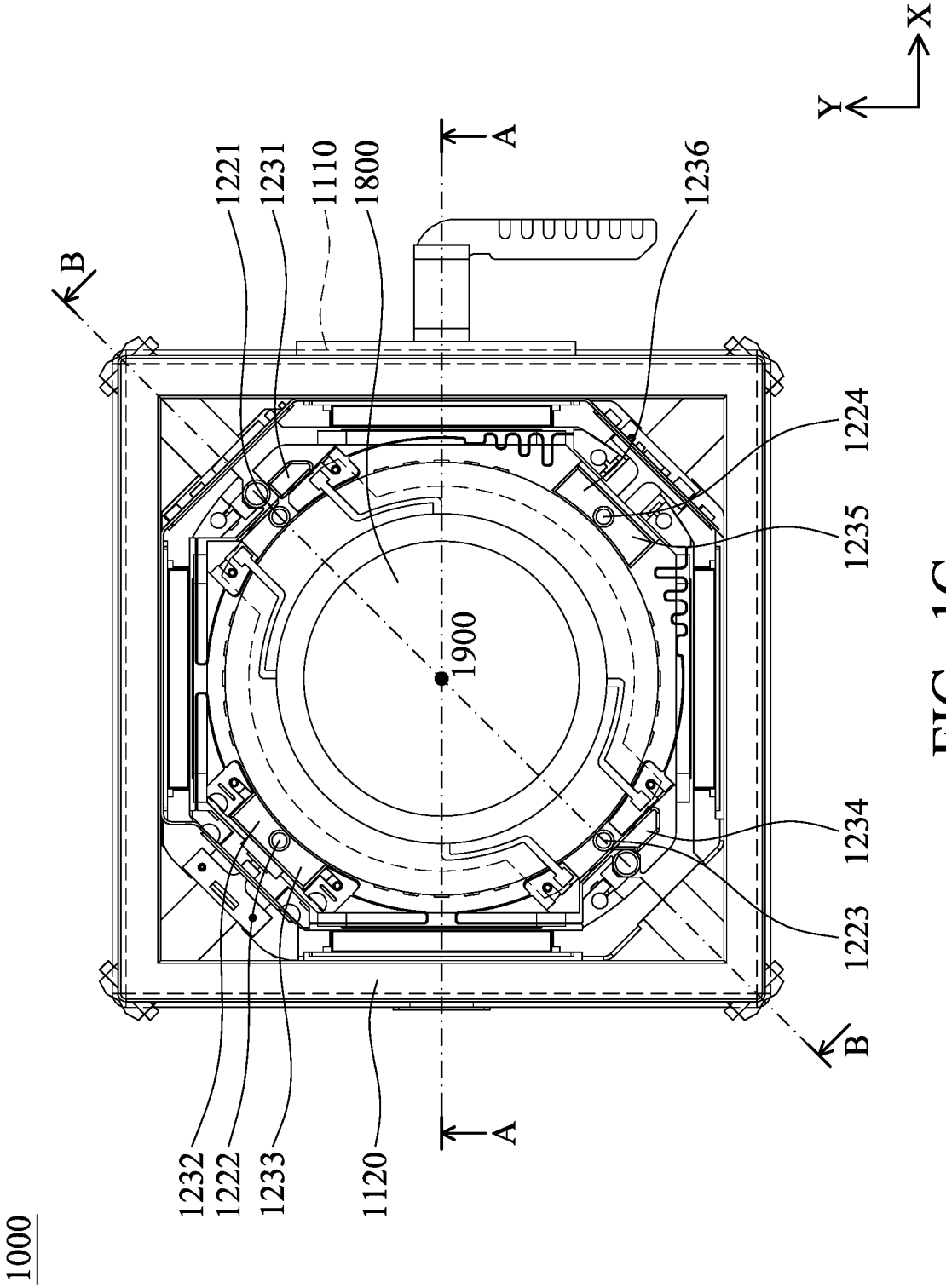
1140

FIG. 1B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1900
A
A
B
B
Y
X

FIG. 1C

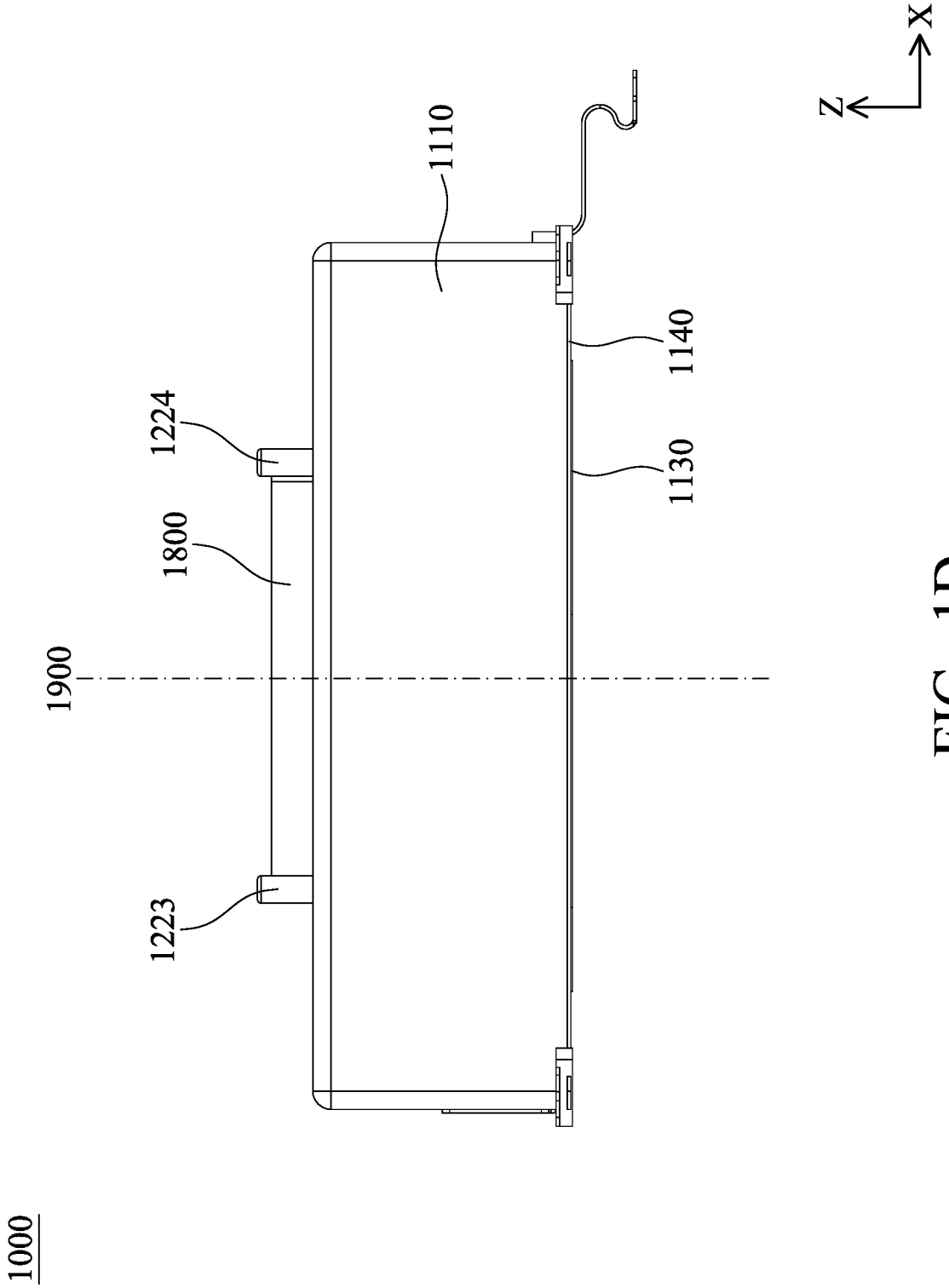
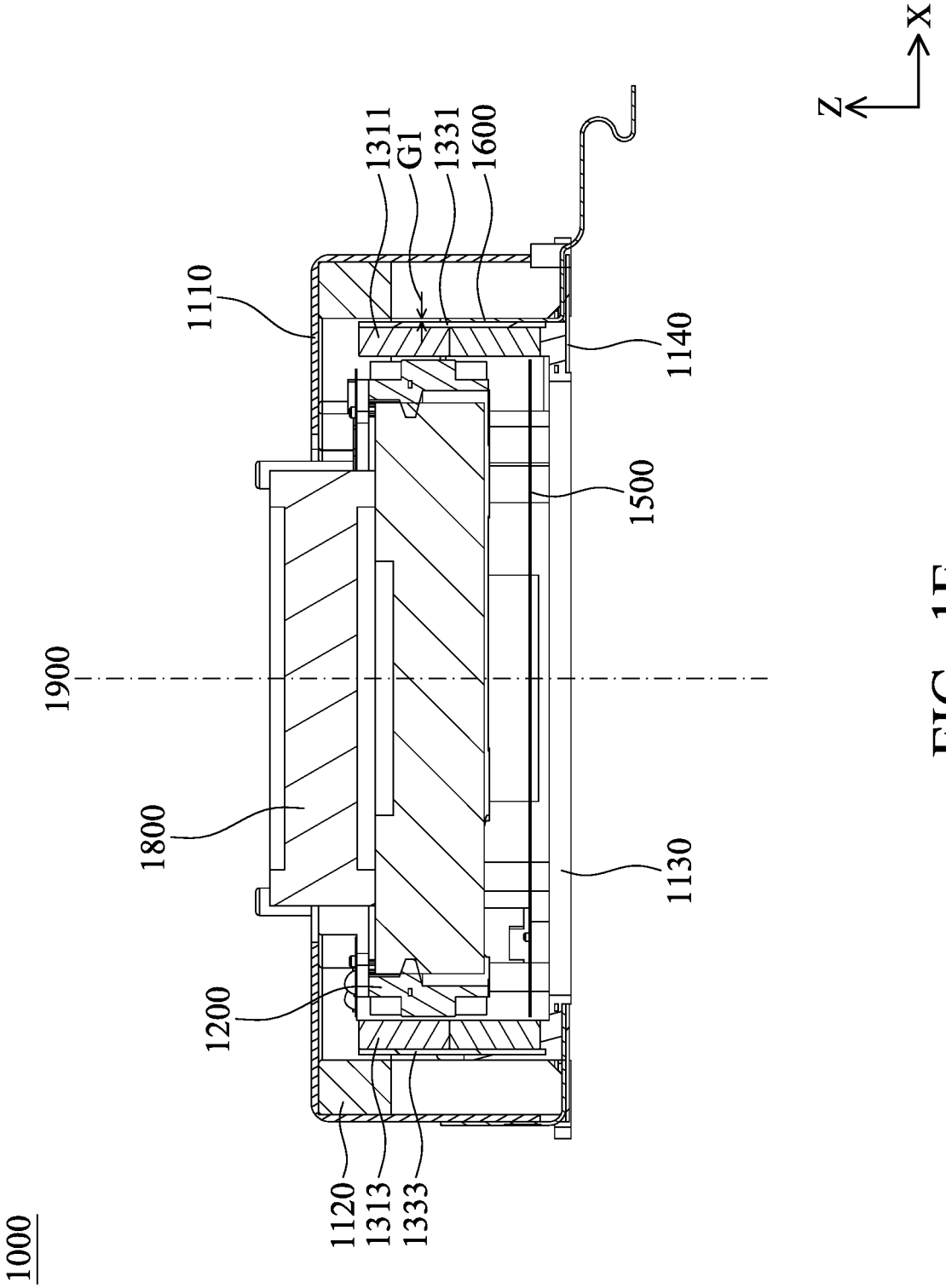


FIG. 1D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1110
1311
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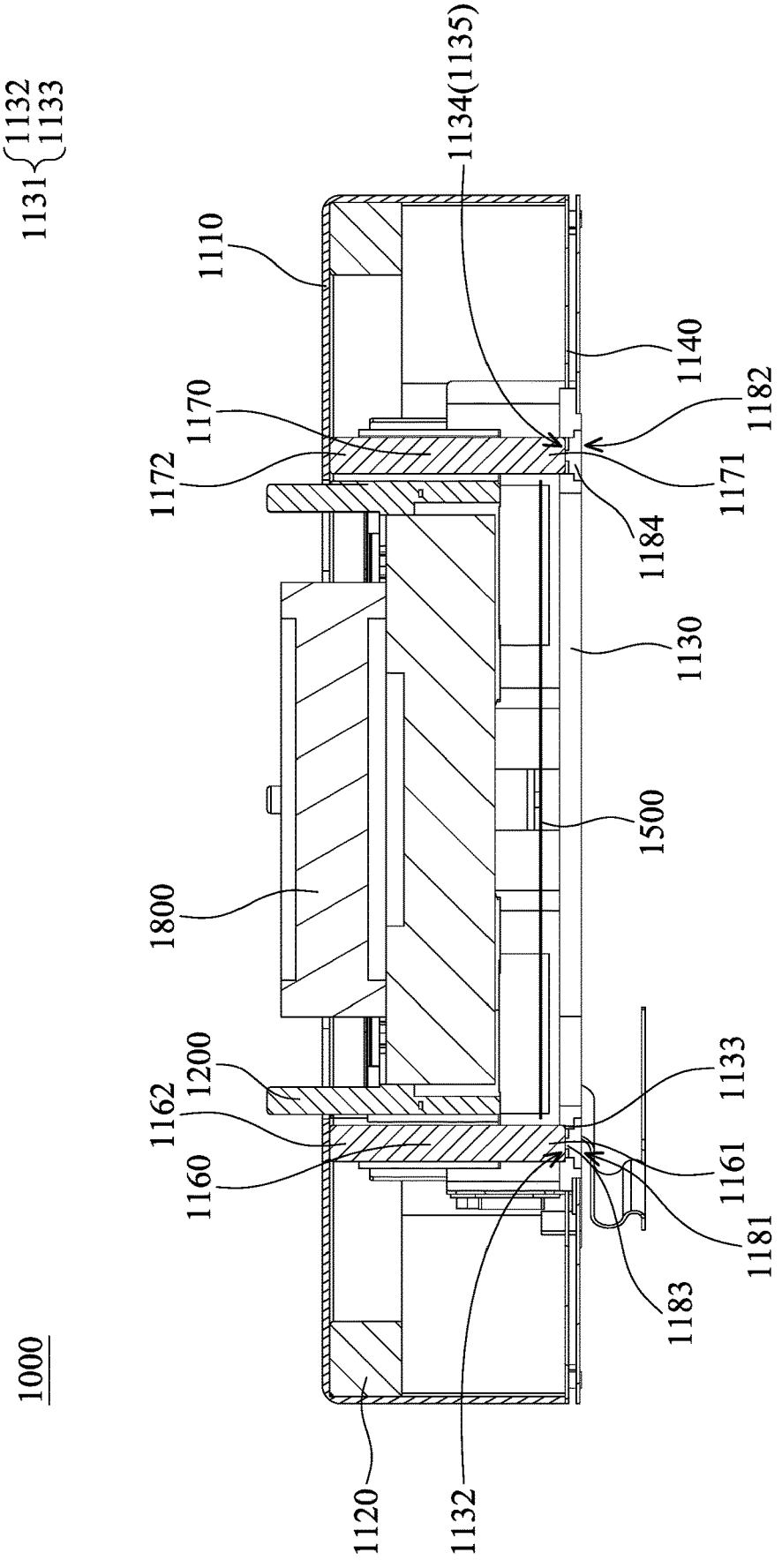
1331
1600
1140
1500
1130
Z
X

FIG. 1E


1000
1131
1132
1133
1134(1135)
1110
1140
1182
1170
1172
1171
1184
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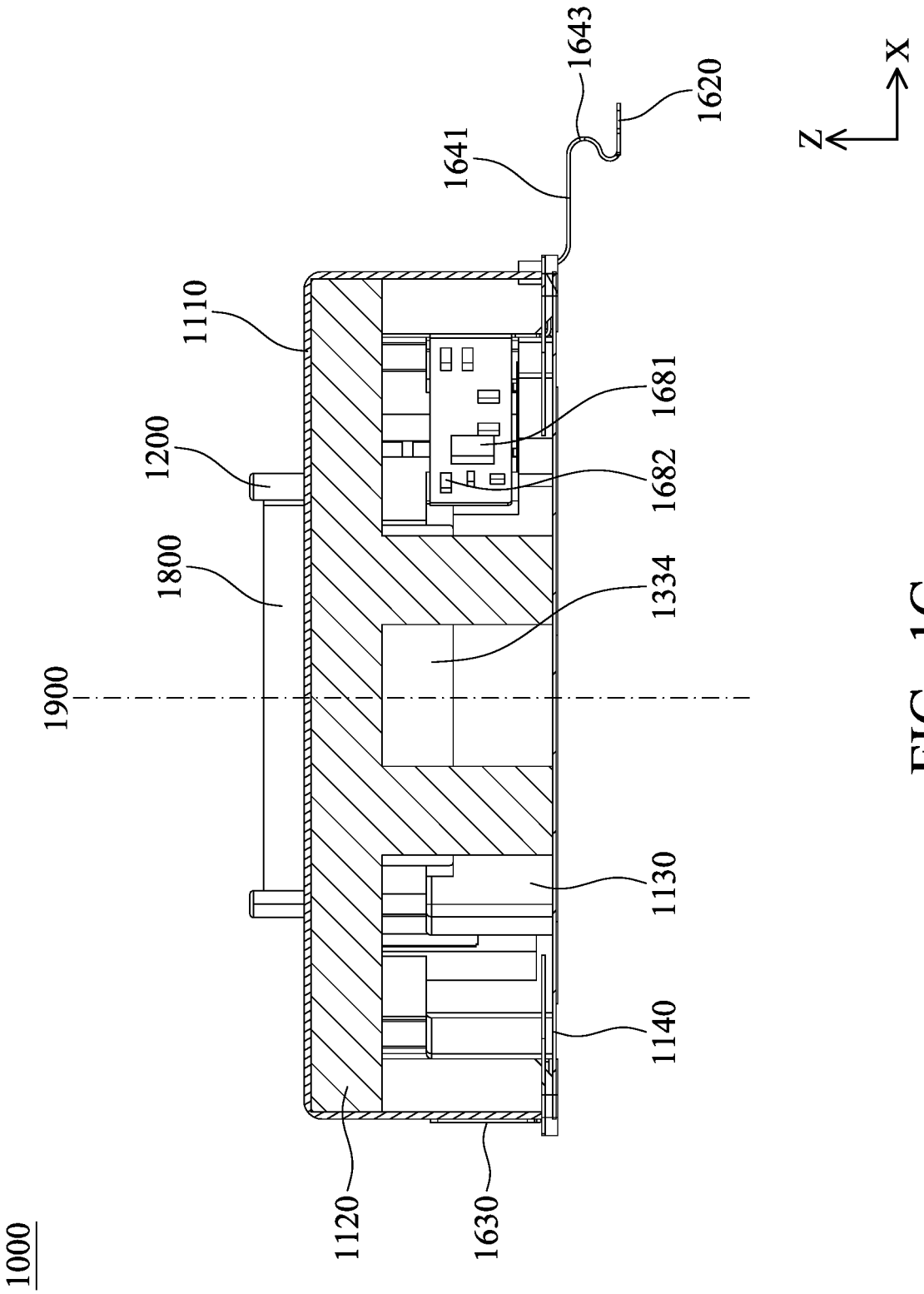
1800
1200
1162
1160
1133
1161
1181
1183
1120
1132
Z
X

FIG. 1F


1643
1620
1641
X
Z
1110
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1682
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1334
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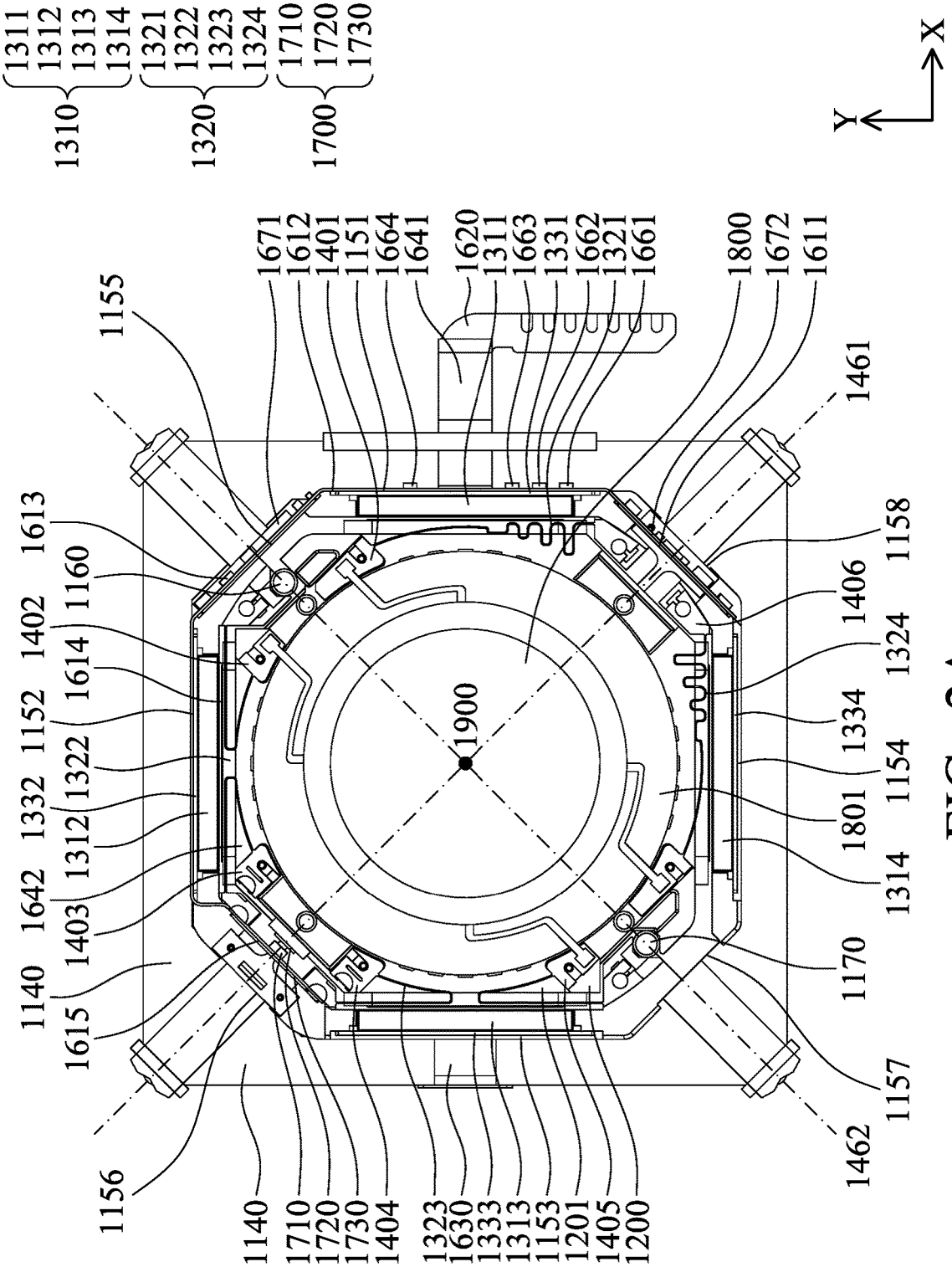
1130
1140
1120
1630
1000

FIG. 1G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1314
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1320
1710
1720
1730
1700
Y
X
1671
1612
1401
1151
1664
1641
1620
1311
1663
1331
1662
1321
1661
1800
1672
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1402
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1312
1642
1403
1140
1615
1158
1406
1324
1334
1154
1801
1314
1170
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1462
1156
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1153
1201
1405
1200

FIG. 2A

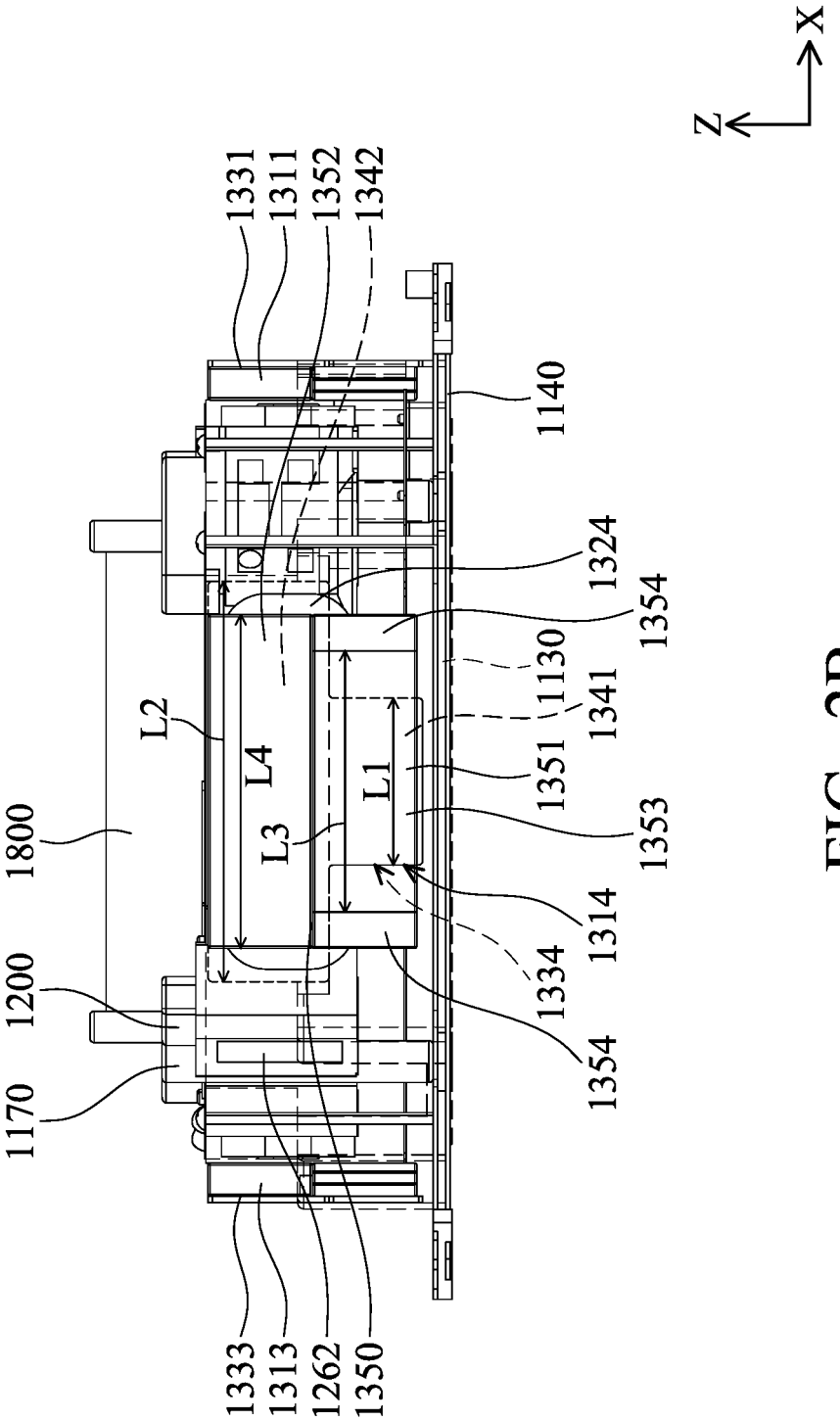

X
Z
1331
1311
1352
1342
1140
1324
1354
1130
1341
1351
1353
1314
1334
1354
1333
1313
1262
1350
1800
1200
1170
L2
L4
L3
L1

FIG. 2B

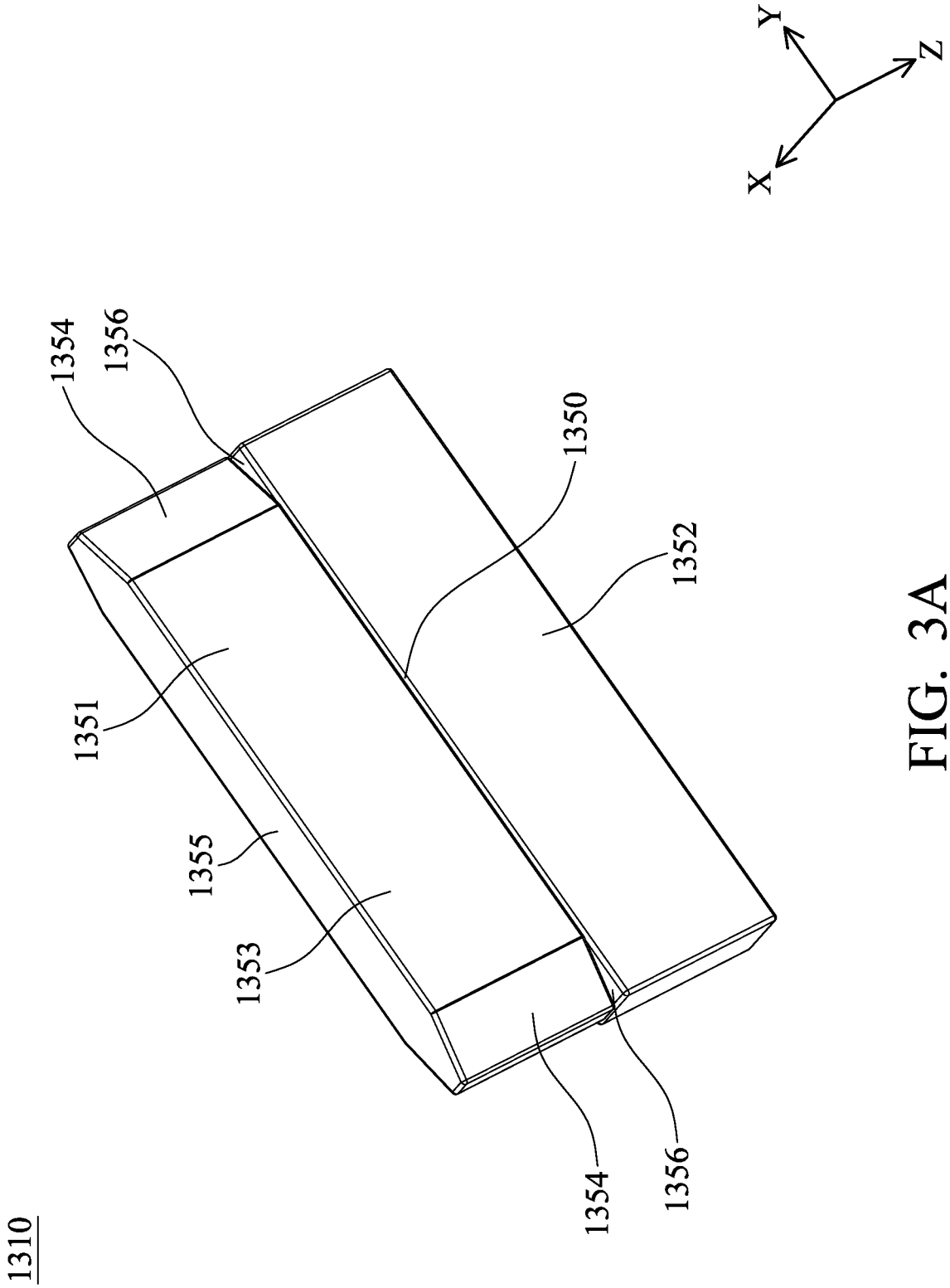
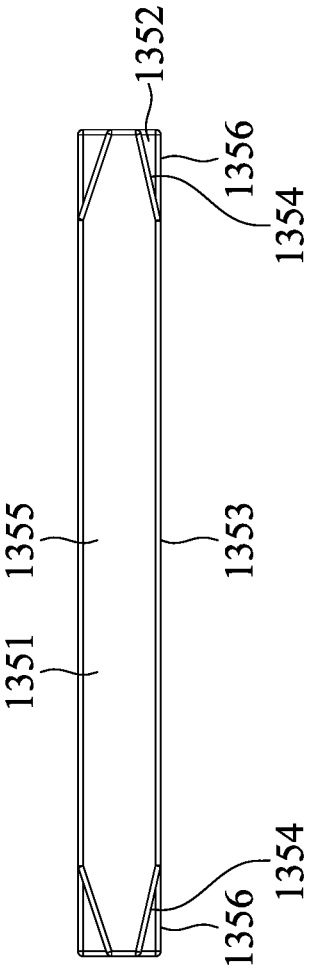


FIG. 3A



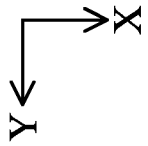
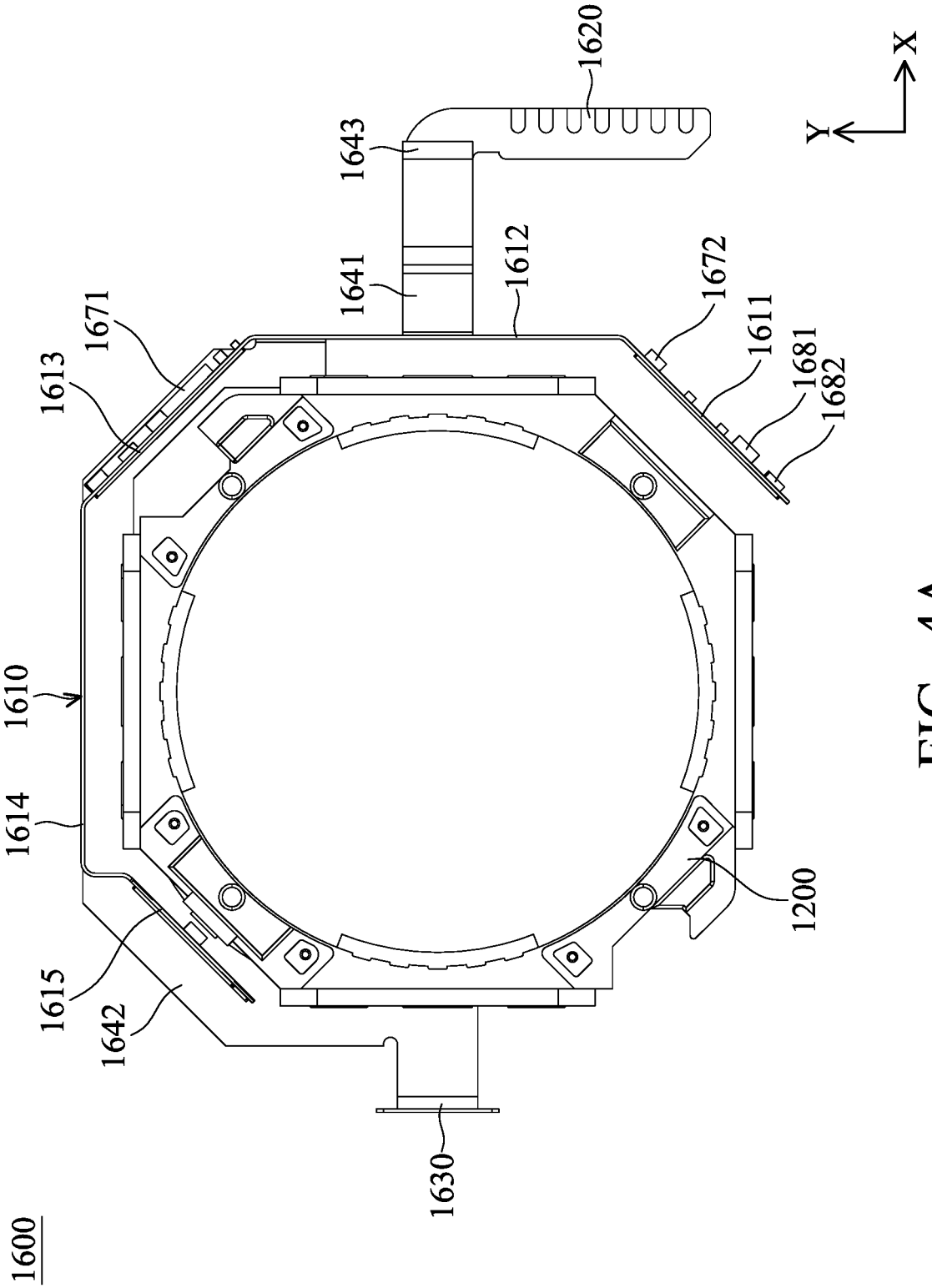


FIG. 3B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1612
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1642
1643
1671
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1681
1682
1200
X
Y

FIG. 4A

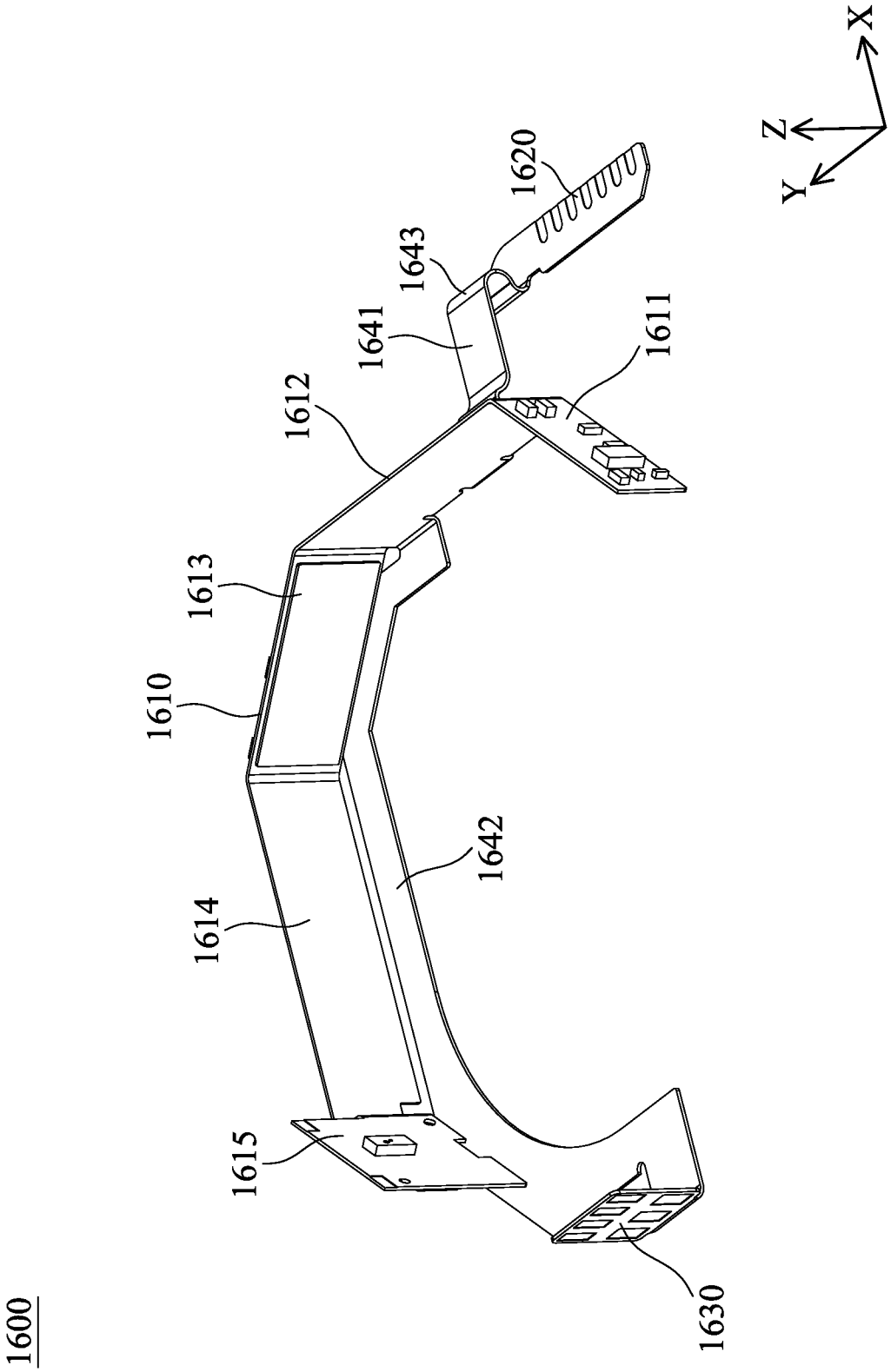
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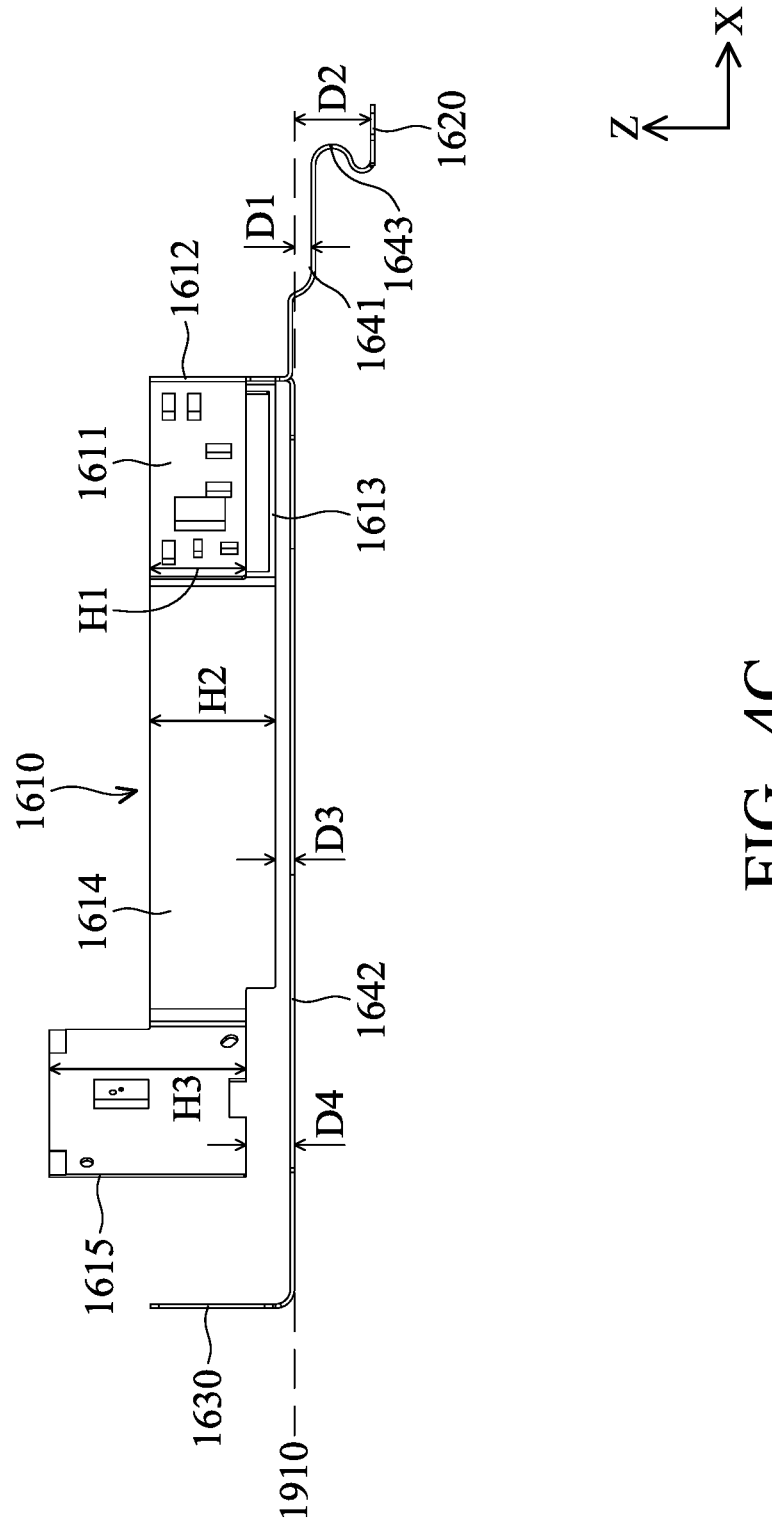
FIG. 4B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H3
D4
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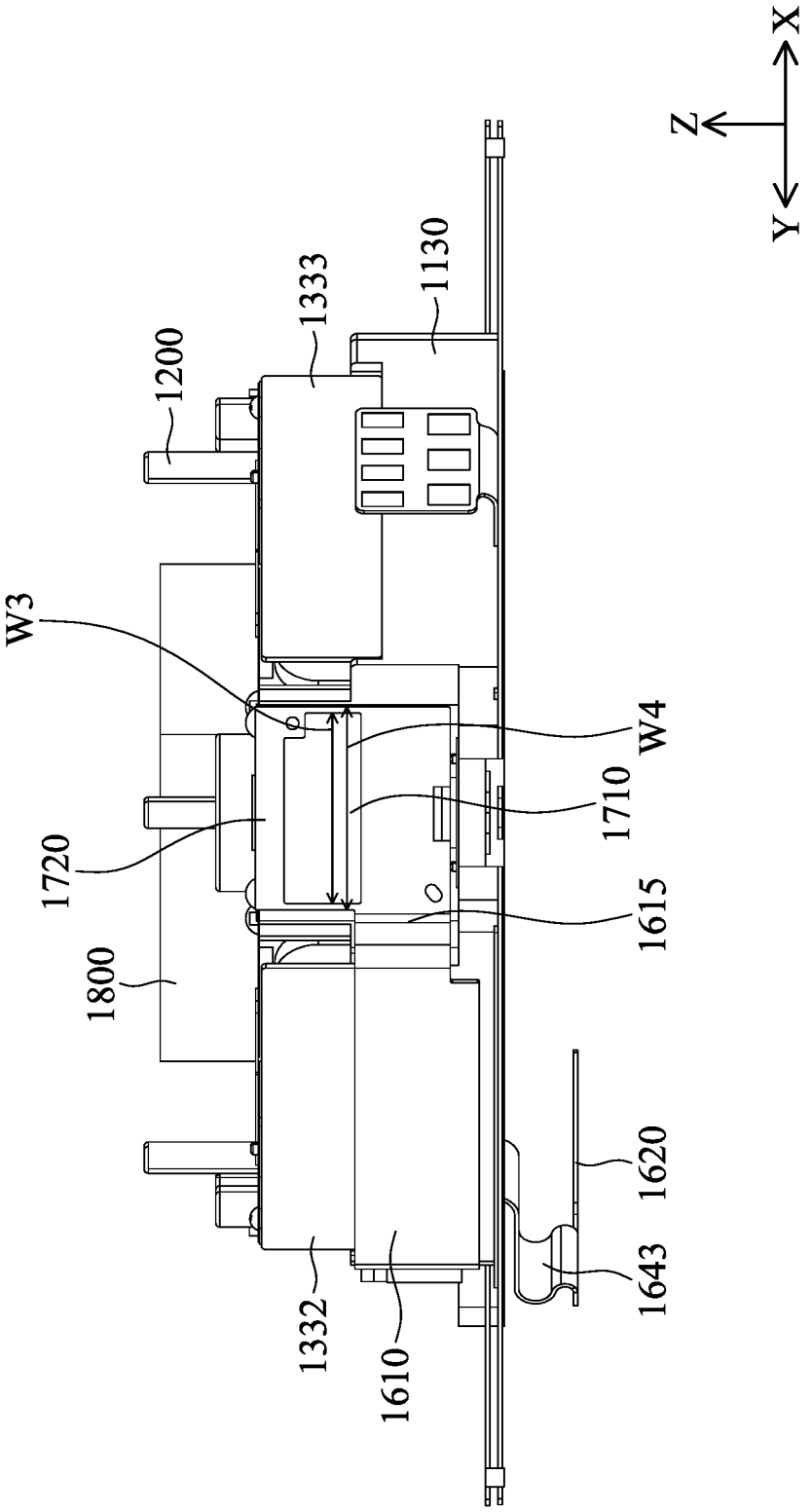
FIG. 4C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W3
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FIG. 5A

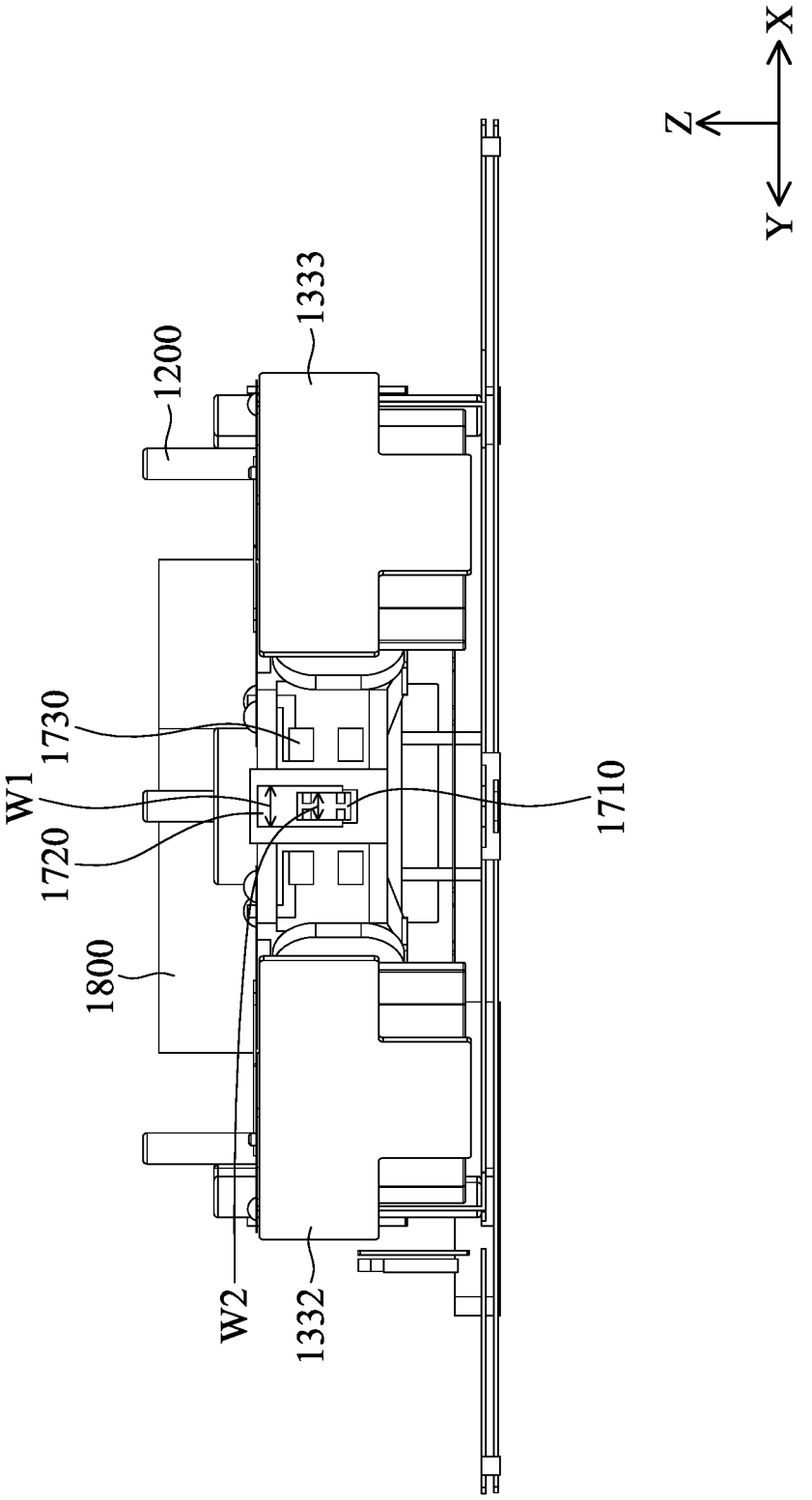
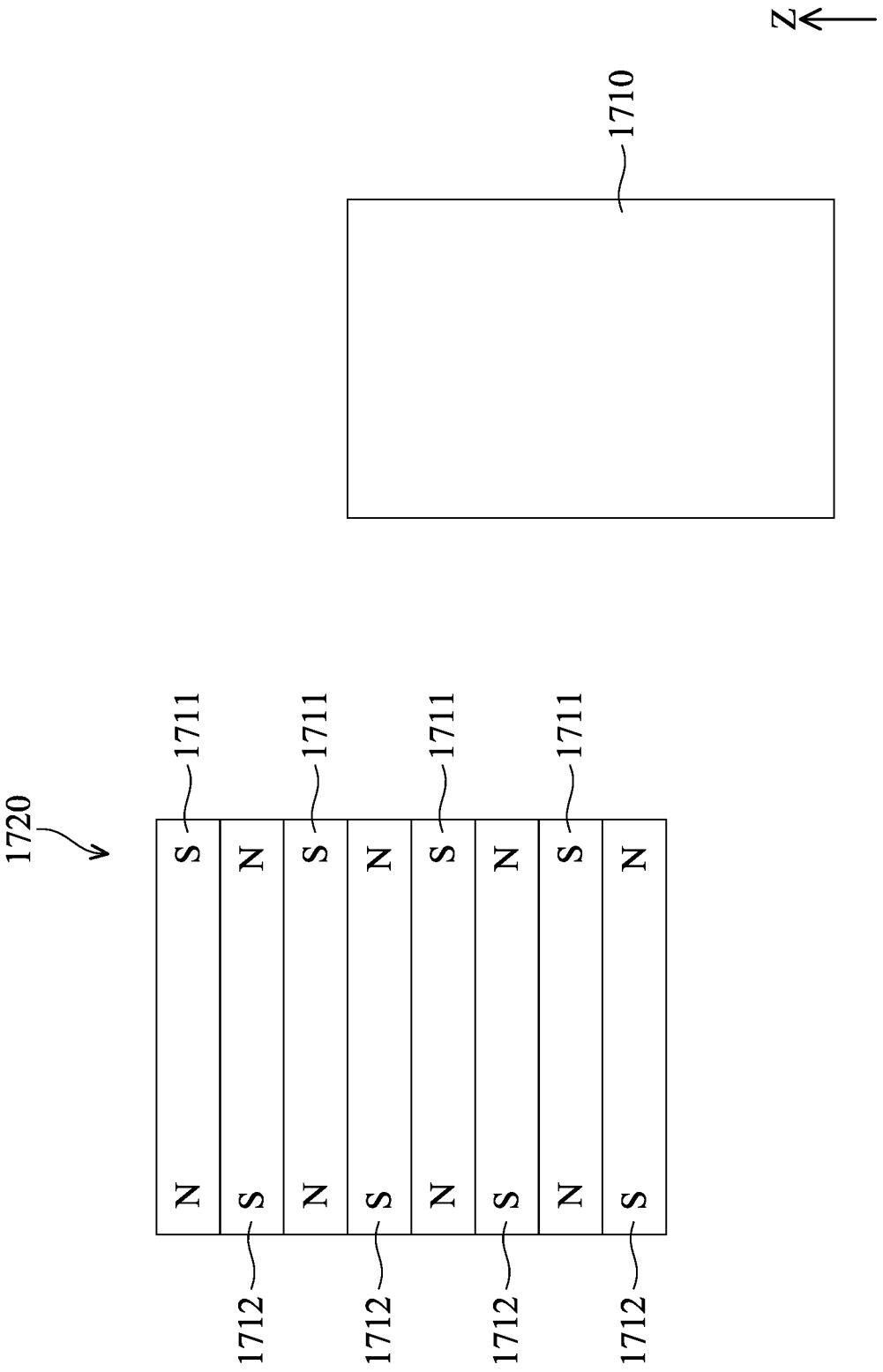


FIG. 5B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S
N
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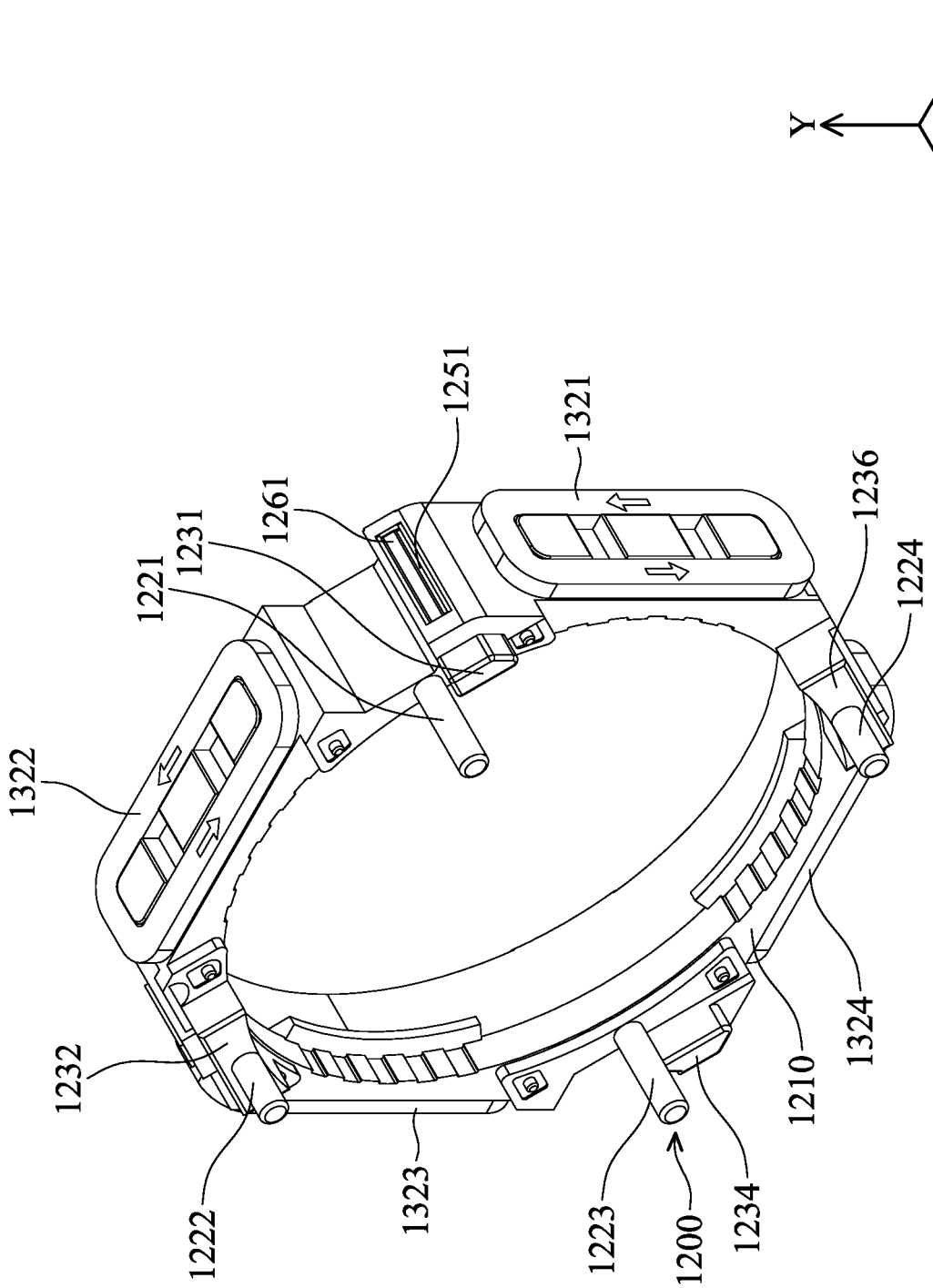
FIG. 5C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Z
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FIG. 6A

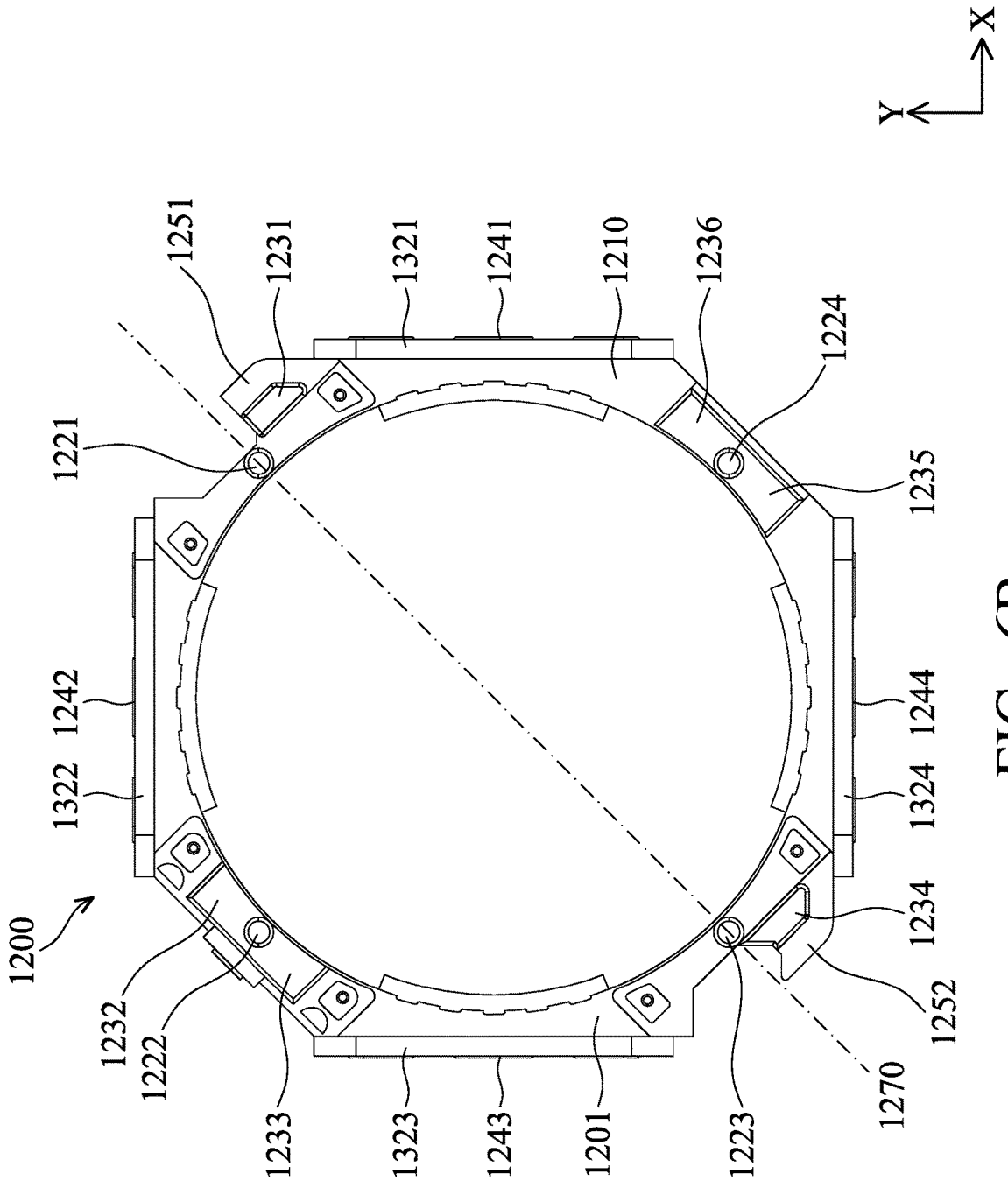
X
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FIG. 6B

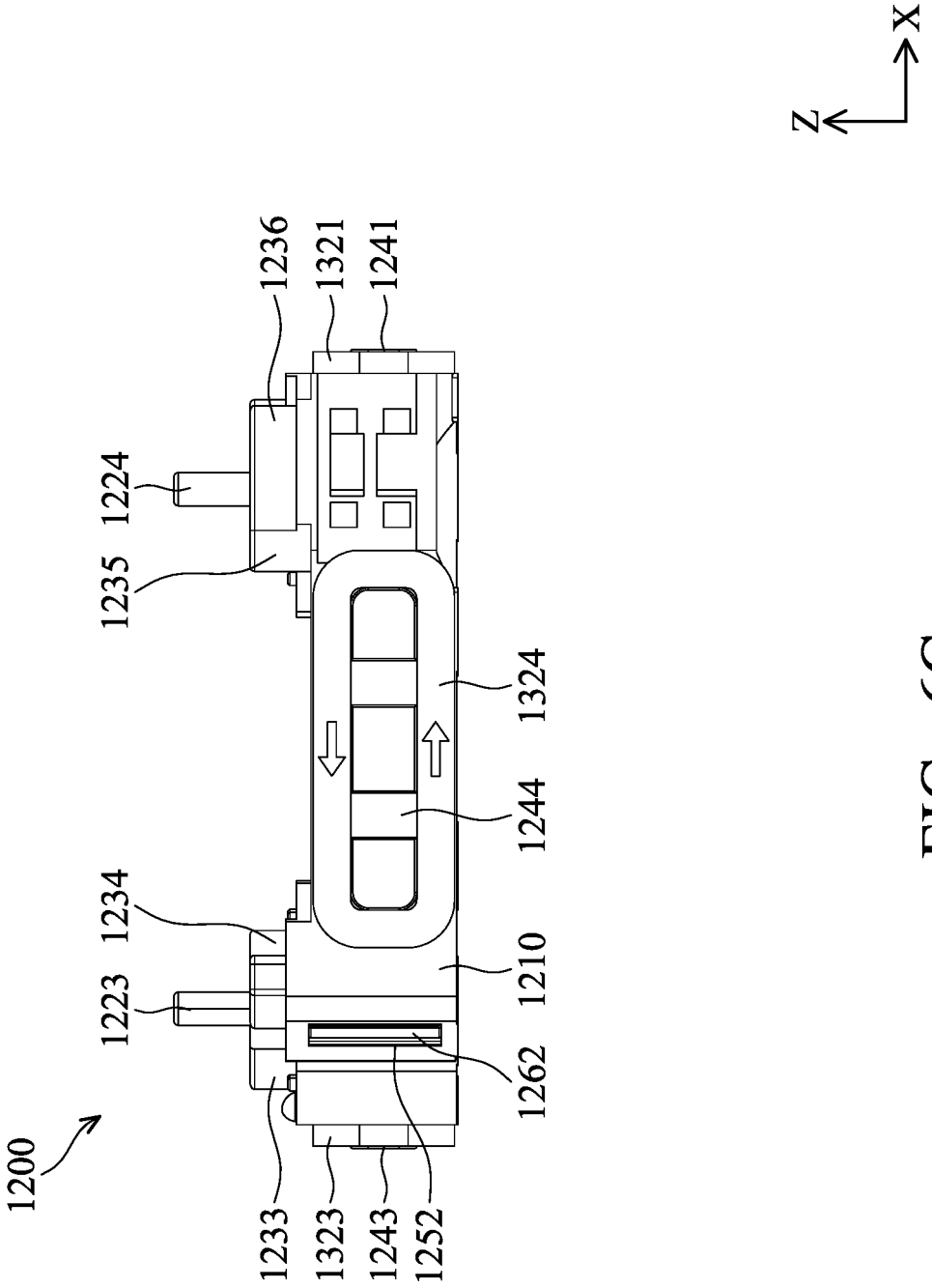
X
Z
1200
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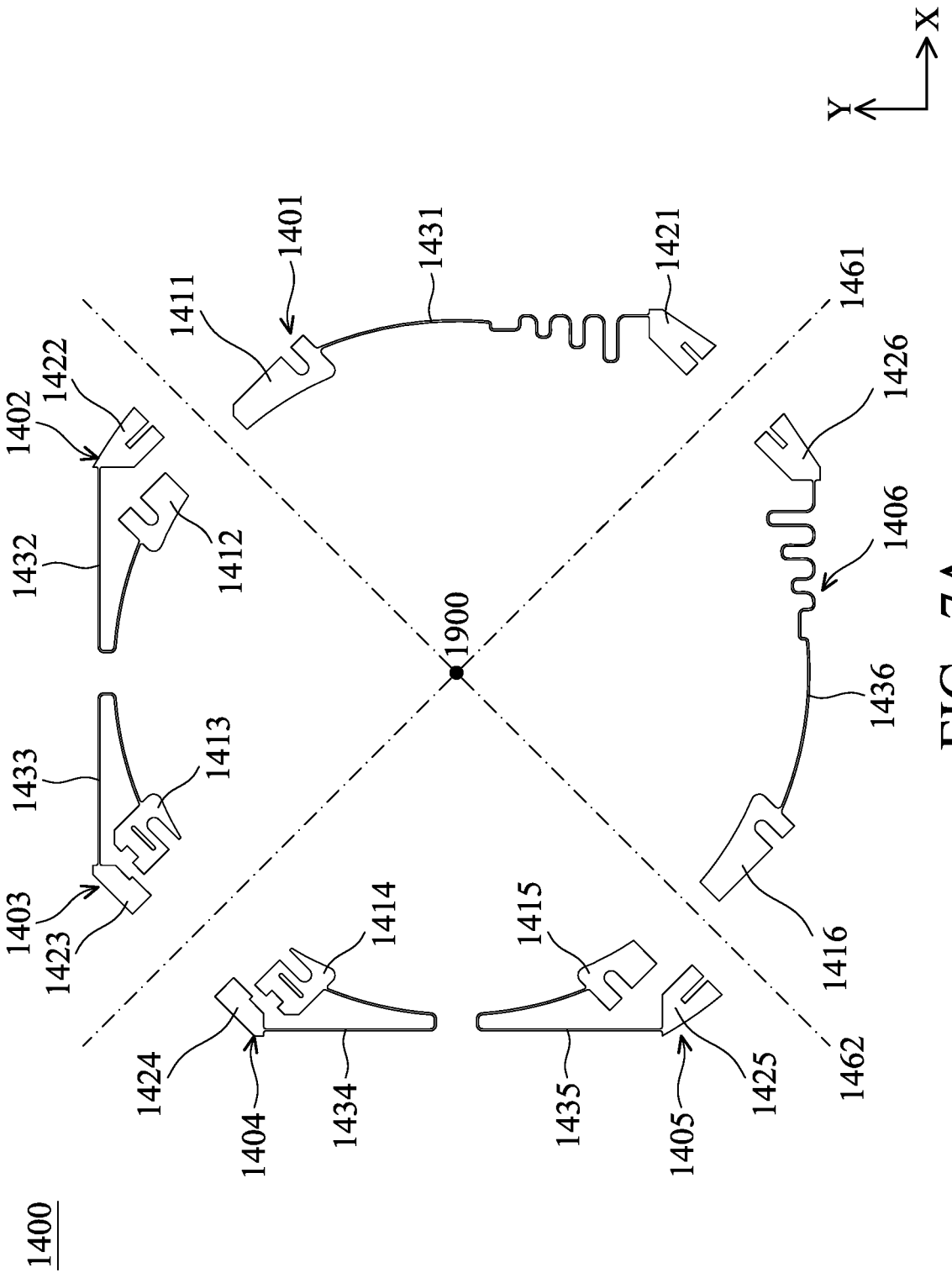
FIG. 6C


1400
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1462
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Y

FIG. 7A

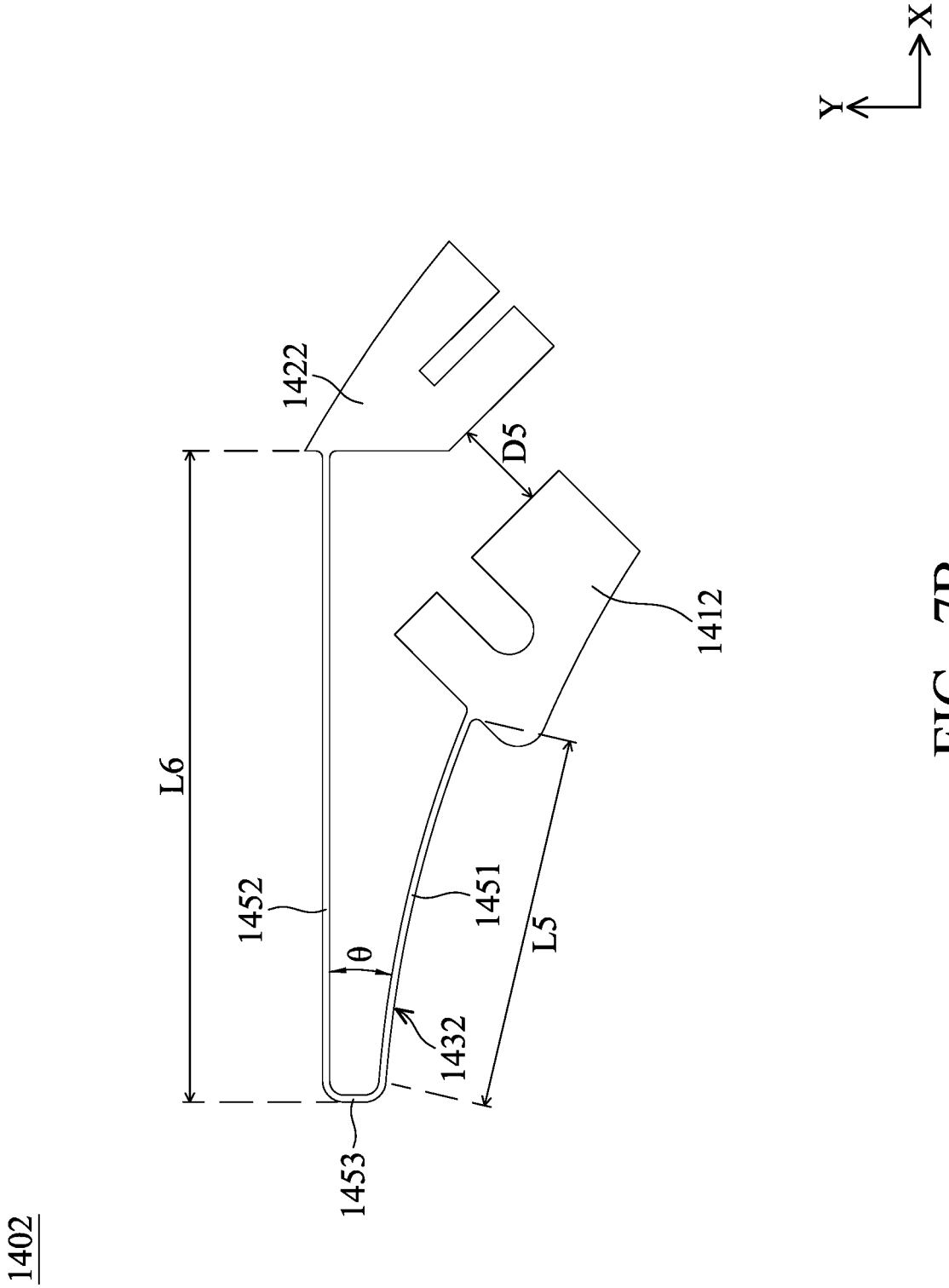
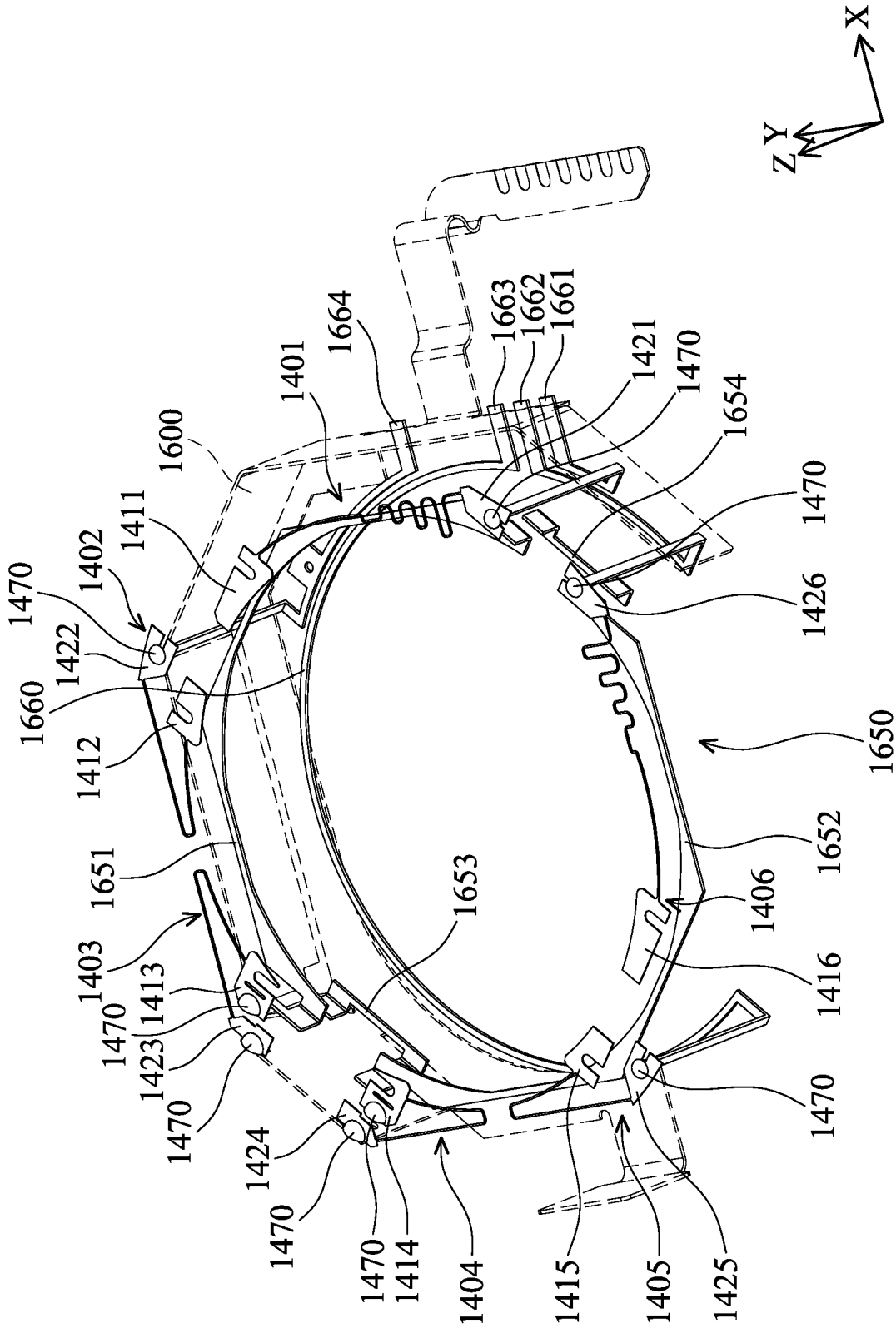


FIG. 7B


X
Y
Z
1600
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1416
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FIG. 8

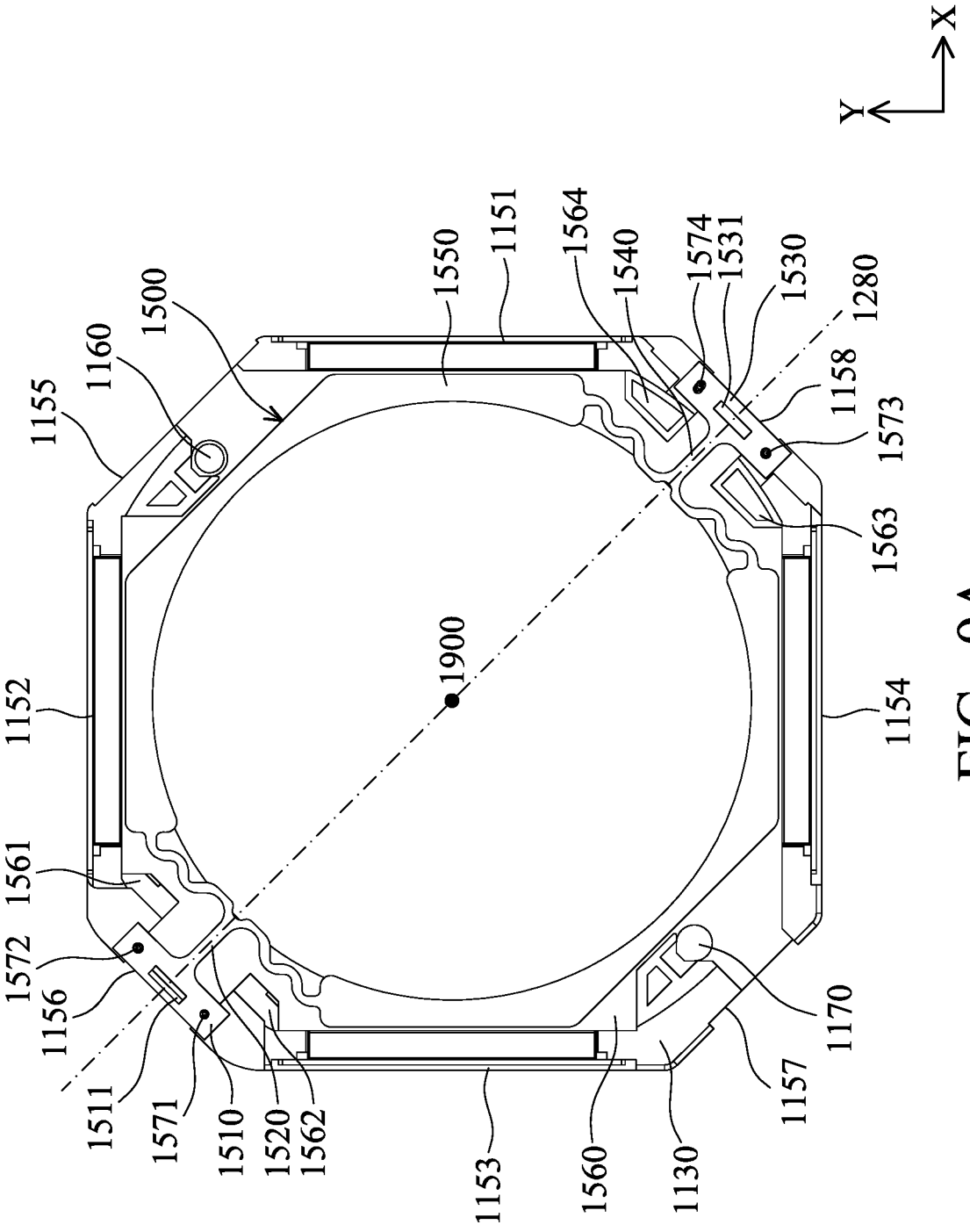
Y
X
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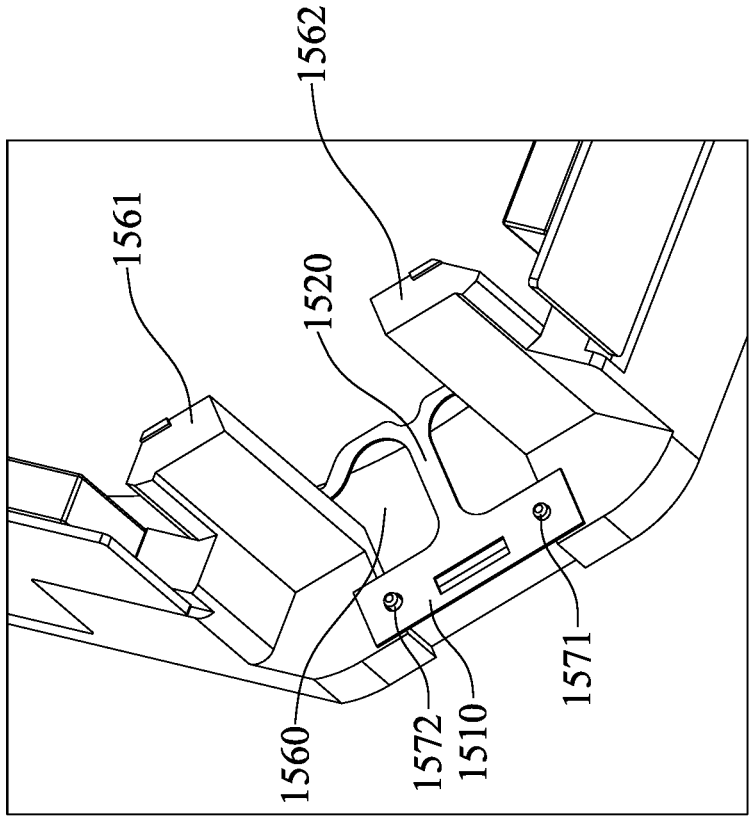
FIG. 9A



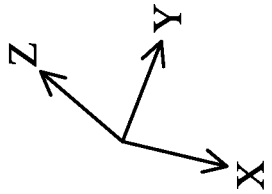


FIG. 9B

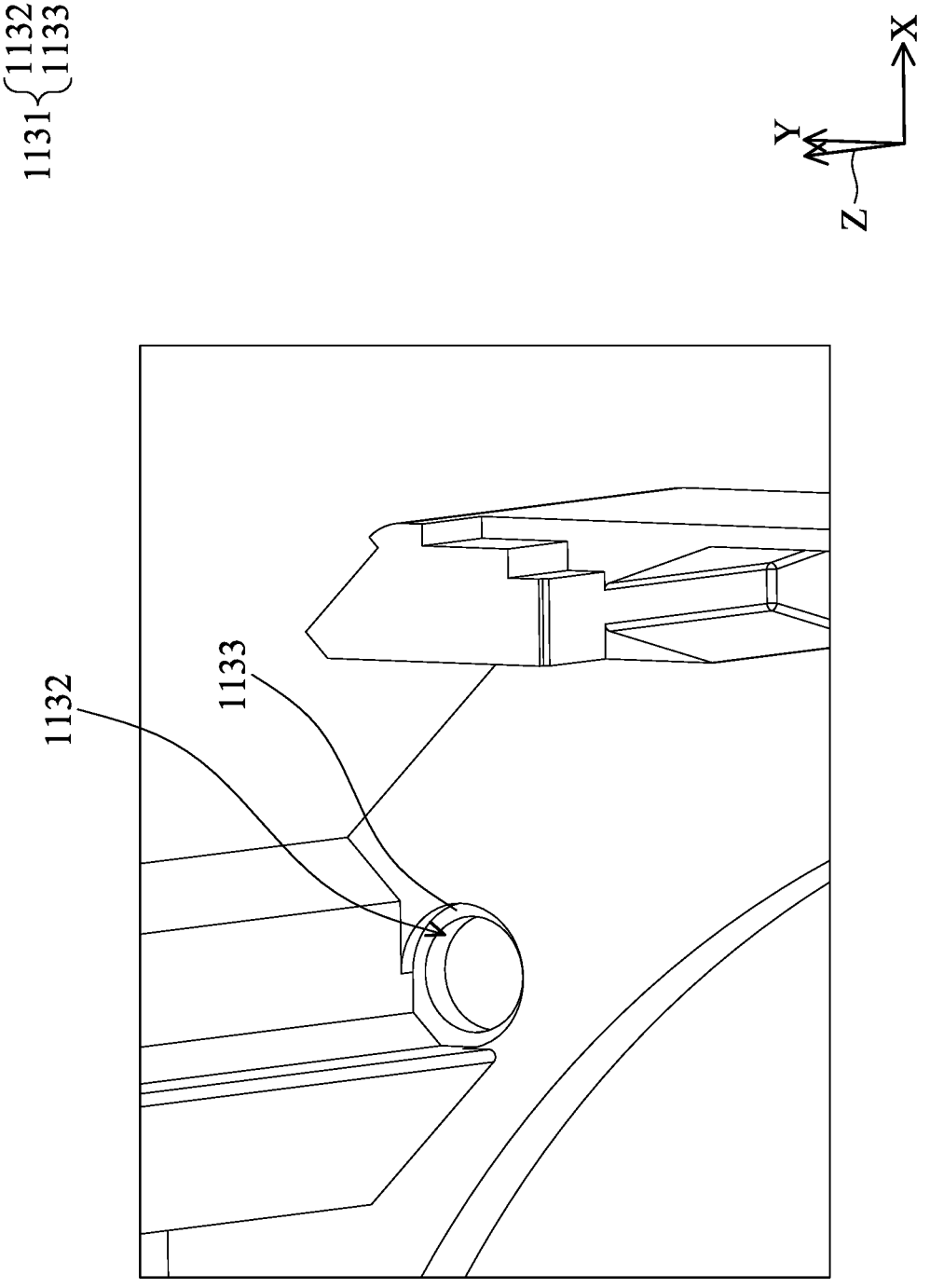


FIG. 9C

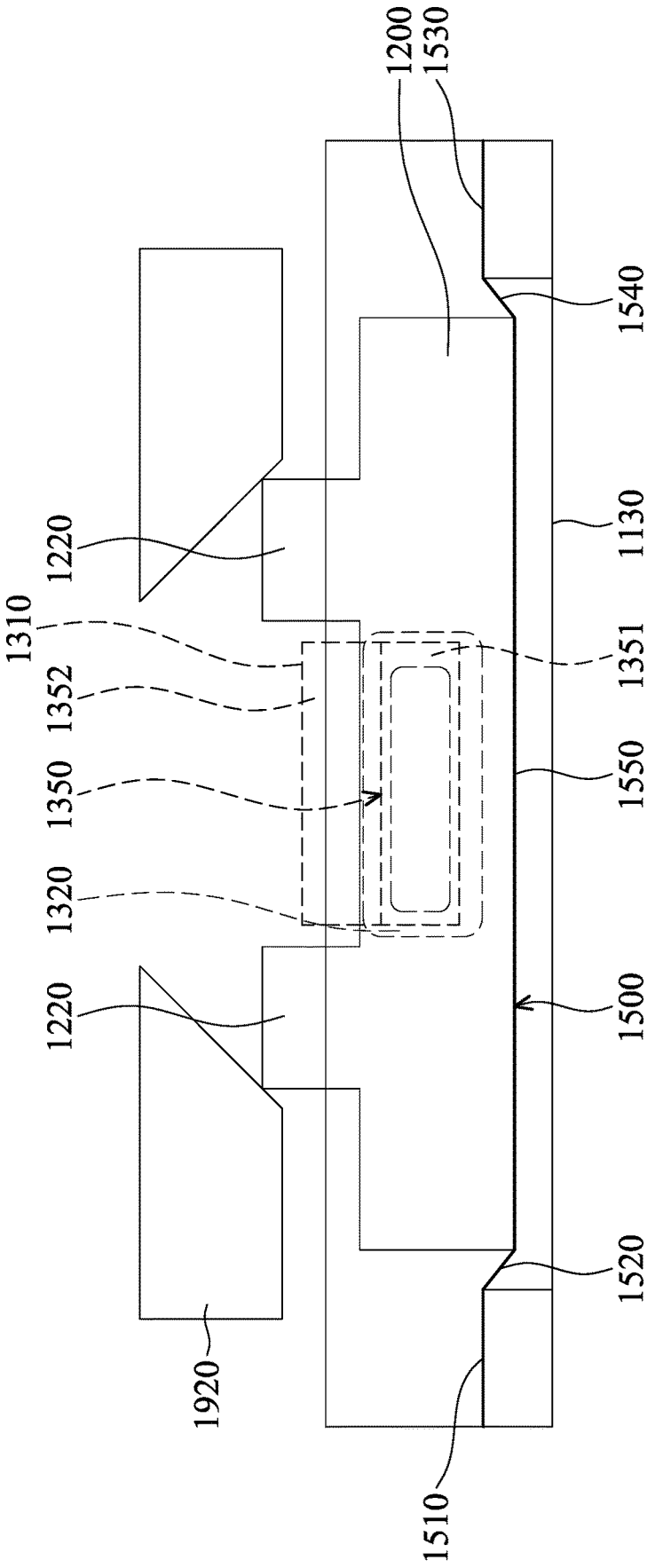

1200
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FIG. 10A

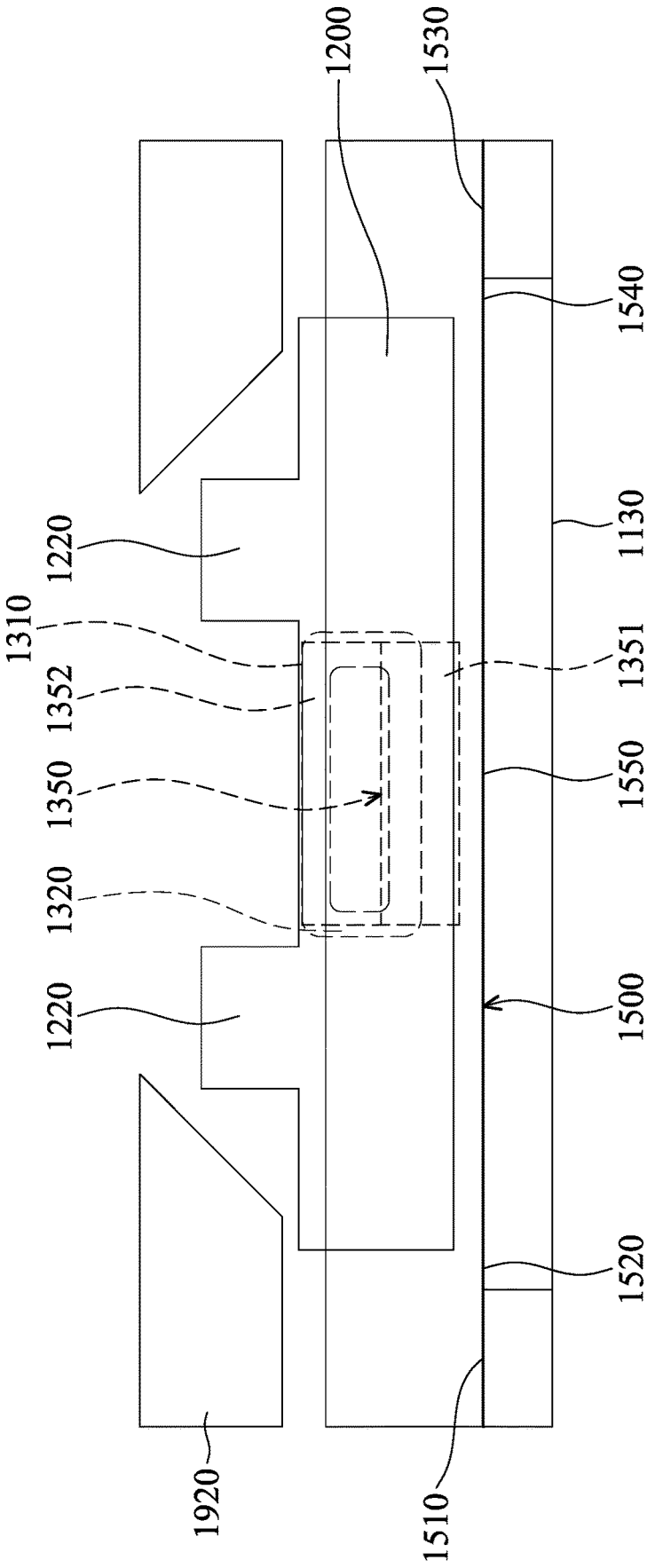
1200
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FIG. 10B

OPTICAL ELEMENT DRIVING MECHANISM

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority of China Patent Application No. 202211377118.7, filed on Nov. 4, 2022, the entirety of which is incorporated by reference herein.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The present disclosure relates to an optical element driving mechanism.

Description of the Related Art

[0003] As technology has developed, it has become more common to include image-capturing and video-recording functions into many types of modern electronic devices, such as smartphones and digital cameras. These electronic devices are used more and more often, and new models have been developed that are convenient, thin, and lightweight, offering more choice to consumers.

[0004] Electronic devices that have image-capturing or video-recording functions normally include an optical system to drive an optical element (such as a lens) to move along its optical axis, thereby achieving auto focus (AF) or optical image stabilization (OIS). Light may pass through the optical element and may form an image on an optical sensor. However, the trend in modern mobile devices is to have a smaller size and a higher durability. As a result, how to effectively reduce the size of the optical system and how to increase its durability has become an important issue.

BRIEF SUMMARY OF THE INVENTION

[0005] Some embodiments of the present disclosure provide an optical element driving mechanism that includes a movable portion, a fixed portion, and a driving assembly. The movable portion is used to connect the optical element. The movable portion may move relative to the fixed portion. The driving assembly is used to drive the movable portion to move relative to the fixed portion.

[0006] In some embodiments, the optical element driving mechanism further includes a circuit assembly disposed on the fixed portion. The fixed portion includes a case and a base arranged along a main axis, and the main axis extends in a first direction. The base is polygonal when viewed along the main axis. The fixed portion includes a first side, a second side, a third side, and a fourth side. The driving assembly is disposed on the first side, the second side, the third side, and the fourth side.

[0007] In some embodiments, the first side and the third side are opposite. The second side and the fourth side are opposite. The circuit assembly is disposed on the first side, the second side, and the third side. The circuit assembly is not disposed on the fourth side.

[0008] In some embodiments, the fixed portion further includes a fifth side, a sixth side, a seventh side, and an eighth side. The fifth side is between the first side and the second side. The sixth side is between the second side and the third side. The seventh side is between the third side and the fourth side. The eighth side is between the fourth side and the first side. The fixed portion further includes a bottom plate.

[0009] In some embodiments, the circuit assembly includes: a surrounding portion including a first segment, a second segment, a third segment, a fourth segment, and a fifth segment surrounding the main axis. A first extending portion disposed on the first side and extending from the surrounding portion in a second direction perpendicular to the first direction. And a second extending portion between the base and the bottom plate and connecting to the second segment.

[0010] In some embodiments, the circuit assembly further includes: a resilient connecting portion connecting to the first extending portion. A first circuit connecting portion connecting to the resilient connecting portion and extending in a third direction different from the first direction and the second direction. And a second circuit connecting portion connecting to the second extending portion and extending in the first direction.

[0011] In some embodiments, the first segment is disposed on the eighth side. The second segment is disposed on the first side. The third segment is disposed on the fifth side. The fourth segment is disposed on the second side. The fifth segment is disposed on the sixth side. A normal direction of the second extending portion is parallel to the first direction. Normal directions of the first segment, the second segment, the third segment, the fourth segment, and the fifth segment are perpendicular to the first direction. The resilient connecting portion is separated from the fixed portion.

[0012] In some embodiments, the circuit assembly further includes: a first electronic element disposed on the surrounding portion, on the fifth side, and between the surrounding portion and the case. A second electronic element disposed on the surrounding portion, on the eighth side, and between the surrounding portion and the case.

[0013] In some embodiments, the optical element driving mechanism further includes a sensing assembly, wherein the sensing assembly includes: a position sensing element disposed on the surrounding portion, on the sixth side, and between the surrounding portion and the movable portion. A sensing magnetic element disposed on the movable portion, and the position sensing element and the sensing magnetic element at least partially overlap each other in a fourth direction perpendicular to the first direction. And a reinforcement element disposed on the surrounding portion and on the sixth side, and the circuit assembly is between the reinforcement element and position sensing element.

[0014] In some embodiments, the fourth direction is different from the second direction and the third direction. Material of the reinforcement element includes metal. The reinforcement element includes nonmagnetic permeable material.

[0015] In some embodiments, the driving assembly includes a driving magnetic element and a driving coil. The driving magnetic element is disposed on the fixed portion. The driving coil is disposed on the movable portion.

[0016] In some embodiments, the optical element driving mechanism further includes a magnetic permeable element disposed on the driving magnetic element. The magnetic permeable element and the driving coil are on opposite sides of the driving magnetic element. The magnetic permeable is disposed on a portion of the circuit assembly.

[0017] In some embodiments, the optical element driving mechanism further includes an insulating element disposed between the circuit assembly and the case, and used for connecting the circuit assembly and the case. The sensing assembly and the second extending portion at least partially overlap each other when viewed along the main axis. The surrounding portion and the second extending portion at least partially overlap each other when viewed along the main axis. The first extending portion and the second extending portion do not overlap each other when viewed along the main axis. The base and the circuit assembly at least partially overlap each other when viewed along the main axis.

[0018] In some embodiments, the first electronic element and the sensing assembly are disposed on opposite sides of the movable portion. A bottom surface of the second extending portion coincides with a virtual plane. A first distance is between the first extending portion and the virtual plane in the first direction. A second distance is between the first circuit connecting portion and the virtual plane in the first direction. A third distance is between the fourth segment and the virtual plane in the first direction. A fourth distance is between the fifth segment and the virtual plane in the first direction. The first distance is less than the second distance. The first distance is less than the fourth distance. The second distance is greater than the third distance. The second distance is greater than the fourth distance. The third distance is less than the fourth distance.

[0019] In some embodiments, the first segment has a first height in the first direction. The fourth segment has a second height in the first direction. The fifth segment has a third height in the first direction. The first height is less than the second height. The first height is less than the third height. The second height is less than the third height.

[0020] In some embodiments, the first segment and the third segment at least partially overlap each other when viewed in the third direction. At least a portion of the third segment is exposed from the first segment when viewed in the third direction. The second extending portion does not overlap the surrounding portion when viewed in the third direction.

[0021] In some embodiments, the first electronic element includes a plurality of connection pins, and at least half of the connection pins do not electrically connect to the circuit assembly. At least a portion of the reinforcement element overlaps the position sensing element and the sensing magnetic element when viewed in the fourth direction.

[0022] In some embodiments, at least a portion of the sensing magnetic element is exposed from the reinforcement element when viewed in the fourth direction. The fifth segment and the sensing assembly at least partially overlap each other when viewed in the fourth direction.

[0023] In some embodiments, a width of the sensing magnetic element is greater than a width of the position sensing element when viewed in the fourth direction. A width of the reinforcement element is less than a width of the fifth segment when viewed in the fourth direction. The width of the reinforcement element is greater than the width of the sensing magnetic element when viewed in the fourth direction. At least a portion of the resilient connecting portion overlaps the base when viewed in the fourth direction.

[0024] In some embodiments, at least a portion of the movable portion overlaps the second extending portion when viewed in the first direction. The movable portion does not overlap the surrounding portion when viewed in the first direction.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] Aspects of the present disclosure are best understood from the following detailed description when read with the accompanying figures. It should be noted that, in accordance with the standard practice in the industry, various features are not drawn to scale. In fact, the dimensions of the various features may be arbitrarily increased or reduced for clarity of discussion.

[0026] FIG. **1**A is a schematic view of an optical element driving mechanism.

[0027] FIG. **1**B is an exploded view of the optical element driving mechanism.

[0028] FIG. **1**C is a top view of the optical element driving mechanism.

[0029] FIG. **1**D is a side view of the optical element driving mechanism.

[0030] FIG. **1**E is a cross-sectional view illustrated along line A-A in FIG. **1**C.

[0031] FIG. **1**F is a cross-sectional view illustrated along line B-B in FIG. **1**C.

[0032] FIG. **1**G is a perspective view of the optical element driving mechanism.

[0033] FIG. **2**A is a top view of some elements of the optical element driving mechanism,

[0034] FIG. **2**B is a perspective view of some elements of the optical element driving mechanism

[0035] FIG. **3**A is a schematic view of the driving magnetic elements.

[0036] FIG. **3**B is a top view of the driving magnetic elements.

[0037] FIG. **4**A is a top view of the circuit assembly.

[0038] FIG. **4**B is a schematic view of the circuit assembly.

[0039] FIG. **4**C is a side view of the circuit assembly.

[0040] FIG. **5**A is a schematic view of some elements of the optical element driving mechanism.

[0041] FIG. **5**B is a schematic view of some elements of the optical element driving mechanism.

[0042] FIG. **5**C is a schematic view of the position sensing element and the sensing magnetic element.

[0043] FIG. **6**A is a schematic view of the movable portion and the driving coils.

[0044] FIG. **6**B is a top view of the movable portion and the driving coils.

[0045] FIG. **6**C is a side view of the movable portion and the driving coils.

[0046] FIG. **7**A is a schematic view of the first resilient element.

[0047] FIG. **7**B is an enlarged view of the second resilient unit.

[0048] FIG. **8** is a schematic view of some elements of the optical element driving mechanism.

[0049] FIG. **9**A is a schematic view of some elements of the optical element driving mechanism, mainly showing the base and the second resilient element.

[0050] FIG. **9**B is an enlarged view of some elements of the optical element driving mechanism.

[0051] FIG. **9**C is an enlarged view of a portion of the base.

[0052] FIG. **10**A and FIG. **10**B are schematic views showing the switching of the optical element driving mechanism from a first state to a second state through an external driving assembly.

DETAILED DESCRIPTION OF THE INVENTION

[0053] The following disclosure provides many different embodiments, or examples, for implementing different features of the provided subject matter. Specific examples of elements and arrangements are described below to simplify the present disclosure. These are, of course, merely examples and are not intended to be limiting. For example, in some embodiments, the formation of a first feature over or on a second feature in the description that follows may include embodiments in which the first and second features are in direct contact, and may also include embodiments in which additional features may be disposed between the first and second features, such that the first and second features may not be in direct contact.

[0054] In addition, the present disclosure may repeat reference numerals and/or letters in the various examples. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various embodiments and/or configurations discussed. Moreover, the formation of a feature on, connected to, and/or coupled to another feature in the present disclosure that follows may include embodiments in which the features are in direct contact, and may also include embodiments in which additional features may be disposed interposing the features, such that the features may not be in direct contact. In addition, spatially relative terms, for example, "vertical," "above," "over," "below,", "bottom," etc. as well as derivatives thereof (e.g., "downwardly," "upwardly," etc.) are used in the present disclosure for ease of description of one feature's relationship to another feature. The spatially relative terms are intended to cover different orientations of the device, including the features.

[0055] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure belongs. It should be appreciated that each term, which is defined in a commonly used dictionary, should be interpreted as having a meaning conforming to the relative skills and the background or the context of the present disclosure, and should not be interpreted in an idealized or overly formal manner unless defined otherwise.

[0056] Use of ordinal terms such as "first", "second", etc., in the claims to modify a claim element does not by itself connote any priority, precedence, or order of one claim element over another or the temporal order in which acts of a method are performed, but are used merely as labels to distinguish one claim element having a certain name from another element having the same name (but for use of the ordinal term) to distinguish the claim elements.

[0057] In addition, in some embodiments of the present disclosure, terms concerning attachments, coupling and the like, such as "connected" and "interconnected", refer to a relationship wherein structures are secured or attached to one another either directly or indirectly through intervening structures, as well as both movable or rigid attachments or relationships, unless expressly described otherwise.

[0058] Embodiments of the present disclosure disclose an optical element driving mechanism used for driving an optical element to move. For example, FIG. **1**A is a schematic view of an optical element driving mechanism **1000**. FIG. **1**B is an exploded view of the optical element driving mechanism **1000**. FIG. **1**C is a top view of the optical element driving mechanism **1000**. FIG. **1**D is a side view of the optical element driving mechanism **1000**. FIG. **1**E is a cross-sectional view illustrated along line A-A in FIG. **1**C. FIG. **1**F is a cross-sectional view illustrated along line B-B in FIG. **1**C. FIG. **1**G is a perspective view of the optical element driving mechanism **1000**.

[0059] As shown in FIG. **1**A to FIG. **1**G, the optical element driving mechanism **1000** may mainly include a fixed portion **1100**, a movable portion **1200**, a driving assembly **1300**, a first resilient element **1400**, a second resilient element **1500**, and a circuit assembly **1600** arranged along a main axis **1900**. The optical element driving mechanism **1000** may be used for driving an optical element **1800** to move. In particular, the optical element **1800** may be disposed on the movable portion **1200**, and the driving assembly **1300** may be used for driving the movable portion **1200** and the optical element **1800** to move together relative to the fixed portion **1100** to achieve auto focus (AF). The main axis **1900** may extend in a first direction (Z direction).

[0060] In some embodiments, the optical element **1800** may be, for example, a lens, a mirror, a prism, a reflective polished surface, an optical coating, a beam splitter, an aperture, a liquid lens, an image sensor, a camera module, or a ranging module. It should be noted that the definition of the optical element is not limited to the element that is related to visible light, and other elements that relate to invisible light (e.g., infrared or ultraviolet) are also included in the present disclosure.

[0061] In some embodiments, the fixed portion **1100** may include a case **1110**, a frame **1120**, a base **1130**, and a bottom plate **1140** arranged along the main axis **1900**. The case **1110** and the bottom plate **1140** may combine together to form a shell of the optical element driving mechanism **1000** for accommodating and protecting other elements. The frame **1120** and the base **1130** may be disposed between the case **1110** and the bottom plate **1140** to increase the structural strength of the optical element driving mechanism **1000**. In some embodiments, the base **1130** may be polygonal when viewed along the main axis **1900**.

[0062] In some embodiments, the driving assembly **1300** may include driving magnetic elements **1310** and driving coils **1320** disposed on the fixed portion **1100** and the movable portion **1200**, respectively. Alternatively, their positions may be interchanged, depending on design requirement. When current passes through the driving coils **1320**, the driving coils **1320** will interact with the magnetic field of the driving magnetic elements **1310** to generate an electromagnetic force to drive the movable portion **1200** and the optical element **1800** to move relative to the fixed portion **1100** to achieve auto focus. In some embodiments, the driving assembly **1300** may include other driving elements such as piezoelectric, shape memory alloy, etc.

[0063] In some embodiments, the first resilient element **1400** and the second resilient element **1500** may be disposed on opposite sides of the movable portion **1200**. The first resilient element **1400** may be elastically connected to the fixed portion **1100** (e.g. the base **1130**) and the movable portion **1200**, and may be electrically connected to the driving coils **1320** and the circuit assembly **1600** to provide current to the driving coils **1320**. The second resilient

element **1500** may be disposed on the fixed portion **1100** (e.g. the base **1130**), and the movable portion **1200** may be separated from the second resilient element **1500** or in contact with each other to control the position of the movable portion **1200**, which will be described later.

[0064] In some embodiments, a first guiding rod **1160** and a second guiding rod **1170** disposed on the fixed portion **1100** may be used for movably connecting the movable portion **1200** and the fixed portion **1100**. The first guiding rod **1160** includes a first guiding rod first end **1161** and a first guiding rod second end **1162** opposite to each other, the first guiding rod first end **1161** may be affixed on the base **1130**, and the first guiding rod second end **1162** may be affixed on the case **1110**. The second guiding rod **1170** includes a first end of second guiding rod **1171** and a second end of second guiding rod **1172** opposite to each other, the first end of second guiding rod **1171** may be affixed on the base **1130**, and the second end of second guiding rod **1172** may be affixed on the case **1110**. Therefore, the first guiding rod **1160** and the second guiding rod **1170** are allowed to be fixed on the fixed portion **1100**.

[0065] In some embodiments, when viewed along the main axis **1900**, the first guiding rod **1160** and the second guiding rod **1170** may be in direct contact with the movable portion **1200** to define the moving direction of the movable portion **1200** relative to the fixed portion **1100**. The first guiding rod **1160** and the second guiding rod **1170** may include magnetic permeable materials.

[0066] In some embodiments, the way that the first guiding rod first end **1161** connecting to the base **1130** may be different from that of the first guiding rod second end **1162** connected to the case **1110**, and the way that the first end of second guiding rod **1171** connecting to the base **1130** may be different from that of the second end of second guiding rod **1172** connected to the case **1110**. For example, as shown in FIG. **1**F, the first guiding rod first end **1161** and the first end of second guiding rod **1171** may be adhered to the case **1110** by glue. Moreover, the base **1130** may include a first connection opening **1181** and the second connection opening **1182**. The first connection opening **1181** and the second connection opening **1182** allows laser to be provided to the first guiding rod second end **1162** and the second end of second guiding rod **1172** from the backside of the base **1130** (the side facing away from the case **1110**) to heat the first guiding rod second end **1162** and the second end of second guiding rod **1172**, and thus the first guiding rod **1160** and the second guiding rod **1170** may be connected to the first connection opening **1181** and the second connection opening **1182** by laser welding, respectively.

[0067] In some embodiments, a first adhesive element **1183** and a second adhesive element **1184** may be provided in the first connection opening **1181** and the second connection opening **1182**, respectively, to connect the base **1130** to the first guiding rod **1160** and the second guiding rod **1170**. In other words, in the first direction (Z direction), the first adhesive element **1183** and the first guiding rod **1160** at least partially overlap each other, the second adhesive element **1184** and the second guiding rod **1170** at least partially overlap each other, the first guiding rod **1160** does not expose from the first connection opening **1181**, and the second guiding rod **1170** does not expose from the second connection opening **1182** to ensure the amounts of the first adhesive element **1183** and the second adhesive element **1184** are enough. Therefore, the base **1130** may be further affixed to the first guiding rod **1160** and the second guiding rod **1170**.

[0068] FIG. **2**A is a top view of some elements of the optical element driving mechanism **1000**, FIG. **2**B is a perspective view of some elements of the optical element driving mechanism **1000**, wherein the case **1110** is omitted to show position relationship of other elements. As shown in FIG. **1**F and FIG. **2**A, the first guiding rod **1160** and the second guiding rod **1170** may extend in the Z direction, the movable portion **1200** may in contact with the first guiding rod **1160** and the second guiding rod **1170**. The first guiding rod **1160** and the second guiding rod **1170** may be used for define the moving direction of the movable portion **1200**, such as the movable portion **1200** may slide relative to the first guiding rod **1160** and the second guiding rod **1170** in the Z direction. To make the slide easier, a first lubricating coating and a second lubricating coating (e.g. Teflon) may be provided on the first guiding rod **1160** and the second guiding rod **1170**, respectively. Moreover, additional lubricating element (e.g. lubricating oil) may be provided on the first guiding rod **1160** and the second guiding rod **1170** and in direct contact with the first lubricating coating and a second lubricating coating, to further allow the movable portion **1200** to slide relative to the first guiding rod **1160** and the second guiding rod **1170**.

[0069] As shown in FIG. **2**A, the base **1130** of the fixed portion **1100** may include a first edge **1151**, a second edge **1152**, a third edge **1153**, a fourth edge **1154**, a fifth edge **1155**, a sixth edge **1156**, a seventh edge **1157**, and an eighth edge **1158**. The first edge **1151** is opposite to the third edge **1153**, the second edge **1152** is opposite to the fourth edge **1154**, the fifth edge **1155** is opposite to the sixth edge **1156**, and the seventh edge **1157** is opposite to the eighth edge **1158**. The fifth edge **1155** is between the first edge **1151** and the second edge **1152**, the sixth edge **1156** is between the second edge **1152** and the third edge **1153**, the seventh edge **1157** is between the third edge **1153** and the fourth edge **1154**, and the eighth edge **1158** is between the fourth edge **1154** and the first edge **1151**. In some embodiments, the first guiding rod **1160** may position at the fifth edge **1155**, and the second guiding rod **1170** may position at the seventh edge **1157**. In other words, the first guiding rod **1160** and the second guiding rod **1170** may be disposed on opposite sides of the movable portion **1200**.

[0070] In some embodiments, the driving magnetic elements **1310** may include a first driving magnetic element **1311**, a second driving magnetic element **1312**, a third driving magnetic element **1313**, and a fourth driving magnetic element **1314** disposed on the first edge **1151**, the second edge **1152**, the third edge **1153**, and the fourth edge **1154**, respectively. The driving coils **1320** may include a first driving coil **1321**, a second driving coil **1322**, a third driving coil **1323**, and a fourth driving coil **1324** disposed on the movable portion **1200** and corresponding to the first driving magnetic element **1311**, the second driving magnetic element **1312**, the third driving magnetic element **1313**, and the fourth driving magnetic element **1314**, respectively. Furthermore, in some embodiments, a first magnetic permeable element **1331**, a second magnetic permeable element **1332**, a third magnetic permeable element **1333**, and a fourth magnetic permeable element **1334** may be disposed on the base **1130** and they correspond to the first driving magnetic element **1311**, the second driving magnetic element **1312**,

the third driving magnetic element **1313**, and the fourth driving magnetic element **1314**, respectively.

[0071] In some embodiments, the first driving magnetic element **1311**, the second driving magnetic element **1312**, the third driving magnetic element **1313**, and the fourth driving magnetic element **1314** may have similar structures. Taking the fourth driving magnetic element **1314** as an example, the fourth driving magnetic element **1314** may include a first driving magnetic unit **1351** and a second driving magnetic unit **1352** arranged in the first direction. In some embodiments, when viewed in a second direction (e.g., Y direction), as shown in FIG. **2**B, the first driving magnetic unit **1351** and the fourth driving coil **1324** at least partially expose from the fourth magnetic permeable element **1334**, and the second driving magnetic unit **1352** does not expose from the fourth magnetic permeable element **1334**. Moreover, as shown in FIG. **1**E, when viewed in the second direction, a gap G**1** greater than zero is between the first magnetic permeable element **1331** and the case **1110** in a third direction (e.g., X direction), and the second magnetic permeable element **1332**, the third magnetic permeable element **1333**, and the fourth magnetic permeable element **1334** may have gaps greater than zero to the case **1110** as well.

[0072] FIG. **3**A is a schematic view of the driving magnetic elements **1310**. FIG. **3**B is a top view of the driving magnetic elements **1310**. In some embodiments, the first driving magnetic unit **1351** includes a first side surface **1353**, a second side surface **1354**, and a first lower surface **1355**. The second driving magnetic unit **1352** includes a second lower surface **1356**, wherein the second side surface **1354** is adjacent to the second lower surface **1356**, and the first side surface **1353** and the second side surface **1354** are not perpendicular or parallel to each other. The first side surface **1353** connects to the second side surface **1354**. In some embodiments, as shown in FIG. **2**B, when viewed in the second direction, at least a portion of the fourth magnetic permeable element **1334** overlaps the first side surface **1353**, and the first side surface **1353** and the second side surface **1354** at least partially expose from the fourth magnetic permeable element **1334**. In some embodiments, the first lower surface **1355** and the second lower surface **1356** face an identical direction (e.g., −Z direction). When viewed in the first direction, the second lower surface **1356** at least partially expose from the first driving magnetic unit **1351**, wherein the first driving magnetic unit **1351** is polygonal, and the second driving magnetic unit **1352** is rectangular. Since the first driving magnetic unit **1351** is polygonal, the required space may be reduced to achieve miniaturization. Moreover, the second driving magnetic unit **1352** is rectangular, which is bigger than the first driving magnetic unit **1351**, higher magnetic force may be provided to improve the performance of the optical element driving mechanism **1000**.

[0073] In some embodiments, the first magnetic permeable element **1331**, the second magnetic permeable element **1332**, the third magnetic permeable element **1333**, and the fourth magnetic permeable element **1334** may have similar structures. Taking the fourth magnetic permeable element **1334** as an example, as shown in FIG. **2**B, the fourth magnetic permeable element **1334** may include a first guiding magnetic unit **1341** and a second guiding magnetic unit **1342** connect with each other. In the third direction, the first guiding magnetic unit **1341** has a first length L**1**, the second guiding magnetic unit **1342** has a second length L**2**, and the first length L**1** is less than the second length L**2**. In some embodiments, the first guiding magnetic unit **1341** may at least partially overlap the first driving magnetic unit **1351**, and the second guiding magnetic unit **1342** may at least partially overlap the first driving magnetic unit **1351** and the second driving magnetic unit **1352** for magnetic conduction. In some embodiments, in the third direction, the first side surface **1353** has a third length L**3**, the second driving magnetic unit **1352** has a fourth length L**4**, and L**2**>L**4**>L**3**>L**1**.

[0074] FIG. **4**A is a top view of the circuit assembly **1600**. FIG. **4**B is a schematic view of the circuit assembly **1600**. FIG. **4**C is a side view of the circuit assembly **1600**. The circuit assembly **1600** may be disposed on the fixed portion **1100**, and may include a surrounding portion **1610**, a first circuit connecting portion **1620**, a second circuit connecting portion **1630**, a first extending portion **1641**, a second extending portion **1642**, and a resilient connecting portion **1643**. The surrounding portion **1610** may surround the movable portion **1200** and the main axis **1900**, and may include a first segment **1611**, a second segment **1612**, a third segment **1613**, a fourth segment **1614**, and a fifth segment **1615** sequentially connected to each other. In some embodiments, the first magnetic permeable element **1331**, the second magnetic permeable element **1332**, the third magnetic permeable element **1333**, and the fourth magnetic permeable element **1334** may be disposed on the circuit assembly **1600**. When viewed along the main axis **1900**, the surrounding portion **1610** and the second extending portion **1642** may at least partially overlap each other, the first extending portion **1641** and the second extending portion **1642** may not overlap each other, the base **1130** and the circuit assembly **1600** may at least partially overlap each other, the movable portion **1200** and the second extending portion **1642** may at least partially overlap each other and does not overlap the surrounding portion **1610**.

[0075] As shown in FIG. **2**A, the first segment **1611** is at the eighth edge **1158**, the second segment **1612** is at the first edge **1151**, the third segment **1613** is at the fifth edge **1155**, the fourth segment **1614** is at the second edge **1152**, and the fifth segment **1615** is at the sixth edge **1156**. The first extending portion **1641** is at the first edge **1151** and extends from the surrounding portion **1610** in the second direction. In other words, the circuit assembly **1600** does not dispose on the fourth edge **1154**. The second extending portion **1642** may connect to the second segment **1612** and be between the base **1130** and the bottom plate **1140**. The resilient connecting portion **1643** may connect to the first extending portion **1641**, and the first circuit connecting portion **1620** may connect to the resilient connecting portion **1643** and extend in the third direction. The second circuit connecting portion **1630** may connect to the second extending portion **1642** and extend in the first direction.

[0076] In some embodiments, a normal direction of the second extending portion **1642** is parallel to the first direction. Normal directions of the first segment **1611**, the second segment **1612**, the third segment **1613**, the fourth segment **1614**, and the fifth segment **1615** are perpendicular to the first direction, and the resilient connecting portion **1643** and the fixed portion **1100** are separated from each other. Furthermore, in some embodiments, the first magnetic permeable element **1331** and the third magnetic permeable element **1333** at least partially overlap the circuit assembly **1600** in

the third direction. The second magnetic permeable element **1332** at least partially overlaps the circuit assembly **1600** in the second direction. Moreover, when viewed in the second direction, as shown in FIG. **1**G, the fourth magnetic permeable element **1334** is exposed from the circuit assembly **1600** and separated from the circuit assembly **1600**. In some embodiments, an insulating element (not shown) may be disposed between the circuit assembly **1600** and the case **1110**, such as glue, to connect the circuit assembly **1600** and the case **1110** and prevent short circuit.

[0077] In some embodiments, as shown in FIG. **2**A and FIG. **4**A, the circuit assembly **1600** may further include a first electronic element **1671** and a second electronic element **1672** disposed on the surrounding portion **1610** and between the surrounding portion **1610** and the case **1110**, and respectively disposed on the fifth edge **1155** and the eighth edge **1158**.

[0078] In some embodiments, as shown in FIG. **4**C, a bottom surface of the second extending portion **1642** coincides a virtual plane **1910**. The first extending portion **1641** and the surrounding portion **1610** are at opposite sides of the virtual plane **1910**. In the first direction, a first distance D**1** is between the first extending portion **1641** and the virtual plane **1910**, a second distance D**2** is between the first circuit connecting portion **1620** and the virtual plane **1910**, a third distance D**3** is between the fourth segment **1614** and the virtual plane **1910**, a fourth distance D**4** is between the fifth segment **1615** and the virtual plane **1910**, and D**2**>D**4**>D**3**>D**1**. In some embodiments, the third distance D**3** may be less than the first distance D**1**, depending on design requirement. In some embodiments, in the first direction, the first segment **1611** has a first height H**1**, the fourth segment **1614** has a second height H**2**, the fifth segment **1615** has a third height H**3**, and H**1**<H**2**<H**3**. In some embodiments, when viewed in the second direction, the first segment **1611** at least partially overlaps the third segment **1613**. Moreover, when viewed in the second direction, the first segment **1611** at least partially exposed from the third segment **1613**, and the second extending portion **1642** does not overlap the surrounding portion **1610** to achieve miniaturization.

[0079] FIG. **5**A and FIG. **5**B are schematic views of some elements of the optical element driving mechanism **1000**. As shown in FIG. **2**A, FIG. **5**A, and FIG. **5**B, the optical element driving mechanism **1000** may further include a sensing assembly **1700** disposed on the sixth edge **1156** and including a position sensing element **1710**, a sensing magnetic element **1720**, and a reinforcement element **1730**. In some embodiments, the sensing assembly **1700** and the second extending portion **1642** may at least partially overlap each other when viewed along the main axis **1900**.

[0080] In some embodiments, the position sensing element **1710** may include a Hall sensor, a magnetoresistance effect sensor (MR sensor), a giant magnetoresistance effect sensor (GMR sensor), a tunneling magnetoresistance effect sensor (TMR sensor), or a fluxgate sensor. The position sensing element **1710** may detect the magnetic field generated from the sensing magnetic element **1720**, and the position sensing element **1710** and the sensing magnetic element **1720** may be disposed on the fixed portion **1100** (or the circuit assembly **1600**) and the movable portion **1200**, respectively, or their positions may be interchanged. Therefore, the position of the movable portion **1200** relative to the fixed portion **1100** (or to the circuit assembly **1600**) may be detected by the sensing assembly **1700**. In some embodiments, the first electronic element **1671** and the sensing assembly **1700** may be disposed on opposite sides of the movable portion **1200** to prevent interference. In some embodiments, the first electronic element **1671** may include multiple connection pins, and at least half of the connection pins do not electrically connect to the circuit assembly **1600**.

[0081] In some embodiments, the reinforcement element **1730** may be disposed on the fixed portion **1100** or the circuit assembly **1600**, such as may be disposed on the fifth segment **1615** of the surrounding portion **1610**, the circuit assembly **1600** may be between the reinforcement element **1730** and the position sensing element **1710**, and the sensing magnetic element **1720** and the reinforcement element **1730** may be disposed on opposite sides of the position sensing element **1710**. In some embodiments, the material of the reinforcement element **1730** may include nonmagnetic permeable metal to provide structural strength.

[0082] As shown in FIG. **5**B, when viewed in a fourth direction perpendicular to the fifth segment **1615** (parallel to the normal direction of the fifth segment **1615**), the reinforcement element **1730** at least partially overlaps the position sensing element **1710** and the sensing magnetic element **1720**, the sensing magnetic element **1720** is at least partially exposed from the reinforcement element **1730**, the fifth segment **1615** at least partially overlaps the position sensing element **1710**, the sensing magnetic element **1720**, and the reinforcement element **1730**, and the resilient connecting portion **1643** and the base **1130** at least partially overlap each other. The fourth direction is perpendicular to the first direction. Moreover, the sensing magnetic element **1720** has a width W**1**, the position sensing element **1710** has a width W**2**, the reinforcement element **1730** has a width W**3**, and the fifth segment **1615** has a width W**4**, and W**4**>W**3**>W**1**>W**2**. In some embodiments, when viewed in the fourth direction, the circuit assembly **1600** at least partially overlaps the second magnetic permeable element **1332** and the third magnetic permeable element **1333**, and the second magnetic permeable element **1332** and the third magnetic permeable element **1333** do not overlap the sensing assembly **1700** to achieve miniaturization.

[0083] FIG. **5**C is a schematic view of the position sensing element **1710** and the sensing magnetic element **1720**. In some embodiments, the position sensing element **1710** may include a plurality of first sensing magnetic units **1711** and second sensing magnetic units **1712** arranged alternatively in the first direction, and the first sensing magnetic units **1711** and the second sensing magnetic units **1712** have opposite pole directions. Therefore, when relative movement in the Z direction occurs between the position sensing element **1710** and the sensing magnetic element **1720**, the position sensing element **1710** may detect the magnetic field variation caused by the first sensing magnetic units **1711** and the second sensing magnetic units **1712** of the sensing magnetic element **1720** to get the position of the movable portion **1200** relative to the fixed portion **1100**.

[0084] In some embodiments, as shown in FIG. **4**A, the optical element driving mechanism **1000** may further include a storage unit **1681** and a processing unit **1682** disposed on the fixed portion **1100** or the circuit assembly **1600**. In some embodiments, the storage unit **1681** may include storage devices such as memory (e.g., dynamic random access memory (DRAM) device, static random access memory (SRAM) device, high bandwidth memory

(HBM) device, etc.). In some embodiments, the processing unit **1682** may include process units such as logic device (e.g., central processing units (CPUs), graphics processing unit (GPUs), system-on-chips (SoCs), application processors (APs), micro controllers, application-specific integrated circuit (ASIC), etc.

[0085] In some embodiments, the processing unit **1682** may be configured to determine the position of the movable portion **1200** relative to the fixed portion **1100** according to the calibration information stored in the storage unit **1681**. In some embodiments, since the elements of the optical element driving mechanism **1000** may have tolerances during manufacture, the calibration information of the optical element driving mechanism **1000** may be obtained through the following steps. First, move the movable portion **1200** from an initial position to a final position, such as move the entire stroke in the Z direction. Next, the magnetic field of the sensing magnetic element **1720** is sensed by the position sensing element **1710** to obtain first position information, and the first position information includes magnetic field values at different positions. Next, the first position information is analyzed to obtain calibration information.

[0086] In some embodiments, the operation of analyzing first position information may include differentiating the first position information to obtain second position information. Then, based on the number of positive and negative changes in the second position information, the number of sensing magnetic elements passing through the first sensing magnetic units **1711** and the second sensing magnetic units **1712** is determined, and the position interval information is obtained based on this number. Based on the position interval information and the magnetic field sensed by the position sensing element, the detailed position of the movable portion **1200** relative to the fixed portion **1100** is determined. For example, if the positive and negative values change once, it represents passing through one first sensing magnetic unit **1711** and one second sensing magnetic unit **1712**, thus the relative distance of movement between the sensing magnetic element **1720** and the position sensing element **1710** may be determined. Finally, calibration information may be obtained through the detailed position of the movable portion **1200** relative to the fixed portion **1100**, the position interval information, and the magnetic field.

[0087] FIG. **6**A is a schematic view of the movable portion **1200** and the driving coils **1320**. FIG. **6**B is a top view of the movable portion **1200** and the driving coils **1320**. FIG. **6**C is a side view of the movable portion **1200** and the driving coils **1320**. In some embodiments, as shown in FIG. **6**A to FIG. **6**C, the movable portion **1200** may mainly include a main body **1210**, a first pressing portion **1221**, a second pressing portion **1222**, a third pressing portion **1223**, a fourth pressing portion **1224**, a first upper stopping portion **1231**, a second upper stopping portion **1232**, a third upper stopping portion **1233**, a fourth upper stopping portion **1234**, a fifth upper stopping portion **1235**, a sixth upper stopping portion **1236**, a first side stopping portion **1241**, a second side stopping portion **1242**, a third side stopping portion **1243**, and a fourth side stopping portion **1244**.

[0088] In some embodiments, the first pressing portion **1221**, the second pressing portion **1222**, the third pressing portion **1223**, the fourth pressing portion **1224**, the first upper stopping portion **1231**, the second upper stopping portion **1232**, the third upper stopping portion **1233**, the fourth upper stopping portion **1234**, the fifth upper stopping portion **1235**, and the sixth upper stopping portion **1236** may extend from the main body **1210** in the first direction. As seen in FIG. **1**C and FIG. **1**D, when viewed in the first direction or the second direction, the first pressing portion **1221**, the second pressing portion **1222**, the third pressing portion **1223**, and the fourth pressing portion **1224** are exposed from the case **1110**. When viewed in the first direction, the first pressing portion **1221**, the second pressing portion **1222**, the third pressing portion **1223**, and the fourth pressing portion **1224** are arranged in a counterclockwise manner around the main axis **1900**. In some embodiments, materials for the first pressing portion **1221**, the second pressing portion **1222**, the third pressing portion **1223**, and the fourth pressing portion **1224** may include soft materials (e.g. plastic).

[0089] In some embodiments, the first upper stopping portion **1231** is adjacent to the first pressing portion **1221**, the second upper stopping portion **1232** and the third upper stopping portion **1233** are adjacent to the second pressing portion **1222**, the fourth upper stopping portion **1234** is adjacent to the third pressing portion **1223**, and the fifth upper stopping portion **1235** and the sixth upper stopping portion **1236** are adjacent to the fourth pressing portion **1224**. In some embodiments, when viewed in the first direction, the connection **1270** passes through the first pressing portion **1221** and the third pressing portion **1223**, and the first upper stopping portion **1231** and the fourth upper stopping portion **1234** are on a same side of the connection **1270**. In some embodiments, when viewed in the first direction, the first upper stopping portion **1231**, the second upper stopping portion **1232**, the third upper stopping portion **1233**, the fourth upper stopping portion **1234**, the fifth upper stopping portion **1235**, and the sixth upper stopping portion **1236** are arranged in a counterclockwise order around the main axis **1900**. In some embodiments, the first upper stopping portion **1231**, the second upper stopping portion **1232**, the third upper stopping portion **1233**, the fourth upper stopping portion **1234**, the fifth upper stopping portion **1235**, and the sixth upper stopping portion **1236** at least partially overlap with the case **1110** and do not expose from the case **1110**.

[0090] In other words, when the movable portion **1200** moves in the Z direction, the first upper stopping portion **1231**, the second upper stopping portion **1232**, the third upper stopping portion **1233**, the fourth upper stopping portion **1234**, the fifth upper stopping portion **1235**, and the sixth upper stopping portion **1236** may be used to restrict the range of motion of the movable portion **1200**, while the first pressing portion **1221**, the second pressing portion **1222**, the third pressing portion **1223**, and the fourth pressing portion **1224** may protrude from the case **1110** to allow external driving assembly to apply pressure to the movable portion **1200** and control the position of the movable portion **1200** (as explained later).

[0091] In some embodiments, the movable portion **1200** may also include a first opening **1251** and a second opening **1252**, and the optical element driving mechanism **1000** may also include a first positioning magnetic element **1261** and a second positioning magnetic element **1262** disposed in the first opening **1251** and the second opening **1252**, respectively. For example, the first positioning magnetic element **1261** and the second positioning magnetic element **1262** may be magnets and may be adjacent to the first guiding rod **1160** and the second guiding rod **1170**, respectively. Due to

the first guiding rod **1160** and the second guiding rod **1170** have magnetic permeable material, the first positioning magnetic element **1261** and the second positioning magnetic element **1262** may generate magnetic forces between the first guiding rod **1160** and the second guiding rod **1170**, so that after the driving assembly **1300** is used to move the movable portion **1200** to a specific position, the position of the movable portion **1200** may be fixed without continuously providing power to the driving assembly **1300** to fix the position of the movable portion **1200**, thus saving energy usage.

[0092] The first side stopping portion **1241**, the second side stopping portion **1242**, the third side stopping portion **1243**, and the fourth side stopping portion **1244** may be disposed on the main body **1210** and extend towards the X or Y direction. The first driving coil **1321**, the second driving coil **1322**, the third driving coil **1323**, and the fourth driving coil **1324** may be respectively disposed on the first side stopping portion **1241**, the second side stopping portion **1242**, the third side stopping portion **1243**, and the fourth side stopping portion **1244**, and the distance between the first side stopping portion **1241**, the second side stopping portion **1242**, the third side stopping portion **1243**, and the fourth side stopping portion **1244** and the case **1110** may be less than the distance between the first driving coil **1321**, the second driving coil **1322**, the third driving coil **1323**, and the fourth driving coil **1324** and the case **1110**, in order to avoid direct collision between the first driving coil **1321**, the second driving coil **1322**, the third driving coil **1323**, and the fourth driving coil **1324** and the case **1110**.

[0093] In some embodiments, as shown in FIG. **2**A and FIG. **6**B, the movable portion **1200** may include a movable portion top surface **1201**, and the optical element **1800** may include an optical element surface **1801**, facing an identical direction (e.g. in the +Z direction). In addition, in some embodiments, a dust-catching element (not shown, such as a dust-catching adhesive) may be disposed on the movable portion top surface **1201** or the optical element surface **1801** to capture any dust generated during the operation of the optical element driving mechanism **1000**, to avoid interfering with the photosensitivity of the optical element driving mechanism **1000**.

[0094] FIG. **7**A is a schematic view of the first resilient element **1400**. As shown in FIG. **2**A and FIG. **7**A, the first resilient element **1400** may include a first resilient unit **1401**, a second resilient unit **1402**, a third resilient unit **1403**, a fourth resilient unit **1404**, a fifth resilient unit **1405**, and a sixth resilient unit **1406**. The first resilient unit **1401** may be disposed on the first edge **1151**, the second resilient unit **1402** and the third resilient unit **1403** may be disposed on the second edge **1152**, the fourth resilient unit **1404** and the fifth resilient unit **1405** may be disposed on the third edge **1153**, and the sixth resilient unit **1406** may be disposed on the fourth edge **1154**. When observing along the main axis **1900**, a first segment **1461** passes through the main axis **1900**, the first resilient unit **1401** and the sixth resilient unit **1406** are symmetrical to the first segment **1461**, the second resilient unit **1402** and the fifth resilient unit **1405** are symmetrical to the first segment **1461**, and the third resilient unit **1403** and the fourth resilient unit **1404** are symmetrical to the first segment **1461**. That is to say, the first segment **1461** may be the symmetrical axis of the first resilient element **1400**, and the first segment **1461** does not pass through the first guiding rod **1160** and the second guiding rod **1170**.

[0095] In some embodiments, a second segment **1462** passes through the first guiding rod **1160** and second guiding rod **1170**, and the first segment **1461** and the second segment **1462** are vertically oriented with respect to each other. In some embodiments, when viewed along the main axis **1900**, the first resilient unit **1401** and the sixth resilient unit **1406** are located on one side of the second segment **1462** and the second resilient unit **1402**, the third resilient unit **1403**, the fourth resilient unit **1404**, and the fifth resilient unit **1405** are located on the other side of the second segment **1462**. Additionally, the second segment **1462** does not pass through the first resilient element **1400**.

[0096] The first resilient element **1400** may be electrically connected to the circuits in the fixed portion **1100** and the movable portion **1200**. For example, the first resilient unit **1401** may include a first movable portion connecting portion **1411**, a first fixed portion connecting portion **1421**, and a first string **1431**. The second resilient unit **1402** may include a second movable portion connecting portion **1412**, a second fixed portion connecting portion **1422**, and a second string **1432**. The third resilient unit **1403** may include a third movable portion connecting portion **1413**, a third fixed portion connecting portion **1423**, and a third string **1433**. The fourth resilient unit **1404** may include a fourth movable portion connecting portion **1414**, a fourth fixed portion connecting portion **1424**, and a fourth string **1434**. The fifth resilient unit **1405** may include a fifth movable portion connecting portion **1415**, a fifth fixed portion connecting portion **1425**, and a fifth string **1435**. The sixth resilient unit **1406** may include a sixth movable portion connecting portion **1416**, a sixth fixed portion connecting portion **1426**, and a sixth string **1436**.

[0097] In some embodiments, the first movable portion connecting portion **1411**, the second movable portion connecting portion **1412**, the third movable portion connecting portion **1413**, the fourth movable portion connecting portion **1414**, the fifth movable portion connecting portion **1415**, and the sixth movable portion connecting portion **1416** may be disposed on the movable portion **1200**, while the first fixed portion connecting portion **1421**, the second fixed portion connecting portion **1422**, the third fixed portion connecting portion **1423**, the fourth fixed portion connecting portion **1424**, the fifth fixed portion connecting portion **1425**, and the sixth fixed portion connecting portion **1426** may be disposed on the fixed portion **1100**. In this way, electrical connections may be made between the circuits in the fixed portion **1100** and the movable portion **1200**.

[0098] In some embodiments, the first string **1431** connects the first movable portion connecting portion **1411** and the first fixed portion connecting portion **1421**. The second string **1432** connects the second movable portion connecting portion **1412** and the second fixed portion connecting portion **1422**. The third string **1433** connects the third movable portion connecting portion **1413** and the third fixed portion connecting portion **1423**. The fourth string **1434** connects the fourth movable portion connecting portion **1414** and the fourth fixed portion connecting portion **1424**. The fifth string **1435** connects the fifth movable portion connecting portion **1415** and the fifth fixed portion connecting portion **1425**. The sixth string **1436** connects the sixth movable portion connecting portion **1416** and the sixth fixed portion connecting portion **1426**.

[0099] In some embodiments, the first resilient unit **1401** and the sixth resilient unit **1406** may have symmetrical

structures, while the second resilient unit **1402**, the third resilient unit **1403**, the fourth resilient unit **1404**, and the fifth resilient unit **1405** may have similar structures. For example, the distance between the first movable portion connecting portion **1411** and the first fixed portion connecting portion **1421** or the distance between the sixth movable portion connecting portion **1416** and the sixth fixed portion connecting portion **1426** may be greater than the distance between the second movable portion connecting portion **1412** and the second fixed portion connecting portion **1422**, the distance between the third movable portion connecting portion **1413** and the third fixed portion connecting portion **1423**, the distance between the fourth movable portion connecting portion **1414** and the fourth fixed portion connecting portion **1424**, or the distance between the fifth movable portion connecting portion **1415** and the fifth fixed portion connecting portion **1425**.

[0100] In some embodiments, since the second resilient unit **1402**, the third resilient unit **1403**, the fourth resilient unit **1404**, and the fifth resilient unit **1405** may have similar structures, the structure details are further explained with the second resilient unit **1402** as an example. FIG. **7**B is an enlarged view of the second resilient unit **1402**. The second string **1432** of the second resilient unit **1402** may also include a second string first portion **1451**, a second string second portion **1452**, and a second string bending portion **1453**. The second string first portion **1451** may connect to the second movable portion connecting portion **1412**, the second string second portion **1452** may connect to the second fixed portion connecting portion **1422**, and the second string bending portion **1453** may connect to the second string first portion **1451** and the second string second portion **1452**.

[0101] It should be noted that in some embodiments, the second string first portion **1451** and the second string second portion **1452** may extend in different directions, and an angle θ between the second string first portion **1451** and the second string second portion **1452** is an acute. In some embodiments, the angle θ may be less than 45 degrees. In some embodiments, a distance D**5** between the second movable portion connecting portion **1412** and the second fixed portion connecting portion **1422** is smaller than a length L**5** of the second string first portion **1451** and a length L**6** of the second string second portion **1452**. In other words, the second resilient unit **1402** (and other similar resilient units) is not designed to bear weight, but to conduct electricity, thus reducing the size of the second resilient unit **1402** and achieving miniaturization.

[0102] In some embodiments, the first movable portion connecting portion **1411**, the second fixed portion connecting portion **1422**, and the second movable portion connecting portion **1412** may be disposed on the fifth edge **1155**, the third fixed portion connecting portion **1423**, the third movable portion connecting portion **1413**, the fourth fixed portion connecting portion **1424**, and the fourth movable portion connecting portion **1414** may be disposed on the sixth edge **1156**. The fifth fixed portion connecting portion **1425**, the fifth movable portion connecting portion **1415**, and the sixth movable portion connecting portion **1416** may be disposed on the seventh edge **1157**, while the first fixed portion connecting portion **1421** and the sixth fixed portion connecting portion **1426** may be disposed on the eighth edge **1158**.

[0103] FIG. **8** is a schematic view of some elements of the optical element driving mechanism **1000**, mainly showing the first resilient element **1400**, the circuit assembly **1600**, the first conductive assembly **1650** embedded in the movable portion **1200**, and the conductive assembly **1660** embedded in the base **1130**. In some embodiments, the first conductive assembly **1650** and the conductive assembly **1660** may be electrically insulating from each other.

[0104] In some embodiments, the first conductive assembly **1650** may include a first conductive portion **1651**, a second conductive portion **1652**, a third conductive portion **1653**, and a fourth conductive portion **1654**, and in the first direction, the first conductive portion **1651** and the second conductive portion **1652** are at different heights from the third conductive portion **1653** and the fourth conductive portion **1654**. The circuit assembly **1600** may be electrically connected to the first driving coil **1321** and the second driving coil **1322** via the third resilient unit **1403** and the first conductive portion **1651**, and may be electrically connected to the third driving coil **1323** and the fourth driving coil **1324** via the fourth resilient unit **1404** and the second conductive portion **1652**, thus allowing the first driving coil **1321** connects the second driving coil **1322** in series, and allowing the third driving coil **1323** connects the fourth driving coil **1324** in series. In some embodiments, the first driving coil **1321** and the second driving coil **1322** are connected to the third driving coil **1323** and the fourth driving coil **1324** in parallel via the third conductive portion **1653** and the fourth conductive portion **1654**.

[0105] In some embodiments, an additional optical module (not shown) may be disposed on the optical element driving mechanism **1000**, such as an aperture. Additionally, the optical module may be electrically connected to the conductive assembly **1660** via the first resilient unit **1401**, the second resilient unit **1402**, the fifth resilient unit **1405**, and the sixth resilient unit **1406** of the first resilient element **1400** to control the optical module. Furthermore, the third resilient unit **1403** and the fourth resilient unit **1404** are electrically insulated from the first resilient unit **1401**, the second resilient unit **1402**, the fifth resilient unit **1405**, and the sixth resilient unit **1406** to avoid interference between the signals controlling the optical element driving mechanism **1000** and the signals controlling the optical module.

[0106] In some embodiments, as shown in FIG. **2**A and FIG. **8**, the conductive assembly **1660** may include a first terminal **1661**, a second terminal **1662**, a third terminal **1663**, and a fourth terminal **1664** arranged in sequence on the first edge **1151**. The first terminal **1661**, the second terminal **1662**, the third terminal **1663**, and the fourth terminal **1664** may be sequentially electrically connected to the first resilient unit **1401**, the sixth resilient unit **1406**, the fifth resilient unit **1405**, and the second resilient unit **1402**, respectively, to separately control each driving coil.

[0107] In some embodiments, the optical element driving mechanism **1000** may also include an adhesive element **1470** (e.g., a conductive adhesive element, such as a solder ball or silver paste), disposed on the first fixed portion connecting portion **1421**, the second fixed portion connecting portion **1422**, the third movable portion connecting portion **1413**, the third fixed portion connecting portion **1423**, the fourth movable portion connecting portion **1414**, the fourth fixed portion connecting portion **1424**, the fifth fixed portion connecting portion **1425**, the sixth fixed portion connecting portion **1426**, to electrically connect the first

resilient element **1400**, the first conductive assembly **1650**, and the conductive assembly **1660**.

[0108] FIG. **9**A is a schematic view of some elements of the optical element driving mechanism **1000**, mainly showing the base **1130** and the second resilient element **1500**. FIG. **9**B is an enlarged view of some elements of the optical element driving mechanism **1000**. In some embodiments, the second resilient element **1500** may mainly include a first base connecting portion **1510**, a first string portion **1520**, a second base connecting portion **1530**, a second string portion **1540**, and a contact portion **1550**. The first base connecting portion **1510** and the second base connecting portion **1530** may be used to connect the base **1130**, the first string portion **1520** may be used to connect the first base connecting portion **1510** and the contact portion **1550**, and the second string portion **1540** may be used to connect the second base connecting portion **1530** and the contact portion **1550**. In some embodiments, when viewed in the first direction, the first base connecting portion **1510** and the second base connecting portion **1530** may be disposed on opposite sides of the base **1130**, and the first string portion **1520** and the second string portion **1540** may also be disposed on opposite sides of the base **1130**. Additionally, the first guiding rod **1160**, the second guiding rod **1170**, the first base connecting portion **1510**, and the first string portion **1520** may be disposed on different sides of the base **1130** to further utilize the space of the optical element driving mechanism **1000**.

[0109] In some embodiments, the contact portion **1550** may be disposed on the first edge **1151**, the second edge **1152**, the third edge **1153**, and the fourth edge **1154**, while the first base connecting portion **1510** and the first string portion **1520** may be disposed on the sixth edge **1156**, and the second base connecting portion **1530** and the second string portion **1540** may be disposed on the eighth edge **1158**. In other words, the first base connecting portion **1510**, the second base connecting portion **1530**, and the contact portion **1550** may be located on different sides of the base **1130**. It should be noted that the first edge **1151**, the second edge **1152**, the third edge **1153**, the fourth edge **1154**, the fifth edge **1155**, and the seventh edge **1157** are not in direct contact with the second resilient element **1500**, but are separated from the second resilient element **1500** by a distance in the first direction (as shown in FIG. **1**E and FIG. **1**F).

[0110] In some embodiments, the base **1130** may further include a main body **1560**, a first protrusion **1561**, a second protrusion **1562**, a third protrusion **1563**, the fourth protrusion **1564**, the first connecting element **1571**, the second connecting element **1572**, the third connecting element **1573**, and the fourth connecting element **1574**, which may protrude in the first direction from the main body **1560**. The first string portion **1520** may be disposed between the first protrusion second protrusion second protrusion **1562** and the second protrusion **1562**, while the second string portion **1540** may be disposed between the third protrusion **1563** and the fourth protrusion **1564**, to protect the first string portion **1520** and the second string portion **1540**. The first connecting element **1571** and the second connecting element **1572** may pass through the first base connecting portion **1510**, and the third connecting element **1573** and the fourth connecting element **1574** may pass through the second base connecting portion **1530**, to secure the relative position between the second resilient element **1500** and the base **1130**.

[0111] In some embodiments, a connection **1280** may pass through the first string portion **1520**, the second string portion **1540**, and the main axis **1900**, with the first connecting element **1571** and the second connecting element **1572** being disposed on opposite sides of the connection **1280**, and the third connecting element **1573** and the fourth connecting element **1574** also being disposed on opposite sides of the connection **1280**. In some embodiments, the first base connecting portion **1510** may include a first opening **1511**, the second base connecting portion **1530** may include a second opening **1531**, and when viewed in the first direction, at least a portion of the base **1130** may be exposed from the first opening **1511** and the second opening **1531**. The first opening **1511** may be disposed between the first connecting element **1571** and the second connecting element **1572**, the second opening **1531** may be disposed between the third connecting element **1573** and the fourth connecting element **1574**, and the connection **1280** may pass through the first opening **1511** and the second opening **1531**. In some embodiments, additional adhesive elements (not shown) may be disposed on the first opening **1511** and the second opening **1531** and in direct contact with the base **1130** and the second resilient element **1500** to further fix the relative position of the base **1130** and the second resilient element **1500**.

[0112] In some embodiments, the thickness of first resilient element **1400** may differ from that of the second resilient element **1500**. For example, the thickness of first resilient element **1400** may be less than that of the second resilient element **1500**. In some embodiments, a ratio of the thickness of first resilient element **1400** to that of second resilient element **1500** may be between about 0.5 and about 0.8, allowing second resilient element **1500** to have a higher mechanical strength.

[0113] FIG. **9**C is an enlarged view of a portion of the base **1130**. As shown in FIG. **1**F and FIG. **9**C, the base **1130** may include a first guiding rod disposing portion **1131** and a second guiding rod disposing portion **1134**, the first guiding rod disposing portion **1131** may include a first guiding rod disposing recess **1132** and a first guiding rod disposing surface **1133**, and the second guiding rod disposing portion **1134** may include a second guiding rod disposing recess **1135**. In some embodiments, the first guiding rod disposing surface **1133** is disposed in the first guiding rod disposing recess **1132**, the first guiding rod **1160** is disposed in and protruding from the first guiding rod disposing recess **1132** and directly contacts the first guiding rod disposing surface **1133**. The second guiding rod **1170** may be disposed on the second guiding rod disposing recess **1135** to fix the relative position of the first guiding rod **1160**, the second guiding rod **1170**, and the base **1130**. In some embodiments, the first guiding rod disposing recess **1132** and the second guiding rod disposing recess **1135** may also include structures with openings.

[0114] FIG. **10**A and FIG. **10**B are schematic views showing the switching of the optical element driving mechanism **1000** from a first state (FIG. **10**A) to a second state (FIG. **10**B) through an external driving assembly **1920**. As shown in FIG. **10**A, in the first state, the movable portion **1200** directly contacts the second resilient element **1500** and is separated from the fixed portion **1100**. At this time, the movable portion **1200** is in the first position. It should be noted that the first driving magnetic unit **1351** of the driving magnetic elements **1310** may contact the second driving

magnetic unit **1352**, which means the interface **1350** is between the first driving magnetic unit **1351** and the second driving magnetic unit **1352**. When viewed from the second direction in the first state, the driving coils **1320** and the interface **1350** at least partially overlap each other.

[0115] In some embodiments, the pressing portion **1220** of the movable portion **1200** (such as the first pressing portion **1221**, the second pressing portion **1222**, the third pressing portion **1223**, and the fourth pressing portion **1224**) may at least partially exposed from the base **1130**, and the external driving assembly **1920** may directly contact the pressing portion **1220** to apply a first downward force to the movable portion **1200** through the pressing portion **1220**. Thus, the movable portion **1200** may directly contact the contact portion **1550** of the second resilient element **1500**, so that the first base connecting portion **1510** (and the second base connecting portion **1530**) and the contact portion **1550** are in different planes. At this time, the second resilient element **1500** undergoes deformation and then applies an upward second force to the movable portion **1200** through the contact portion **1550**, and the first force and the second force are in opposite directions, so as to fix the movable portion **1200** in the first position.

[0116] Then, as shown in FIG. **10**B, by moving the external driving assembly **1920** away from the pressing portion **1220**, the movable portion **1200** is only subjected to the second force provided by the second resilient element **1500**, causing the movable portion **1200** to move upwardly (+Z direction) along the main axis **1900** to reach the second position. Then, the driving assembly **1300** applies an upward driving force on the movable portion **1200** to further drive the movable portion **1200** to the third position, which is referred to as a second state. The optical element driving mechanism **1000** may move during the second state to achieve auto focusing. It should be noted that during the second state, the first base connecting portion **1510** (and the second base connecting portion **1530**) and the contact portion **1550** may be in a same plane, meaning that the movable portion **1200** and the second resilient element **1500** may be separated from each other to prevent the second resilient element **1500** from affecting the movement of the movable portion **1200**. It should be noted that when the optical element driving mechanism **1000** operates later, the movable portion **1200** and second resilient element **1500** may be separated from each other, and the pressing portion **1220** is at least partially exposed from the base **1130**.

[0117] Next, when retracting the movable portion **1200** into the fixed portion **1100**, since the pressing portion **1220** is partially exposed from the base **1130**, the first force may be reapplied to the pressing portion **1220** of the movable portion **1200** by the external driving assembly **1920** to drive the movable portion **1200** reaching the first position, returning to the state shown in the FIG. **10**A. Most of the movable portion **1200** may be accommodated within the fixed portion **1100** to reduce the size of optical element driving mechanism **1000** in the Z direction and achieve miniaturization, and the movable portion **1200** may be protected.

[0118] In summary, some embodiments of the present disclosure provide an optical element driving mechanism that includes a movable portion, a fixed portion, and a driving assembly. The movable portion is used to connect the optical element. The movable portion may move relative to the fixed portion. The driving assembly is used to drive the movable portion to move relative to the fixed portion. This allows an external driving assembly to move the movable portion, thereby enabling the movement of optical elements with larger sizes and also achieving miniaturization.

[0119] The relative positions and size relationship of the elements in the present disclosure may allow the driving mechanism achieving miniaturization in specific directions or for the entire mechanism. Moreover, different optical modules may be combined with the driving mechanism to further enhance optical quality, such as the quality of photographing or accuracy of depth detection. Therefore, the optical modules may be further utilized to achieve multiple anti-vibration systems, so image stabilization may be significantly improved.

[0120] Although embodiments of the present disclosure and their advantages already have been described in detail, it should be understood that various changes, substitutions and alterations may be made herein without departing from the spirit and the scope of the disclosure as defined by the appended claims. Moreover, the scope of the present application is not intended to be limited to the particular embodiments of the process, machine, manufacture, and composition of matter, means, methods and steps described in the specification. As one of ordinary skill in the art will readily appreciate from the disclosure of the present disclosure, processes, machines, manufacture, compositions of matter, means, methods, or steps, presently existing or later to be developed, that perform substantially the same function or achieve substantially the same result as the corresponding embodiments described herein may be utilized according to the present disclosure. Accordingly, the appended claims are also intended to include within their scope of such processes, machines, manufacture, and compositions of matter, means, methods, or steps. In addition, each claim herein constitutes a separate embodiment, and the combination of various claims and embodiments are also within the scope of the disclosure.

What is claimed is:

1. An optical element driving mechanism, comprising:
- a movable portion used for connecting an optical element;
- a fixed portion, wherein the movable portion is movable relative to the fixed portion; and
- a driving assembly used for driving the movable portion to move relative to the fixed portion.

2. The optical element driving mechanism as claimed in claim **1**, further comprising a circuit assembly disposed on the fixed portion, wherein:
- the fixed portion comprises a case and a base arranged along a main axis, and the main axis extends in a first direction;
- the base is polygonal when viewed along the main axis;
- the fixed portion comprises a first side, a second side, a third side, and a fourth side;
- the driving assembly is disposed on the first side, the second side, the third side, and the fourth side.

3. The optical element driving mechanism as claimed in claim **2**, wherein:
- the first side and the third side are opposite;
- the second side and the fourth side are opposite;
- the circuit assembly is disposed on the first side, the second side, and the third side;
- the circuit assembly is not disposed on the fourth side.

4. The optical element driving mechanism as claimed in claim **3**, wherein:

the fixed portion further comprises a fifth side, a sixth side, a seventh side, and an eighth side;

the fifth side is between the first side and the second side;

the sixth side is between the second side and the third side;

the seventh side is between the third side and the fourth side;

the eighth side is between the fourth side and the first side;

the fixed portion further comprises a bottom plate.

5. The optical element driving mechanism as claimed in claim **4**, wherein the circuit assembly comprises:

a surrounding portion comprising a first segment, a second segment, a third segment, a fourth segment, and a fifth segment surrounding the main axis;

a first extending portion disposed on the first side and extending from the surrounding portion in a second direction perpendicular to the first direction; and

a second extending portion between the base and the bottom plate and connecting to the second segment.

6. The optical element driving mechanism as claimed in claim **5**, wherein the circuit assembly further comprises:

a resilient connecting portion connecting to the first extending portion;

a first circuit connecting portion connecting to the resilient connecting portion and extending in a third direction different from the first direction and the second direction; and

a second circuit connecting portion connecting to the second extending portion and extending in the first direction.

7. The optical element driving mechanism as claimed in claim **6**, wherein:

the first segment is disposed on the eighth side;

the second segment is disposed on the first side;

the third segment is disposed on the fifth side;

the fourth segment is disposed on the second side;

the fifth segment is disposed on the sixth side;

a normal direction of the second extending portion is parallel to the first direction;

normal directions of the first segment, the second segment, the third segment, the fourth segment, and the fifth segment are perpendicular to the first direction;

the resilient connecting portion is separated from the fixed portion.

8. The optical element driving mechanism as claimed in claim **7**, wherein the circuit assembly further comprises:

a first electronic element disposed on the surrounding portion, on the fifth side, and between the surrounding portion and the case;

a second electronic element disposed on the surrounding portion, on the eighth side, and between the surrounding portion and the case.

9. The optical element driving mechanism as claimed in claim **8**, further comprising a sensing assembly, wherein the sensing assembly comprises:

a position sensing element disposed on the surrounding portion, on the sixth side, and between the surrounding portion and the movable portion;

a sensing magnetic element disposed on the movable portion, and the position sensing element and the sensing magnetic element at least partially overlap each other in a fourth direction perpendicular to the first direction; and

a reinforcement element disposed on the surrounding portion and on the sixth side, and the circuit assembly is between the reinforcement element and the position sensing element.

10. The optical element driving mechanism as claimed in claim **9**, wherein:

the fourth direction is different from the second direction and the third direction;

material of the reinforcement element comprises metal;

the reinforcement element comprises nonmagnetic permeable material.

11. The optical element driving mechanism as claimed in claim **10**, wherein:

the driving assembly comprises a driving magnetic element and a driving coil;

the driving magnetic element is disposed on the fixed portion;

the driving coil is disposed on the movable portion.

12. The optical element driving mechanism as claimed in claim **11**, further comprising a magnetic permeable element disposed on the driving magnetic element, wherein:

the magnetic permeable element and the driving coil are on opposite sides of the driving magnetic element;

the magnetic permeable is disposed on a portion of the circuit assembly.

13. The optical element driving mechanism as claimed in claim **12**, further comprising an insulating element disposed between the circuit assembly and the case, and used for connecting the circuit assembly and the case;

wherein:

the sensing assembly and the second extending portion at least partially overlap each other when viewed along the main axis;

the surrounding portion and the second extending portion at least partially overlap each other when viewed along the main axis;

the first extending portion and the second extending portion do not overlap each other when viewed along the main axis;

the base and the circuit assembly at least partially overlap each other when viewed along the main axis.

14. The optical element driving mechanism as claimed in claim **13**, wherein:

the first electronic element and the sensing assembly are disposed on opposite sides of the movable portion;

a bottom surface of the second extending portion coincides with a virtual plane;

a first distance is between the first extending portion and the virtual plane in the first direction;

a second distance is between the first circuit connecting portion and the virtual plane in the first direction;

a third distance is between the fourth segment and the virtual plane in the first direction;

a fourth distance is between the fifth segment and the virtual plane in the first direction;

the first distance is less than the second distance;

the first distance is less than the fourth distance;

the second distance is greater than the third distance;

the second distance is greater than the fourth distance;

the third distance is less than the fourth distance.

15. The optical element driving mechanism as claimed in claim **14**, wherein:

the first segment has a first height in the first direction;

the fourth segment has a second height in the first direction;

the fifth segment has a third height in the first direction;

the first height is less than the second height;

the first height is less than the third height;

the second height is less than the third height.

16. The optical element driving mechanism as claimed in claim **15**, wherein:

the first segment and the third segment at least partially overlap each other when viewed in the third direction;

at least a portion of the third segment is exposed from the first segment when viewed in the third direction;

the second extending portion does not overlap the surrounding portion when viewed in the third direction.

17. The optical element driving mechanism as claimed in claim **16**, wherein:

the first electronic element comprises a plurality of connection pins, and at least half of the connection pins do not electrically connect to the circuit assembly;

at least a portion of the reinforcement element overlaps the position sensing element and the sensing magnetic element when viewed in the fourth direction.

18. The optical element driving mechanism as claimed in claim **17**, wherein:

at least a portion of the sensing magnetic element is exposed from the reinforcement element when viewed in the fourth direction;

the fifth segment and the sensing assembly at least partially overlap each other when viewed in the fourth direction.

19. The optical element driving mechanism as claimed in claim **18**, wherein:

a width of the sensing magnetic element is greater than a width of the position sensing element when viewed in the fourth direction;

a width of the reinforcement element is less than a width of the fifth segment when viewed in the fourth direction;

the width of the reinforcement element is greater than the width of the sensing magnetic element when viewed in the fourth direction;

at least a portion of the resilient connecting portion overlaps the base when viewed in the fourth direction.

20. The optical element driving mechanism as claimed in claim **19**, wherein:

at least a portion of the movable portion overlaps the second extending portion when viewed in the first direction;

the movable portion does not overlap the surrounding portion when viewed in the first direction.

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