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(71) Applicant: **Aichi Machine Industry Co., Ltd.**
Nagoya-shi, Aichi 456-8601 (JP)

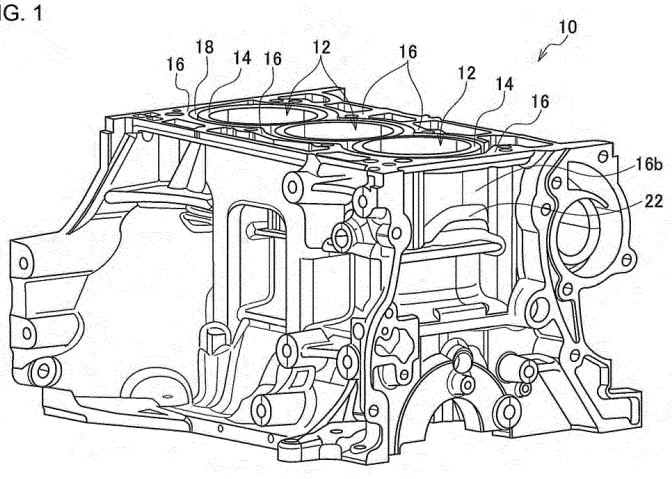
(72) Inventors:
- **YANO, Yukihiro**
  Nagoya-shi
  Aichi 456-8601 (JP)
- **KUSANO, Masamichi**
  Nagoya-shi
  Aichi 456-8601 (JP)
- **TOKURA, Koichi**
  Nagoya-shi
  Aichi 456-8601 (JP)
- **KITAMURA, Shinji**
  Nagoya-shi
  Aichi 456-8601 (JP)

(74) Representative: **Global IP Europe**
Patentanwaltskanzlei
Pfarrstraße 14
80538 München (DE)

(54) CYLINDER BLOCK AND INTERNAL COMBUSTION ENGINE

(57) A casted cylinder block having: a cylinder bore wall part; a water jacket groove arranged on the outer periphery of the cylinder bore wall part; and a water jacket external wall part defining the water jacket groove together with the cylinder bore wall part. The water jacket groove includes a shallow groove part in which the groove depth becomes shallower towards the end portion of the cylinder bore wall part. When the direction that the groove becomes deeper is taken to be the downward direction, the portion of the cylinder bore wall part where the shallow groove part is arranged includes a second outside wall surface facing the water jacket groove, and a third outside wall surface constituting the outer wall surface of the cylinder block and arranged in the downward direction from the groove bottom of the shallow groove part. The third outside wall surface is depressed towards a cylinder bore.

FIG. 1



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Description

Technical Field

[0001] The present invention relates to a cylinder block manufactured by casting, and an internal combustion engine.

Background Art

[0002] To date, cylinder blocks made from lightweight alloys such as aluminum alloys have been formed by casting. The cylinder bores are being produced linerless by forming a sprayed coating using a ferrous alloy material on the internal wall surfaces of the cylinder bore walls that are made from aluminum, without providing cast iron cylinder liners.
In this case, it is demanded that there is proper flow of the melt during casting, without the formation of cavities on the internal wall surfaces of the cylinder bore walls. If cavities form on the internal wall surface of the cylinder bore walls, recesses will remain on the surface even after forming the sprayed coating on the internal wall surface.
[0003] Under these circumstances, a method for manufacturing a cylinder block is known in which there is a cooling liquid jacket on the block side provided so as to surround a plurality of cylinder bores that form a plurality of cylinders (Patent Document 1). The cylinder block is the main body of a liquid-cooled internal combustion engine having at least one bank with a plurality of cylinders disposed in line. In this method, resin impregnation processing is carried out after casting. The manufactured cylinder block can also be applied to linerless engines.

Citation List Patent Literature

[0004] Patent Document 1: Japanese Unexamined Patent Application Document No. 2012-246831 A

Summary of Invention

Technical Problem

[0005] When forming such a cylinder block by casting, there is a possibility that sufficient flow of the melt will not be obtained. In addition, in order to manufacture the linerless cylinder block, when forming the sprayed coating on the internal wall surface of the cylinder bore wall after casting, there is a possibility of damage due to thermal deformation of the external wall of the water jacket.
[0006] Therefore it is an object of the present invention to provide a cylinder block configured so as to be suitable as a linerless cylinder block and that is capable of improved melt flow during forming by casting, and an internal combustion engine using this cylinder block.

Solution to Problem

[0007] One aspect of the present invention relates to a casted cylinder block. The cylinder block includes: a cylinder bore wall part having a plurality of cylinder bores aligned along a first direction; a water jacket groove having a groove bottom and arranged on an outer periphery of the cylinder bore wall part so as to surround the cylinder bore wall part; and a water jacket external wall part arranged on an outer periphery of the water jacket groove, and defines the water jacket groove together with the cylinder bore wall part. The water jacket groove includes a shallow groove part where the groove depth becomes shallower toward an end of the cylinder bore wall part in the alignment direction of the plurality of cylinder bores. A portion of the water jacket external wall part where the shallow groove part is formed includes a first inner wall surface facing the water jacket groove and a first outer wall surface on the opposite side to the first inner wall surface. From among the groove depth directions, the direction in which the groove becomes deeper is taken to be the downward direction. A portion of the cylinder bore wall part where the shallow groove part is arranged has a second outside wall surface facing the water jacket groove, and a third outside wall surface arranged in the downward direction from the groove bottom and constituting the outside wall surface of the cylinder block together with the first outer wall surface of the water jacket external wall part. The third outside wall surface is depressed towards a cylinder bore with respect to the first outer wall surface.
[0008] Preferably a rib projecting from the first outer wall surface is arranged , along the shallow groove part and on the first outer wall surface at a position corresponding to the groove bottom of the shallow groove part with respect to the groove depth direction.
[0009] In this case, preferably, when the direction in which the groove depth of the groove bottom becomes deeper is taken to be the downward direction, the rib is arranged at a position in the downward direction from the groove bottom of the shallow groove part.
[0010] Preferably, the rib projecting from the first outer wall surface is arranged continuously over at least a part of the portion of the water jacket external wall part where the shallow groove part is arranged.
[0011] Preferably, an inclined surface extending from the rib towards the depressed portion of the third outside wall surface includes a portion that bulges to the outside of the cylinder block such that the thickness of the water jacket external wall part is increased.
[0012] Preferably, the portion of the shallow groove part where the groove depth is shallowest continues continuously.
[0013] Preferably, the groove depth of the shallow groove part is shallowest at the end portion in the alignment direction of the plurality of cylinder bores.
[0014] Preferably, in addition to the shallow groove part, the water jacket groove includes a deep groove part

with a constant groove depth, and the shallowest groove depth of the shallow groove part is 20 to 80% of the groove depth of the deep groove part.

[0015] Preferably, the region of the water jacket groove where the shallow groove part is arranged has an angle of view from 45 to 180 degrees with reference to a center point of the circular arc shape of the cylinder bore located at the end where the shallow groove part is arranged.

[0016] Preferably, the cylinder block has no cast iron cylinder liner, and a spray coated film is formed on the inner wall surfaces of the cylinder bore wall part.

[0017] Another aspect of the present invention is an internal combustion engine having any one of the cylinder block mentioned above.

Advantageous Effects of invention

[0018] The cylinder block and the internal combustion engine as described above can be applied to a linerless cylinder block, and is capable of improved melt flow during forming by casting.

Brief Description of Drawings

[0019]

FIG. 1 is an external perspective view of a cylinder block of an engine according to a first embodiment;
FIG. 2A is a top view of the cylinder block illustrated in FIG. 1, and FIG. 2B is a side view of the cylinder block illustrated in FIG. 1;
FIG. 3 is a cross-sectional view sectioned along the line A-A in the direction of the arrows in FIG. 2B;
FIGS. 4A and 4B are perspective views of the cylinder block sectioned along the lines B-B and C-C respectively in the direction of the arrows in FIG. 2A;
FIG. 5 is a side view of a cylinder block of an engine according to a second embodiment;
FIG. 6A is a cross-sectional view of the cylinder block sectioned along the line D-D in the direction of the arrows in FIG. 5, and FIG. 6B is a perspective view of the cylinder block sectioned along the line D-D in the direction of the arrows in FIG. 5; and
FIG. 7A is a cross-sectional view of the cylinder block sectioned along the line E-E in the direction of the arrows in FIG. 5, and FIG. 6B is a perspective view of the cylinder block sectioned along the line E-E in the direction of the arrows in FIG. 5.

Embodiments of the Invention

[0020] Below, a first embodiment and a second embodiment of a cylinder block, which is a constituent member of an engine, are described with reference to the drawings.

First Embodiment

[0021] FIG. 1 is an external perspective view of a cylinder block 10 of a 3-cylinder engine according to the first embodiment. FIG. 2A is a top view of the cylinder block 10, and FIG. 2B is a side view of the cylinder block 10. The cylinder block 10 is made from an aluminum alloy, and is cast using a mold that is not illustrated on the drawings. The cylinder block 10 of the first embodiment is used as a constituent member of an engine (internal combustion engine).

[0022] The cylinder block 10 includes a cylinder bore wall part 14, a water jacket external wall part 16, and a water jacket groove 18.

[0023] The cylinder bore wall part 14 is a wall provided so as to surround three cylinder bores 12 arranged in one direction. The three cylinder bores 12 are arranged in line in one direction. Therefore, the cylinder bore wall part 14 surrounds the peripheries of the three cylinder bores 12.

A film of a ferrous alloy material is formed by spray coating the inner wall surface of the cylinder bore wall part 14 facing the cylinder bores 12. In this way a linerless cylinder block can be obtained. In other words, the cylinder block 10 does not have a cast iron cylinder liner, but a spray coated film is formed on the inner wall surfaces of the cylinder bore wall part 14.

[0024] The water jacket groove 18 is provided on the outer periphery of the cylinder bore wall part 14 so as to surround the cylinder bore wall part 14, and has a groove bottom. Cooling water flows in the water jacket groove 18 when the engine is operating, to cool the cylinder bore wall part 14.

[0025] The water jacket external wall part 16 is provided on the outer periphery of the water jacket groove 18, and is a wall that demarcates both the cylinder bore wall part 14 and the water jacket groove 18. The water jacket external wall part 16 is provided so as to form a gap with a predetermined space on the outside of the cylinder bore wall part 14. This gap is the water jacket groove 18.

[0026] FIG. 3 is a cross-sectional view sectioned along the line A-A in the direction of the arrows in FIG. 2B. FIG. 4A and 4B are perspective views of the cylinder block 10 in FIG. 2A sectioned along the lines B-B and C-C respectively in the direction of the arrows.

As illustrated in FIGS. 4A and 4B, the water jacket groove 18 formed between the cylinder bore wall part 14 and the water jacket external wall part 16 includes a shallow groove part 20 in which the groove depth becomes shallower the closer to an end of the cylinder bore wall part 14 in the alignment direction of the cylinder bores 12. In FIG. 3 and FIGS. 4A and 4B, the groove bottom of the water jacket groove 18 is indicated with a dotted line. This shallow groove part 20 is provided to improve the flow of the melt when casting the cylinder block 10. When casting the cylinder block 10 using an aluminum alloy melt, at the portion of the casting mold corresponding to the cylinder bore wall part 14 a melt supply sprue and

melt discharge outlet are provided at the two ends of the cylinder block 10 so that the melt flows from a first end of the cylinder bore wall part 14 to a second end in the alignment direction of the cylinder bore 12 (from the top side towards the bottom side in FIG. 2A). Also, in the portion of the casting mold corresponding to the water jacket external wall part 16, the flow is from the first end towards the second end. At this time, in the portions of the casting mold corresponding to the cylinder bore wall part 14 and the water jacket external wall part 16, the melt flows together near the second end, and finally the melt flows out together with air bubbles from the melt discharge outlet of the casting mold provided near the second end. In particular, the portion of the casting mold corresponding to the water jacket groove 18 located near the second end of the cylinder bore wall part 14 is a portion that is a wall that obstructs the flow of the melt, so it is difficult for the melt to flow towards the discharge outlet. Moreover, near the second end, the melt flows together from two sides, so it can easily stagnate. Therefore, in the first embodiment in the region near the discharge outlet of the melt, in other words in the region that includes the second end on the downstream side in the direction of flow of the melt, the water jacket groove 18 includes the shallow groove part 20 with a shallow groove bottom. Therefore, in the region of the casting mold corresponding to the shallow groove part 20, the height of the wall corresponding to the water jacket groove 18, which is a wall that can easily obstruct the flow of the melt, is made lower. Also, the groove depth of the shallow groove part 20 becomes shallower towards the end of the cylinder bore wall part 14 in the alignment direction of the cylinder bores 12 such that the melt flows easily. In other words, the groove bottom of the shallow groove part 20 is inclined so that it becomes shallower the closer to the end of the cylinder bore wall part 14, and the groove bottom is shallowest in the region that includes this end.

[0027] The portion of the water jacket external wall part 16 where the shallow groove part 20 is provided includes a first inner wall surface 16a that faces the water jacket groove 18, and a first outer wall surface 16b on the opposite side to the first inner wall surface 16a.

[0028] When the groove depth direction in which the groove becomes deeper is the downward direction, the portion of the cylinder bore wall part 14 where the shallow groove part 20 is provided includes a second outside wall surface 14a that faces the water jacket groove 18 (see FIG. 4A), and a third outside wall surface 14b from which the outer wall surface of the cylinder block 10 is configured provided in the downward direction from the groove bottom of the shallow groove part 20 (see FIG. 4A). The third outside wall surface 14b together with the first outer wall surface 16b of the water jacket external wall part 16 constitute the outside wall surface of the cylinder block 10. In this case, preferably the third outside wall surface 14b has a recess shape depressed with respect to the first outer wall surface 16b towards the cylinder bore 12. The third outside wall surface 14b has a depressed shape with respect to the first outer wall surface 16b in order to improve the flow of the melt. Specifically, if the third outside wall surface 14b is not depressed with respect to the first outer wall surface 16b, in other words, if the outside wall surface is formed without providing a step in the third outside wall surface 14b with respect to the first outer wall surface 16b, the thickness of the wall between the third outside wall surface 14b and the inside wall surface 14c of the cylinder bore wall part 14 that faces the cylinder bore 12 will be greater compared with its surroundings, and during casting a large quantity of melt can easily accumulate in this portion, the melt can easily stagnate, and in addition gas bubbles can accumulate. Therefore, in order to make the thickness of the wall at this portion the same as that of its surroundings, the third outside wall surface 14b is formed as a recess depressed with respect to the first outer wall surface 16b towards the cylinder bore 12. Also, by providing the depressed shape, the mass can be reduced.

[0029] In other words, at one end of the water jacket external wall part 16 in the direction of alignment of the cylinder bores 12 (the first end), as illustrated in FIG. 3, the cylinder bore wall part 14 is provided extending from below upwards, and from a position that is partway upwards in the extension of the cylinder bore wall part 14, the cylinder bore wall part 14 branches to form the water jacket groove 18 with the water jacket external wall part 16 towards the outside. The third outside wall surface 14b of the cylinder bore wall part 14 below the groove bottom of the shallow groove part 20 is depressed into a recess shape towards the cylinder bore 12 with respect to the first outer wall surface 16b of the water jacket external wall part 16 so that the wall of the cylinder bore wall part 14 at this position does not become thick.

[0030] In addition, a rib 22 projecting from the first outer wall surface 16b is provided in the first outer wall surface 16b at a position in the groove depth direction corresponding to the groove bottom of the shallow groove part 20, and along the shallow groove part 20. More specifically, when the direction in which the groove depth of the groove bottom becomes deeper is taken to be the downward direction, the rib 22 is provided on the first outer wall surface 16b in a position downward from the position of the groove bottom of the shallow groove part 20, as illustrated in FIG. 3.

[0031] This rib 22 is provided to reinforce the mechanical strength of the groove bottom 20. When the sprayed coating is formed on the inner wall surface of the cylinder bore wall part 14 after casting the aluminum alloy in order that the cylinder block 10 can be used as a linerless cylinder block, the cylinder bore wall part 14 and the water jacket external wall part 16 are raised to a high temperature, and damage can easily occur due to thermal deformation of the water jacket external wall part 16. Specifically, when the water jacket external wall part 16 in which a portion has plastically deformed due to thermal expansion is cooled, the plastically deformed portion does not return to the shape prior to spray coating, so

damage can easily occur due to cracking in the part around the groove bottom of the shallow groove part 20 of the water jacket external wall part 16. Therefore, the rib 22 is provided in the first outer wall surface 16b corresponding to a position in the groove depth direction of the groove bottom of the shallow groove part 20 downward from the groove bottom of the shallow groove part 20, and along the shallow groove part 20. In this way, the mechanical strength around the groove bottom of the shallow groove part 20 can be ensured. Note that if the thickness of the wall of the water jacket external wall part 16 is not locally thickened as with the rib 22, and the thickness of the whole wall is increased, the mechanical strength of the water jacket external wall part 16 around the groove bottom of the shallow groove part 20 will be increased, but at the same time the mass will be increased. The inventors discovered that providing the rib 22 in this way is effective for ensuring the mechanical strength.

[0032] Note that the rib 22 is provided continuously corresponding to the portion of the water jacket external wall part 16 where the shallow groove part 20 is provided, but it does not necessarily have to be provided continuously. The rib 22 may be partially disconnected. However, preferably the rib 22 is provided continuously from the point of view of ensuring the mechanical strength of the water jacket external wall part 16 around the groove bottom of the shallow groove part 20, and obtaining resistance to thermal deformation caused by heating when the sprayed coating is formed. In this case, as a preferred embodiment it is provided continuously in the whole region of the water jacket external wall part 16 where the shallow groove part 20 is provided. Alternatively, as another preferred embodiment it is provided continuously over a portion of the whole region of the shallow groove part 20. Also, preferably it is provided continuously in the portion of the shallow groove part 20 where the groove depth is shallowest.

Second Embodiment

[0033] FIG. 5 is a side view of a cylinder block 10 according to a second embodiment that is different from the cylinder block 10 for a three cylinder engine illustrated in FIGS. 1 to 4. The side view of the cylinder block 10 illustrated in FIG. 5 is the cylinder block 10 viewed from a direction corresponding to the upward direction in the plane of the paper in FIG. 2A. Namely, the second embodiment is an embodiment in which the shallow groove part 20 is provided at the end on the opposite side in the alignment direction of the cylinder bores 12 to the side on which the depression is provided in the third outside wall surface 14b of the cylinder block 10 as illustrated in FIG. 2B (the lower side in the drawing). In the cylinder block 10 according to this embodiment, a melt supply sprue and melt discharge outlet are provided at the two ends of the cylinder block 10 so that during casting the melt flows in a direction corresponding to the direction from the lower side to the upper side in the plane of the paper in FIG. 2A (the direction from the distant side towards the near side in the direction normal to the plane of the paper in FIG. 5), unlike the flow of the melt in the cylinder block 10 of the first embodiment. In other words, in the second embodiment, the shallow groove part 20 is provided at the end in the alignment direction of the cylinder bores 12 where the melt is discharged during casting.

[0034] The cylinder block 10 according to the second embodiment also includes the cylinder bores 12, the cylinder bore wall part 14, the water jacket external wall part 16, the water jacket groove 18, the shallow groove part 20, the rib 22, the first inner wall surface 16a, the first outer wall surface 16b, third outside wall surface 14b, and the inside wall surface 14c, the same as for the cylinder block 10 according to the first embodiment, so their descriptions are omitted. Note that in the second embodiment also, the third outside wall surface 14b is depressed towards the cylinder bores 12 with respect to the first outer wall surface 16b, the same as in the first embodiment.

[0035] FIG. 6A is a cross-sectional view of the cylinder block 10 sectioned along the line D-D in the direction of the arrows in FIG. 5, and FIG. 6B is a perspective view of the cylinder block 10 sectioned along the line D-D in the direction of the arrows in FIG. 5. FIG. 7A is a cross-sectional view of the cylinder block 10 sectioned along the line E-E in the direction of the arrows in FIG. 5, and FIG. 7B is a perspective view of the cylinder block 10 sectioned along the line E-E in the direction of the arrows in FIG. 5.

The cylinder block 10 according to the second embodiment differs from that of the first embodiment in the region where the rib 22 is provided. As illustrated in FIG. 5, a circular arc-shaped rib 24 that extends in a large-radius circular arc shape is provided on the cylinder block 10 on the outer wall of the cylinder block 10. A portion of the circular arc-shaped rib 24 forms the rib 22 projecting from the first outer wall surface 16b, provided corresponding to a position in the groove depth direction of the groove bottom of the shallow groove part 20. More specifically, preferably the rib 22 is provided in a position below the groove bottom of the shallow groove part 20. Preferably the rib 22 is provided in the region of the water jacket external wall part 16 where the shallow groove part 20 is provided. Unlike in the first embodiment, the rib 22 is not provided over the whole region of the shallow groove part 20, but is provided over at least a portion of the region of the shallow groove part 20, for example it is provided in a region of the shallow groove part 20 where the groove depth is shallowest. Even when the rib 22 is provided over a portion of the region of the shallow groove part 20 in this way, the mechanical strength around the groove bottom of the shallow groove part 20 can be ensured. Also, as illustrated in FIGS. 7A and 7B, preferably the sloping surface that extends from the rib 22 towards the depression of the third outside wall surface 14b has a

portion 26 that bulges to the outside of the cylinder block 10. By providing the bulging out portion 26 in this way, the thickness of the water jacket external wall part 16 is increased at some positions. In this way, the mechanical strength around the groove bottom of the shallow groove part 20 can be further increased. This completes the description of the second embodiment.

[0036] Note that in the cylinder block 10 according to the first embodiment illustrated in FIGS. 1 to 4 and the cylinder block 10 according to the second embodiment illustrated in FIGS. 5 to 7, besides the shallow groove part 20, the water jacket groove 18 includes a deep groove part 21 having a constant groove depth. In the case of the portion of the shallow groove part 20 at which the groove depth is shallowest, the shallower the groove depth the better in order to improve the flow of the melt, and the deeper the better in order to prevent damage due to thermal deformation of the water jacket external wall part 16. From these requirements there is no particular limitation on the groove depth of the portion of the shallow groove part 20 at which the groove depth is shallowest, but it is preferably in the range of 20 to 80% of the constant groove depth of the deep groove part 21 as described above.

In both the cylinder block 10 according to the first embodiment and the cylinder block 10 according to the second embodiment, when the region of the water jacket groove 18 where the shallow groove part 20 is provided is viewed as the angle of view with reference to the center point of the circular arc shape of the cylinder bore 12 located at the end that the shallow groove part 20 is provided, the wider the angle of view of the region of the water jacket groove 18 where the shallow groove part 20 is provided the better. In this way, the groove depth of the water jacket groove 18 changes smoothly, so damage due to thermal deformation of the water jacket external wall part 16 can be prevented. Also, the melt can flow smoothly. However, in some cases it is not possible to increase the angle of view due to restrictions of the cooling water path. Therefore, the angle of view of the region of the water jacket groove 18 is not particularly limited, but preferably is from 45 to 180 degrees.

Also, in both the cylinder block 10 according to the first embodiment and the cylinder block 10 according to the second embodiment, preferably the portion of the shallow groove part 20 where the groove depth is shallowest continues continuously. In this case the groove depth of the shallow groove part 20 changes smoothly from the shallow groove part 20 to the deep groove part 21, and the portion of the shallow groove part 20 where the groove depth is shallowest is at the end in the alignment direction of the cylinder bores 12, which is preferable for improving the flow of the melt, and is preferable for preventing damage due to thermal deformation of the water jacket external wall part 16.

[0037] The following is a summary of the description of the cylinder blocks 10 of the first embodiment and the second embodiment as described above. In the cylinder block 10, the water jacket groove 18 includes the shallow groove part 20 in which the groove depth becomes shallower the closer to the end portion of the cylinder bore wall part 14 in the alignment direction of the cylinder bores 12. The portion of the cylinder bore wall part 14 where the shallow groove part 20 is provided includes the second outside wall surface 14a that faces the water jacket groove 18, and the third outside wall surface 14b from which the outer wall surface of the cylinder block 10 is configured, provided below the groove bottom. At this time, the third outside wall surface 14b is formed depressed towards the cylinder bore 12 with respect to the first outer wall surface 16b of the water jacket external wall part 16. Therefore when casting the cylinder block 10, the melt can flow smoothly without forming a part where the melt accumulates. In other words, the flow of the melt when casting the cylinder block 10 can be improved.

[0038] Also, the portion of the water jacket external wall part 16 where the shallow groove part 20 is provided includes the first inner wall surface 16a facing the water jacket groove 18, and the first outer wall surface 16b. The rib 22 is provided projecting from the first outer wall surface 16b along the shallow groove part 20, in a position in the groove depth direction corresponding to the groove bottom of the shallow groove part 20. Therefore due to the shallow groove part 20, the flow of the melt during casting of the cylinder block 10 can be improved compared with when the shallow groove part 20 is not provided. In addition, when the rib 22 is provided on the periphery of the water jacket external wall part 16 along the shallow groove part 20, the mechanical strength around the groove bottom of the shallow groove part 20 is ensured, and therefore there is no damage due to high temperatures when forming the sprayed coating on the inside wall surfaces of the cylinder bores 12.

[0039] Also, in the first embodiment and the second embodiment, the rib 22 that projects from the first outer wall surface 16b of the water jacket external wall part 16 is provided continuously in a portion of the water jacket external wall part 16 where the shallow groove part 20 is provided. Therefore, the strength around the groove bottom of the shallow groove part 20 can be ensured, and thermal deformation caused by heating when forming the sprayed coating can be resisted. It is not necessary to provide the rib 22 over the whole region of the shallow groove part 20, and it may be provided over at least a portion of the region of the shallow groove part 20.

[0040] Preferably the portion of the shallow groove part 20 where the groove depth is shallowest continues continuously. In this case the groove depth changes smoothly from the shallow groove part 20 to the deep groove part 21, and the end portion in the alignment direction of the cylinder bores 12 where the shallow groove part 20 is provided is the portion of the shallow groove part 20 where the groove depth is shallowest, so the flow of the melt can be improved.

[0041] Besides the shallow groove part 20, the water

jacket groove 18 has a deep groove part 21 with a constant groove depth. By making the groove depth of the portion of the shallow groove part 20 where the groove depth is shallowest 20 to 80% of the groove depth of the deep groove part 21, both improvement in the flow of the melt and prevention of damage due to the heat load can be achieved.

[0042] When the region of the water jacket groove 18 where the shallow groove part 20 is provided is viewed with an angle of view with reference to the center point of the circular arc shape of the cylinder bore 12 located on the end where the shallow groove part 20 is provided, by making the angle of view of this region 45 to 180 degrees, improvement in the flow of the melt, prevention of damage due to the heat load, and ensuring the path of the cooling water can be achieved.

[0043] The cylinder block and internal combustion engine according to the present invention were described in detail above, but the present invention is not limited to the above-described embodiments, and various improvements and changes may be made within the range that does not deviate from the intention of the present invention. In the first and second embodiments, three cylinder bores were used, but it is sufficient that there are at least two or more cylinder bores 12, and there may be four or five or more.

[0044] Also, in the first and second embodiments, a melt supply sprue and a melt discharge outlet were provided at the two ends of the cylinder block 10 so that the melt flows from the first end to the second end in the alignment direction of the cylinder bores 12. However, a configuration in which the melt supply sprue is provided near the center of the cylinder block 10, and the melt discharge outlet is provided at both ends of the cylinder block 10 can also be applied. In this case, the configuration of the first embodiment and the second embodiment can be applied to both ends of the cylinder block 10 (the upper part and the lower part in FIG. 2A) close to the melt discharge outlet on the downstream side in the direction of flow of the melt. In this way, the configuration of the first embodiment and the second embodiment can be applied to the ends of the cylinder block 10 close to the melt discharge outlet on the downstream side in the direction of flow of the melt, regardless of the position of the melt supply sprue. In the first and second embodiments, a linerless cylinder block was described in detail in which the sprayed coating was formed on the inside wall surfaces of the cylinder bore wall part 14. However, the configurations of the first and second embodiments can also be applied to cylinder blocks using cast iron cylinder liners, in order to improve the flow of the melt during casting.

Reference Signs List

[0045]

10 Cylinder block
12 Cylinder bore
14 Cylinder bore wall part
14a Second outside wall surface
14b Third outside wall surface
14c Inside wall surface
16 Water jacket external wall part
16a First inner wall surface
16b First outer wall surface
18 Water jacket groove
20 Shallow groove part
21 Deep groove part
22 Rib
24 Circular arc-shaped rib
26 Portion

Claims

1. A casted cylinder block, comprising:

a cylinder bore wall part having a plurality of cylinder bores aligned along a first direction;
a water jacket groove having a groove bottom and arranged on an outer periphery of the cylinder bore wall part so as to surround the cylinder bore wall part; and
a water jacket external wall part arranged on an outer periphery of the water jacket groove, and defines the water jacket groove together with the cylinder bore wall part, wherein
the water jacket groove includes a shallow groove part where the groove depth becomes shallower toward an end of the cylinder bore wall part in the alignment direction of the plurality of cylinder bores,
a portion of the water jacket external wall part where the shallow groove part is formed includes a first inner wall surface facing the water jacket groove and a first outer wall surface on an opposite side to the first inner wall surface,
when from among the groove depth directions the direction in which the groove becomes deeper is taken to be the downward direction, a portion of the cylinder bore wall part where the shallow groove part is arranged has

a second outside wall surface facing the water jacket groove, and
a third outside wall surface arranged in the downward direction from the groove bottom and constituting the outside wall surface of the cylinder block together with the first outer wall surface of the water jacket external wall part, the third outside wall surface being depressed towards a cylinder bore with respect to the first outer wall surface.

2. The cylinder block according to claim 1, wherein a

rib projecting from the first outer wall surface is arranged along the shallow groove part and on the first outer wall surface at a position corresponding to the groove bottom of the shallow groove part with respect to the groove depth direction.

3. The cylinder block according to claim 2, wherein when the direction in which the groove depth of the groove bottom becomes deeper is taken to be the downward direction, the rib is arranged at a position in the downward direction from the groove bottom of the shallow groove part.

4. The cylinder block according to claim 2 or 3, wherein the rib projecting from the first outer wall surface is arranged continuously over at least a part of the portion of the water jacket external wall part where the shallow groove part is arranged.

5. The cylinder block according to any one of claims 1 to 4, wherein an inclined surface extending from the rib towards the depressed portion of the third outside wall surface includes a portion that bulges to the outside of the cylinder block such that the thickness of the water jacket external wall part is increased.

6. The cylinder block according to any one of claims 1 to 5, wherein the portion of the shallow groove part where the groove depth is shallowest continues continuously.

7. The cylinder block according to any one of claims 1 to 6, wherein the groove depth of the shallow groove part is shallowest at the end portion in the alignment of the plurality of cylinder bores.

8. The cylinder block according to any one of claims 1 to 7, wherein, in addition to the shallow groove part, the water jacket groove includes a deep groove part with a constant groove depth, and the shallowest groove depth of the shallow groove part is 20 to 80% of the groove depth of the deep groove part.

9. The cylinder block according to any one of claims 1 to 8, wherein the region of the water jacket groove where the shallow groove part is arranged has an angle of view from 45 to 180 degrees with reference to a center point of the circular arc shape of the cylinder bore located at the end where the shallow groove part is arranged.

10. The cylinder block according to any one of claims 1 to 9, wherein the cylinder block has no cast iron cylinder liner, and a spray coated film is formed on the inner wall surfaces of the cylinder bore wall part.

11. An internal combustion engine having a cylinder block according to any one of claims 1 to 10.

FIG. 1

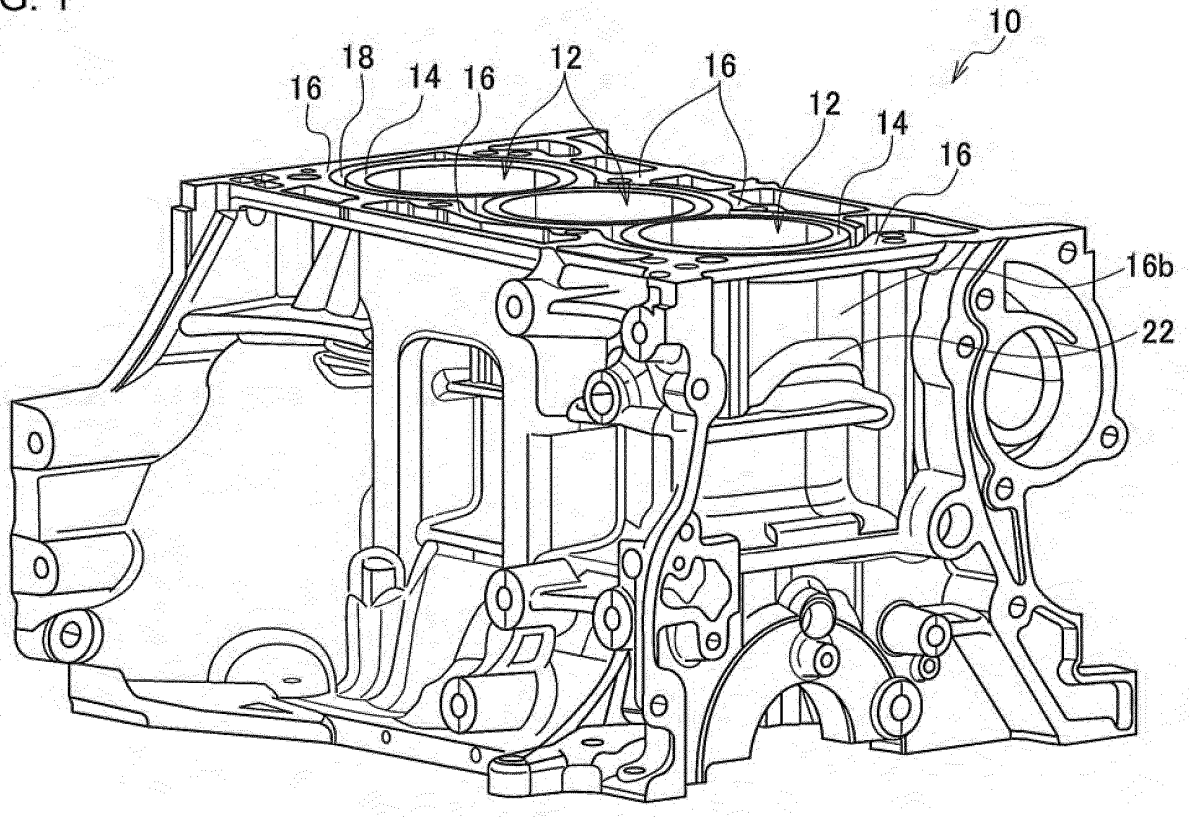


FIG. 2A

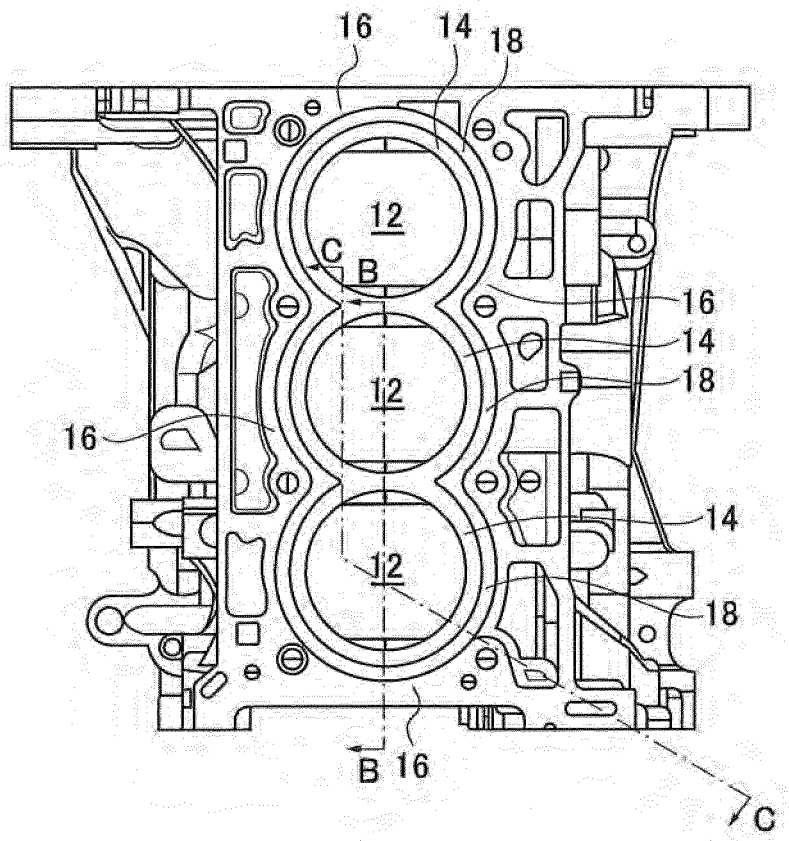


FIG. 2B

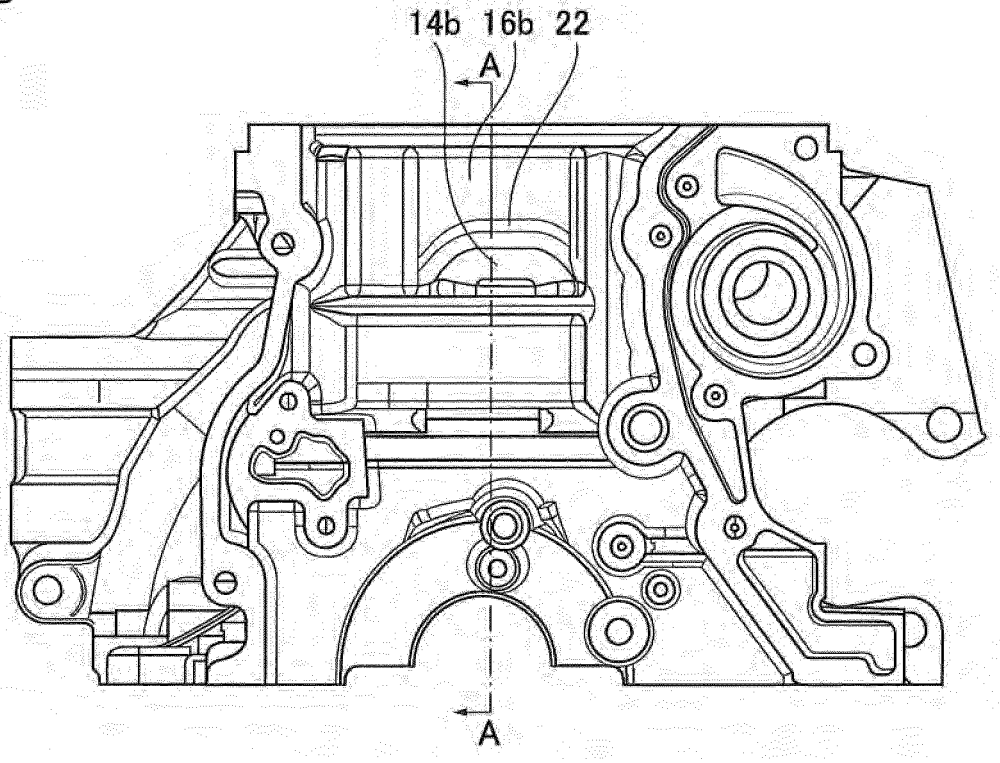


FIG. 3

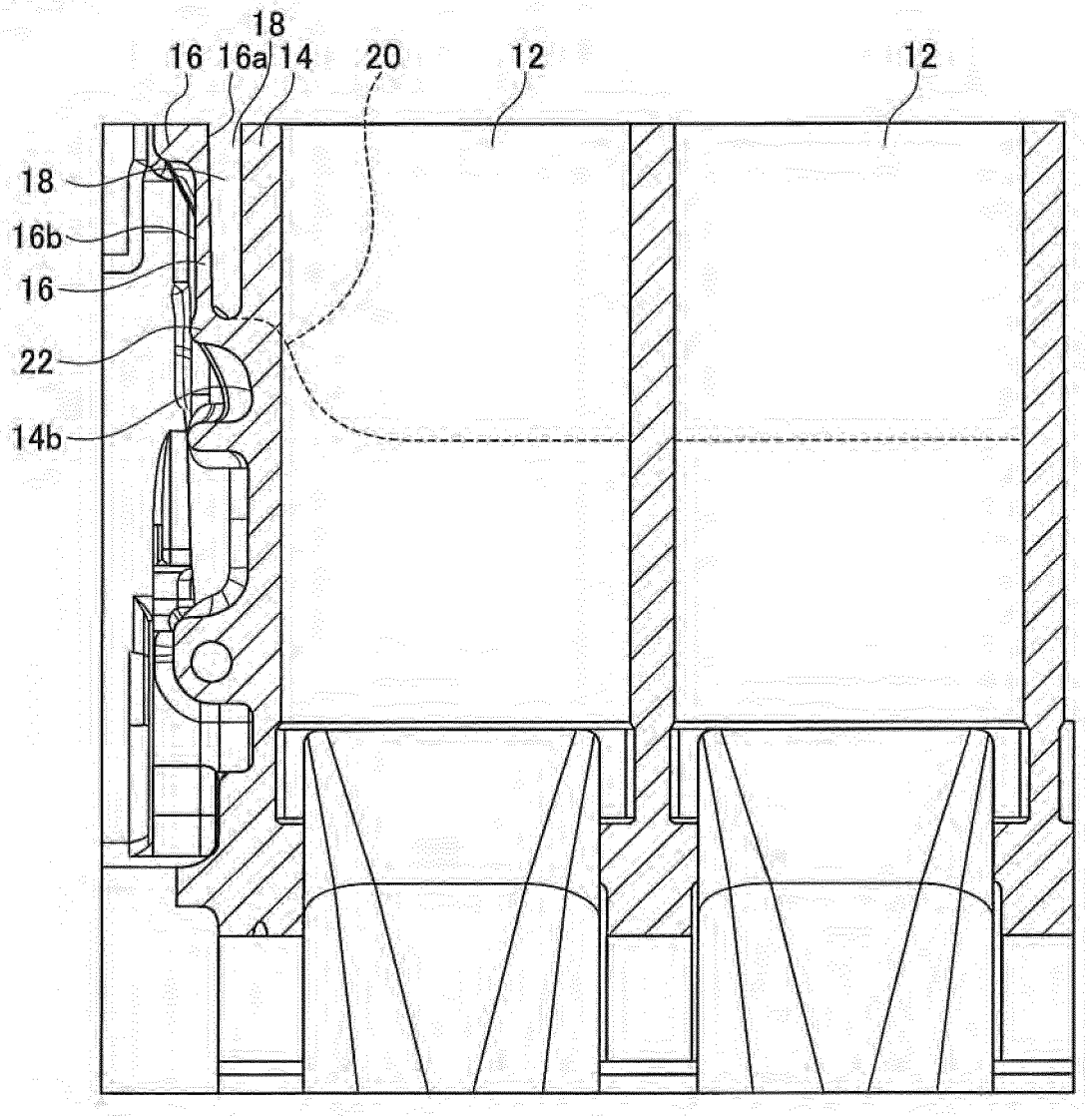


FIG. 4A

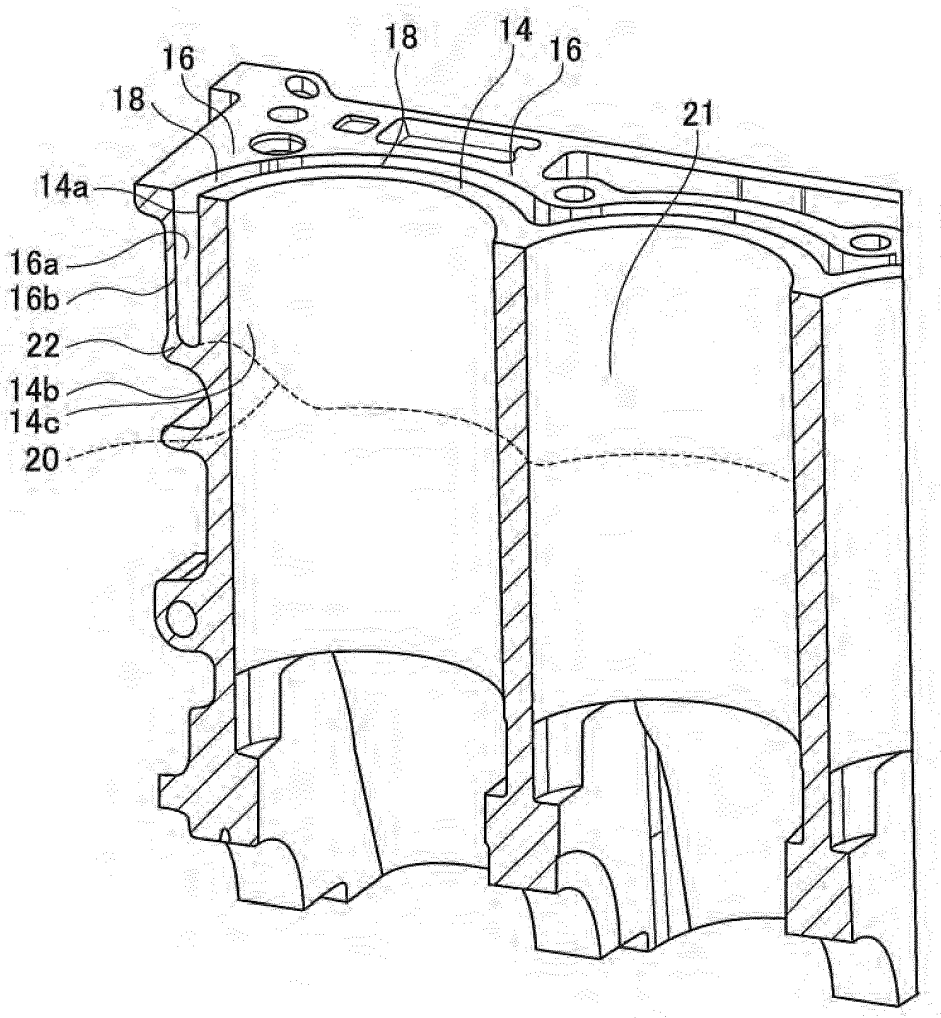
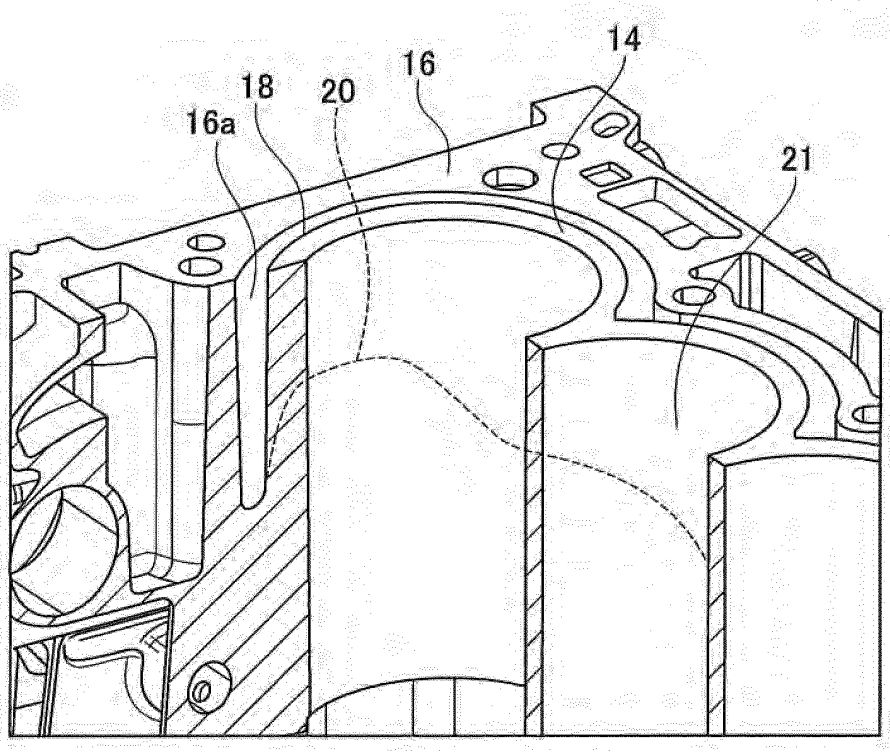


FIG. 4B



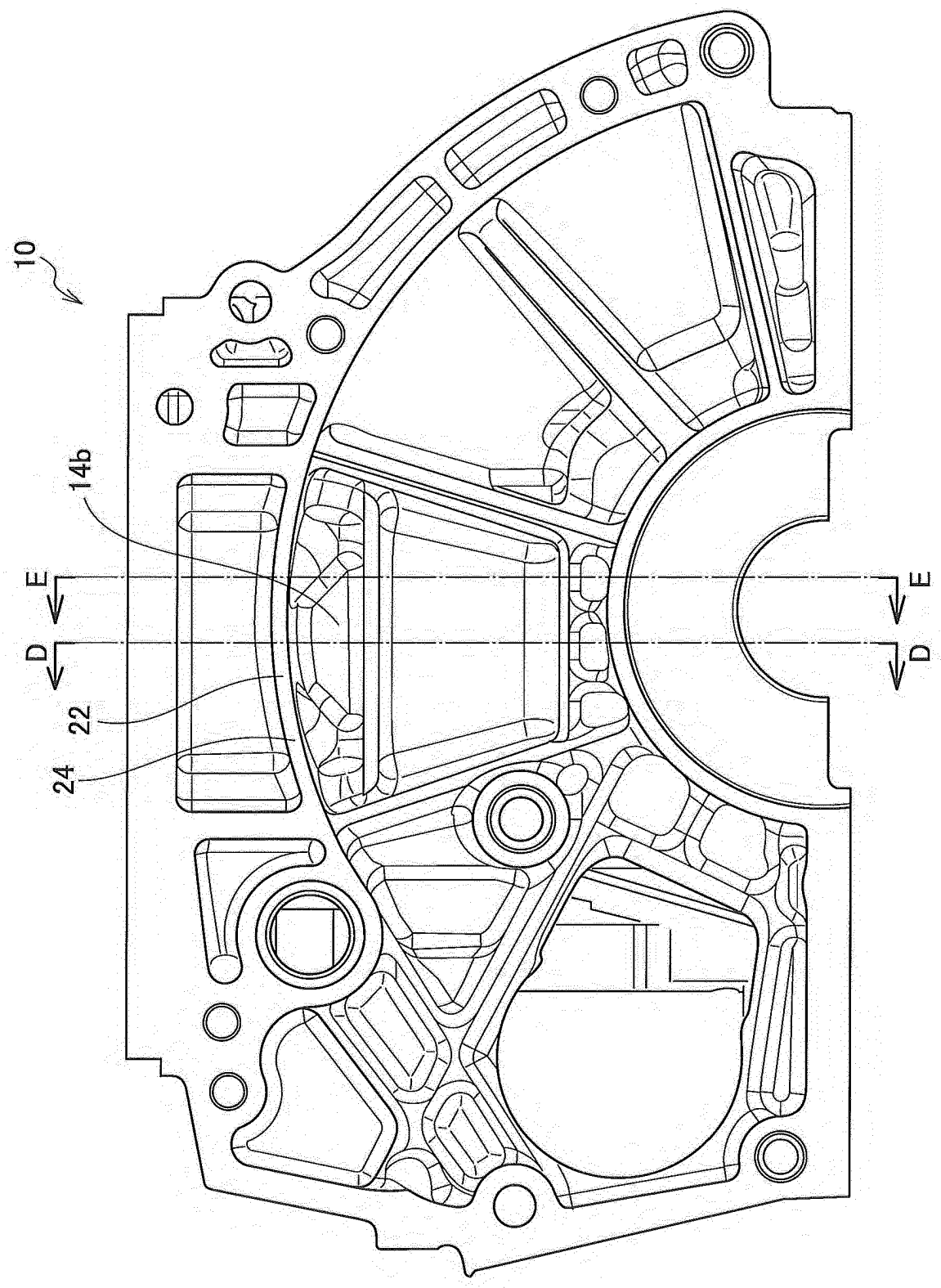


FIG. 5

FIG. 6A

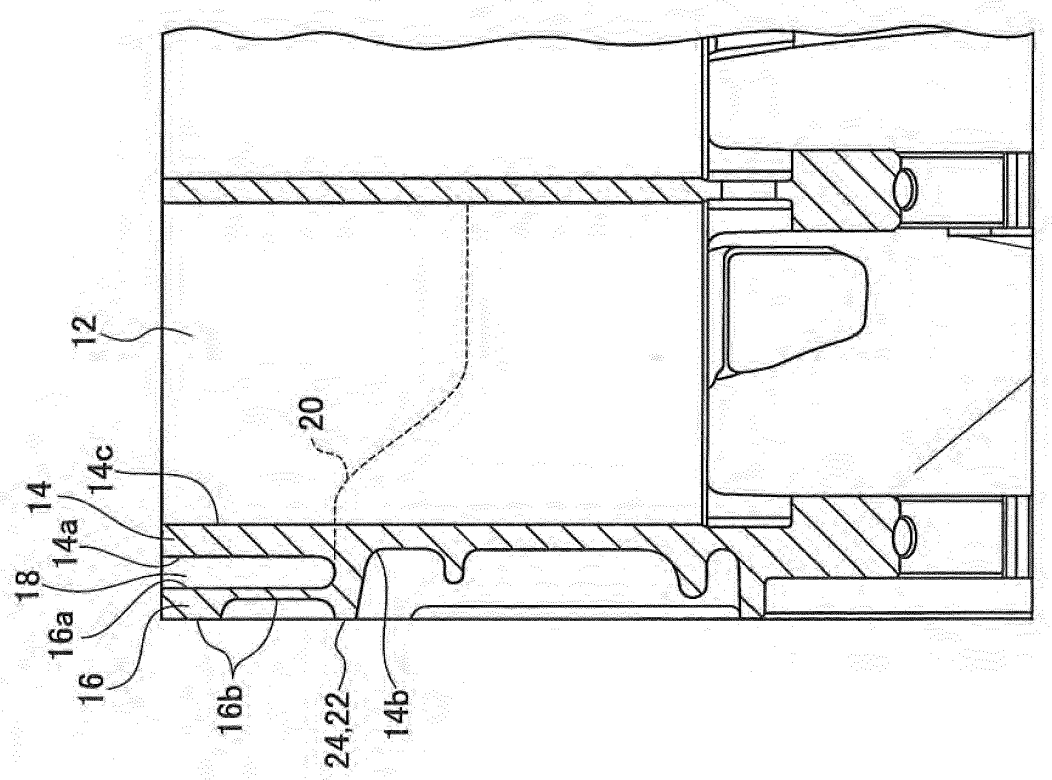
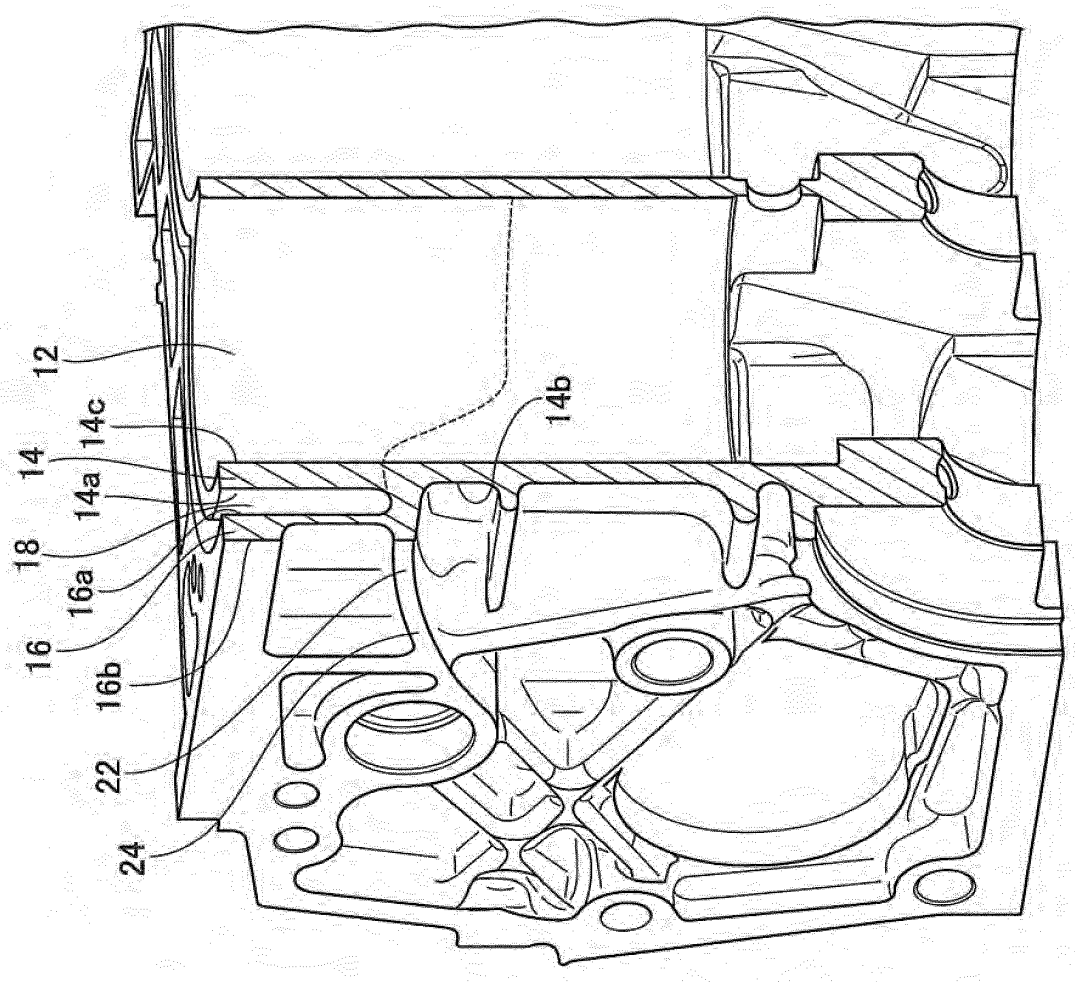

12
20
14c
14
14a
18
16a
16
16b
24,22
14b

FIG. 6B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14a
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16a
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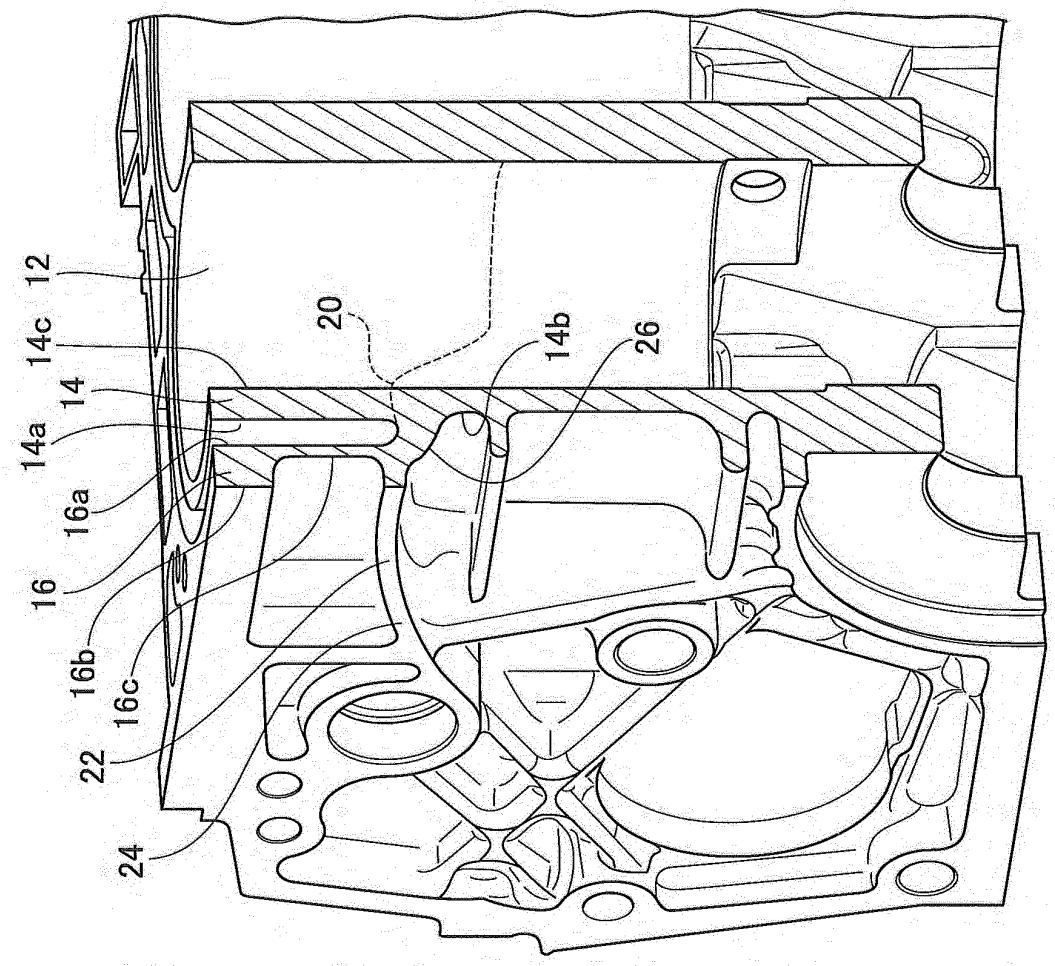
16b
22
24
14b

FIG. 7B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16a
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16b
16c
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24
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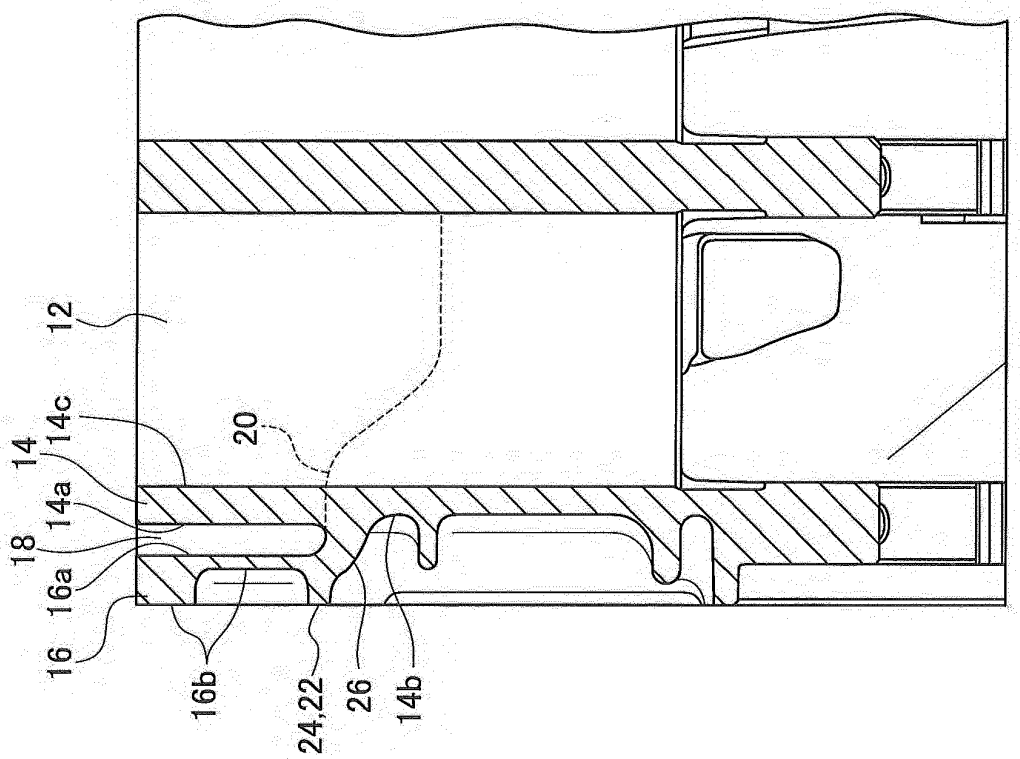
14b
26

FIG. 7A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16b
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26
14b
20

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/071664

A. CLASSIFICATION OF SUBJECT MATTER
F02F1/00(2006.01)i, *F02F1/10*(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)
F02F1/00, F02F1/10

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 1996-2014
Kokai Jitsuyo Shinan Koho 1971-2014 Toroku Jitsuyo Shinan Koho 1994-2014

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 2936888 B2 (Nissan Motor Co., Ltd.), 23 August 1999 (23.08.1999), paragraphs [0007] to [0024]; fig. 4 (Family: none)	1-11
A	JP 2007-196242 A (Toyota Motor Corp.), 09 August 2007 (09.08.2007), paragraphs [0025] to [0043]; fig. 1 (Family: none)	1-11
A	JP 2012-246831 A (Toyota Motor Corp.), 13 December 2012 (13.12.2012), paragraphs [0022] to [0074]; fig. 1 (Family: none)	1-11

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

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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
28 October, 2014 (28.10.14)	11 November, 2014 (11.11.14)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2012246831 A **[0004]**