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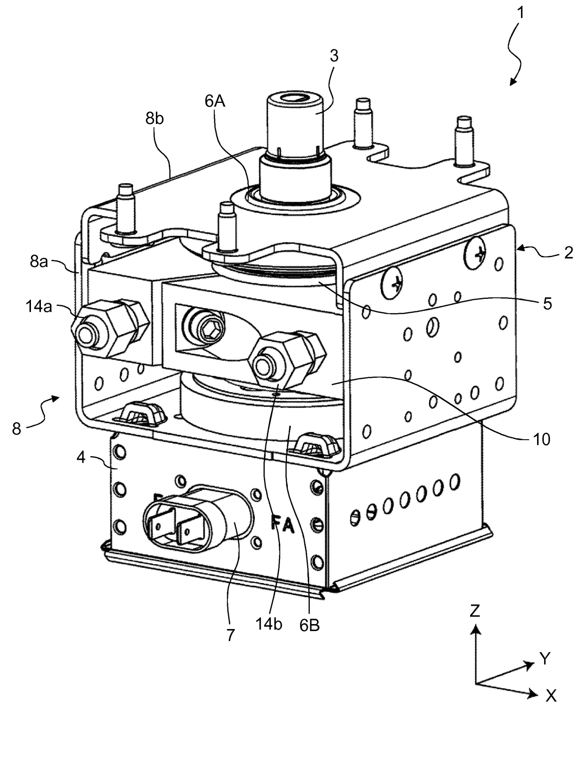
(54) **MAGNETRON**

(57) Magnetron (1) includes anode cylinder (5), cooling block (10), a fastener, and a pair of pipe joints (14a, 14b). The fastener is disposed between the pipe joints (14a, 14b) of cooling block (10), and a discontinuous part between both ends of cooling block (10) facing each other extends tilted in an annular direction of cooling block (10) relative to a flow direction of cooling liquid at a connecting part of the pair of pipe joints (14a, 14b) and circulation passage. The fastener passing the discontinuous part extends in a tilted manner relative to a face perpendicular to the flow direction of the cooling liquid at the connecting part of the pair of pipe joints (14a, 14b) and circulation passage.

FIG. 1



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Description

Technical Field

[0001] The present disclosure relates to magnetrons that generate microwaves.

Background Art

[0002] Magnetrons that generate microwaves have been employed in magnetron utilization equipment, such as microwave ovens, and are available in various structures. To remove heat generated by magnetrons, in line with generation of microwaves, an air cooling system and liquid cooling system have been employed. Magnetrons adopting the liquid cooling system use a cooling block with a circulation passage for cooling liquid (e.g., PTL1).

[0003] A structure of a liquid-cooling magnetron in PTL1 is described with reference to Fig. 9 showing the entire structure of the magnetron, and Fig. 10 showing a structure of the cooling block.

[0004] As shown in Fig. 9, cooling block 110 provided in magnetron 100 is closely attached along an outer peripheral face of an anode cylinder (not illustrated) in yoke 106. Cooling block 110 has a circulation passage 112 inside for passing liquid for cooling the anode cylinder.

[0005] As shown in Fig. 10, cooling block 110 is made of a material having a cooling function and formed in an approximately rectangular-parallelepiped shape. Inlet pipe joint 112A and outlet pipe joint 112B communicated with circulation passage 112 are connected to one side face of rectangular parallelepiped cooling block 110.

[0006] Cooling block 110 includes an annular continuous part around the outer peripheral face of the anode cylinder, and a discontinuous part where both ends of the annular continuous part face each other. More specifically, flange 114 is formed at each end of the annular continuous part and an annular discontinuous part is located between mutually-facing flanges 114.

[0007] Each flange 114 has through hole 115, and fastener 116 communicates with opposing through holes 115 and is screwed. This narrows a distance between flanges 14 and an inner peripheral face of cooling block 110 is tightened to closely attach to an outer peripheral face of the anode cylinder.

Citation List

Patent Literature

[0008] PTL1: Japanese Patent Unexamined Publication No. 2011-192459

Summary of Invention

[0009] Cooling block 110 in above conventional magnetron 100 is formed as an integral component with desired shape by cutting a substantially rectangular-parallelepiped material.

[0010] However, in cooling block 110 in PTL1, flange 114 is formed at both ends of the annular continuous part for fastening cooling block 110. Flanges 114 are larger than the connecting faces of pipe joints 112A and 112, and protruding outward.

[0011] To cut the substantially rectangular-parallelepiped material to form the shape of cooling block 110 in PTL1, a large portion of material is cut and wasted.

[0012] In the state pipe joints 112A and 112B are connected to cooling block 110, it may be difficult to insert fastener 116 into through holes 115 in flanges 114. It may also become difficult to gain access to fastener 116 in the state engaged with flanges 114.

[0013] Accordingly, an object of the present disclosure is to solve the above disadvantages, and offer a magnetron that can reduce wasted material in fabricating the cooling block, and ensure a good access to the pipe joint and fastener.

[0014] To achieve the above object, a magnetron in an exemplary embodiment of the present disclosure includes an anode cylinder, a cooling block, a fastener, and a pair of pipe joints.

[0015] The cooling block is an integral component having an annular shape in which both ends of an annular continuous part face each other. The cooling block is fastened on an outer peripheral face of the anode cylinder to surround the anode cylinder. In addition, the cooling block has a cooling liquid circulation passage inside, so as to cool the anode cylinder.

[0016] The fastener is engaged with both ends of the cooling block facing each other. An inner peripheral face of the cooling block is pushed toward the outer peripheral face of the anode cylinder by tightening the fastener to narrow a distance between both ends. A pair of pipe joints are provided on the outer peripheral face of the cooling block, so as to communicate with the circulation passage.

[0017] The fastener is disposed between the pair of pipe joints, and a discontinuous part between both ends of the cooling block facing each other extends in a tilted manner in the annular direction of the cooling block relative to the flow direction of the cooling liquid at a connecting part of the pair of pipe joints and circulation passage. The fastener passing the discontinuous part extends in a direction tilted in a face perpendicular to the flow direction of the cooling liquid at the connecting part of the pair of pipe joints and circulation passage.

[0018] The exemplary embodiment can offer a magnetron that can reduce wasteful material in fabrication of the cooling block, and also secure a good access to the pipe joints and fastener.

Brief Description of Drawings

[0019]

Fig. 1 is a perspective view of an entire structure of a magnetron in accordance with an exemplary embodiment of the present disclosure.

Fig. 2 is a bottom view of the magnetron in accordance with the exemplary embodiment.

Fig. 3 is a perspective view of a cooling block provided in the magnetron in accordance with the exemplary embodiment.

Fig. 4 is a perspective view in a state that a pipe joint and a fastener are removed from the cooling block in Fig. 3.

Fig. 5 is a plan sectional view of the cooling block in Fig. 3.

Fig. 6 is a perspective view of an entire structure of a cooling block in a modified example of the exemplary embodiment.

Fig. 7 is a perspective view of an entire structure of a cooling block in another modified view of the exemplary embodiment.

Fig. 8 is a perspective view of an entire structure of a cooling block in still another modified view of the exemplary embodiment.

Fig. 9 is a front view of an entire structure of a conventional magnetron.

Fig. 10 is a perspective view of a structure of a cooling block in the conventional magnetron.

Description of Embodiments

[0020] A magnetron in a first embodiment includes an anode cylinder, a cooling block, a fastener, and a pair of pipe joints.

[0021] The cooling block is an integral component having an annular shape with both ends of an annular continuous part facing each other. The cooling block is fastened on an outer peripheral face of the anode cylinder such that the cooling block surrounds the anode cylinder. The cooling block also has a cooling liquid circulation passage inside, so as to cool the anode cylinder.

[0022] The fastener is engaged with both ends of the cooling block facing each other, and pushes an inner peripheral face of the cooling block toward the outer peripheral face of the anode cylinder by tightening and narrowing a distance between both ends. The pair of pipe joints are provided on the outer peripheral face of the cooling block to communicate with the circulation passage.

[0023] The fastener is disposed between the pair of pipe joints, and a discontinuous part between both ends of the cooling block facing each other extends in a tilted manner in the annular direction of the cooling block relative to the flow direction of the cooling liquid at a connecting part of the pair of pipe joints and circulation passage. The fastener passing the discontinuous part extends in a direction tilted relative to a face perpendicular to the flow direction of the cooling liquid at the connecting part of the pair of pipe joints and circulation passage.

[0024] In the embodiment, the discontinuous part and fastener in the cooling block are disposed in a tilted manner so that interference of these components can be suppressed at gaining access to the pipe joints and the fastener. Accordingly, a good access to the pipe joints and the fastener is secured.

[0025] Since interference with one of the fastener and the pipe joint at gaining access to the other of the fastener and the pipe joint can be suppressed, layout flexibility of the pipe joints on a connecting face in the cooling block can be increased. Accordingly, the pipe joints and fastener can be disposed in a layout that can reduce a cut and wasted part on cutting out the cooling block.

[0026] In a magnetron in a second embodiment, a recess is formed between a pair of pipe joints in the first embodiment, and at least a part of the fastener is disposed in the recess. By forming the recess for inserting the fastener in the embodiment, interference with each component at gaining access to the pipe joints or fastener can be suppressed. Accordingly, a good access to the pipe joints and fastener can be secured.

[0027] In a magnetron in a third embodiment, one end of the fastener is disposed in the recess in the first or second embodiment. This layout enables to place the fastener without being protruded from the outer peripheral face of the cooling block. An interference with the fastener at particularly gaining access to the pipe joints can be suppressed. Accordingly, a good access to the pipe joints and fastener can be secured.

[0028] In a magnetron in a fourth embodiment, the fastener extends in a direction perpendicular to the discontinuous part in one of the first to third embodiments. The embodiment enables to further uniformly tighten the cooling block and the anode cylinder, and thus further reliable tightening becomes feasible.

[0029] In a magnetron in a fifth embodiment, the discontinuous part extends along a radial direction of the anode cylinder disposed in the cooling block in one of the first to fourth embodiments. The embodiment enables to further uniformly tighten the cooling block and the anode cylinder, and thus further reliable tightening becomes feasible.

[0030] In a magnetron in a sixth embodiment, the cooling block has substantially a rectangle outer periphery, and a connecting face is provided on one end of the outer periphery in one of the first to fifth embodiments. This embodiment can reduce wasted material in cutting out the cooling block, and also secure a good access to the pipe joints and fastener while adopting a centralized layout of disposing the pipe joints and fastener on one end in the outer periphery.

[0031] In a magnetron in a seventh embodiment, a connecting face of the cooling block to which one of the pair of pipe joints is connected is provided on substantially the same plane as a connecting face of the cooling block to which the other of the pair of pipe joints is connected in one of the first to sixth embodiments. The embodiment facilitates fabrication of the cooling block.

[0032] In a magnetron in an eighth embodiment, the fastener extends in a direction parallel to a plane including the annular direction of the cooling block in one of the first to seventh embodiments. The embodiment enables to further reliably tighten the cooling block and anode cylinder, compared to a case of extending the fastener in a direction tilted relative to a plane including the annular direction of the cooling block.

[0033] In a magnetron in a ninth embodiment, the fastener extends in a direction tilted relative to a plane including the annular direction of the cooling block in one of the first to eighth embodiments. The embodiment enables to reduce an area of the recess in the connecting face of the cooling block, compared to a case of extending the fastener in the plane including the annular direction of the cooling block. Accordingly, the embodiment can improve the tightening strength of the cooling block and anode cylinder at the connecting face.

[0034] An exemplary embodiment of the present disclosure is detailed below with reference to drawings.

[0035] Fig. 1 is an overall structure of magnetron 1 in the exemplary embodiment of the present disclosure, and Fig. 2 is a bottom view of magnetron 1.

[0036] As shown in Fig. 1 and Fig. 2, magnetron 1 includes magnetic yoke 2, output unit 3 provided above magnetic yoke 2, and filter 4 provided below magnetic yoke 2.

[0037] Magnetic yoke 2 houses anode cylinder 5, two annular permanent magnets 6A and 6B provided on top and bottom ends of anode cylinder 5, and cooling block 10 disposed around anode cylinder 5. Filter 4 includes choke coil (not illustrated) and feedthrough capacitor 7.

[0038] In Fig. 1, the vertical direction (axial direction of anode cylinder 5) is the Z direction, and directions orthogonal to the Z direction and also orthogonal to each other are the X direction and Y direction. In the description, the X direction is the right and left direction, the Y direction is the front and back direction, and the Z direction is the top and bottom direction. However, directions are not particularly limited.

[0039] Magnetron 1 in the exemplary embodiment gives an example of setting the Z direction (top and bottom direction) to the axial direction of anode cylinder 5. However, the axial direction of anode cylinder 5 may be the left and right direction or the front and back direction.

[0040] Magnetic yoke 2 includes main body 8a whose pair of opposing side faces and a top face are open, and cover 8b that closes an opening on the top face of main body 8a. Annular permanent magnets 6A and 6B, anode cylinder 5, and cooling block 10 are housed in casing 8 of magnetic yoke 2.

[0041] Anode cylinder 5 is fixed with casing 8 of magnetic yoke 2 such that it is externally sandwiched by annular permanent magnets 6A and 6B disposed on both vertical ends. Annular permanent magnet 6B disposed at the bottom in Fig. 1 is an input magnet, and annular permanent magnet 6A disposed on the top is an output magnet.

[0042] Anode vanes (not illustrated) inside anode cylinder 5 are radially disposed. A space surrounded by adjacent anode vanes and anode cylinder 5 forms a cavity resonator. A cathode structure (not illustrated) is disposed at the center of anode cylinder 5. A space surrounded by this cathode structure and anode vanes is an interaction space.

[0043] When magnetron 1 in the exemplary embodiment is used, required power is applied to the cathode structure to emit thermoelectrons after inside magnetron 1 is vacuumed, and DC high voltage is applied between the anode vanes and cathode structure.

[0044] In the interaction space, annular permanent magnets 6A and 6B form a magnetic field in a direction orthogonal to a direction that the cathode structure and anode cylinder 5 face each other. By applying DC high voltage between the anode vanes and cathode structure, electrons released from the cathode structure are led to the anode vanes.

[0045] Electrons turn and circulate by the electric field and magnetic field in the interaction space, and reach the anode vanes. Here, energy produced by electron motion is given to the cavity resonator to emit microwaves.

[0046] Next is described a structure of cooling block 10 in magnetron 1 in the exemplary embodiment. Fig. 3 is a perspective view of cooling block 10, and Fig. 4 is a perspective view of cooling block 10 in which a pipe joint and fastener for connecting a cooling liquid pipe are removed. Fig. 5 is a lateral sectional view (XY plane) inside cooling block 10 in Fig. 3.

[0047] Cooling block 10 has a function of cooling anode cylinder 5 and annular permanent magnets 6A and 6B by making direct or indirect contact with these components. More specifically, as shown in Fig. 3 and Fig. 4, cooling block 10 has a substantially rectangular-parallelepiped outer shape, and is integrally formed with, for example, a metal material with high heat conductivity (e.g., copper and aluminum). Circulation passage 9 for passing cooling liquid is formed inside cooling block 10.

[0048] Cooling block 10 includes an annular continuous part around an outer peripheral face of anode cylinder 5, and has an annular shape in which both ends of this annular continuous part face each other in a close distance. In other words, an annular discontinuous part (space S in the exemplary embodiment) exists only on a part of cooling block 10 when seen from the top (in the Z direction) in Fig. 3.

[0049] Inner peripheral face 11 of cooling block 10 is formed as an inner peripheral face attachable to an outer peripheral face of anode cylinder 5. The outer periphery of cooling block 10 is formed substantially rectangle to be fitted in casing 8 of magnetic yoke 2.

[0050] Cooling block 10 makes indirect contact with annular permanent magnet 6A near inner peripheral face 11 on the top face of cooling block 10 via other components, and makes indirect contact with annular permanent magnet 6B near inner peripheral face 11 on the bottom face of cooling block 10 via other components. In the description below, both ends of the annular continuous part of cooling block are referred to as opposing ends 12a and 12b.

[0051] A pair of pipe joints 14a and 14b for supply and discharge that communicate with circulation passage 9 are connected to connecting faces 13a and 13b where opposing ends 12a and 12b are disposed on the substantially rectangle outer periphery of cooling block 10.

[0052] Opposing ends 12a and 12b are positioned between pipe joints 14a and 14b. Pipe joint 14a is connected to connecting face 13a including opposing end 12a, and pipe joint 14b is connected to connecting face 13b including opposing end 12b.

[0053] Pipe joints 14a and 14b include anchoring bolt 16a and anchoring bolt 16b, connecting nut 17a and connecting nut 17b for detachably connecting a supply pipe/discharge pipe of the cooling liquid, respectively.

[0054] By turning connecting nuts 17a and 17b, the supply pipe/discharge pipe can be attached or detached. Circulation passage 9 in cooling block 10 is formed from a connecting part of pipe joint 14a to a connecting part of pipe joint 14b via the outer periphery of anode cylinder 5.

[0055] Opposing ends 12a and 12b are disposed on connecting faces 13a and 13b, respectively, and space S is provided between opposing ends 12a and 12b. This space S between opposing ends 12a and 12b is the annular discontinuous part, and is formed from inner peripheral face 11 of cooling block 10 to the outer peripheral face of cooling block 10.

[0056] In the exemplary embodiment, connecting faces 13a and 13b are provided on substantially the same plane across space S. In other words, connecting face 13a to which pipe joint 14a is connected and connecting face 13b to which pipe joint 14b is connected are provided on substantially the same plane.

[0057] Fastener 15 (e.g., anchoring bolt and nut) is engaged with each of opposing ends 12a and 12b, and fastener 15 is disposed in recess 13c in connecting face 13b. By tightening fastener 15 with screw, space S (distance) between opposing ends 12a and 12b can be narrowed.

[0058] By narrowing space S between opposing ends 12a and 12b, inner peripheral face 11 of cooling block 10 is pushed toward and closely attached to the outer peripheral face of anode cylinder 5, so as to fasten cooling block 10 onto anode cylinder 5. In the exemplary embodiment, space S is set to, for example, about 3 mm before being tightened.

[0059] As shown in Fig. 3 to Fig. 5, fastener 15 extends in a direction parallel to a plane (XY plane) including the annular direction (a turning direction of anode cylinder 5) of cooling block 10. Recess 13c opened to the side is formed in connecting face 13b connected to pipe joint 14b.

[0060] Fastener 15 is inserted inside recess 13c, and engagement hole 13d and engagement hole 13e that engage with inserted fastener 15 are formed in an inner face of recess 13C (see Fig. 4). In a state that fastener 15 is inserted to and engaged with both engagement holes 13d and 13e (Fig. 3), fastener 15 is housed inside recess 13c.

[0061] As shown in Fig. 5, YZ plane passing center C of anode cylinder 5 and perpendicular to connecting faces 13a and 13b is plane 18. The Y direction that is the flow direction of the cooling liquid at a connecting part (connecting faces 13a and 13b) of pair of pipe joints 14a and 14b and circulation passage 9 exists in plane 18.

[0062] The flow direction of cooling liquid matches the connecting direction of pipe joints 14a and 14b to cooling block 10, the connecting direction of pipes (not illustrated) to pipe joints 14a and 14b, the pipe axial direction of pipe joints 14a and 14b, and the front and back direction of cooling block 10 in the exemplary embodiment.

[0063] Space S in cooling block 10 extends in a direction tilted relative to plane 18 perpendicular to connecting faces 13a and 13b. More specifically, the direction that space S extends in the exemplary embodiment is tilted by 30° relative to plane 18 in a plan view.

[0064] More specifically, space S is tilted by 30° in the annular direction of cooling block 10 relative to the flow direction (Y direction) of the cooling liquid at the connecting part of pair of pipe joints 14a and 14b and circulation passage 9 (i.e., tilted by 30 ° in the XY plane). However, a tilt angle of space S is not limited.

[0065] Still more, in the exemplary embodiment, space S extends in a direction passing center C of anode cylinder 5, and crosses plane 18 at center C. With this layout, space S extends in the normal direction (i.e., radial direction of cooling block 10) perpendicular to the tangential direction of inner peripheral face 11 of cooling block 10.

[0066] Still more, in the exemplary embodiment, fastener 15 is disposed inside recess 13c in cooling block 10 such that fastener 15 extends in a direction perpendicular to this space S. In other words, fastener 15 passing space S extends in a direction tiled relative to a face perpendicular to the flow direction of the cooling liquid at the connecting part of pair of pipe joints 14a and 14b and circulation passage 9 (XZ plane). The tilt angle is set to 30°.

[0067] As shown in Fig. 5, a space for placing fastener 15 in cooling block 10 (space crossing space S) ends at a position not reaching circulation passage 9 to avoid interference with circulation passage 9. One end (bolt head) of fastener 15 disposed in this space is placed in recess 13c so that it does not protrude to the XZ plane where connecting faces 13a and 13b are provided.

[0068] Next is described tightening of cooling block 10 and anode cylinder 5 with fastener 15.

[0069] When fastener 15 is disposed in recess 13c in cooling block 10 and tightened, space S is narrowed. This fastens the inner peripheral face 11 of cooling block 10 onto anode cylinder 5 to anchor anode cylinder 5. In this tightening operation, fastener 15 is simply inserted into recess 13c and turned, and thus the operation can be implemented without interfering with pipe joints 14a and 14b.

[0070] This workability is effectively achieved, in particular, when space S is tilted relative to plane 18 perpendicular to connecting faces 13a and 13b, and also tilted relative to a face (XZ plane) perpendicular to the flow direction (Y direction) of the cooling liquid at the connecting part of pair of pipe joints 14a and 14b and circulation passage 9.

[0071] Compared to the case of tightening the fastener from both sides relative to the cooling block, as shown in Fig. 9 and Fig. 10, a component for closing the fastener, such as a nut, can be omitted. This has an advantage of reducing manufacturing cost.

[0072] Compared to the structure shown in Fig. 9 and Fig. 10, an area of connecting faces 13a and 13b that have a function to retain the tightening strength on tightening can be secured. This can achieve a predetermined tightening strength.

[0073] Furthermore, in the exemplary embodiment, space S extends in the radial direction of anode cylinder 5 in cooling block 10. Fastener 15 is disposed in a direction perpendicular to space S (and its extending plane). This layout enables to further uniformly tighten cooling block 10 and anode cylinder 5 with fastener 15. Cooling block 10 and anode cylinder 5 can thus be fixed in a further stable state.

[0074] In the same way, fastener 15 extends in a direction parallel to a plane (XY plane) including the annular direction of cooling block 10 (turning direction of anode cylinder 5). This enables to further uniformly and stably tighten cooling block 10 and anode cylinder 5 in good balance, compared to the case of tilting fastener 15 relative to the XY plane.

[0075] In the exemplary embodiment, connecting faces 13a and 13b are provided on substantially the same plane across space S. This structure facilitates fabrication of cooling block 10. Cooling block 10 and anode cylinder 5 can be stably fixed in a good balance also when fastener 15 is tightened to narrow space S.

[0076] Description "substantially the same plane" includes cases when relative positions of opposing ends 12a and 12b are deviated due to tightening of fastener 15, in addition to the case when connecting faces 13a and 13b are on the same plane.

[0077] In the magnetron as configured in the exemplary embodiment, space S and fastener 5 are disposed in a tilted manner, in addition to pipe joints 14a and 14b and fastener 15 disposed on connecting faces 13a and 13b. This reduces an influence of pipe joints 14a and 14b at gaining access to fastener 15 even though a structure of disposing fastener 15 between pair of pipe joints 4a and 14b is adopted.

[0078] In addition, an influence of fastener 15 can be reduced at gaining access to pipe joints 14a and 14b. Accordingly, fastener 15 can be used and tightened in the state pair of pipe joints 14a and 14b are connected to cooling block 10 and the cooling liquid pipe is also connected.

[0079] In the state fastener 15 is engaged with cooling block 10, the user can gain access to pipe joints 14a and 14b to turn anchoring bolts 16a and 16b and connecting nuts 17a and 17b. Accordingly, a good access to pipe joints 14a and 14b and fastener 15 can be achieved in cooling block 10.

[0080] Since an interference of one of fastener 15 and pipe joints 14a and 14b when the user gains access to the other is prevented, connecting faces 13a and 13b for connecting pipe joints 14a and 14b in cooling block 10 can be more flexibly disposed.

[0081] For example, in a structure shown in Fig. 9 and Fig. 10, the connecting face of pipe joint is set back toward the center of cooling block. However, in the exemplary embodiment, mutual interference at gaining access between pipe joints 14a and 14b and fastener 15 does not need to be considered.

[0082] Therefore, when forming cooling block 10 by cutting out a substantially rectangular-parallelepiped material, for example, pipe joints 14a and 14b and fastener 15 can be disposed in a layout that can reduce shaved material, compared to the conventional cooling block shown in Fig. 9 and Fig. 10.

[0083] Accordingly, wasted material in fabrication of cooling block 10 can be reduced, and also a good access to pipe joints 14a and 14b and fastener 15 can be secured. Less portion to cut can increase the volume of cooling block 10, and thus cooling performance can be improved.

[0084] The present disclosure is described with reference to the above exemplary embodiment. However, the present disclosure is not limited to the aforementioned exemplary embodiment. The above exemplary embodiment refers to the case of leaving a space without completely closing space S when fastener 15 is tightened. However, the present disclosure is not limited to this structure. Opposing ends 12a and 12b may also mutually contact.

[0085] The above exemplary embodiment refers to the case of placing one end of fastener 15 in recess 13c, and this one end does not cross the XZ plane where connecting faces 13a and 13b are provided. However, the present disclosure is not limited to this structure, as long as at least a part of fastener 15 is placed in recess 13c.

[0086] Fastener 15 can be placed without being protruded, in particular, from the outer peripheral face of cooling block 10 when one end of fastener 15 is placed in recess 13, as in the exemplary embodiment. This can further suppress, in particular, interference with fastener 15 at gaining access to pipe joints 14a and 14b. This secures a good access to pipe joints 14a and 14b and fastener 15.

[0087] The above exemplary embodiment refers to the case of extending space S in the radial direction of anode cylinder 5. Other than this structure, space S may be extended in a direction different from the radial direction of anode cylinder 5.

[0088] The exemplary embodiment refers to the case of extending fastener 15 in a direction perpendicular to space S. Other than this structure, fastener 15 may be extended in a direction not perpendicular to space S.

[0089] Cooling block 10 and anode cylinder 5 can be further uniformly tightened when space S is extended in the radial direction of anode cylinder 5 and fastener 15 is extended in a direction perpendicular to space S, as in the exemplary embodiment.

[0090] In the exemplary embodiment, connecting faces 13a and 13b are provided on substantially the same plane across space S in the state fastener 15 is not tightened in cooling block 10. However, the present disclosure is not limited to this structure. For example, as shown in Fig. 6 and Fig. 7, the shape of connecting face 13b where recess 13c is formed may have an uneven surface (relative to the XZ plane).

[0091] Shapes of connecting faces 13a and 13b can be changed as required (in particular, adjustment of unevenness of connecting faces 13a and 13b) in cooling block 10 shown in the exemplary embodiment. Cooling block 10 in the exemplary embodiment thus offers high flexibility in changing design.

[0092] In the exemplary embodiment, fastener 15 extends in a direction parallel to a plane including the annular direction of cooling block 10. However, the present disclosure is not limited to this structure. For example, as shown in Fig. 8, fastener 15 may be extended in a direction tilted relative to a plane including the annular direction of cooling block 10.

[0093] In this case, in particular, recess 13c protrudes from the top face of cooling block 10, and thus an area of recess 13c in connecting face 13b can be reduced, compared to that in the exemplary embodiment and the embodiment shown in Fig. 6 and Fig. 7. Accordingly, the tightening strength of connecting faces 13a and 13b on tightening fastener 15 can be secured. Cooling block 10 in the exemplary embodiment also offers high flexibility in setting the extending direction of fastener 15.

[0094] The exemplary embodiment gives an example of cooling block 10 having a substantially rectangle outer peripheral face. However, cooling block 10 may also have a polygonal or curved outer peripheral face.

[0095] The exemplary embodiment refers to the case of separately forming pipe joints 14a and 14b from cooling block 10 and connecting them to cooling block 10 (i.e., fastener 15 is disposed between the connecting parts of pair of pipe joints 14a and 14b to cooling block 10). However, the present disclosure is not limited to this structure. Pipe joints 14a and 14b may be integrally formed with cooling block 10.

[0096] The exemplary embodiment refers to the case that pipe joints 14a and 14b have a straight shape with the Y direction in the longer-hand direction. However, the present disclosure is not limited to this structure. A range of shapes (e.g., L shape) are acceptable. Also in other shapes, the flow direction of the cooling liquid at the connecting parts of pair of pipe joints 14a and 14b and circulation passage 9 and the longer-hand direction of pipe joints 14a and 14b match the Y direction. Multiple fasteners 15 may also be used.

[0097] A combination of some of exemplary embodiments in the above various exemplary embodiments can achieve the effect of each exemplary embodiment.

INDUSTRIAL APPLICABILITY

[0098] The magnetron in the present disclosure is applicable to magnetron utilization equipment, typically microwave ovens.

Reference marks in the drawings

[0099]

1, 100	Magnetron
2	Magnetic yoke
3	Output unit
4	Filter
5	Anode cylinder
6A, 6B	Annular permanent magnet
7	Feedthrough capacitor
8	Casing
9, 112	Circulation passage
10, 110	Cooling block
11	Inner peripheral face
12a, 12b	Opposing end
13a, 13b	Connecting face
13c	Recess
13d, 13e	Engagement hole
14a, 14b, 112A	Pipe joint
15, 116	Fastener
16a, 16b	Anchoring bolt
17a, 17b	Connecting nut
18	Plane

Claims

1. A magnetron comprising:

an anode cylinder;
a cooling block that is an integral component having an annular shape with both ends of an annular continuous part facing each other, the cooling block being fastened to an outer peripheral face of the anode cylinder to surround the anode cylinder and having a circulation passage for cooling liquid inside to cool the anode cylinder;
a fastener engaged with each of the both ends of the cooling block facing each other to press an inner peripheral face of the cooling block against the outer peripheral face of the anode cylinder by tightening and narrowing a distance between the both ends; and
a pair of pipe joints provided on an outer periph-

eral face of the cooling block and communicated with the circulation passage,
wherein
the fastener is disposed between the pair of pipe joints, a discontinuous part between the both ends of the cooling block facing each other extends in a tilted manner in an annular direction of the cooling block relative to a flow direction of the cooling liquid at a connecting part of the pair of pipe joints and the circulation passage, and the fastener passing the discontinuous part extends in a tilted manner relative to a face perpendicular to the flow direction of the cooling liquid at the connecting part of the pair of pipe joints and the circulation passage.

2. The magnetron of claim 1, wherein a recess is formed between the pair of pipe joints, and at least a part of the fastener is placed in the recess.

3. The magnetron of claim 1, wherein one end of the fastener is placed in the recess.

4. The magnetron of claim 1, wherein the fastener extends in a direction perpendicular to the discontinuous part.

5. The magnetron of claim 1, wherein the discontinuous part extends along a radial direction of the anode cylinder disposed in the cooling block.

6. The magnetron of claim 1, wherein the cooling block has a substantially rectangle outer periphery, and a connecting face is provided on one end of the outer periphery.

7. The magnetron of claim 1, wherein the connecting face of the cooling block to which one of the pair of pipe joints is connected is provided on a substantially same plane as the connecting face of the cooling block to which other of the pair of pipe joints is connected.

8. The magnetron of claim 1, wherein the fastener extends in a direction parallel to a plane including an annular direction of the cooling block.

9. The magnetron of claim 1, wherein the fastener extends in a direction tilted relative to a plane including an annular direction of the cooling block.

FIG. 1

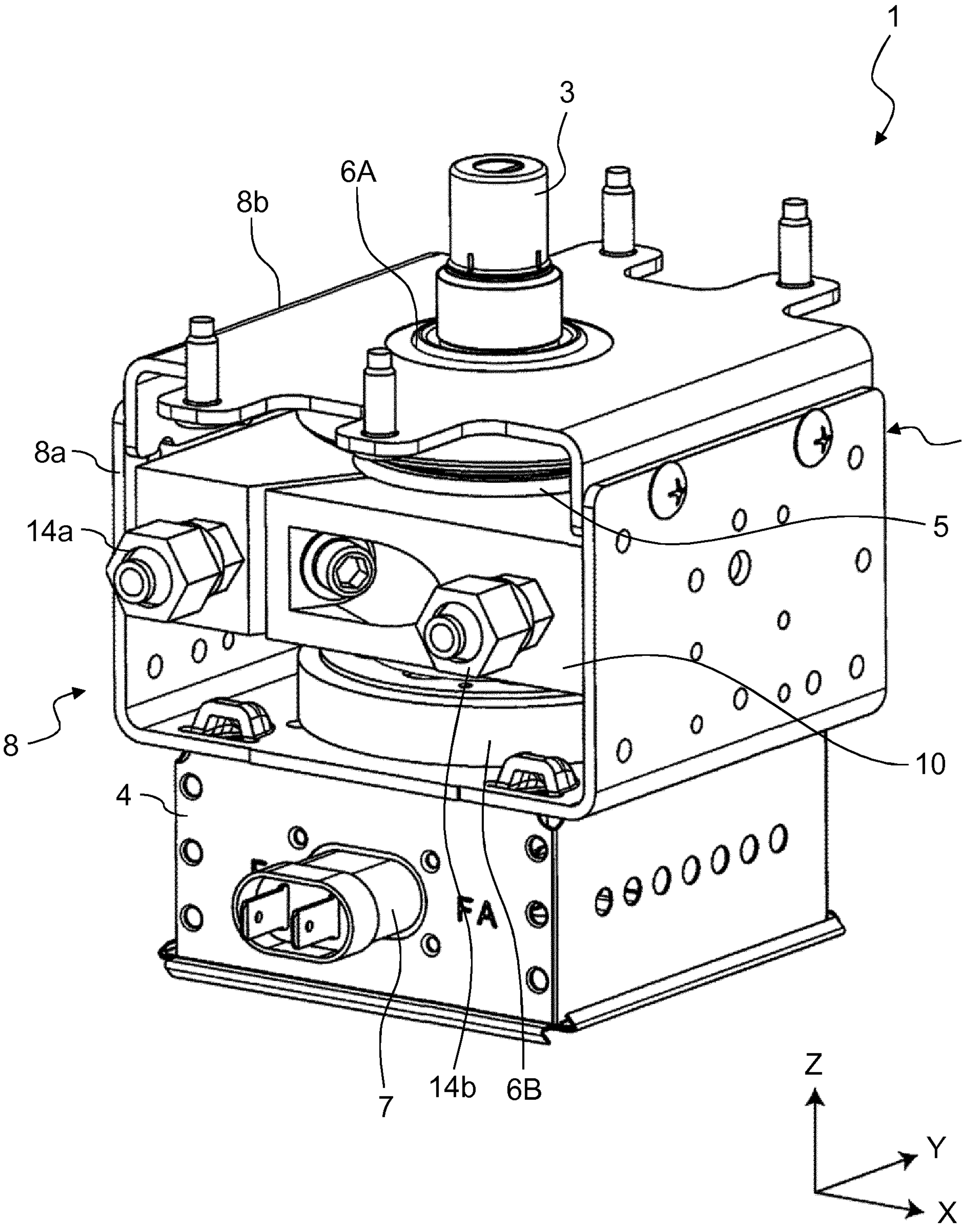


FIG. 2

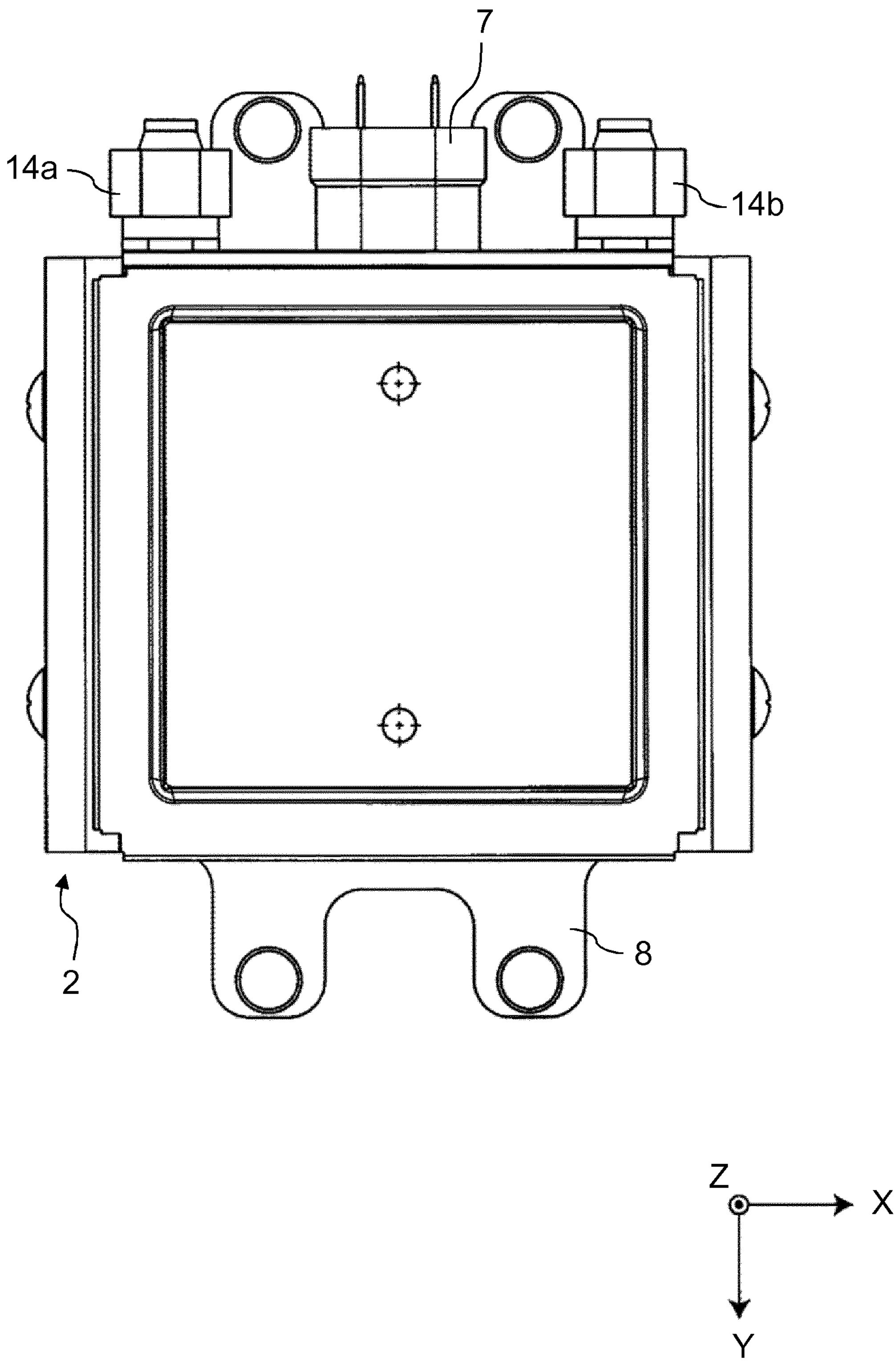
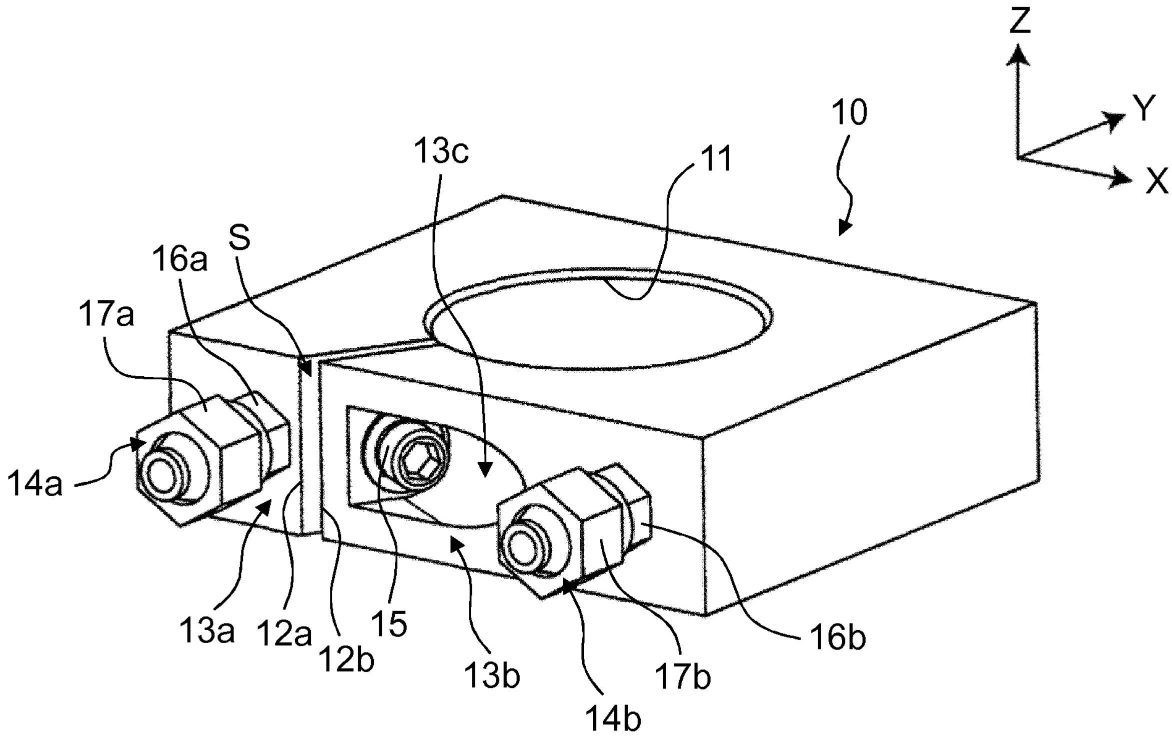


FIG. 3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11
13c
S
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17a
14a
13a
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12b
15
13b
14b
17b
16b

FIG. 4

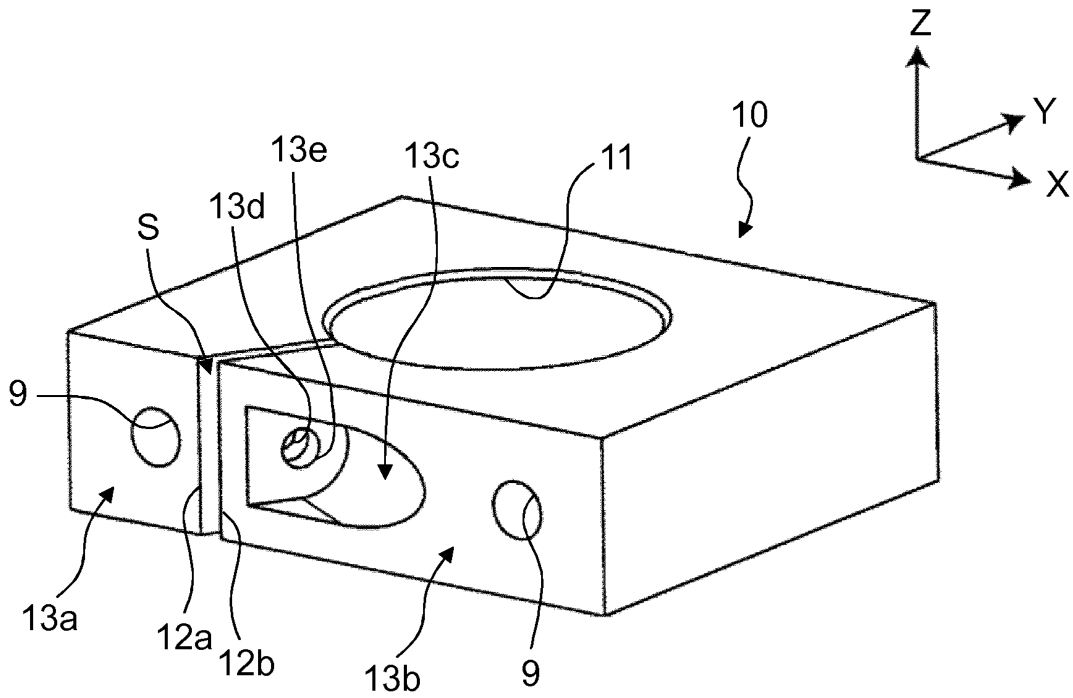
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FIG. 5

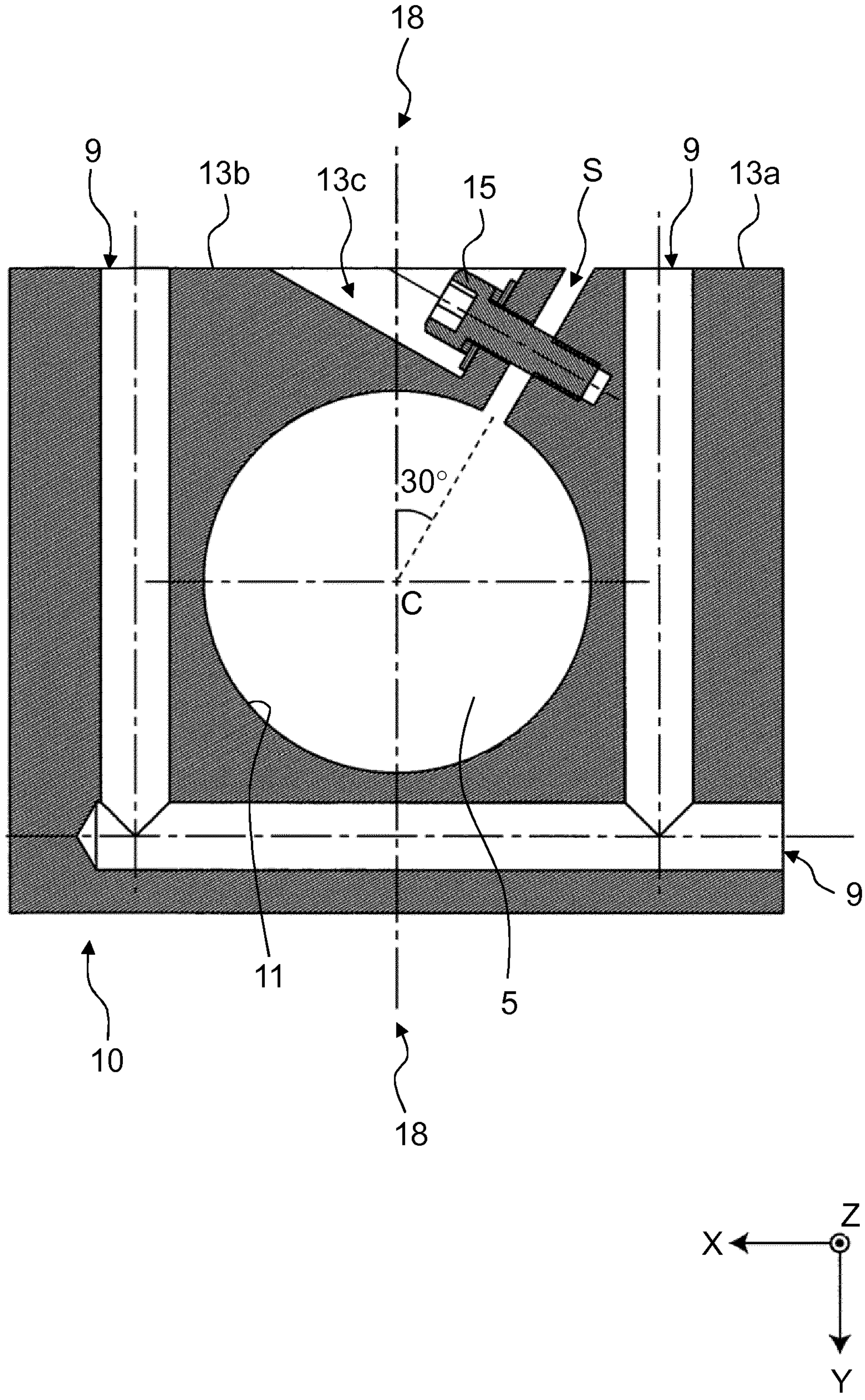

FIG. 6

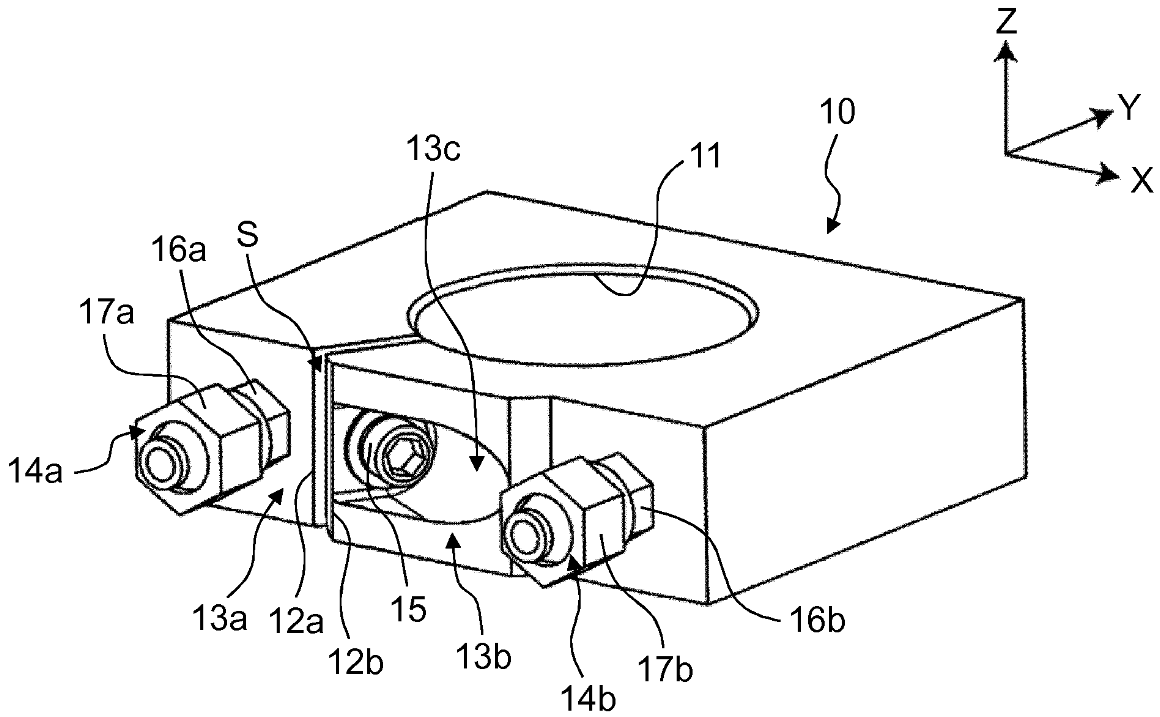
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FIG. 7

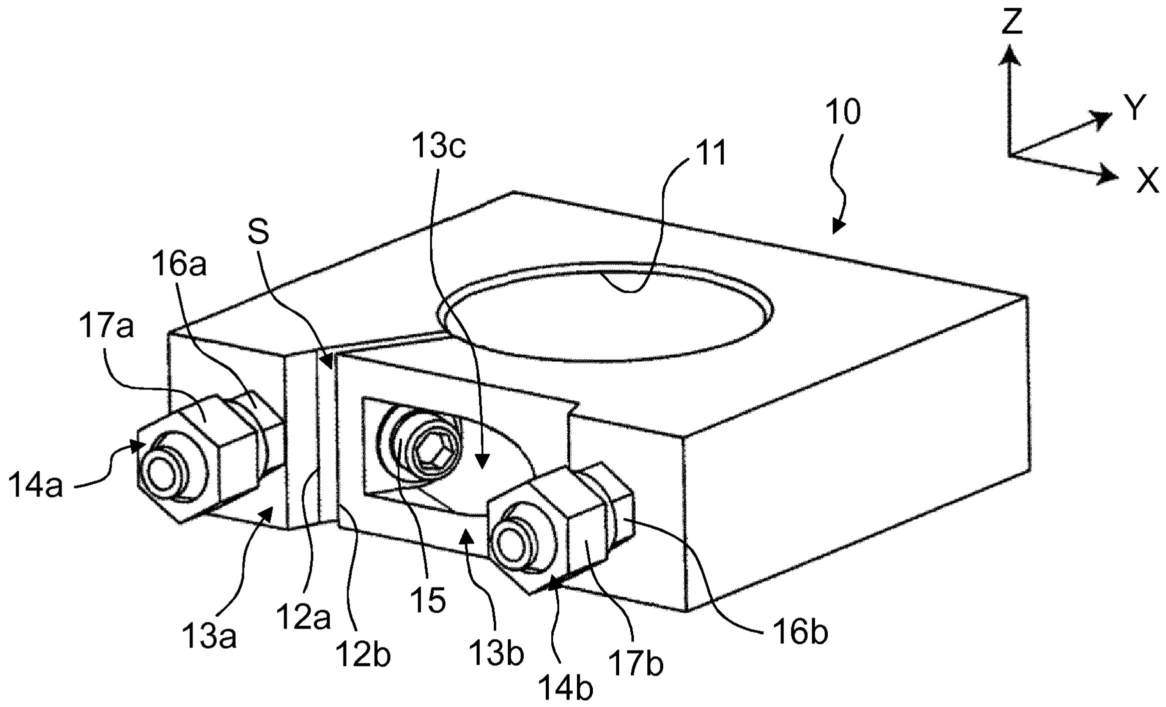
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FIG. 8

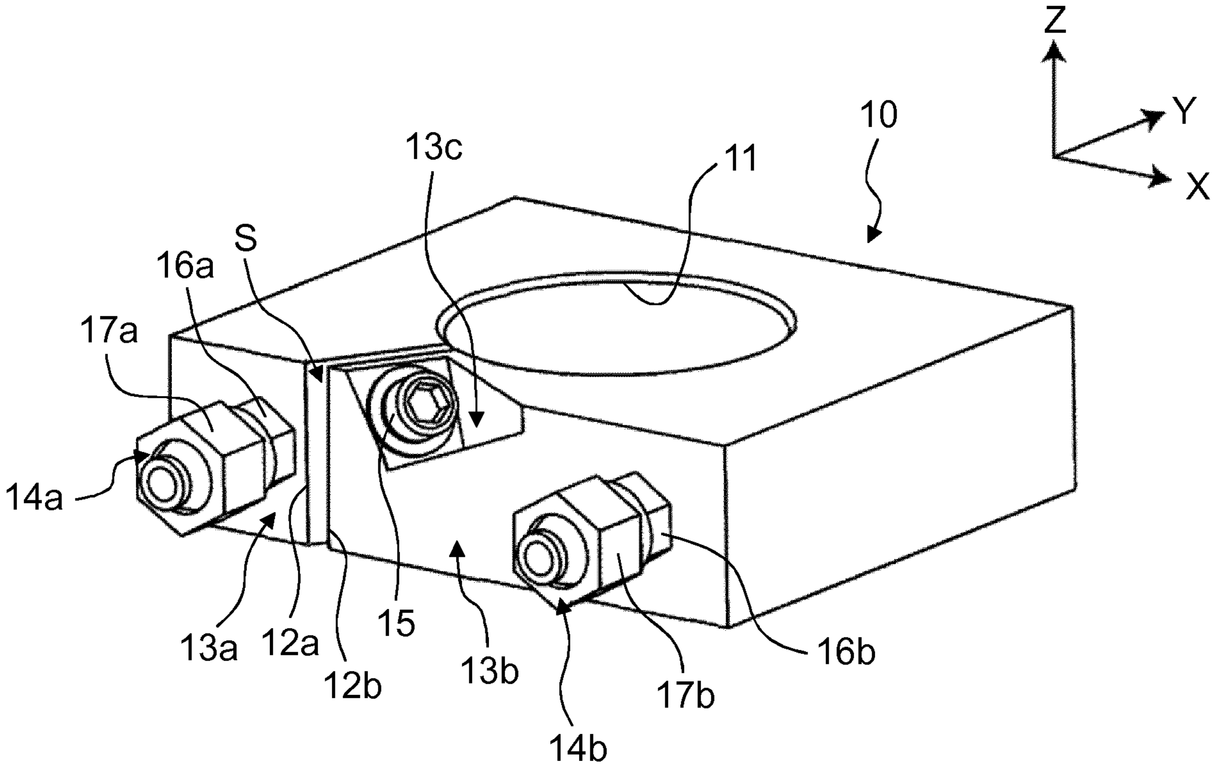


FIG. 9

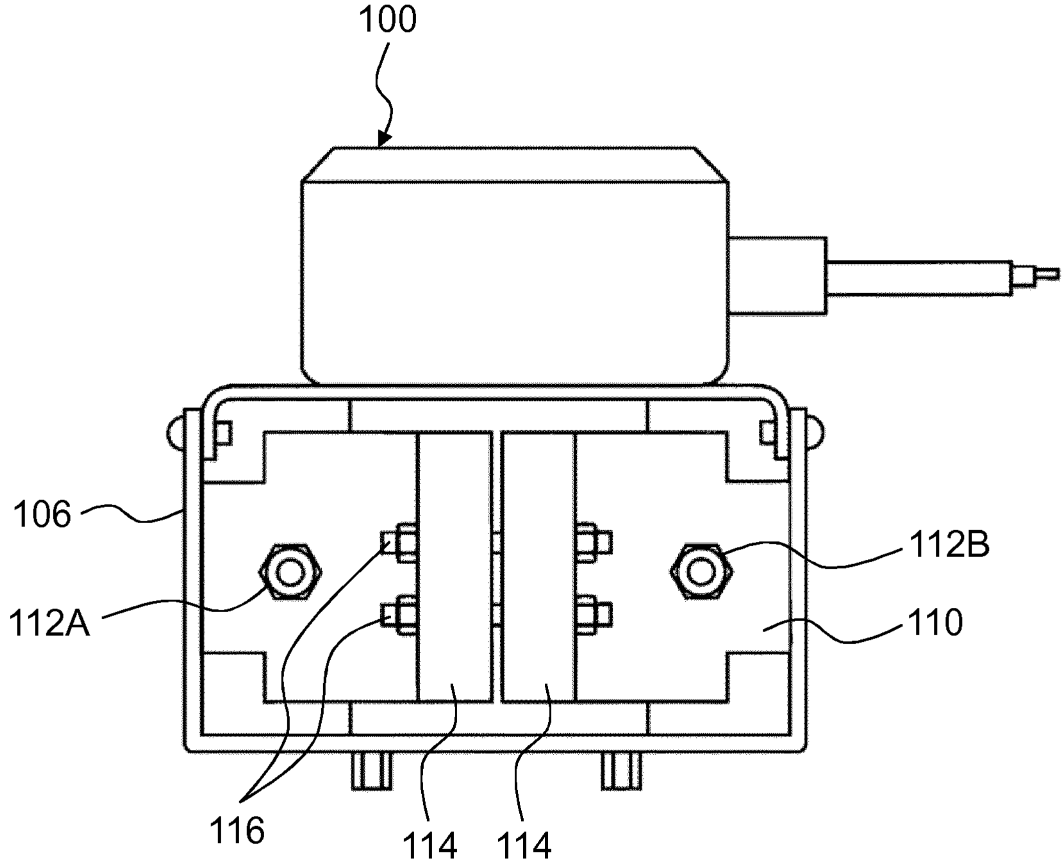
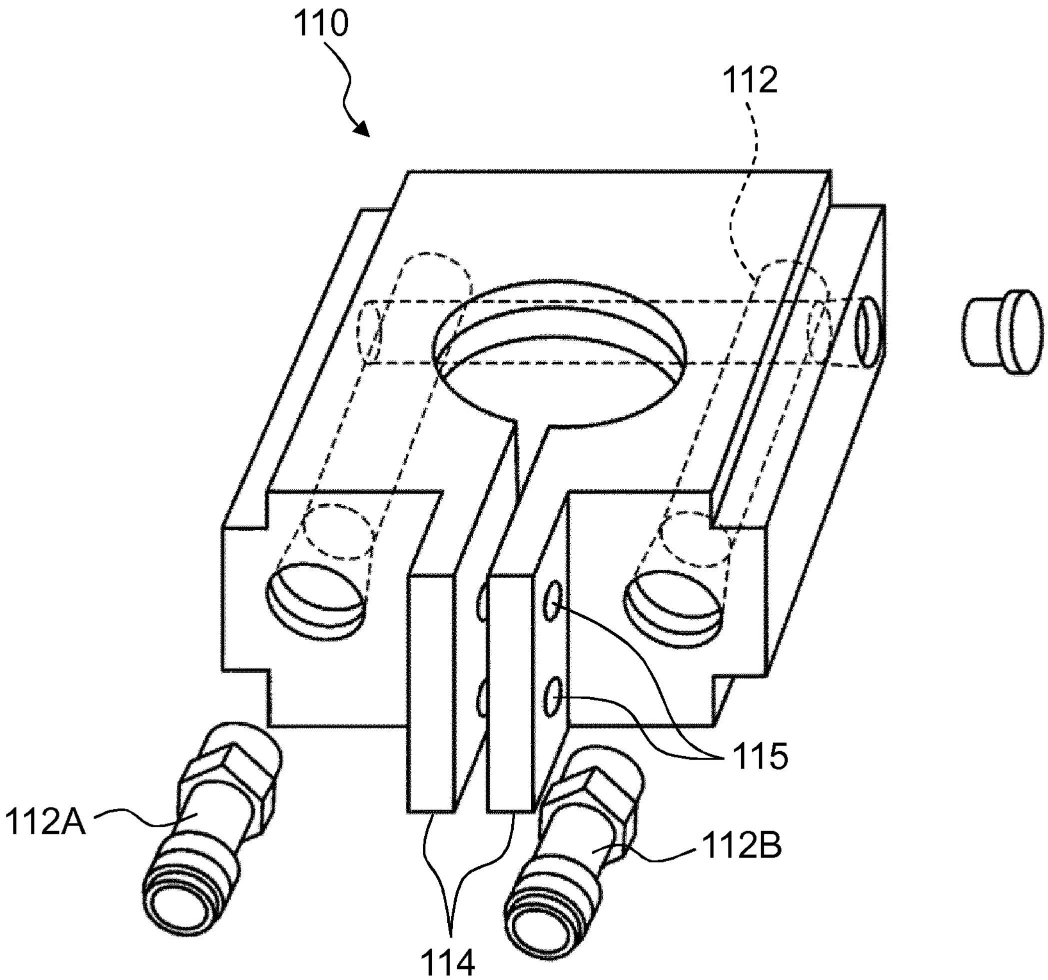


FIG. 10



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/001581

A. CLASSIFICATION OF SUBJECT MATTER
H01J23/00(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01J23/00, H01J23/033

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2016
Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2011-192459 A (Panasonic Corp.), 29 September 2011 (29.09.2011), entire text; all drawings & WO 2011/111396 A1 & EP 2546861 A1 entire text; all drawings	1-9
P,A	JP 2015-090850 A (Panasonic Intellectual Property Management Co., Ltd.), 11 May 2015 (11.05.2015), entire text; all drawings & US 2015/0123538 A1 entire text; all drawings & EP 2871664 A1 & CN 104637756 A	1-9

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

* Special categories of cited documents:
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 May 2016 (17.05.16)	24 May 2016 (24.05.16)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2011192459 A **[0008]**