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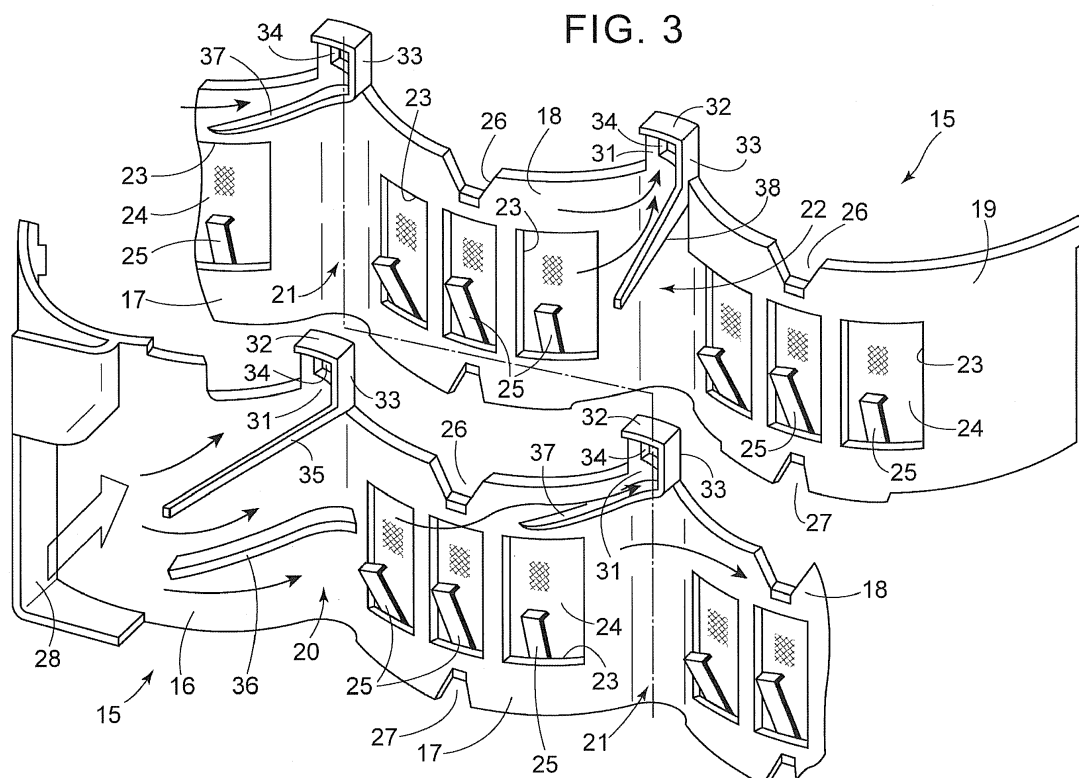
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(54) **INTERNAL COMBUSTION ENGINE**

(57) An internal combustion engine includes a cylinder block and a guide member (15). A coolant passage having an inlet opened to a water jacket is provided in an inter-bore portion of the cylinder block. The guide

member (15) is disposed in the water jacket of the cylinder block. The guide member (15) is configured to guide coolant to the coolant passage.



Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The invention relates to an internal combustion engine and has a feature in cooling structure for a cylinder block.

2. Description of Related Art

[0002] A cylinder block constituting an internal combustion engine is formed with a water jacket surrounding a plurality of cylinder bores. Coolant circulates in the water jacket, but it may occur that cooling of inter-bore portions becomes insufficient. In view of this, Japanese Patent Application Publication No. 2012-188959 (JP 2012-188959 A) discloses a configuration in which coolant passages are provided in inter-bore portions. The coolant passages of JP 2012-188959 A each have an inlet opened at an inner wall surface of a water jacket and an outlet opened at an upper surface of the inter-bore portion. According to the configuration disclosed in JP 2012-188959 A, the coolant flows into a cylinder head through the coolant passages.

SUMMARY OF THE INVENTION

[0003] In order to properly cool the inter-bore portions, it is necessary to introduce a necessary amount of the coolant into the coolant passages. However, since each coolant passage is formed as a lateral hole in the wall surface of the water jacket, there may occur a phenomenon in which the coolant passes by the inlets of the coolant passages. Thus, introducing the necessary amount of the coolant into the coolant passages may be difficult. The present invention provides an internal combustion engine that enables to introduce required water amount into the coolant passage.

[0004] An example aspect of the present invention provides an internal combustion engine that includes a cylinder block and a guide member. The cylinder block has a plurality of cylinder bores arranged side by side in a crank axis direction, and a water jacket that surround the plurality of cylinder bores. The cylinder block has a coolant passage. The coolant passage is provided in an inter-bore portion between the adjacent cylinder bores of the plurality of cylinder bores. The coolant passage has an inlet opened to the water jacket and an outlet opened at an upper surface of the cylinder block. The guide member is disposed in the water jacket. The guide member includes a guide. The guide is configured to guide coolant to the inlet of the coolant passage

[0005] In the internal combustion engine, the guide member may have a communication hole that introduces the coolant into the inlet of the coolant passage. The guide may include a guide rib. The guide rib may include

a start end located upstream and a finish end located downstream in a flow direction of the coolant. The finish end may be located more on an upper surface side of the cylinder block than the start end. The guide rib may extend from the start end to the finish end such that the guide rib guides the coolant toward the communication hole. The guide member may be a water jacket spacer.

[0006] In the invention, it is facilitated by the guide member that the coolant flowing in the water jacket flows into the coolant passage. Therefore, the coolant in an amount that can properly cool the inter-bore portion can be introduced into the coolant passage. Further, since the guide member is a separate member from the cylinder block, it can be applied also to the existing cylinder block and thus is excellent in versatility.

[0007] When the water jacket spacer is used also as the guide member as in the configuration described above, it is not necessary to newly prepare a dedicated member. Therefore, there is an advantage in that the manufacturing cost and the time and effort for the assembly work can be reduced. Further, when the water jacket spacer is used as the guide member, it is possible to easily control the coolant to adequately flow into the coolant passage by providing an auxiliary guide rib to the water jacket spacer or the like. Also in this aspect, it is preferable to use the water jacket spacer also as the guide member.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Features, advantages, and technical and industrial significance of exemplary embodiments of the invention will be described below with reference to the accompanying drawings, in which like numerals denote like elements, and wherein:

FIG. 1 is a diagram showing an internal combustion engine according to an embodiment: a partial plan view of only a cylinder block and a longitudinal sectional side view of a water jacket spacer;

FIG. 2 is a plan view in a state where the water jacket spacer is attached;

FIG. 3 is a perspective view of the water jacket spacer;

FIG. 4 is a partially cutaway fragmentary plan view of the internal combustion engine according to the embodiment; and

FIG. 5 is a sectional view taken along line V-V of FIG. 4.

DETAILED DESCRIPTION OF EMBODIMENTS

[0009] Next, an embodiment of the invention will be described with reference to the drawings. In this embodiment, a state when viewed in a crank axis direction is defined as a front view, and the crank axis direction is defined as a longitudinal direction.

[0010] First, the basic configuration of this embodiment

will be described. FIG. 1 is a diagram showing an internal combustion engine according to this embodiment. FIG. 1 shows a partial plan view of only a cylinder block 1, and a longitudinal sectional side view showing a water jacket spacer of this embodiment. As shown in the partial plan view of FIG. 1, the internal combustion engine of this embodiment is a four-cylinder engine. A cylinder block 1 is provided with first to fourth four cylinder bores 3 to 6 arranged side by side in a direction of a crank axis 2. In the cylinder block 1, a water jacket 7 of a closed loop shape is formed on an outer side of the group of cylinder bores 3 to 6.

[0011] The water jacket 7 includes recessed portions 7a at which the water jacket 7 approaches to the crank axis 2 (more precisely, the center line of the cylinder bore group). The recessed portions 7a are positioned at portions of the cylinder block 1 corresponds to inter-bore portions 8 each being a portion between adjacent two of the cylinder bores 3 to 6. Therefore, each inter-bore portion 8 is disposed between the two recessed portions 7a sandwiching the crank axis 2 therebetween. A pair of coolant passages 9 are disposed in each inter-bore portion 8 on its opposite sides sandwiching the crank axis 2 therebetween.

[0012] As shown in FIG. 5, the coolant passage 9 includes a first drilled hole 9a inclined and opened to the recessed portion 7a of the water jacket 7 and a second drilled hole 9b opened at an upper surface of the cylinder block 1. The coolant passage 9 is configured such that an end of the first drilled hole 9a serves as an inlet 10, while an upper end of the second drilled hole 9b serves as an outlet 11. A cylinder head 12 is mounted on the cylinder block 1 via a gasket 1a. The gasket 1a and the cylinder head 12 are formed with suction passages 13 respectively communicating with the second drilled holes 9b.

[0013] Water jacket spacers 15 of synthetic resin are fitted from above into the water jacket 7. The water jacket spacers 15 located on the exhaust side and on the intake side, sandwiching the crank axis 2 therebetween, are paired to form one set. The figures only show the water jacket spacer 15 disposed on the exhaust side.

[0014] The water jacket spacers 15 on the exhaust side and on the intake side are attached to the water jacket 7 in a state where end portions of the water jacket spacers 15 are in contact and engagement with each other. Therefore, a closed loop is formed by the two water jacket spacers on the exhaust side and on the intake side.

[0015] The water jacket spacers 15 are configured to overlap an inner peripheral surface of the water jacket 7 and thus are basically shaped similar to the water jacket 7. Therefore, the water jacket spacer 15 has first to fourth curved portions 16 to 19 curved in an arc shape and corresponding to the cylinder bores 3 to 6, and first to third recessed portions 20 to 22 corresponding to the three recessed portions 7a of the water jacket 7. Upper ends of the curved portions 16 to 19 are slightly lower than an upper end of the water jacket 7.

[0016] As shown in FIGS. 1 and 3, three rectangular holes 23 are opened in a circumferential direction in each of the second to fourth curved portions 17 to 19 of the water jacket spacer 15. A heat insulator 24, which is shaped like a sheet, is attached to the rectangular holes 23. The heat insulator 24 is swollen by absorbing water so as to be in close contact with the inner peripheral surface of the water jacket 7. In the water jacket spacer 15, the rectangular holes 23 are respectively provided with spring pieces 25. The spring pieces 25 are disposed so as to be in contact with an outer peripheral surface of the water jacket 7. The water jacket spacer 15 is held on the inner peripheral surface of the water jacket 7 in an overlapping state by the pressing action of the spring pieces 25. Although free ends of the spring pieces 25 are located outside the water jacket 7 in FIG. 3, this is because FIG. 3 shows a state before deformation of the spring pieces 25.

[0017] The second to fourth curved portions 17 to 19 each have an upward cutout 26 and a downward cutout 27 located at substantially middle portions in the circumferential direction. A holding plate of the heat insulator 24 is fixed to the water jacket spacer 15 by caulking at the cutouts 26 and 27. The spring pieces 25 are also provided to the holding plate.

[0018] As can be clearly seen from FIG. 3, the first curved portion 16 of the water jacket spacer 15 is formed with a partition wall 28 that extends from an upper end to a lower end of the first curved portion 16 and that comes in contact with the outer peripheral surface of the water jacket 7. While coolant pumped from a water pump is discharged toward the first curved portion 16 from an inflow passage 29 (see a one-dot chain line in the longitudinal sectional side view of FIG. 1) formed in the cylinder block 1, the coolant then flows toward the second curved portion 17 side due to the presence of the partition wall 28.

[0019] Then, after flowing in the water jacket 7 along almost its full length, the coolant is delivered to a coolant passage in the cylinder block 1 through a hole (not shown). It is to be noted that the water jacket spacer 15 on the intake side has no partition wall 28.

[0020] As can be seen from FIG. 3, the recessed portions 20 to 22 of the water jacket spacer 15 are each provided with a guide head portion 31 that protrudes upward and that is in close contact with or in close vicinity to the recessed portion 7a of the water jacket 7. The guide head portion 31 is integrally provided with a top plate 32 projecting in an outer peripheral direction of the water jacket 7 from an upper end of the guide head portion 31 and with a side stopper piece 33 connected to the guide head portion 31 and to the top plate 32.

[0021] The guide head portion 31 is formed with a communication hole 34 for introducing the coolant into the inlet 10 of the coolant passage 9. The side stopper piece 33 is located downstream of the communication hole 34 with respect to the flow of the coolant. Consequently, the flow of the coolant is stopped by the side stopper piece 33.

[0022] The first curved portion 16 of the water jacket spacer 15 is provided with a first guide rib 35 continuous with the side stopper piece 33 of the first recessed portion 20. The first guide rib 35 is inclined so as to approach the cylinder block upper surface side as going from its start end located upstream toward its finish end located downstream in the flow direction of the coolant. The finish end of the first guide rib 35 is continuous with the side stopper piece 33 of the first recessed portion 20.

[0023] The height of the start end of the first guide rib 35 is located at an approximately middle height position of the first curved portion 16, and when viewed in the circumferential direction, the start end of the first guide rib 35 is located slightly downstream of a most outward projecting portion of the first curved portion 16. Further, as shown in FIG. 2, the projecting height of the first guide rib 35 is set to about half of the flow passage width on an outer side of the side stopper piece 33. Therefore, the coolant can flow up and down also at the first curved portion 16.

[0024] As shown in FIG. 3, an auxiliary guide rib 36 having a length to overlap the first guide rib 35 in a plan view is projectingly provided below the first guide rib 35. A finish end of the auxiliary guide rib 36 is located at the first recessed portion 20. While the auxiliary guide rib 36 is also inclined, the degree of its inclination is lower than that of the first guide rib 35. Accordingly, the coolant flowing under the first guide rib 35 is controlled by the auxiliary guide rib 36 so as to change its flow direction to upward.

[0025] As shown in FIG. 2, a start end of the auxiliary guide rib 36 has a projecting height so as to be in close contact with or in close vicinity to the outer peripheral surface of the water jacket 7. The projecting height of the start end of the auxiliary guide rib 36 gradually decreases part of the way toward the finish end of the auxiliary guide rib 36. Then, the projecting height of about the half on the rear side is substantially constant.

[0026] The second curved portion 17 is provided with a second guide rib 37 that is inclined and extends to the second recessed portion 21. A finish end of the second guide rib 37 is continuous with a lower end of the side stopper piece 33 of the second recessed portion 21. The second guide rib 37 is located above the rectangular hole 23 at a position on the rear side in the circumferential direction of the second curved portion 17. Therefore, although the height of the second guide rib 37 increases from its start end toward its finish end, the slope angle of the second guide rib 37 is gentle.

[0027] A third guide rib 38 is provided at the third recessed portion 22. The third guide rib 38 is mostly located at the third recessed portion 22 with only its start end located at the third curved portion 18. The third guide rib 38 has a shape that is long in a downward direction, and its start end (lower end) is located at an approximately middle vertical height of the third recessed portion 22.

[0028] In this embodiment, the guide head portion 31 provided with the communication hole 34, the top plate 32, the side stopper piece 33, and the first to third guide

ribs 35, 37, 38 are each one example of a guide. The auxiliary guide rib 36 can also be one example of a guide.

[0029] A portion of the coolant flowing to the first curved portion 16 is directed toward the first recessed portion 20 by the guiding action of the first guide rib 35. Then, at the first recessed portion 20, the coolant is guided toward the inlet 10 of the coolant passage 9 mainly by the damming action of the side stopper piece 33. By this, a portion on the exhaust side of the inter-bore portion 8 (or a first inter-bore portion 8) between the first cylinder bore 3 and the second cylinder bore 4 is forcibly cooled.

[0030] Then, a portion of the coolant is directed toward the second recessed portion 21 by the guiding action of the auxiliary guide rib 36, and the coolant that has reached the second recessed portion 21 is guided toward the inlet 10 of the coolant passage 9 by the damming action of the side stopper piece 33 at the second recessed portion 21. By this, a portion on the exhaust side of the inter-bore portion 8 (or a second inter-bore portion 8) between the second cylinder bore 4 and the third cylinder bore 5 is forcibly cooled.

[0031] Since the coolant flows in the circumferential direction also on an outer side of the first guide rib 35, the second guide rib 37 also serves to direct the coolant, flowing on the outer side of the first guide rib 35, toward the second recessed portion 21.

[0032] The coolant flowing under the auxiliary guide rib 36 flows in the circumferential direction while changing its flow direction to upward by the guiding action of the auxiliary guide rib 36. Then, this coolant and the coolant flowing on the outer sides of the first guide rib 35 and the auxiliary guide rib 36, when having reached the third recessed portion 22, are directed upward by the third guide rib 38, and this coolant flow is guided toward the inlet 10 of the coolant passage 9 by the damming actions of the side stopper piece 33 and the top plate 32 at the third recessed portion 22. By this, a portion on the exhaust side of the inter-bore portion 8 (or a third inter-bore portion 8) between the third cylinder bore 5 and the fourth cylinder bore 6 is forcibly cooled.

[0033] In this way, the portions on the exhaust side of the inter-bore portions 8 are forcibly cooled. Further, portions of the coolant flowing to the intake side are directed toward upper end portions of recessed portions by the guiding actions of guide ribs in the water jacket spacer 15 provided on the intake side and then are forcibly delivered to the coolant passages 9 on the intake side by the guiding actions of side stopper pieces 33 and so on. By this, portions on the intake side of the inter-bore portions 8 are also surely cooled.

[0034] As described above, in this embodiment, the coolant can be forcibly delivered to the coolant passages 9 of the inter-bore portions 8 so that the inter-bore portions 8 can be stably cooled. Consequently, an effect is obtained such that non-uniform deformation of the cylinder bores 3 to 6 can be prevented to reduce the mechanical loss, thereby improving the fuel consumption. Since the guides are provided to the water jacket spacer 15, it

is prevented that the structure becomes complicated and that the assembly work requires time and effort.

[0035] In the embodiment described above, the heat insulator is attached to the water jacket spacer 15, but it is needless to say that the heat insulator may be omitted. The shapes and the number of the guide ribs and so on can be arbitrarily changed as needed. In the case of an internal combustion engine that requires no water jacket spacer, guide members may be disposed individually at recessed portions or the like, or guide members may be integrally connected to each other via joints.

4. The internal combustion engine according to any one of claims 1 to 3, wherein the guide member (15) is a water jacket spacer.

Claims

1. An internal combustion engine comprising
a cylinder block (1), and
a guide member (15),

the cylinder block (1) having a plurality of cylinder bores (3, 4, 5, 6) arranged side by side in a crank axis direction, and a water jacket (7) surrounding the plurality of cylinder bores (3, 4, 5, 6),

the cylinder block (1) having a coolant passage (9), the coolant passage (9) being provided in an inter-bore portion (8) between the adjacent cylinder bores of the plurality of cylinder bores (3, 4, 5, 6), the coolant passage (9) having an inlet (10) opened to the water jacket (7) and an outlet (11) opened at an upper surface of the cylinder block (1), and

the guide member (15) being disposed in the water jacket (7), the guide member (15) including a guide (31, 32, 33, 35, 36, 37, 38), and the guide (31, 32, 33, 35, 36, 37, 38) being configured to guide coolant to the inlet (10) of the coolant passage (9).

2. The internal combustion engine according to claim 1, wherein
the guide member (15) has a communication hole (34) that introduces the coolant into the inlet (10) of the coolant passage (9).

3. The internal combustion engine according to claim 2, wherein
the guide includes a guide rib (35, 36, 37, 38), the guide rib (35, 36, 37, 38) includes a start end located upstream and a finish end located downstream in a flow direction of the coolant, and the finish end is located more on an upper surface side of the cylinder block (1) than the start end, and
the guide rib (35, 36, 37, 38) extends from the start end to the finish end such that the guide rib (35, 36, 37, 38) guides the coolant toward the communication hole (34).

FIG. 1

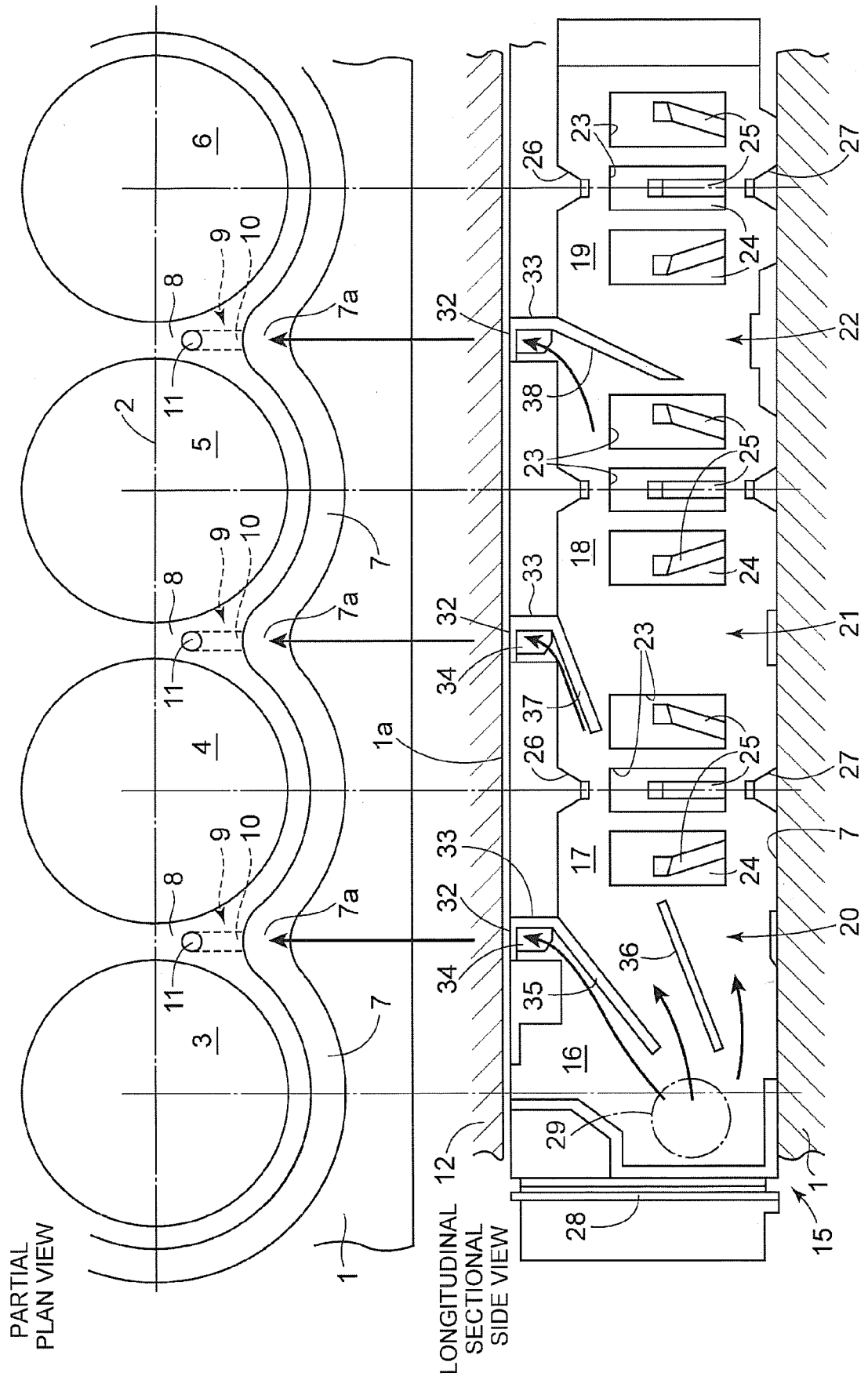


FIG. 2

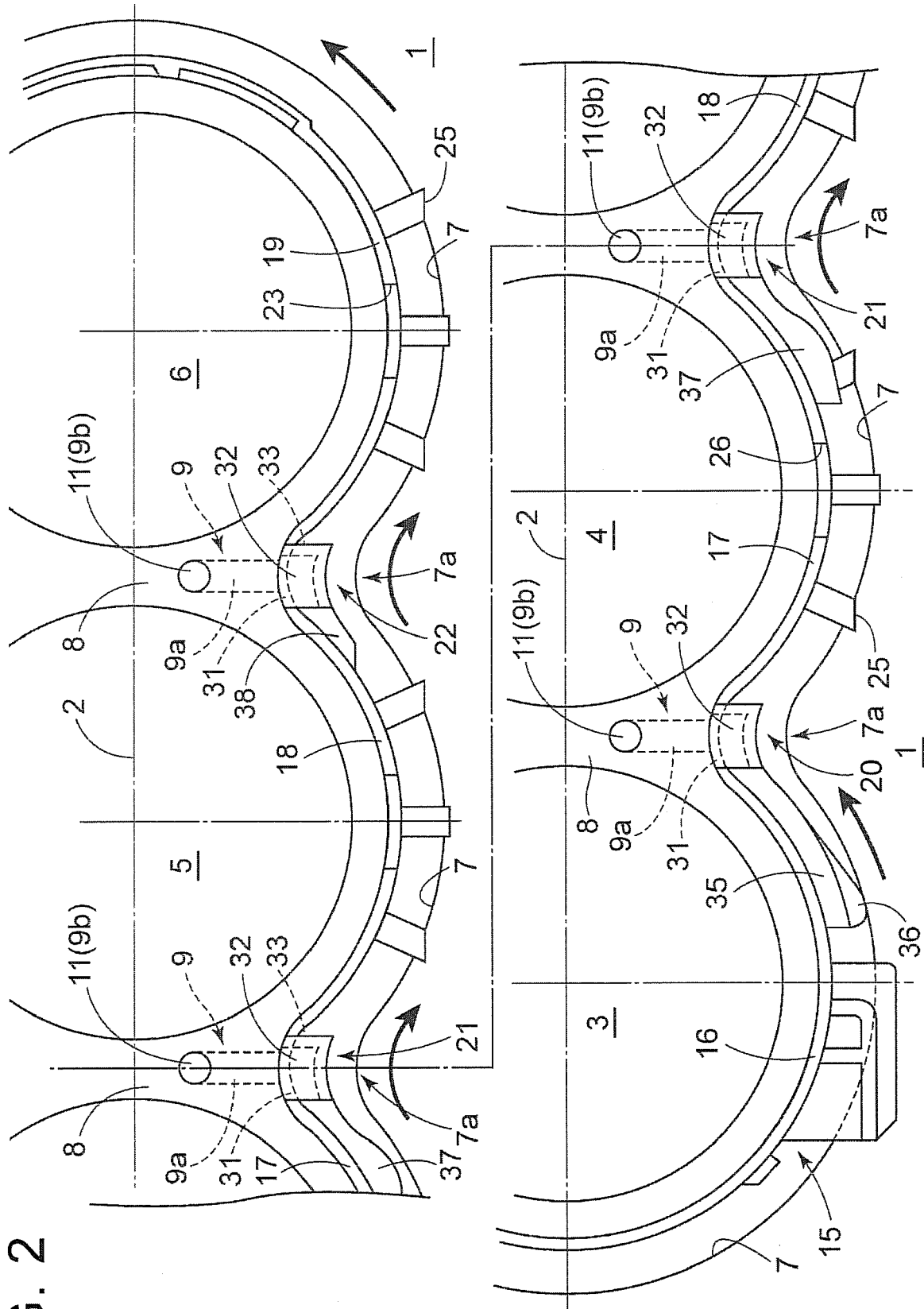


FIG. 3

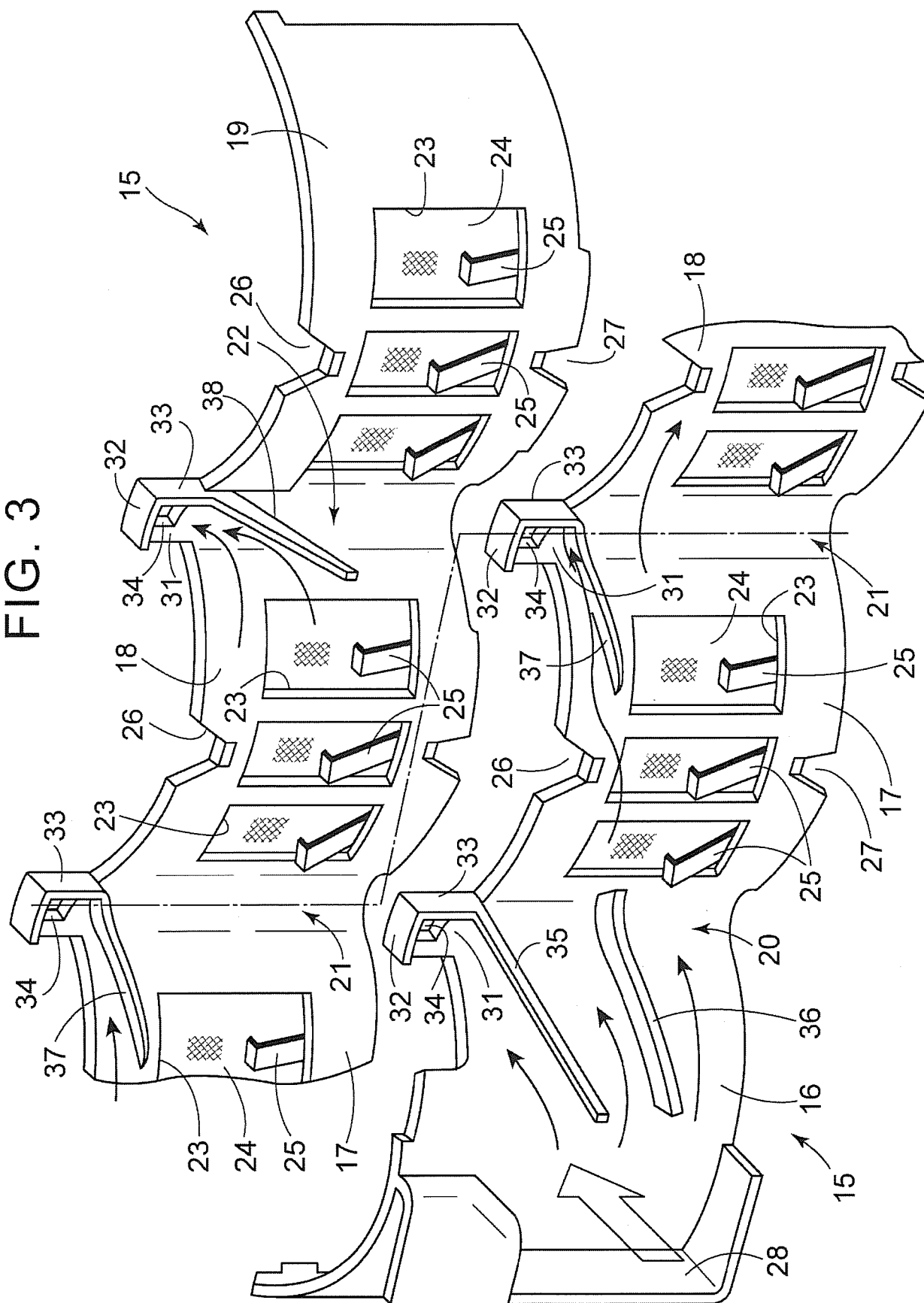


FIG. 4

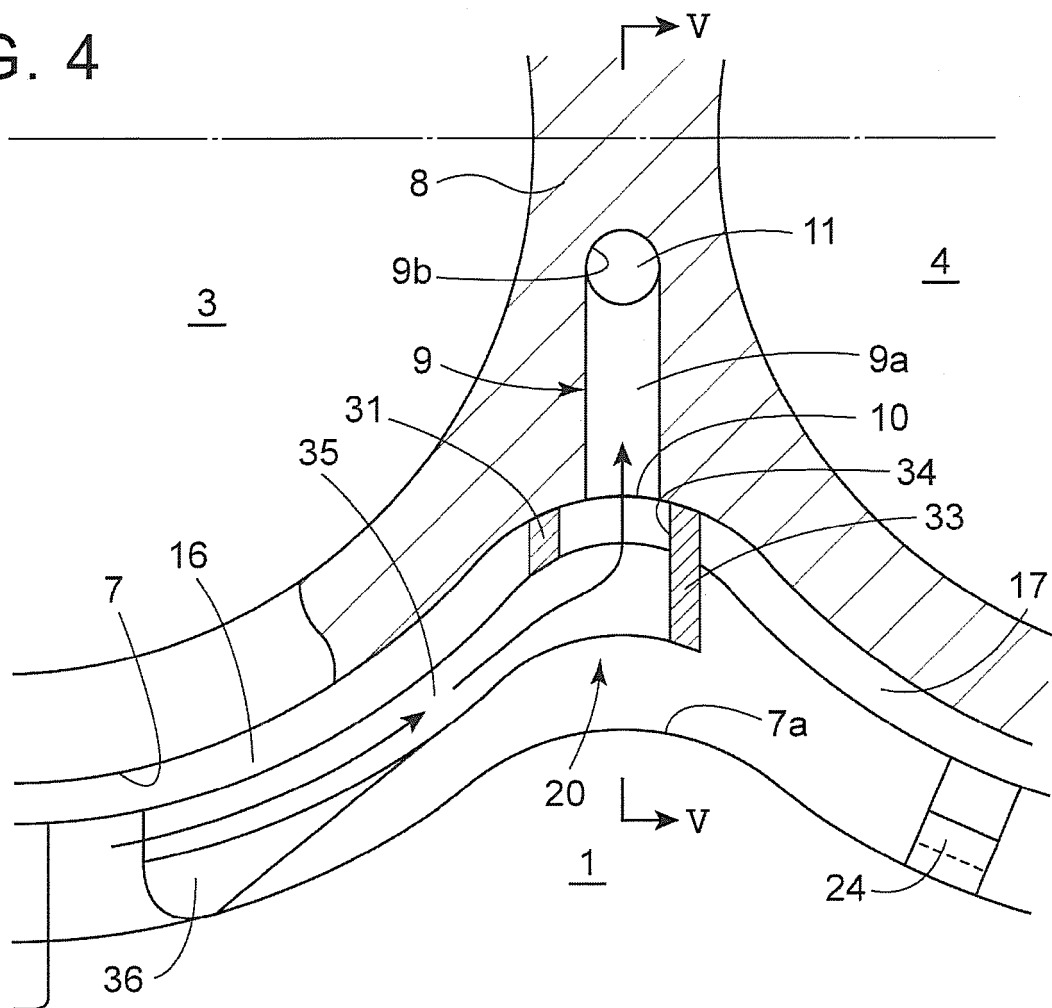
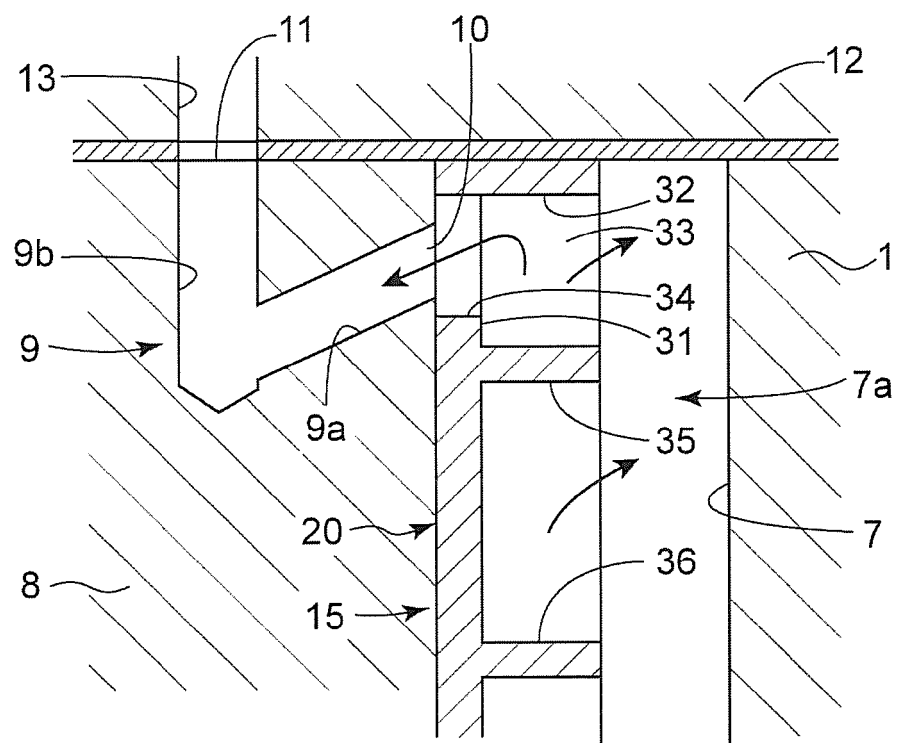


FIG. 5





EUROPEAN SEARCH REPORT

Application Number
EP 16 19 7638

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Place of search		Date of completion of the search	Examiner
The Hague		8 March 2017	Matray, J
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EPO FORM 1503 03.02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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5 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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