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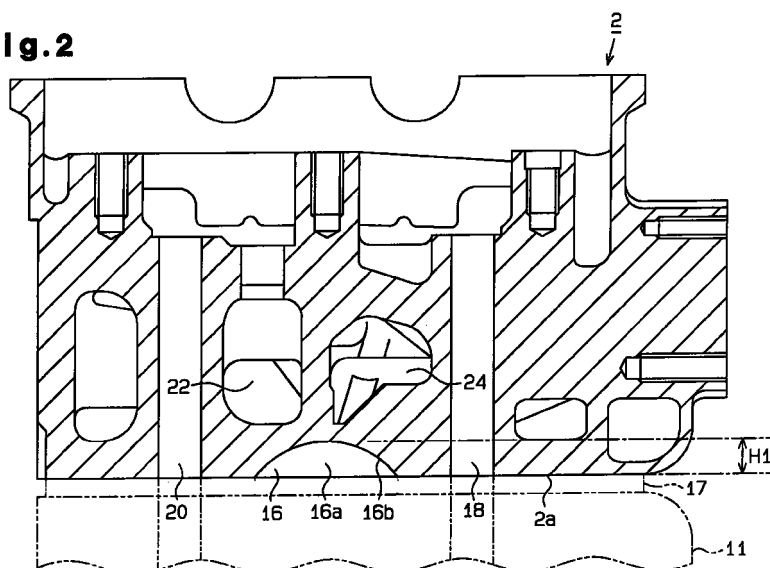
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(54) **Cylinder head structure of internal combustion engines for mitigating thermal stress**

(57) A cylinder head (2) of an internal combustion engine is connected to a cylinder block (11) that has a cylinder bore (13). A bottom surface (2a) faces the cylinder block (11). The bottom surface (2a) has two ceiling surfaces (6). The ceiling surfaces (6) and the cylinder bore (13) define a combustion chamber (15). A slit (16) is formed on the bottom surface (2a) adjacent the ceiling surface (6) to mitigate thermal stress in the cylinder head (2). The slit (16) has a deepest part (16a) located

near a center of the ceiling surfaces (6). The depth of the slit (16) decreases as the distance from the maximum depth part (16a) increases. The slit (16) is separated from other spaces in the cylinder head (2). This cylinder head structure sufficiently mitigates thermal stress and maintains the strength of the cylinder head (2).

Fig.2



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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a cylinder head structure for mitigating thermal stress in internal combustion engines.

[0002] A great amount of heat is produced in the combustion chambers of internal combustion engines such as diesel engines and gasoline engines. Especially, locations on the cylinder center axes in a cylinder head. These locations are surrounded by the corresponding intake ports and exhaust ports, and they tend to be greatly heated since heat tends to concentrate at these locations, which are not readily cooled.

[0003] Heat expands the cylinder head. However, the cylinder head is firmly bolted to a cylinder block and cannot expand freely. This causes compression strain from thermal stress at the cylinder centers in the cylinder head and produces cracks in the cylinder head between the corresponding intake ports and exhaust ports. Further, the effectiveness of a gasket located between the cylinder head and the cylinder block is reduced. As a result, the gasket may be moved or broken by combustion pressure, which deteriorates the seal between the cylinder head and the cylinder block.

[0004] Japanese Unexamined Patent Publication No. 55-160143 and Japanese Unexamined Utility Model Publication No. 58-82453 describe an internal combustion engine having slits formed on the lower surface of a cylinder head between adjacent combustion chambers. The slits absorb thermal strain and prevent cracks of the cylinder head and seal degradation.

[0005] In Publication 55-160143, the slits extend in a direction perpendicular to the longitudinal direction of the cylinder head between adjacent combustion chambers. The slits are connected to head bolt holes and water jackets. Bolts for fixing the cylinder head to the cylinder block are received in the head bolt holes.

[0006] The strength of the cylinder head is reduced when the slits are connected to the head bolt holes or the water jackets. Therefore, the cylinder head may be deformed by various stresses, which reduces the effectiveness of the gasket between the cylinder head and the cylinder block. When the slits are connected to the water jackets, leakage of cooling water through the slits may occur.

[0007] In Publication 58-82453, although the slits are not connected to the head bolt holes and the water jackets, optimum slits for sufficiently maintaining the strength of the cylinder head are not described.

[0008] An objective of the present invention is to provide a cylinder head structure for internal combustion engines that sufficiently mitigates thermal stress and maintains the strength of the cylinder head.

[0009] To achieve the above objective, the present invention provides a cylinder head of an internal combustion engine. The cylinder head is connected to a cylinder block that has a cylinder bore. A contact surface

faces the cylinder block. The contact surface has a ceiling surface that closes an opening of the cylinder bore. The ceiling surface and the cylinder bore define a combustion chamber. A slit is formed on the contact surface adjacent the ceiling surface to mitigate thermal stress in the cylinder head. The slit has a maximum depth part located near a center of the ceiling surface. The depth of the slit decreases as the distance from the maximum depth part increases. The slit is separated from other spaces in the cylinder head.

[0010] Other aspects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The features of the present invention that are believed to be novel are set forth with particularity in the appended claims. The invention, together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

Fig. 1 is a partial bottom plan view of a cylinder head according to a first embodiment of the present invention;

Fig. 2 is a cross-sectional view taken on line 2-2 of Fig. 1;

Fig. 3 is a cross-sectional view taken on line 3-3 of Fig. 1;

Fig. 4 is a cross-sectional view taken on line 4-4 of Fig. 1; and

Fig. 5 is a cross-sectional view like Fig. 2 of a second embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0012] A cylinder head 2 of a diesel engine according to a first embodiment of the present invention will now be described with reference to Figs. 1-4.

[0013] The cylinder head 2 shown in Figs. 1-3 is made of aluminum alloy. As shown in Fig. 3, when the cylinder head 2 is attached to a cylinder block 11, which is made of cast iron, the bottom surface 2a of the cylinder head 2, or a contact surface, closes upper openings of cylinder bores 13, which are formed in the cylinder block 11. The cylinder bores 13 and the bottom surface 2a define combustion chambers 15. The areas enclosed by broken lines in Fig. 1 on the bottom surface 2a

of the cylinder head 2 function as flat ceiling surfaces 6 for the combustion chambers 15. A pair of intake ports 8, a pair of exhaust ports 10, a nozzle hole 12, and a glow plug hole 14 are formed in each ceiling surface 6 of the cylinder.

[0014] As shown in Fig. 3, an annular step 8c is formed in the vicinity of the opening of each intake port 8 in the corresponding ceiling surface 6. A ring-shaped valve seat 8a is attached to each step 8c. An annular step 10c is formed in the vicinity of the opening of each exhaust port 10 in the corresponding ceiling surface 6. A ring-shaped valve seat 10a is attached to each step 10c. A tubular intake valve guide 8b is attached to the cylinder head 2 and is coaxial with each intake valve seat 8a. A tubular exhaust valve guide 10b is attached to the cylinder head 2 and is coaxial with each exhaust valve seat 10a. A poppet valve (not shown) is supported in each valve guide 8b, 10b to move axially. Each poppet valve separates from and contacts the corresponding valve seat 8a, 10a, which opens and closes the corresponding port 8, 10.

[0015] As shown in Figs. 1 and 2, slits 16 are formed on the bottom surface 2a of the cylinder head 2, between the adjacent ceiling surfaces 6. When seen from the bottom surface 2a of the cylinder head 2, each slit 16 extends in a direction perpendicular to the direction (shown by the arrow D of Fig. 1) in which the combustion chambers 15 are arranged. As shown in Fig. 4, the slit 16 has a pair of side walls 16c, which face each other. As shown in Fig. 2, each slit also includes a bottom wall 16b, which is arcuate. Accordingly, the center part of each slit 16 is its deepest part 16a, which corresponds to the center of each combustion chamber 15. The further from the deepest part 16a, the shallower each slit 16 becomes.

[0016] The cylinder head 2 includes head bolt holes 18, 20, in which bolts (not shown) are received to join the cylinder head 2 to the cylinder block 11. The slits 16 are not connected to the head bolt holes 18, 20. Also, each slit 16 is independently formed and is not connected to other spaces in the cylinder head 2, such as water jackets 22, 24. The head bolt holes 18, 20 are located at both ends of each slit 16. The depth of each slit 16 gradually decreases from the deepest part 16a towards the head bolt holes 18, 20.

[0017] As shown in Figs. 2 and 3, the depth H1 of the deepest part 16a of each slit 16 is substantially the same as the height H2 of the uppermost extent of the valve seats 8a, 10a (here, the top of the highest valve seat 8a of each intake port 8). The depth H1 and the height H2 are both measured from the bottom surface 2a of the cylinder head 2. The deepest part 16a is located close to and approximately in alignment with the uppermost position of the valve seat 8a of each intake port 8 in the longitudinal direction of the cylinder head 2.

[0018] The slits 16 are formed by cutting the bottom surface 2a of the cylinder head 2 with a disc-shaped cutter (not shown). The cross section of the edge of the

disc-shaped cutter is U-shaped. Therefore, the cross section of the bottom wall 16b of each slit 16 is generally U-shaped as shown in Fig. 4. Accordingly, the bottom wall 16b of each slit 16 does not have any angular surfaces. The width (in the direction of arrow D of Fig. 1) of each slit 16 is, for example, about 1mm.

[0019] When fixing the cylinder head 2 to the cylinder block 11, a gasket 17 is located between the bottom surface 2a of the cylinder head 2 and the cylinder block 11. The gasket 17 includes holes corresponding to the ceiling surfaces 6, holes corresponding to head bolt holes 18, 20, and holes corresponding to the openings of the water jackets 22, 24 in the bottom surface 2a of the cylinder head 2. The gasket 17 closes the openings of the slits 16.

[0020] The present embodiment has the following advantages.

[0021] Center locations 26 of the cylinder head 2, which are surrounded by corresponding intake ports 8 and exhaust ports 10, are located approximately on the center of the corresponding combustion chambers 15. The central locations 26 are heated to an especially high temperature and are likely to be thermally stressed. In the present embodiment, the deepest parts 16a of the slits 16 are formed at the longitudinal centers of the slits 16. In other words, the deepest parts 16a of the slits 16 are the closest parts of the slits to the center locations 26 of the cylinder head 2, which are subject to the greatest thermal stress. Therefore, the relatively great thermal stress applied to the center locations 26 of the cylinder head 2 is effectively mitigated by the deepest parts 16a.

[0022] Each slit 16 becomes shallower from the deepest part 16a towards its ends. That is, only the part of each slit 16 that is close to the center locations 26 is formed to be relatively deep, and the rest of each slit 16 is relatively shallow. In this way, the slits are no deeper than is required. Therefore, the slits do not reduce the strength of the cylinder head 2. This prevents excessive deformation of the cylinder head 2 and improves sealing between the cylinder head 2 and the cylinder block 11.

[0023] Furthermore, the depth of each slit 16 changes continuously, not stepwise. The bottom wall 16b of each slit 16 is arcuate. The cross sectional shape of the bottom wall 16b is generally U-shaped. Accordingly, the wall that defines each slit 16 has no angles. Stress tends to concentrate at angular junctions, thus stress does not concentrate in the inner wall of the slits 16. This improves the durability of the cylinder head 2. Also, the slits 16 can be easily formed using a disk-shaped cutter, which improves productivity.

[0024] The slits 16 are independently formed and are not connected to other spaces such as head bolt holes 18, 20 or water jackets 22, 24. This sufficiently maintains the strength of the cylinder head 2 and prevents degradation of the seal between the cylinder head 2 and the cylinder block 11 and prevents leakage of water or oil via the slits 16.

[0025] The steps 8c, 10c for supporting the valve seats 8a, 10a are formed at the openings of the intake ports 8 and the exhaust ports 10. Since the steps 8c, 10c have angular surfaces, stress tends to concentrate on the steps 8c, 10c. However, in the present embodiment, the deepest part 16a of each slit 16 is close to the point at the highest extent of the corresponding valve seat 8c. Therefore, the stress concentrated on the steps 8c, 10c is effectively relieved by the slits 16. Further, the slits 16 are relatively shallow, which sufficiently maintains the strength of the cylinder head 2.

[0026] Thermal stress is especially concentrated at locations surrounded by the four valves (two intake valves and two exhaust valves) of the cylinder head 2 of a four-valve-type diesel engine. However, the slits 16 effectively relieve such thermal stress.

[0027] The cylinder head 2 is made of aluminum alloy. The thermal expansion rate of aluminum alloy is greater than that of cast iron, which results in relatively great thermal stress in the aluminum. When the cylinder head 2 is joined to the cylinder block made of cast iron, the thermal stress applied to the cylinder head 2 is great. However, the slits 16 relieve the thermal stress applied to the cylinder head 2 and sufficiently maintain the strength of the cylinder head 2.

[0028] Fig. 5 is a cross-sectional view of a cylinder head 2 according to a second embodiment. Only differences from the first embodiment shown in Figs. 1-4 will now be described. Fig. 5 corresponds to Fig. 2 of the first embodiment. The cylinder head 2 of Fig. 5 includes passages 22a, 24a, which connect the water jackets 22, 24 to other water jackets (not shown) of the cylinder block 11. Each slit 16 is formed between the passages 22a, 24a. The slits 16 of the second embodiment are shorter than the slits shown in Fig. 2 such that the slits 16 are not connected to the passages 22a, 24a. The rest of the structure of the second embodiment is the same as that shown in Figs. 1-4.

[0029] The second embodiment has the following advantages in addition to the first embodiment shown in Figs. 1-4.

[0030] The slits 16 are separated from the passages 22a, 24a that are connected to the cylinder block 11. This prevents leakage of water, maintains the strength of the cylinder head 2, and relieves thermal stress.

[0031] The present invention can further be varied as follows.

[0032] In the first and second embodiments, the slits 16 are formed between the adjacent combustion chambers 15. However, the slits 16 may be formed in other parts of the cylinder head 2.

[0033] The slits 16 may be formed on the cylinder head of a one-cylinder internal combustion engine.

[0034] The present invention may also be applied to gasoline engines.

[0035] It should be apparent to those skilled in the art that the present invention may be embodied in many

other specific forms without departing from the spirit or scope of the invention. Therefore, the present examples and embodiments are to be considered as illustrative and not restrictive and the invention is not to be limited to the details given herein, but may be modified within the scope and equivalence of the appended claims.

[0036] A cylinder head (2) of an internal combustion engine is connected to a cylinder block (11) that has a cylinder bore (13). A bottom surface (2a) faces the cylinder block (11). The bottom surface (2a) has two ceiling surfaces (6). The ceiling surfaces (6) and the cylinder bore (13) define a combustion chamber (15). A slit (16) is formed on the bottom surface (2a) adjacent the ceiling surface (6) to mitigate thermal stress in the cylinder head (2). The slit (16) has a deepest part (16a) located near a center of the ceiling surfaces (6). The depth of the slit (16) decreases as the distance from the maximum depth part (16a) increases. The slit (16) is separated from other spaces in the cylinder head (2). This cylinder head structure sufficiently mitigates thermal stress and maintains the strength of the cylinder head (2).

Claims

1. A cylinder head (2) of an internal combustion engine, the cylinder head (2) being connected to a cylinder block (11) that has a cylinder bore (13), the cylinder head comprising:

a contact surface (2a) for facing the cylinder block (11), wherein the contact surface (2a) has a ceiling surface (6) that closes an opening of the cylinder bore (13), wherein the ceiling surface (6) and the cylinder bore (13) define a combustion chamber (15); and
a slit (16) formed on the contact surface (2a) adjacent the ceiling surface (6) to mitigate thermal stress in the cylinder head (2), the cylinder head (2) being characterized in that:
the slit (16) has a maximum depth part (16a) located near a center of the ceiling surface (6), wherein the depth of the slit (16) decreases as the distance from the maximum depth part (16a) increases, wherein the slit (16) is separated from other spaces in the cylinder head (2).

2. The cylinder head according to claim 1, characterized in that the slit (16) has no angular surfaces.
3. The cylinder head according to claim 1 or 2, characterized in that the depth of the slit (16) changes continuously.
4. The cylinder head according to any one of claims 1 to 3, characterized in that the slit (16) has an arcuate bottom wall (16b), wherein the maximum depth

part (16a) is located at the center of the bottom wall (16b), wherein ends of the slit (16) meet with the contact surface (2a).

5. The cylinder head according to any one of claims 1 to 3, characterized in that the slit (16) has a pair of side walls (16c), which face each other, and a bottom wall (16b) located between the side walls (16c), wherein the bottom wall (16b) smoothly meets with the side walls (16c). 5
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6. The cylinder head according to claim 4 or 5, characterized in that the cross sectional shape of the bottom wall (16b) is substantially U-shaped. 15

7. The cylinder head according to any one of claims 1 to 6, characterized in that the cylinder head (2) has a port (8,10) opening in the ceiling surface (6) to supply or exhaust material to or from the combustion chamber (15), wherein a valve seat (8a,10a) is attached to the port (8,10) such that a distance between the contact surface (2a) and a point on the valve seat (8a,10a) that is furthest from the contact surface (2a) is substantially the same as the depth of the maximum depth part (16a). 20
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8. The cylinder head according to any one of claims 1 to 6, characterized in that the cylinder head (2) has four ports (8,10) opening in the ceiling surface (6) to supply or exhaust material to or from the combustion chamber (15). 30

9. The cylinder head according to any one of claims 1 to 8, characterized in that the internal combustion engine is a diesel engine. 35

10. The cylinder head according to any one of claims 1 to 9, characterized in that the cylinder head (2) is made of aluminum alloy. 40

11. The cylinder head according to any one of claims 1 to 10, characterized in that the cylinder bore (13) is one of at least two cylinder bores (13), wherein the ceiling surface (6) is one of two ceiling surfaces (6) that correspond to the cylinder bores (13), wherein the slit (16) is located between adjacent ceiling surfaces (6) and extends in a direction substantially perpendicular to the direction in which the ceiling surfaces (6) are arranged. 45
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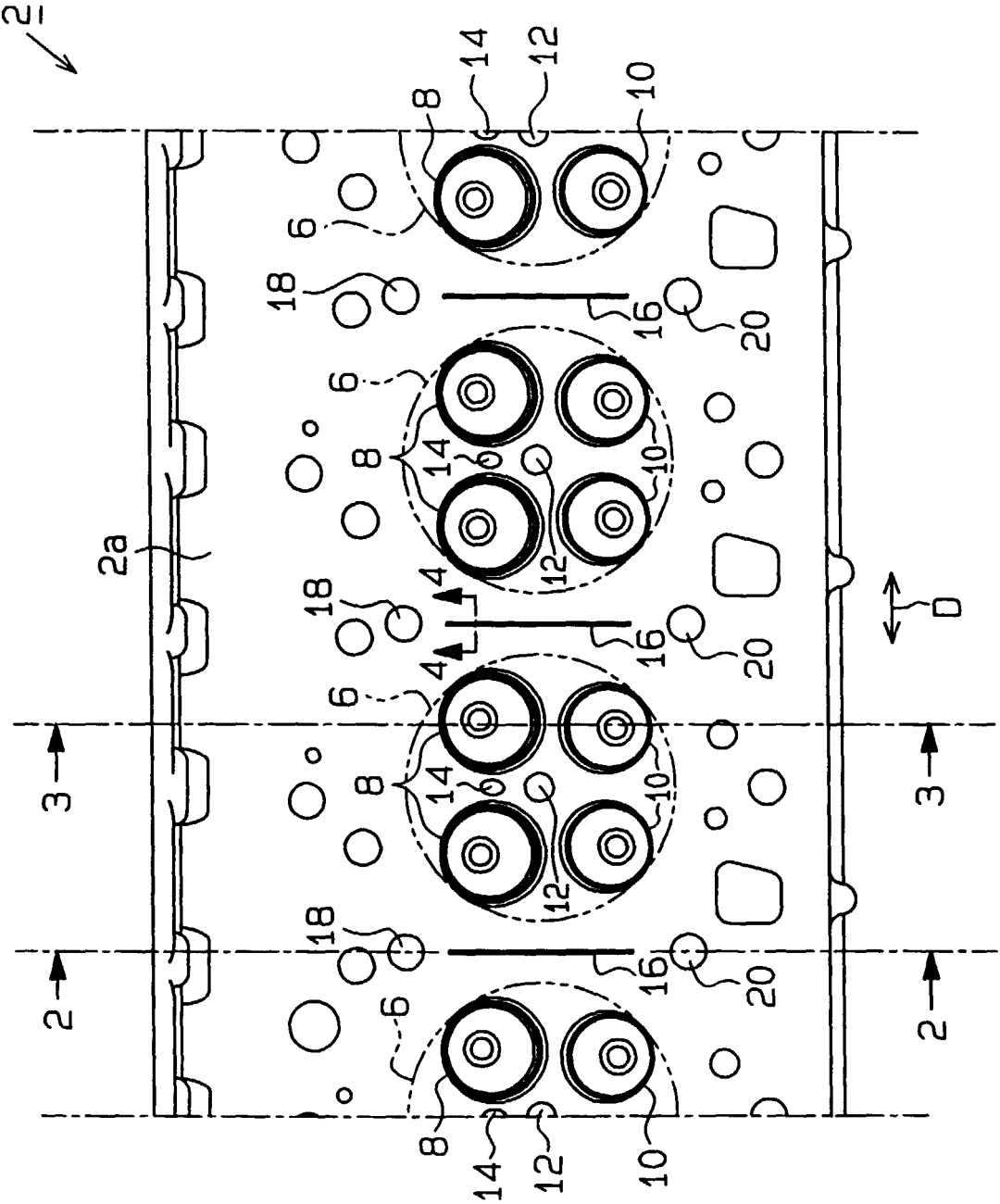
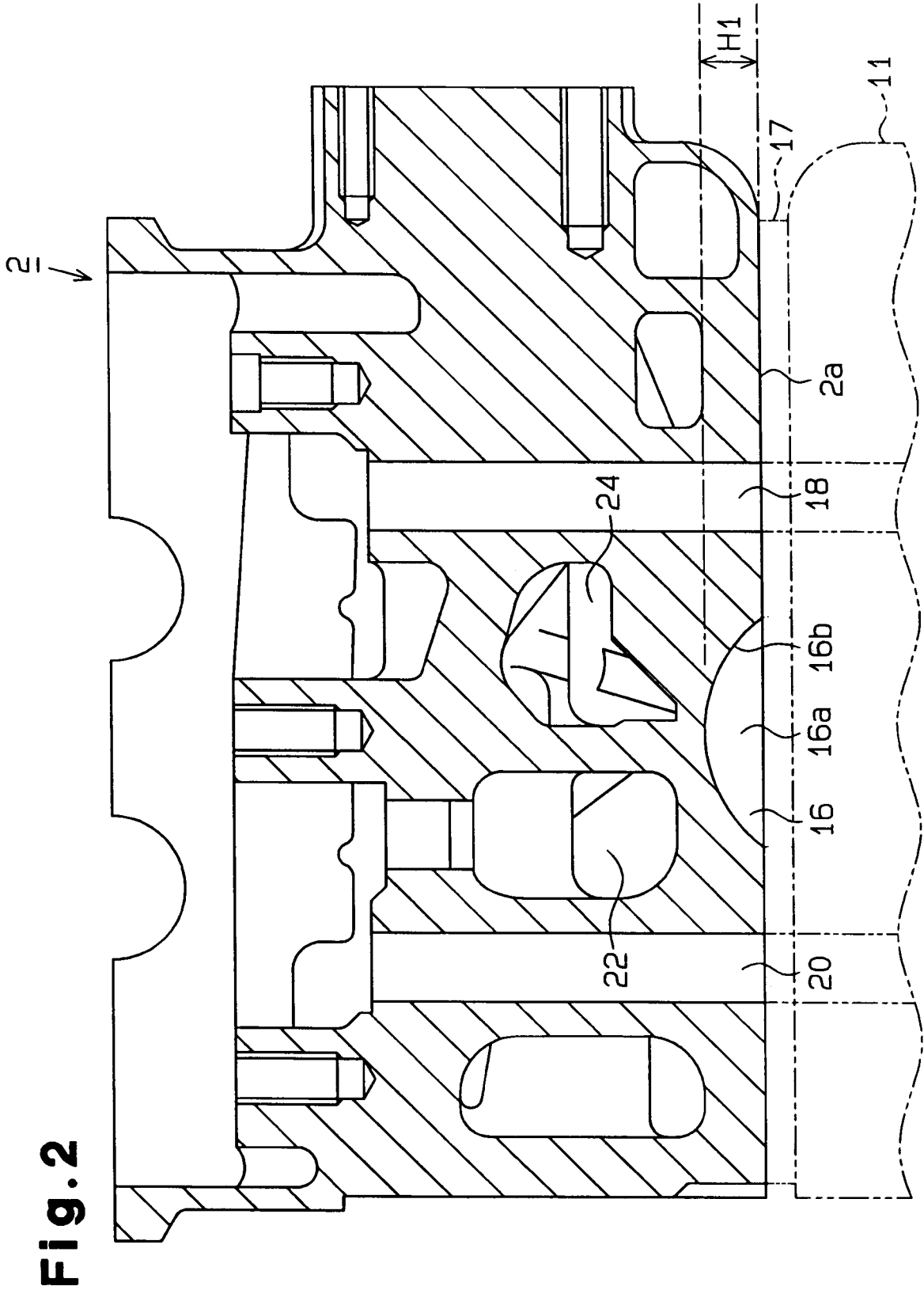


Fig. 1



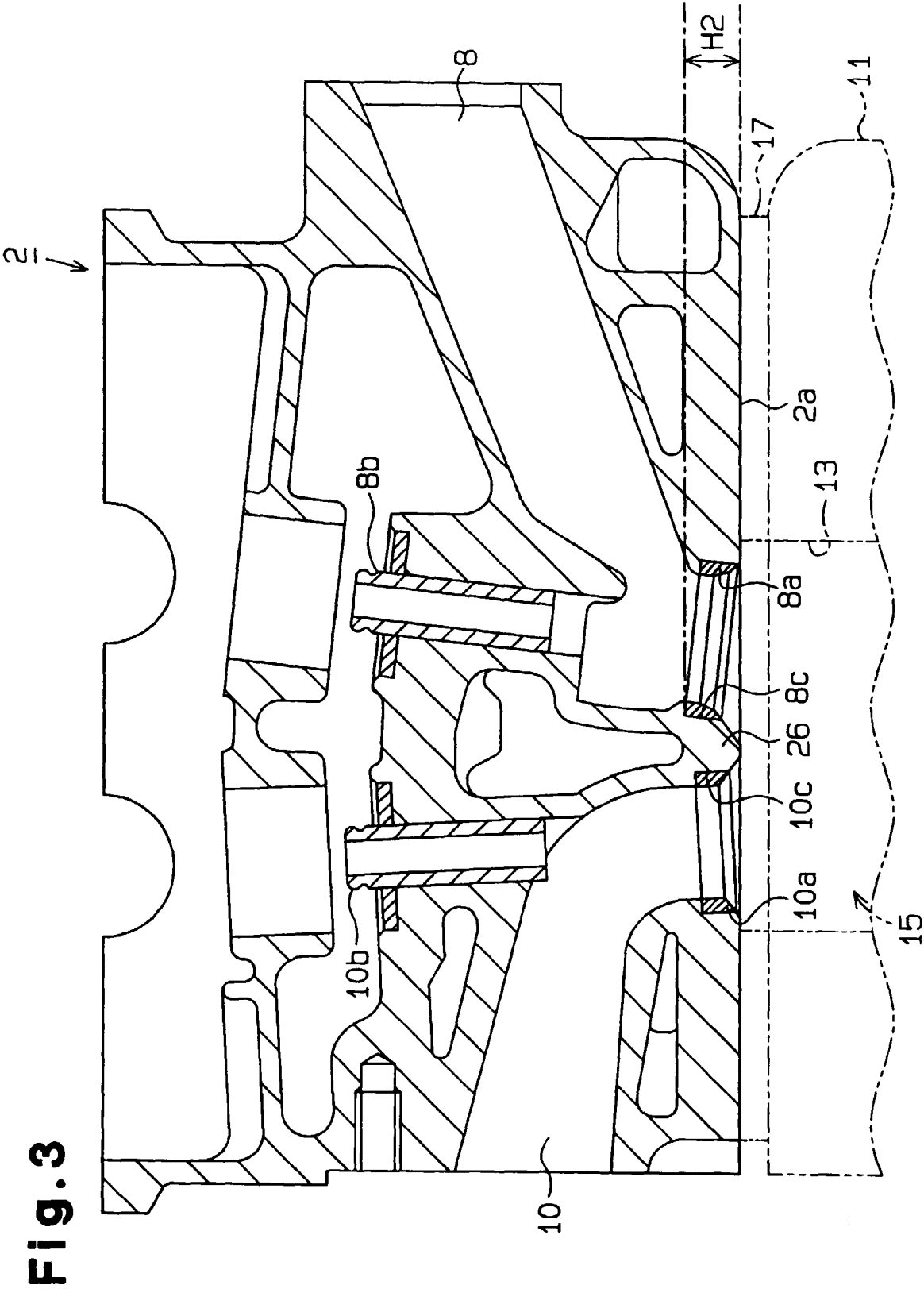
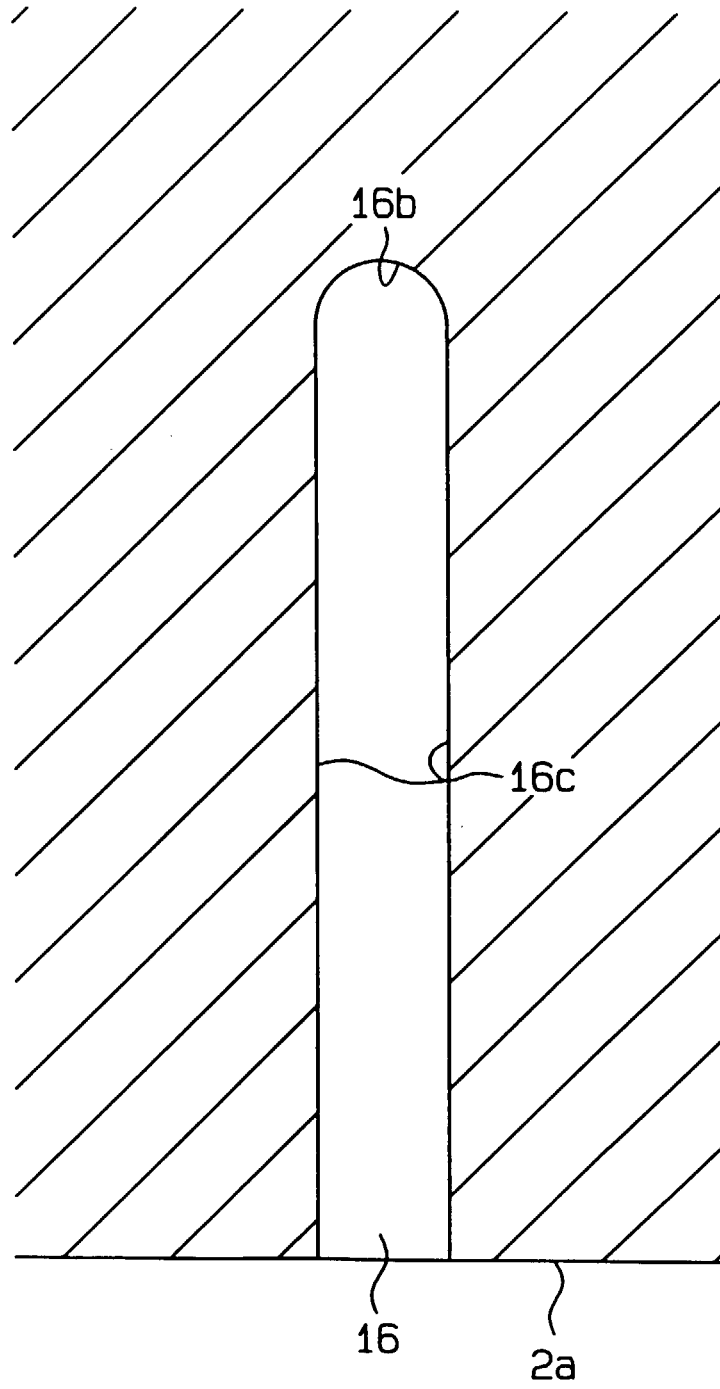
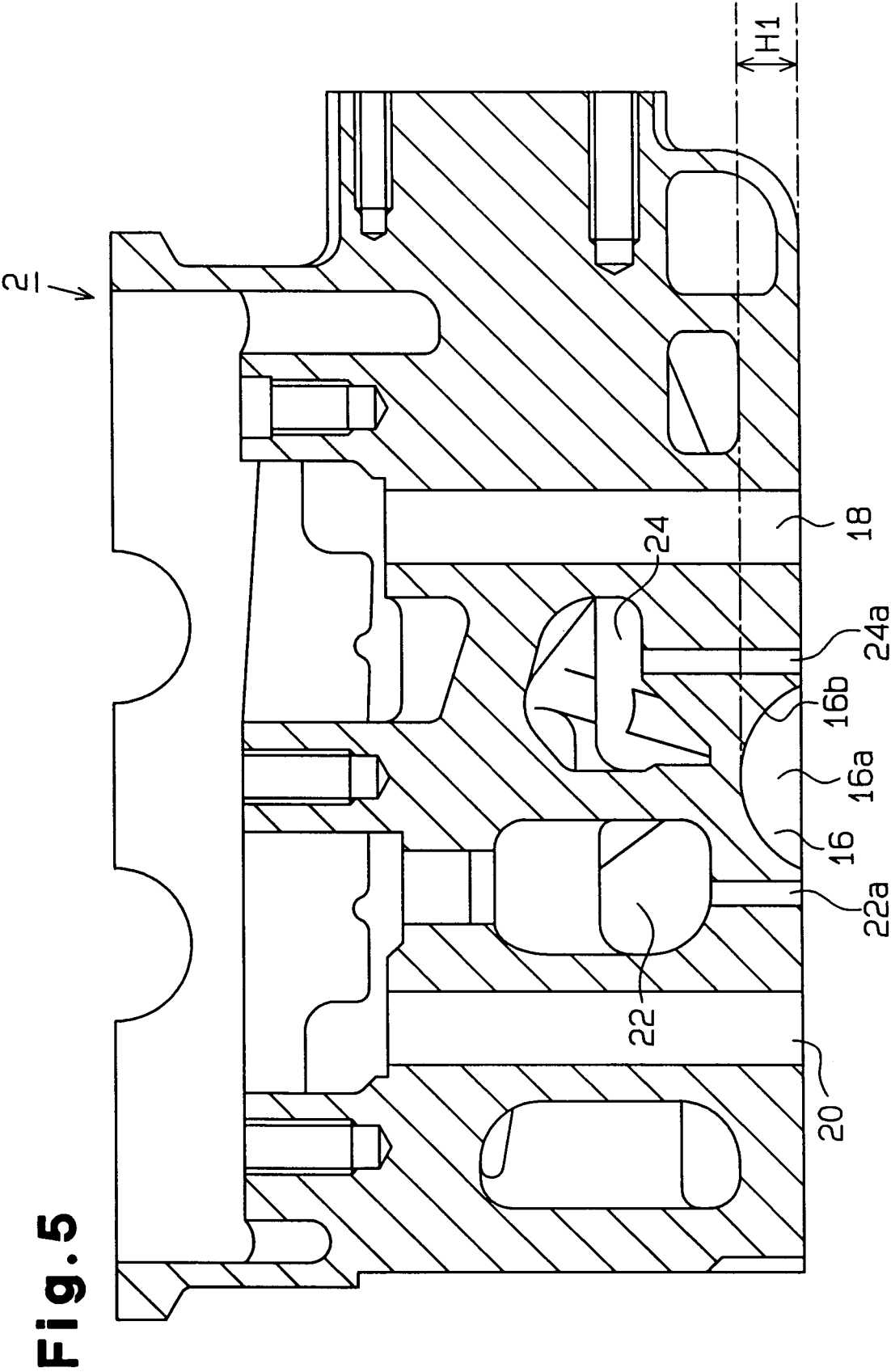


Fig.4







European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 99 12 3425

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Place of search THE HAGUE		Date of completion of the search 27 January 2000	Examiner Mouton, J
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 99 12 3425

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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