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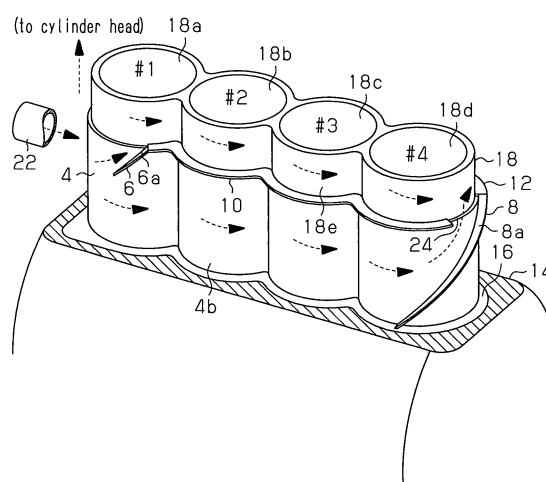
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(54) **Apparatus for controlling heat transfer with heat medium for cooling internal combustion engine**

(57) An apparatus (2) controls heat transfer between a cooling heat medium for cooling an internal combustion engine and an inner wall (18) of a cylinder block (14). The heat medium flows through the groove-like flow passage provided between the inner wall (18) and an outer wall (20). The apparatus (2) includes a lower side cover (4) and a guiding member (6, 8). An upper side of the inner wall (18) is uncovered with the cover (4) and exposed directly to the heat medium so that the upper side of the inner wall (18) is cooled easier than the lower side. Therefore, the difference in temperature in a vertical direction of each of the bores (18a-18d) can be reduced. The guiding member (6, 8) guides the heat medium having a lower temperature from the lower side to the upper side of the inner wall (18) in the direction of arrangement of the cylinders at a plurality of points. Thus, the upper portion of the bores 18a-18d can be sufficiently cooled even at down stream of the water jacket (16) and differences in temperature among the bores (18-18d) of the cylinders #1-4 can be reduced. Thus, not only differences in temperature in the up-and-down direction of each of the cylinder bores (18a-18d) but also differences in temperature among the cylinders (#1-4) can be reduced without partitioning the heat medium among the cylinders (#1-4).

Fig.5



Description

[0001] The present invention relates to an apparatus for controlling heat transfer by placement in a groove-like flow passage provided between an inner wall and an outer wall of the cylinder block of an internal combustion engine in which a plurality of cylinders are disposed and controls heat transfer between the cooling heat medium flowing through the flow passage and the inner wall.

BACKGROUND

[0002] It is generally known that the temperature in the upper portion of a cylinder block in an internal combustion engine, which is near the combustion chamber, becomes higher than the temperature in the lower portion of the cylinder block. Japanese Laid-Open Patent Publication 2000-345838 describes a cooling structure for an internal combustion engine that partitions a groove-like flow passage in the cylinder block of an internal combustion engine in the axial direction of cylinders to reduce the difference in temperature in the vertical direction or the axial direction of cylinder bores in a cylinder block. The cooling structure decreases the difference in temperature in the up-and-down direction of each cylinder bore by providing a difference in flow volume between an upper portion and a lower portion of the groove-like flow passage.

[0003] In the above structure, the difference in temperature in the up-and-down direction of one cylinder bore may be reduced. However, the difference in temperature in the direction of arrangement of a plurality of cylinders cannot be reduced because the temperature of cooling water is increased while it is flowing through the cylinders.

[0004] To address this, Japanese Laid-Open Patent Publication 2005-315118 proposes a cooling structure that raises cooling water at a lower temperature located on lower side of the bore to the upper side of the bore per cylinder.

[0005] Since cooling water is partitioned among the individual cylinders, it is necessary to control flow volume of the cooling water that rises in each cylinder so that a cooling condition of the upper side of the bores in the respective cylinders is the same. Although the flow volume of the cooling water is controlled with a partition panel, high-accuracy control with the panel is quite difficult. Therefore, the difference in temperature in the direction of arrangement of the cylinders cannot be sufficiently reduced.

SUMMARY OF THE INVENTION

[0006] Accordingly, it is an object of the present invention to provide an apparatus for controlling heat transfer with a heat medium for cooling an internal combustion engine that reduces not only a difference in temperature in the up-and-down direction of each cylinder bore but also a difference in temperature among the plurality of cylinders, without partitioning the heat medium among

the cylinders.

[0007] In order to achieve the foregoing object and in accordance with a first aspect of the present invention, an apparatus (2) for controlling heat transfer between a cooling heat medium for cooling an internal combustion engine in which the medium flows through a groove-like flow passage and an inner wall (18, 118, 218, 318) of a cylinder block (14) of the internal combustion engine is provided. The apparatus (2) is disposed in the groove-like flow passage. The groove-like flow passage is provided between the inner wall (18, 118, 218, and 318) and an outer wall (20) of the cylinder block (14) housing a plurality of cylinders (#1-#4). The apparatus (2) comprises includes a lower side cover (4, 104, 204, 304, 404) and a guiding member (6, 8, 106, 108, 206, 208, 306, 308, 406-409). The lower side cover (4, 104, 204, 304, 404) covers a lower side of the inner wall (18, 118, 218, 318) and exposes the upper side of the inner wall (18, 118, 218, 318) to the cooling heat medium that flows from outside of the outer wall (20) through the groove-like flow passage in the direction of arrangement of the cylinders (#1-#4). The guiding member (6, 8, 106, 108, 206, 208, 306, 308, 406-409) is disposed in the groove-like flow passage for upwardly guiding the cooling heat medium that flows on the outer surface of the lower side cover (4, 104, 204, 304, 404) onto the upper side of the inner wall (18, 118, 218, 318).

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] 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. 1A is a plan view; Fig. 1B, a left side view; Fig. 1C, a front view; Fig. 1D, a right side view; and Fig. 1E, a bottom view; illustrating a heat transfer controlling apparatus of a first embodiment;

Fig. 2A is a perspective view of the heat transfer controlling apparatus of the first embodiment of Figs. 1A-E; Fig. 2B is a rear view of the first embodiment of the heat transfer controlling apparatus; and Fig. 2C is a perspective view of the heat transfer controlling apparatus of the first embodiment viewed from a different direction from that of Fig. 2A;

Fig. 3 is an exploded perspective view of the first embodiment of the heat transfer controlling apparatus;

Fig. 4 is a perspective view illustrating mounting of the heat transfer controlling apparatus of the first embodiment in a 4-cylinder internal combustion engine for vehicles;

Fig. 5 is a partial cut-away view of the heat transfer controlling apparatus of the first embodiment mounted in the internal combustion engine with a part of the cylinder block being removed for clarity;

Fig. 6 is a plan view of the heat transfer controlling apparatus of the first embodiment after the apparatus was mounted in the internal combustion engine; Fig. 7 is a schematic view of the heat transfer controlling apparatus of first embodiment taken along the line X-X of Fig. 6 illustrating the arrangement of the apparatus;

Fig. 8A is a plan view; Fig. 8B, a left side view; Fig. 8C, a front view; Fig. 8D, a right side view; and Fig. 8E, a bottom view; illustrating a heat transfer controlling apparatus of a second embodiment;

Fig. 9A is a perspective view of the heat transfer controlling apparatus of the second embodiment of Figs. 8A-E; Fig. 9B is a rear view of the second embodiment of the heat transfer controlling apparatus; and Fig. 9C is a perspective view of the heat transfer controlling apparatus of the second embodiment viewed from a different direction from that of Fig. 9A; Fig. 10 is a partial cut-away view of the heat transfer controlling apparatus of the second embodiment mounted in the internal combustion engine with a part of the cylinder block being removed for clarity; Fig. 11 is a schematic view of the heat transfer controlling apparatus of second embodiment taken along the line Y-Y of Fig. 10 illustrating the arrangement of the apparatus;

Fig. 12A is a plan view; Fig. 12B, a left side view; Fig. 12C, a front view; Fig. 12D, a right side view; and Fig. 12E, a bottom view; illustrating a heat transfer controlling apparatus of a third embodiment;

Fig. 13A is a perspective view of the heat transfer controlling apparatus of the third embodiment of Figs. 12A-E; Fig. 13B is a rear view of the third embodiment of the heat transfer controlling apparatus; and Fig. 13C is a perspective view of the heat transfer controlling apparatus of the third embodiment viewed from a different direction from that of Fig. 13A; Fig. 14 is an exploded perspective view of the third embodiment of the heat transfer controlling apparatus;

Fig. 15 is a partial cut-away view of the heat transfer controlling apparatus of the third embodiment mounted in the internal combustion engine with a part of the cylinder block being removed for clarity; Fig. 16 is a schematic view of the heat transfer controlling apparatus of third embodiment taken along the line Z-Z of Fig. 15 illustrating the arrangement of the apparatus;

Fig. 17 is a partial enlarged view of the heat transfer controlling apparatus of the third embodiment;

Fig. 18A is a plan view; Fig. 18B, a left side view; Fig. 18C, a front view; Fig. 18D, a right side view; and Fig. 18E, a bottom view; illustrating a heat transfer controlling apparatus of a fourth embodiment;

Fig. 19A is a perspective view of the heat transfer controlling apparatus of the fourth embodiment of Figs. 18A-E; and Fig. 19B is a rear view of the fourth embodiment of the heat transfer controlling apparatus;

tus;

Fig. 20 is a partial cut-away view of the heat transfer controlling apparatus of the fourth embodiment mounted in the internal combustion engine with a part of the cylinder block being removed for clarity; Fig. 21 is a schematic view of the heat transfer controlling apparatus of fourth embodiment taken along the line S-S of Fig. 20 illustrating the arrangement of the apparatus;

Fig. 22A is a plan view; Fig. 22B, a left side view; Fig. 22C, a front view; Fig. 22D, a right side view; and Fig. 22E, a bottom view; illustrating a heat transfer controlling apparatus of a further embodiment;

Fig. 23A is a perspective view of the heat transfer controlling apparatus of the further embodiment of Figs. 22A-E; Fig. 23B is a rear view of the further embodiment of the heat transfer controlling apparatus; and Fig. 23C is a perspective view of the heat transfer controlling apparatus of the further embodiment viewed from a different direction from that of Fig. 23A; and

Fig. 24A is a perspective view of the heat transfer controlling apparatus of the further embodiment of Fig. 22 with which guide panels are provided; and Fig. 24B is a front view of the apparatus of Fig. 24A.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0009] An apparatus for controlling heat transfer with a heat medium for cooling an internal combustion engine according to a first embodiment of the present invention is described hereinafter.

[0010] Referring to Figs. 1A-3, a heat transfer controlling apparatus 2 includes a lower side cover 4, guiding members 6 and 8 and partitions 10 and 12. The lower side cover 4 is a part that supports the entire structure of the apparatus 2 and is made of material more rigid than those of the guiding members 6 and 8 and the partitions 10 and 12. In this embodiment, the lower side cover 4 is made of olefin resin. The lower side cover 4 is shaped such that, when inserted into a water jacket 16 provided in an open deck-type cylinder block 14 of an internal combustion engine, the cover 4 is disposed in close contact with a lower portion of an inner wall 18 of cylinder block 14 while an upper portion of the inner wall 18 is left uncovered. The water jacket 16 corresponds to a groove-like flow passage through which the cooling heat medium flows. Specifically, the length of the lower side cover 4 is shorter than the depth of the water jacket 16 and the width of the lower side cover 4 is smaller than that of the water jacket 16. The lower side cover 4 is in a shape corresponding to where circles interface so as to conform to the water jacket 16. Thus, the number of circles is the same as that of the cylinders (in the first embodiment, four, i.e., #1 to #4 cylinders) and the inner peripheral surface 4a of the cover 4 is substantially the same as the outer peripheral surface 18e of the inner wall 18.

[0011] Then, as illustrated in Fig. 4, when the heat transfer controlling apparatus 2, in which the lower side cover 4, the guiding members 6 and 8 and the partitions 10 and 12 are integrally formed, and is placed in the water jacket 16, the lower side cover 4 comes into close contact with the outer peripheral surface 18e of the inner wall 18, as illustrated in Fig. 7. Thus, a flow passage for the cooling water (cooling heat medium) is formed between the lower side cover 4 and the outer wall 20 at the lower side of the inner wall 18. This decreases heat transfer from the inner wall 18 in which bores 18a, 18b, 18c, 18d reside at the lower side of the inner wall 18. The lower side of the inner wall 18 is hard to cool and the temperature of cooling water flowing there is hard to increase. In contrast, the upper side of the inner wall 18 which is not covered with the lower side cover 4 is easy to cool and the temperature of cooling water flowing there is easily increased, since heat transfer from the inner wall 18 is greater at the upper side than the lower side.

[0012] The guiding members 6 and 8 and the partitions 10 and 12 are formed of olefinic elastomer. The partitions 10 and 12 is provided at the upper end of the lower side cover 4 and have a width slight greater than that of the water jacket 16. Thus, when the apparatus 2 is pressed into the water jacket 16 as illustrated in Fig. 4, the apparatus 2 gets into close contact with the inner wall 18 and the outer wall 20 as illustrated Figs. 5 and 7 to vertically divide the water jacket 16 at the level of the partitions 10 and 12.

[0013] The guiding members 6 and 8 extend diagonally from one end of the partitions 10 and 12, respectively, between the outer peripheral surface 4b of the lower side cover 4 and the outer wall 20. Cooling water flows from an inlet 22 formed in the outer wall 20 into the water jacket 16. The shorter guiding member 6 is positioned at upstream end of the partition 10 located on the upstream side of the cooling water. The longer guiding member 8 is positioned at upstream end of the partition 12 located on the downstream side of the cooling water.

[0014] Accordingly, the cooling water flows from the inlet 22 as illustrated by the dashed line in Fig. 5 and about the upper half of the cooling water, which flows on the lower side of the inner wall 18 that is covered with the lower side cover 4, is guided onto the upper side of the inner wall 18 that is uncovered with the lower side cover 4 by an inclined face 6a of the shorter guiding member 6. The guided cooling water at a lower temperature reaches the cooling water at high temperature flowing on the upper side of the inner wall 18 directly from the inlet 22 to merge so that a high volume flow of merged water, the temperature rise of which is suppressed, advances downstream rapidly.

[0015] After the merged water flow passes through the most downstream side of the partition 10, where an opening 24 exists as a gap between the partition 10 and the partition 12. The longer guiding member 8 extends diagonally from the end of the partition 12 toward the opening 24 to the bottom of the water jacket 16.

[0016] The cooling water flow that was not guided onto the upper side of inner wall 18 by the shorter guiding member 6 at the upstream side of the partition 10 is now guided onto the upper side of the inner wall 18 by an inclined face 8a of the longer guiding member 8 to merge with the cooling water flow that flows on the upper side of the inner wall 18 from #1 to #4 cylinders.

[0017] This merger suppresses the temperature rise or decreases the temperature of the cooling water that has flowed over the upper side of the inner wall 18. The merged cooling water flow in high volume rapidly flows on the upper side of the inner wall 18 at the back of the figure from the cylinders #4 to #1 as illustrated in Fig. 5. Then the water flow rises at the cylinder #1 toward the water flow passage on the side of the cylinder head.

[0018] The first embodiment as described has the following advantages.

[0019] First, the heat transfer controlling apparatus 2 does not perform a division among the cylinders about either the upper side or lower side of the inner wall 18 in which there are bores 18a-18d in the cylinder block 14. The cooling water flows in the direction of arrangement of the cylinders without being divided per cylinder.

[0020] The lower side cover 4 covers the lower side of the inner wall 18 such that the lower side of the inner wall 18 is not exposed directly to the cooling water that flows from the outside of the outer wall 20 into the water jacket 16. Meanwhile, the upper side of the inner wall 18, in which combustion is conducted, is exposed directly to the cooling water and cooled easier than the lower side of the inner wall 18. Thus, difference in temperature in the vertical direction of each of the bores 18a-18d can be reduced.

[0021] The guiding members 6 and 8 are provided on the outer surface of the lower side cover 4. The guiding members 6 and 8 include the inclined faces 6a and 8a, respectively, that extend longer from bottom to top as the guiding members 6 and 8 are located further downstream of the cooling water. By virtue of the guiding members 6 and 8, cooling water at a lower temperature is guided from the lower side to the upper side of the inner wall 18 at a plurality of points (here, two points).

[0022] Specifically, the cooling water flowing from outside of the outer wall 20 is first guided onto the upper side of the inner wall 18 at one point by the upstream shorter guiding member 6. This suppresses the temperature rise or decreases the temperature of the cooling water on the upper portion of the inner wall 18. The flow volume of the cooling water on the upper portion of the inner wall 18 is also increased. Thus, the cooling at the upper side of the inner wall 18 is effectively conducted so that the difference in temperature in the up-and-down direction of each of the cylinder bores 18a-18d as well as the differences in temperature among the cylinders are reduced.

[0023] Then, there is another guiding member (i.e., the downstream longer guiding member 8 in this embodiment) in the arranging direction of the cylinders. Again,

the cooling water at a lower temperature is guided from the lower side to the upper side of the inner wall 18. The cooling water having an increased temperature that has flowed on the upper side of the inner wall 18 is merged with the guided cooling water having a relatively low temperature to suppress the temperature rise or decrease the temperature of the cooling water that has flowed on the upper side of thinner wall 18. The upper portion of the bores 18a-18d can be sufficiently cooled even at the downstream of the water jacket 16 and difference in temperature among the bores 18-18d of the cylinders #1-4 can be reduced.

[0024] Thus, not only a difference in temperature in the up-and-down direction of each of the cylinder bores 18a-18d but also a difference in temperatures among the cylinders #1-4 can be reduced without partitioning the cooling water among the cylinders #1-4.

[0025] Second, the partitions 10 and 12 that divide the water jacket 16 in the vertical direction are provided at the upper end of the lower side cover 4. Further, the opening 24 is formed between the partitions 10 and 12. The opening 24 introduces the cooling water, which is guided onto the upper side of the inner wall 18 by the guiding member 8, to the portion of water jacket 16 above the partitions 10 and 12.

[0026] Accordingly, the cooling water guided upward by the guiding member 8 can be easily moved to the space above the partitions 10 and 12, and, again, the cooling water at a lower temperature is introduced to the upper side of the inner wall 18 in the water jacket 16 to suppress the temperature rise or decrease the temperature of the cooling water that has flowed on the upper side of the inner wall 18.

[0027] In particular, the partitions 10 and 12 can reliably divide the cooling water flow into the lower side of the inner wall 18 that is covered with the lower side cover 4 and the upper side of the inner wall 18 that is uncovered with the lower side cover 4. This ensures the control of difference in temperature in the vertical direction of the bores 18a-18d.

[0028] A heat transfer controlling apparatus 102 according to a second embodiment is described as follows.

[0029] As illustrated in Figs. 8A-11, the apparatus 102 of the second embodiment is different from that of the first embodiment in that the upper end of the lower side cover 104 is made lower at the downstream side or back side of the water jacket 116. In other words, the upper end of the lower side cover 104 becomes shorter in the direction of arrangement of the cylinders as the cooling heat medium flows further downstream at every point where the guiding members 106 and 108 are located. In particular, the downstream partition 112 is disposed lower than the upstream partition 110 in the axial direction of the bores 118a-118d. Thus, the length of the downstream guiding member 108 is shorter than that of the guiding member 8 of the first embodiment. Other structure is the same as that of the first embodiment.

[0030] Accordingly, the cooling water flows from the

inlet 122 as illustrated by the dashed line in Fig. 10 and about half of the cooling water, which flows on the lower side of the inner wall 118 that is covered with the lower side cover 104, is guided onto the upper side of the inner wall 118 that is uncovered with the lower side cover 104 by the shorter guiding member 106. Similarly to the first embodiment, the guided cooling water reaches the cooling water flowing on the upper side of the inner wall 118 directly from the inlet 122 to merge so that the merged water advances downstream rapidly.

[0031] After the merged water flow passes through the most down side part of the partition 110, where an opening 124 is provided as a gap between the partition 110 and the partition 112. The guiding member 108 extends diagonally from the end of the partition 112 toward the opening 124 to the bottom of the water jacket 116. The guiding member 108 guides the cooling water that has flowed over the lower side of the inner wall 118 to the upper side of the inner wall 118 and allows the cooling water to merge with the cooling water having a high temperature that has flowed on the upper side of the inner wall 18 from the cylinder #1 to the cylinder #4.

[0032] This merger suppresses the temperature rise or decreases the temperature of the cooling water. The merged cooling water in high volume rapidly flows on the upper side of the inner wall 118 at the back of the figure, which is wider than the upper side of the inner wall 118 at the front of the figure, above the partition 112 from the cylinder #4 to #1, as illustrated in Fig. 10. Then the water flow rises at the cylinder #1 toward the water flow passage on the side of the cylinder head.

[0033] The second embodiment as described has the following advantage.

[0034] As illustrated in Fig. 11, on the downstream side of the opening 124, flow passage of the cooling water is wider on the upper side of the inner wall 118 or above the partition 112. In other words, cross section of the low passage is increased. Thus, in addition to the two advantages of the first embodiment, flow resistance of the heat medium, which plays an important role in cooling the bores, on the upper side of the inner wall 118 is suppressed. Pressure loss is not increased greatly and smooth flow of the medium is maintained.

[0035] Referring to Figs. 12A-17, a heat transfer controlling apparatus 202 according to a third embodiment is described below.

[0036] The apparatus 202 is different from that of the first embodiment in that gaps 250 and 252 are provided between the lower side cover 204 and the inner wall 218, as illustrated in Fig. 16. In the intermediate part of the lower side cover 204, at the location of the cylinder #4 herein, a step 254 extends in a radial direction of the cover 204. Accordingly, the gap 252 on the downstream side is greater than the gap 250 on the upstream side.

[0037] Upstream of the step 254, a flow-resistant panel 256 protrudes upwardly from the upper end of the lower side cover 204. The upper end of the flow-resistant panel 256 is at the same level as the upper end of the inner

wall 218.

[0038] In the intermediate portion of the upstream partition 210 near the upstream end, a shorter guiding member 206 is connected to the partition 210. The partition 210 is made narrower upstream of the guiding member 206. A notch 210a is formed in the downstream end of the partition 210. As illustrated in Fig. 15, the apparatus 202 is mounted in the cylinder block 214 so that the inner side of the partition 210 contacts the outer peripheral surface of the inner wall 218. Then the notch 210a forms a communication port 258 that connects the upper side of the partition 210 with the gap 250 on the upstream side of the flow-resistant panel 256.

[0039] In the intermediate portion of the downstream partition 212 near the upstream end, a longer guiding member 208 is connected to the partition 212. The partition 212 is made narrower upstream of the guiding member 208. Thus, as illustrated in Fig. 17, cooling water flowing on the lower side of the inner wall 218, which has been guided by the guiding member 208, can flow into the upper space of the downstream partition 212 without being disturbed by the flow-resistant panel 256 and the partition 212.

[0040] Accordingly, cooling water, which has been guided to the upper side of the inner wall 218 or above the upstream partition 210 by the shorter guiding member 206, reaches the cylinder #4 as illustrated in Fig. 17. Then, the flow-resistant panel 256 allows the cooling water to flow through the communication port 258 into the gaps 250 and 252. In turn, the flow-resistant panel 256 also allows the cooling water that has flowed over the lower side of the inner wall 218 outside the lower side cover 204 to the cylinder #4 to rise and flow on the upper side of the inner wall 218 or above the downstream partition 212.

[0041] The third embodiment as described has the following advantage.

[0042] By exchanging the cooling water having an elevated temperature with the cooling water having a lower temperature in mid-flow, the same advantage as the two advantages described in the first embodiment can be achieved. Since the cooling water flows are exchanged, not merged, pressure loss is suppressed and smooth flow is maintained, although the flow cross-section above the upstream partition 210 and the flow cross-section above the downstream 212 are the same.

[0043] Referring to Figs. 18A-21, a heat transfer controlling apparatus 302 according to a fourth embodiment is described next.

[0044] The apparatus 302 of the fourth embodiment is different from that of the first embodiment in that no partitions exist. Other structure is the same as that of the first embodiment.

[0045] Accordingly, the cooling water flows from the inlet 322 as illustrated in by dashed line in Fig. 20 and about half of the cooling water, which flows on the lower side of the inner wall 318 that is covered with the lower side cover 304, is guided onto the upper side of the inner

wall 318 that is uncovered with the lower side cover 304 by the upstream guiding member 306. The guided cooling water reaches the cooling water flowing on the upper side of the inner wall 318 directly from the inlet 322 to merge so that the merged water advances downstream while heat is transferred from the inner wall 318. Then, at the location of the cylinder #4, the guiding member 308 that extends the bottom of the water jacket 316 guides the cooling water that has flowed on the lower side of the inner wall 318 to the upper side of the inner wall 318. The cooling water flowing on the upper side of the inner wall 318 from the cylinder #1 to #4 having a high temperature is merged with the cooling water having a lower temperature.

[0046] This merger suppresses the temperature rise or decreases the temperature of the cooling water that directly contacts the outer peripheral surface of the inner wall 318. The merged cooling water then flows in the direction of arrangement of cylinders at the back of the figure from the cylinders #4 to #1 as illustrated in Fig. 20. Then the water flow rises at the cylinder #1 toward the water flow passage on the side of the cylinder head.

[0047] The fourth embodiment as described has the following advantage.

[0048] There are no partitions. However, since the density of the cooling water is decreased due to the increase in temperature, the cooling water that directly contacts the outer peripheral surface of the inner wall 318 on the upper side thereof tends to remain in a flowing path on the upper side. The cooling water flowing on the upper side of the inner wall 318 is difficult to mix with the cooling water flowing on the lower side of inner wall 318. However, it is possible to guide the cooling water having a lower temperature on the lower side of the inner wall 318 upwardly to merge the cooling water on the upper side of the inner wall 318 in mid-flow so that the temperature rise of the cooling water is suppressed or the temperature of the cooling water is decreased. The fourth embodiment provides similar advantages to those of the first embodiment with a simple structure.

[0049] 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. Particularly, it should be understood that the invention may be embodied in the following forms.

[0050] In the above embodiments, the guiding members are provided at two points in the flow direction of the cooling water. However, more than two guiding members may be provided. For example, the first embodiment may be modified according to a further embodiment as illustrated in Fig. 22A-23C. The four guiding members 406, 407, 408 and 409 are disposed over the lower side cover 404 from the upper end of the four partitions 410, 411, 412 and 413, respectively. In this case, the guiding members 406-409 are longer as they are located further downstream.

[0051] By guiding cooling water having a lower temperature upwardly at three points in mid-flow, the tem-

perature among the cylinders becomes more uniform and the difference in temperature is reduced. The quantity of guiding members may be three or more than four. This is applicable to the second to fourth embodiments.

[0052] To divide the cooling water having a lower temperature more uniformly and to merge, it is preferred that the cooling water be divided in the water jacket at as far upstream as possible. For example, with respect to the structure of Figs. 22 and 23, guide panels 452 and 454 may be provided at the distal end of the middle guiding members 407 and 408 along the arranging direction of the cylinders, as illustrated in Fig. 24.

[0053] Other than olefinic resin, the lower side cover may be formed of any material that holds its shape when the temperature in the water jacket is elevated during the operation of the internal combustion engine. For example, the lower side cover may be formed of relatively rigid resin such as polyamide thermoplastic resin (PA66 and PPA), olefinic thermoplastic resin (PP), and polyphenylene sulfide thermoplastic resin (PPS). To enhance the rigidity, the material may be reinforced with glass fiber. Further, the lower side cover may be made of the same material as the guiding members and the partitions, as described below.

[0054] Other than olefinic elastomer, it is preferred that the guiding members and the partitions be made of a rubber elastic body or other flexible resin. For example, the rubber elastic body includes, but is not limited to, crosslinked rubber such as EPDM, silicone, and olefinic thermoplastic elastomer. Particularly, the material which is resistant to the cooling water is selected for the guiding members and the partitions. The guiding members and the partitions may be made of the same material as the lower side cover, as described above.

[0055] The attachment of the guiding members and the partitions to the lower side cover is achieved by adhesion, thermal caulking, fitting, welding, integral molding by injection molding, mechanical fixation with a grommet or a clip, and a combination thereof. Thus, an integral apparatus is produced. However, the apparatus is not necessary integrally formed and it is sufficient if the apparatus as a whole plays its role in the water jacket 16.

[0056] In the above embodiments, the guiding member is attached to the outer peripheral surface of the lower side cover along the entire length of the guiding member. However, by providing one or more inclined faces in the form of a step with the lower side cover, the lower side cover may serve as the guiding member.

Claims

1. An apparatus (2) for controlling heat transfer between a cooling heat medium for cooling an internal combustion engine in which the medium flows through a groove-like flow passage and an inner wall (18, 118, 218, 318) of a cylinder block (14) of the internal combustion engine, the apparatus (2) is dis-

posed in the groove-like flow passage, the groove-like flow passage being provided between the inner wall (18, 118, 218, 318) and an outer wall (20) of the cylinder block (14) housing a plurality of cylinders (#1-#4), **characterized in that** the apparatus (2) comprises

a lower side cover (4, 104, 204, 304, 404) for covering a lower side of the inner wall (18, 118, 218, 318) and exposing the upper side of the inner wall (18, 118, 218, 318) to the cooling heat medium that flows from outside of the outer wall (20) through the groove-like flow passage in the direction of arrangement of the cylinders (#1-#4); and

a guiding member (6, 8, 106, 108, 206, 208, 306, 308, 406-409) disposed in the groove-like flow passage for upwardly guiding the cooling heat medium that flows on the outer surface of the lower side cover (4, 104, 204, 304, 404) onto the upper side of the inner wall (18, 118, 218, 318).

2. The apparatus of claim 1, **characterized in that** the guiding member (6, 8, 106, 108, 206, 208, 306, 308, 406-409) is provided at a plurality of points in the direction of arrangement of the cylinders (#1-#4).

3. The apparatus of claim 2, **characterized in that** a partition (10, 12, 110, 112, 210, 212) for dividing the groove-like flow passage in the vertical direction is provided at the upper end of the lower side cover (4, 104, 204) and an opening (24, 124) for introducing the cooling heat medium that has been guided onto the upper side of the inner wall (18, 118, 218) by the guiding member (8, 108, 208) to the portion of groove-like flow passage above the partitions (10, 12, 110, 112, 210, 212).

4. The apparatus of claim 2 or 3 **characterized in that** the upper end of the lower side cover (104) becomes lower in the direction of arrangement of the cylinders (#1-#4) as the cooling heat medium flows further downstream at each point where the guiding member (106, 108) is located.

5. The apparatus of claim 3 **characterized in that** the lower side cover (204) covers the lower side of the inner wall (218) via a gap (250), a flow-resistant panel (256) is disposed more upstream of the cooling heat medium than the opening (24, 124) above the partition (210) in the groove-like flow passage, and a communication port (258) for communicating the upper side of the partition (210) with the gap (250) is formed in the partition (210) more upstream of the cooling heat medium than the flow-resistant panel (256).

6. The apparatus of any one of claims 1 to 5 **charac-**

terized in that the guiding member (6, 8, 106, 108, 206, 208, 306, 308, 406-409) includes an inclined face(6a, 8a) provided on the outer surface of the lower side cover (4, 104, 204, 304, 404), the inclined face(6a, 8a) extending longer from bottom to top as the guiding members (6, 8, 106, 108, 206, 208, 306, 308, 406-409) are located more downstream of the cooling heat medium. 5

7. The apparatus of any one of claims 1 to 5 **characterized in that** the guiding member (6, 8, 106, 108, 206, 208, 306, 308, 406-409) is longer as the guiding members (6, 8, 106, 108, 206, 208, 306, 308, 406-409) are located more downstream of the cooling heat medium. 10 15

8. The apparatus of any one of claims 1 to 7 **characterized in that** guide panel(452, 454) extends from the distal end of the guiding member (407, 408) along the direction of arrangement of the cylinders (#1-4). 20

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Fig.1A

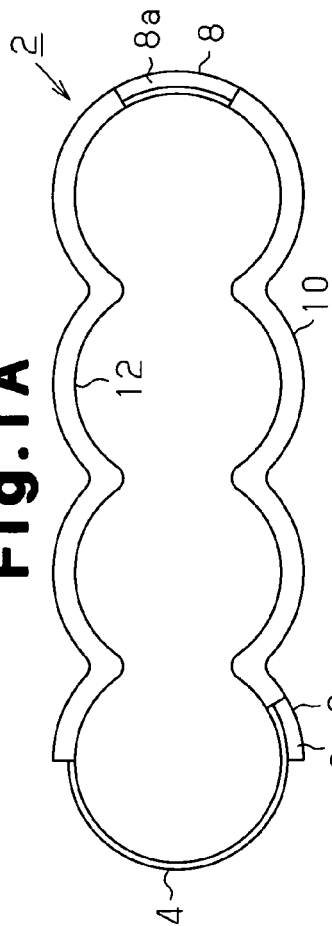


Fig.1B

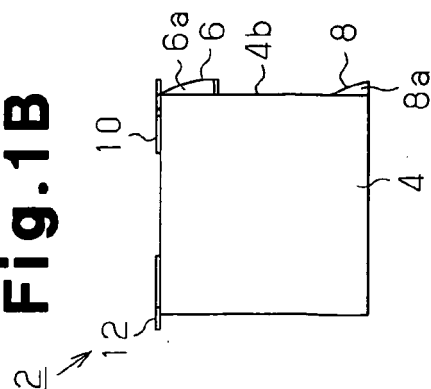


Fig.1C

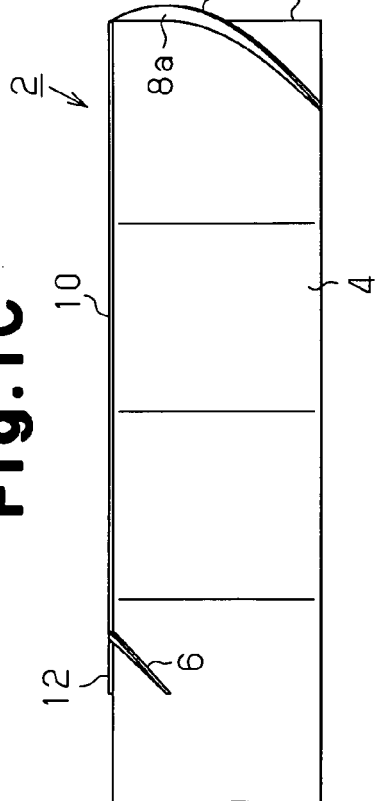


Fig.1D

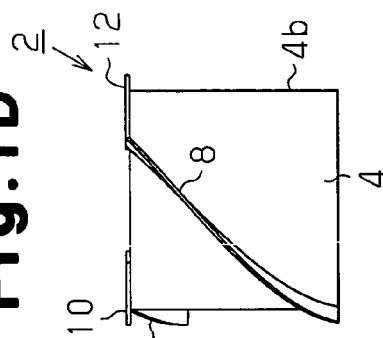


Fig.1E

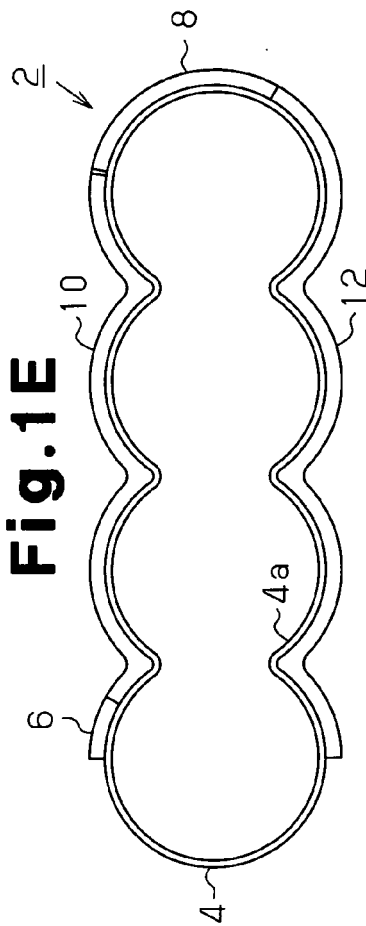


Fig.2A

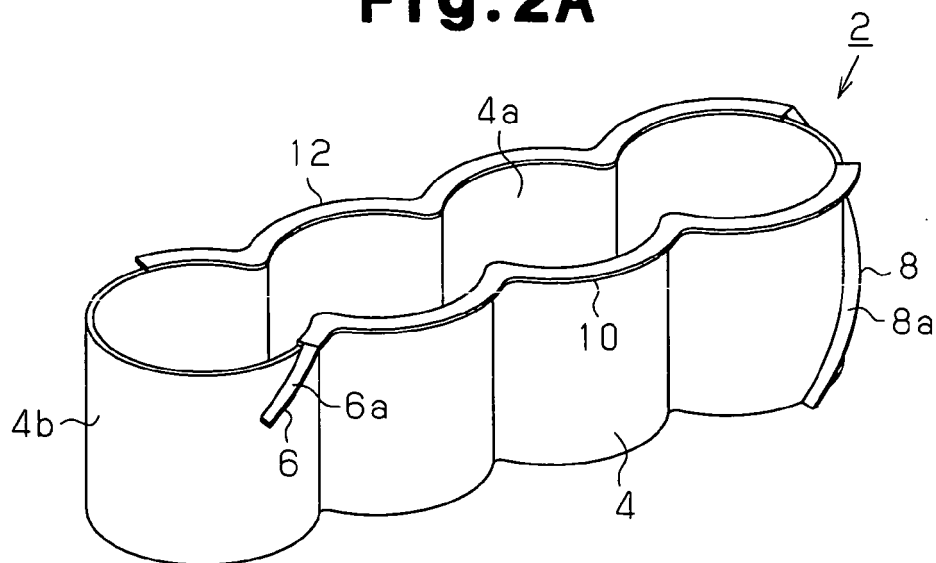


Fig.2B

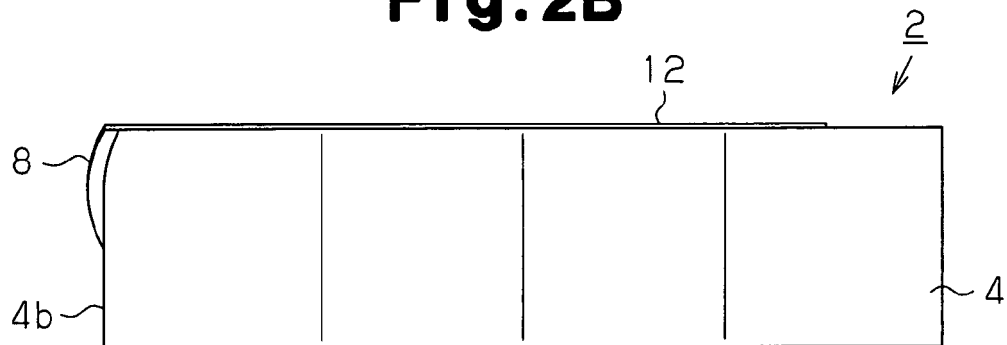


Fig.2C

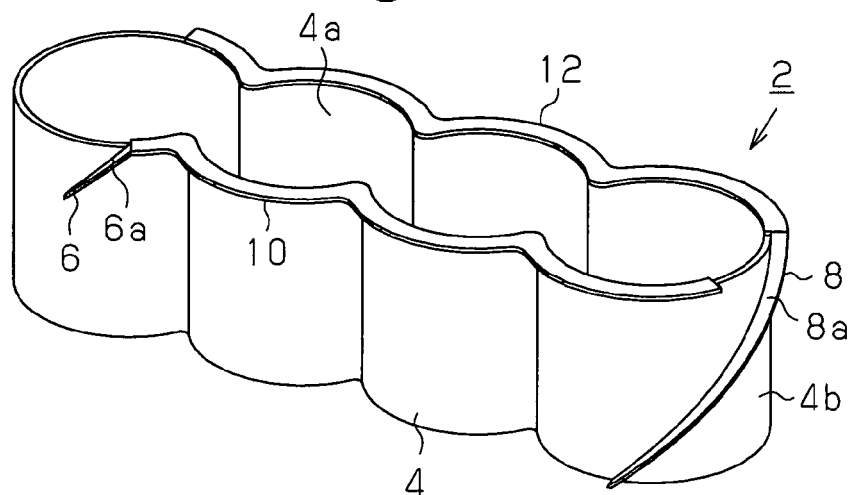


Fig.3

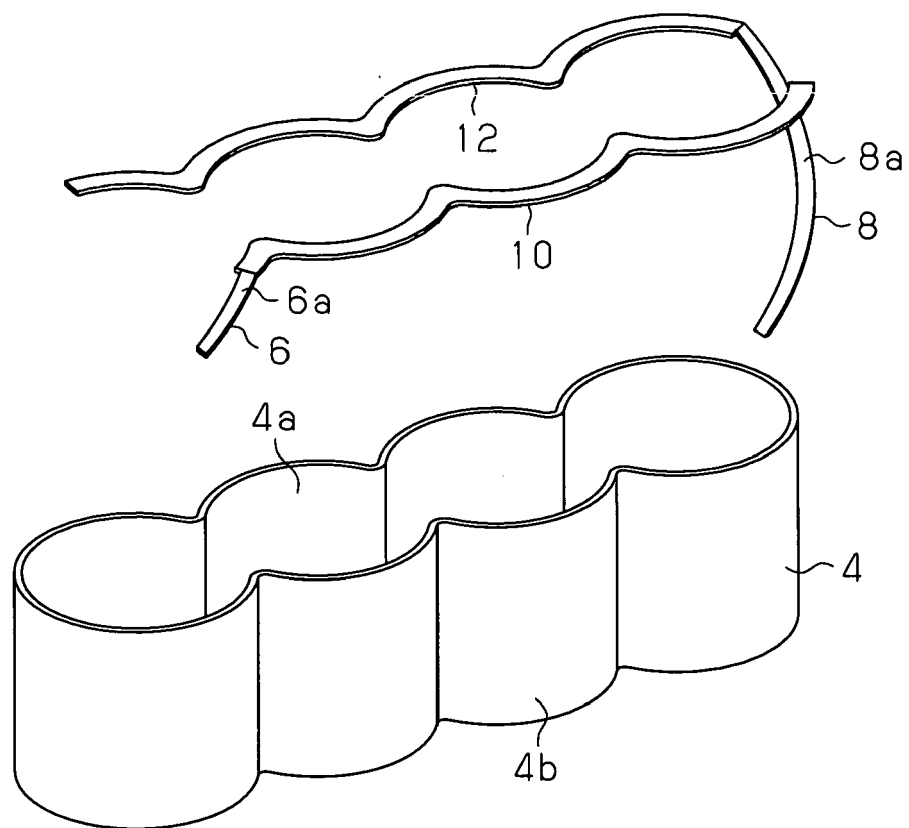


Fig.4

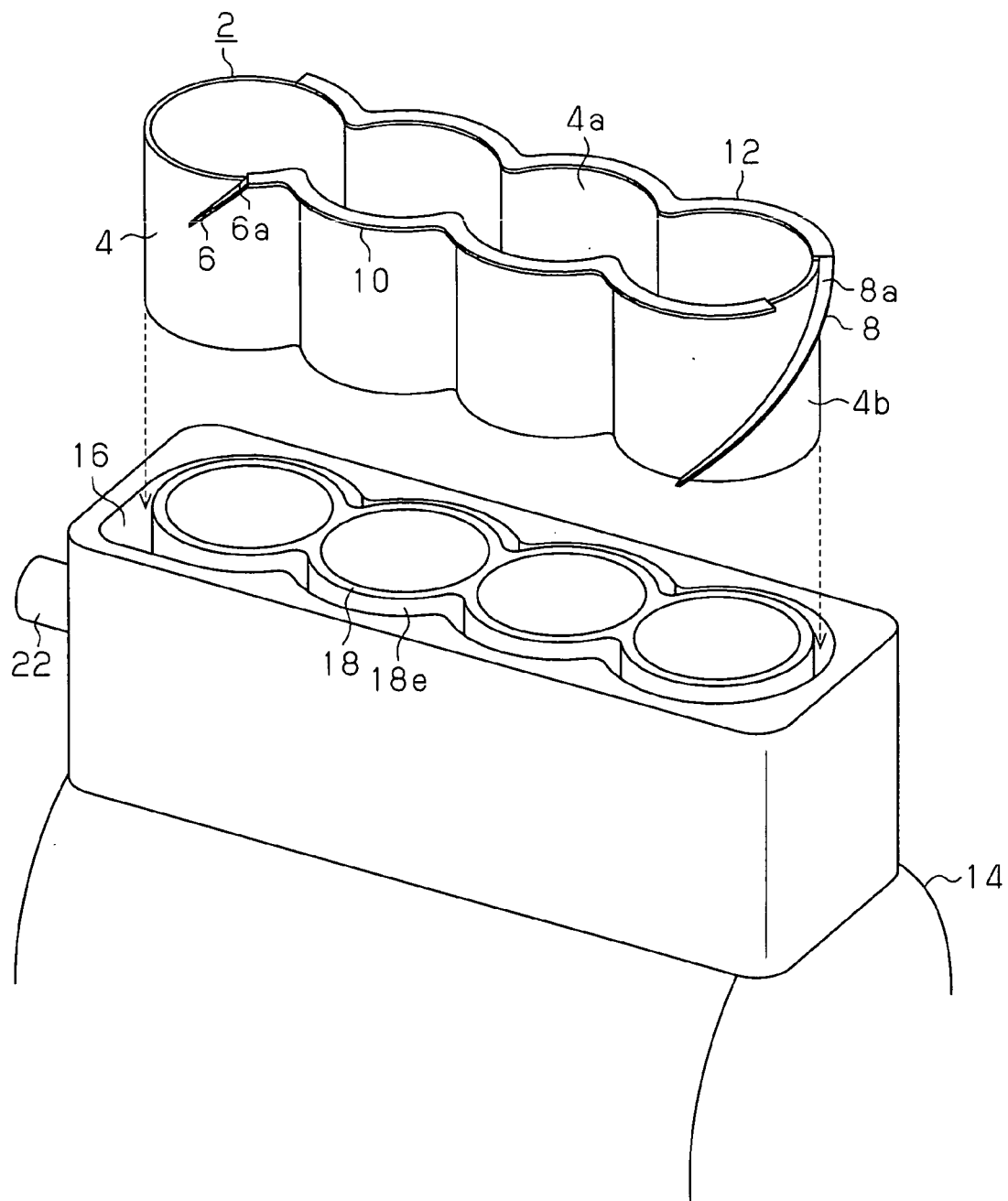


Fig. 5

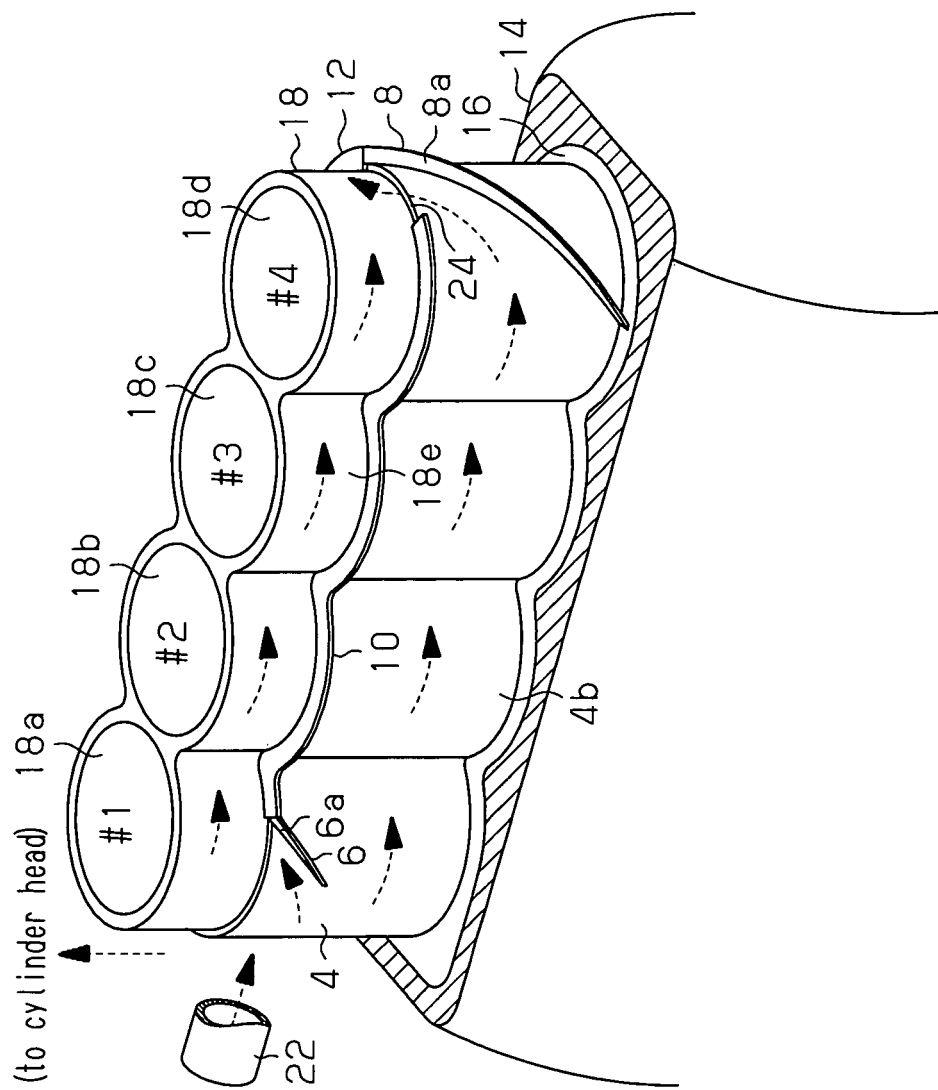


Fig.6

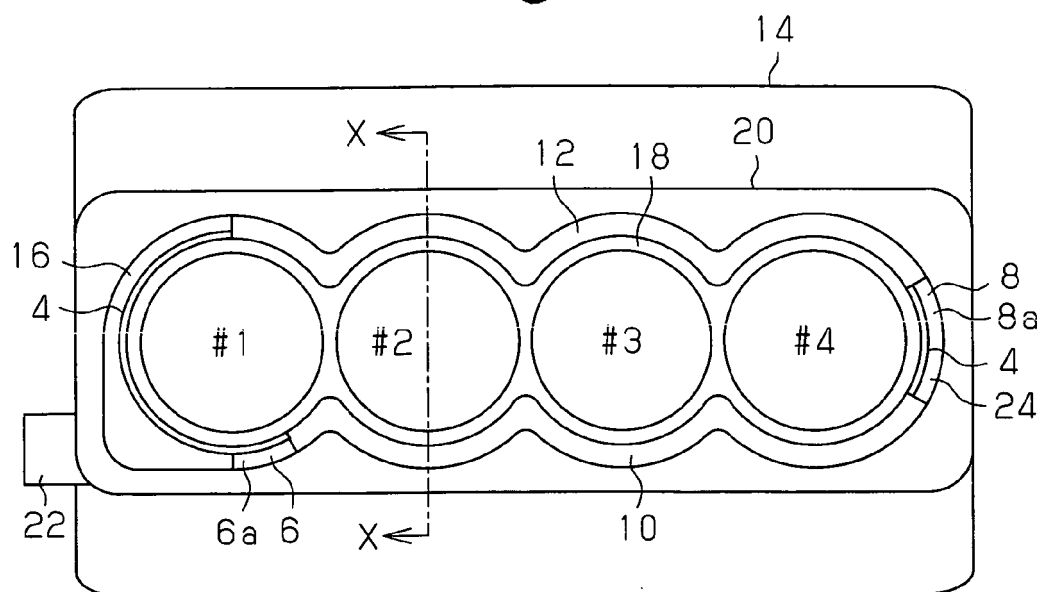
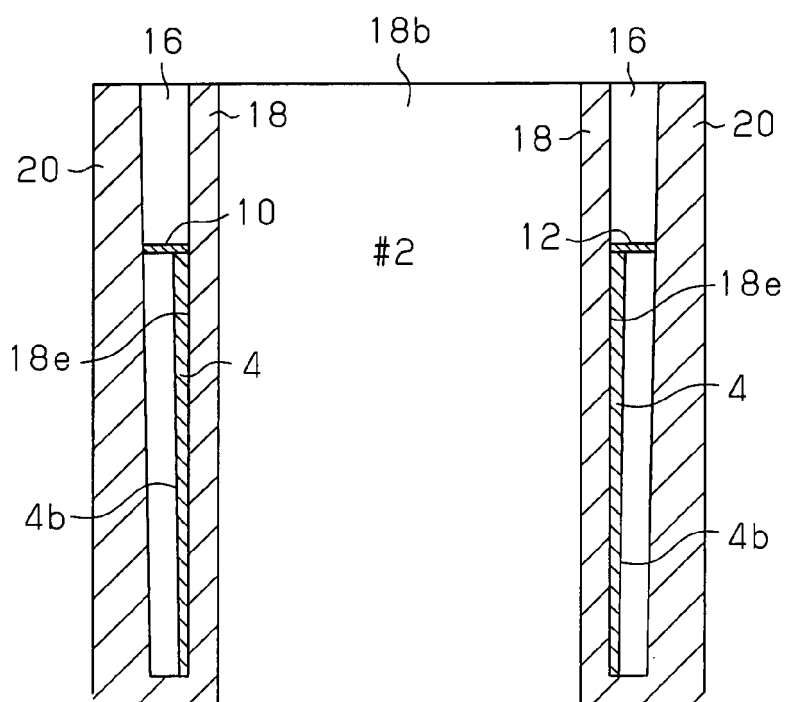


Fig.7



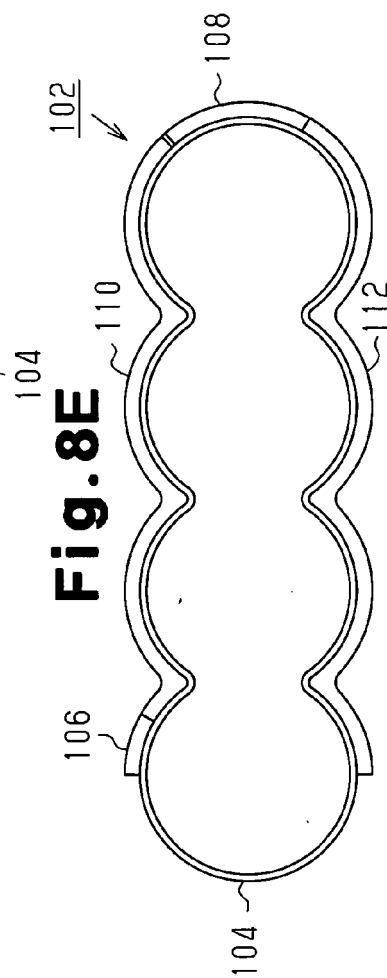
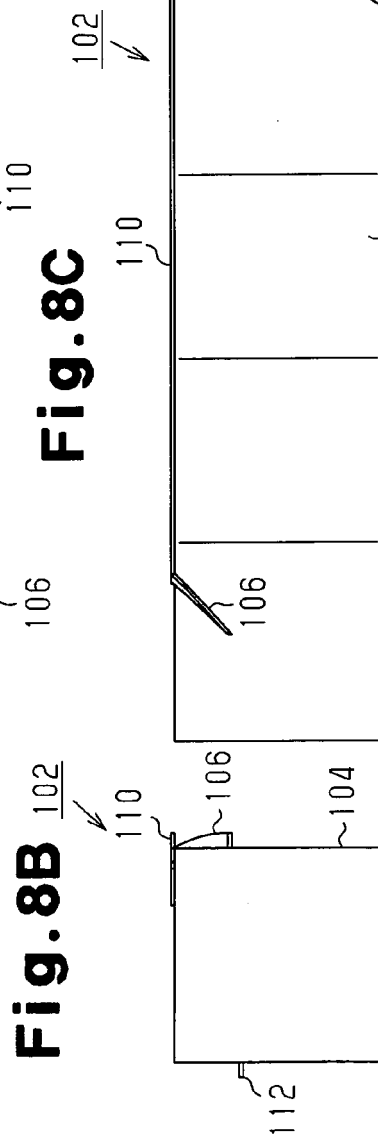
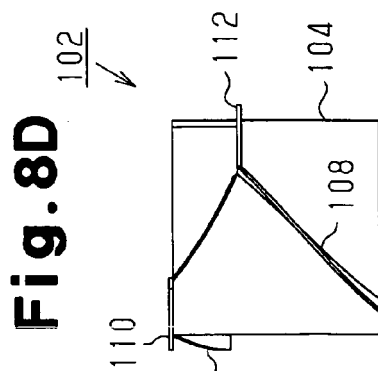
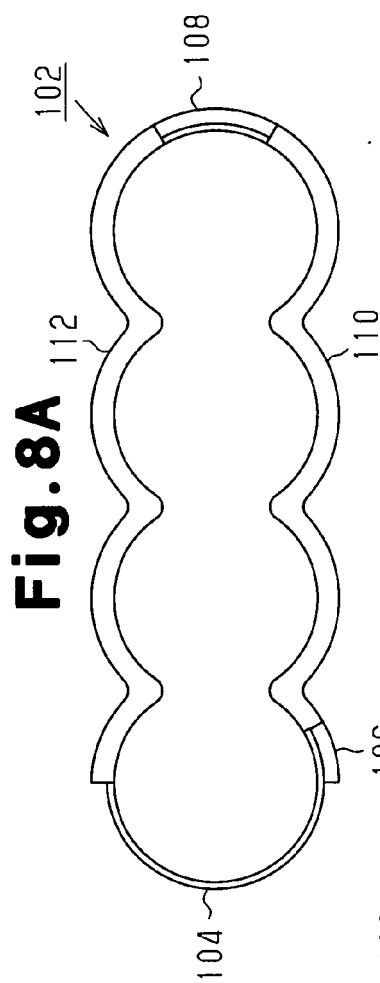


Fig. 9A

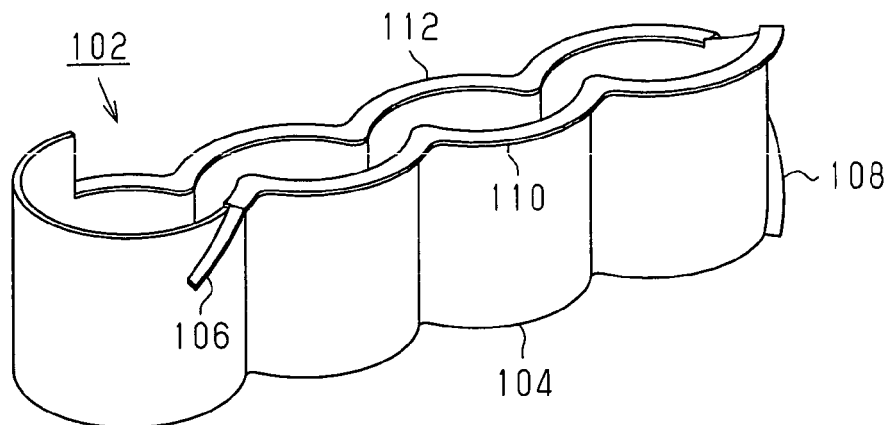


Fig. 9B

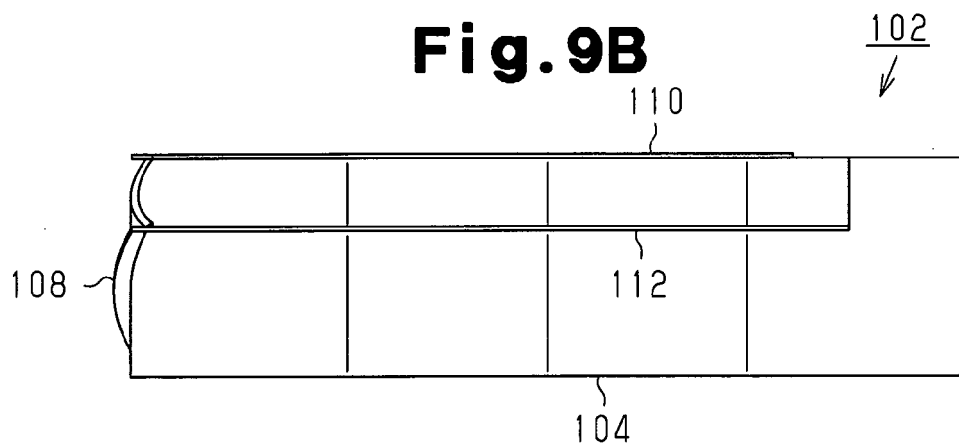


Fig. 9C

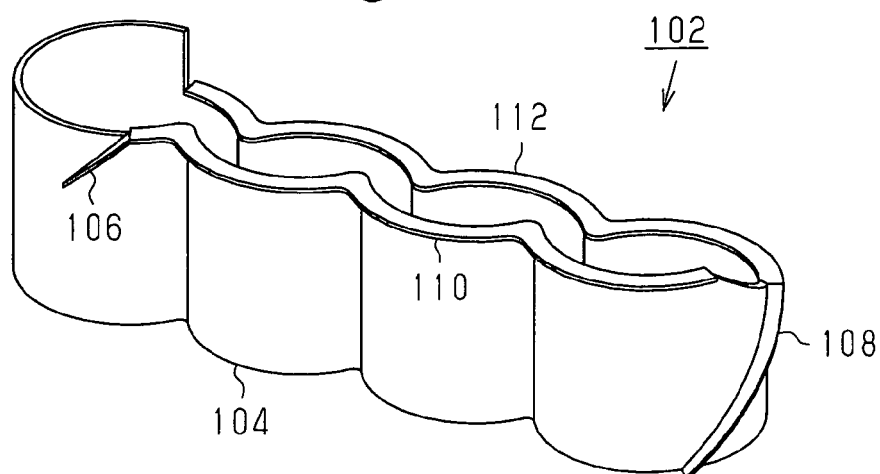


Fig. 10

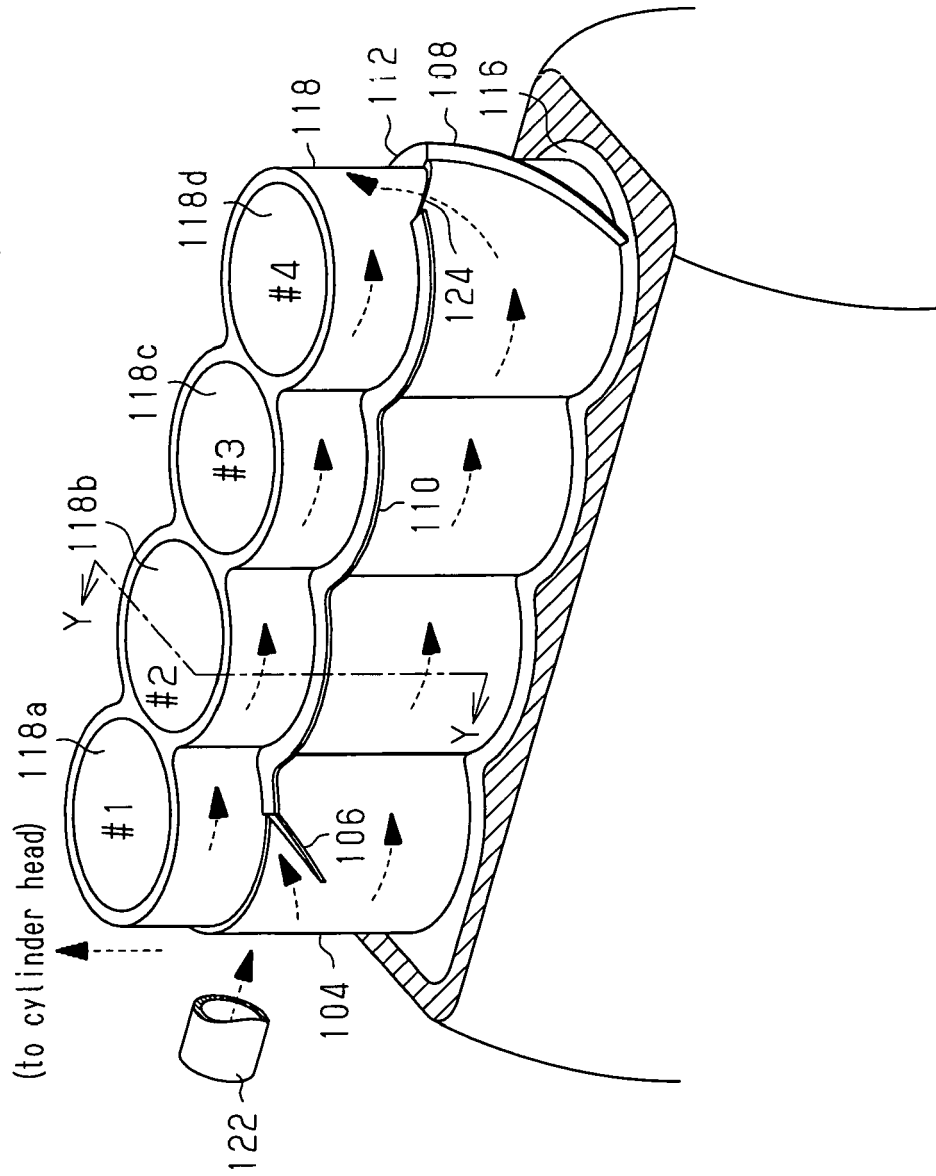
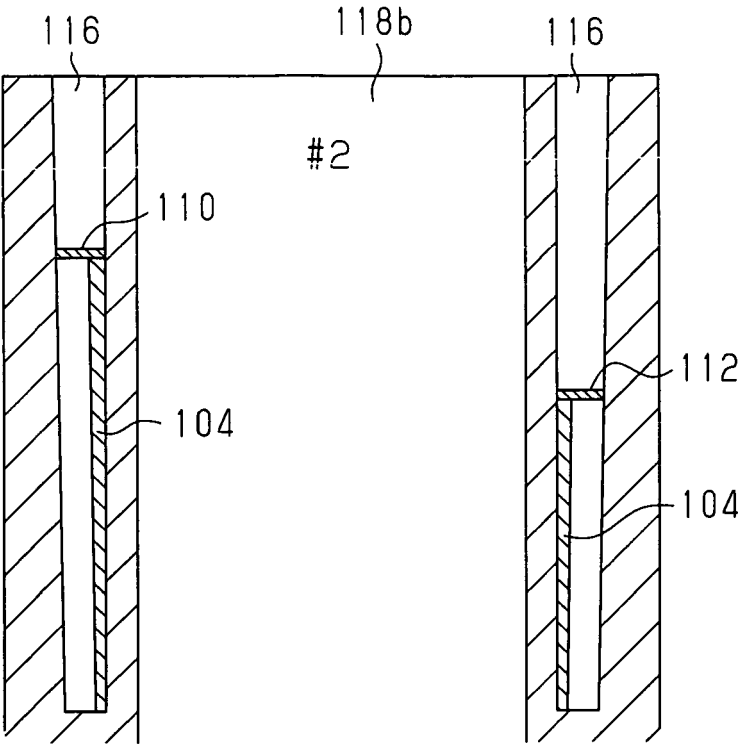


Fig.11



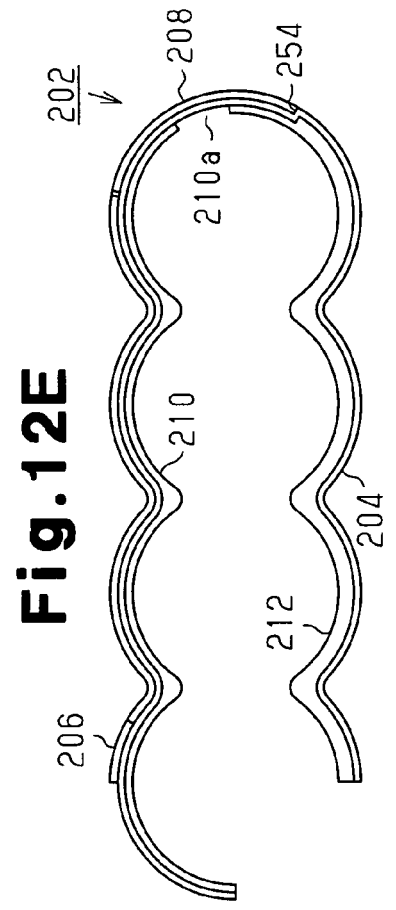
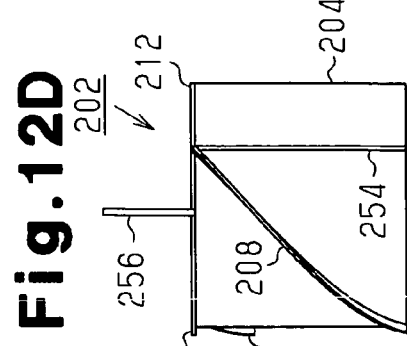
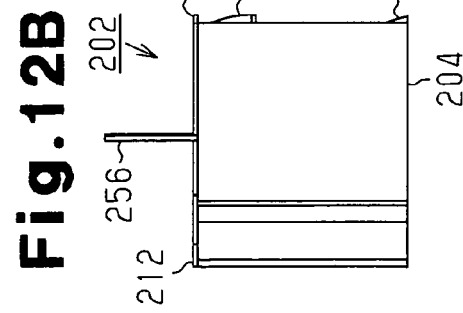
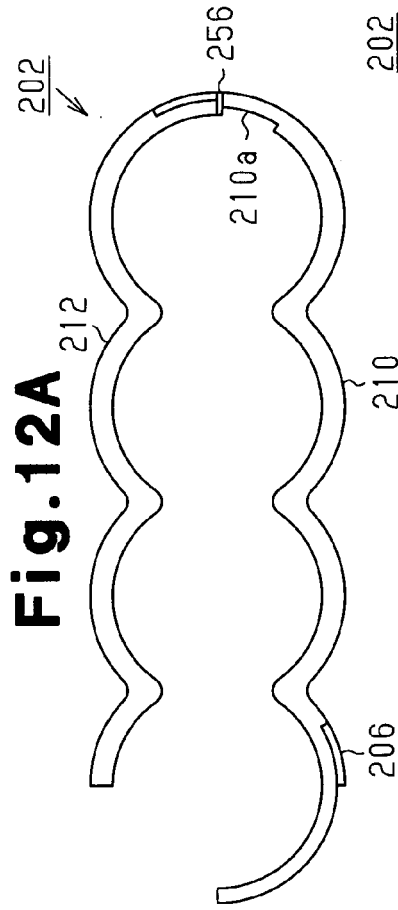


Fig.13A

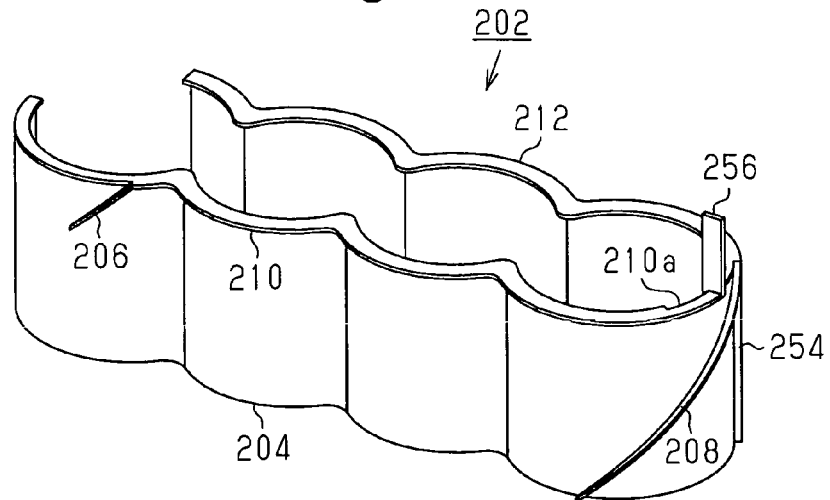


Fig.13B

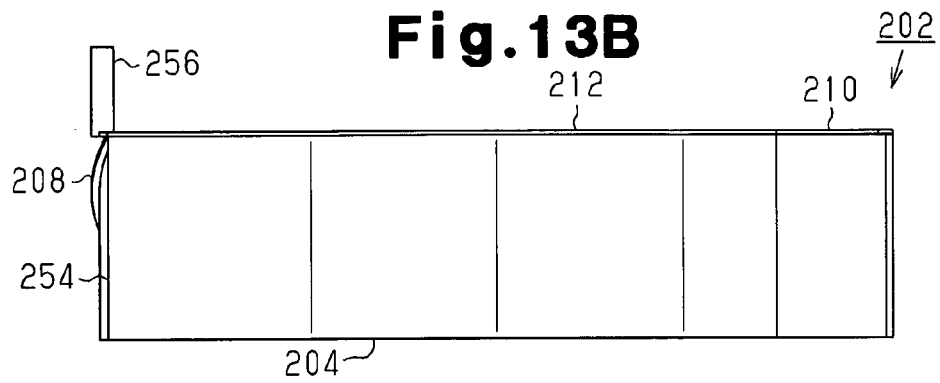


Fig.13C

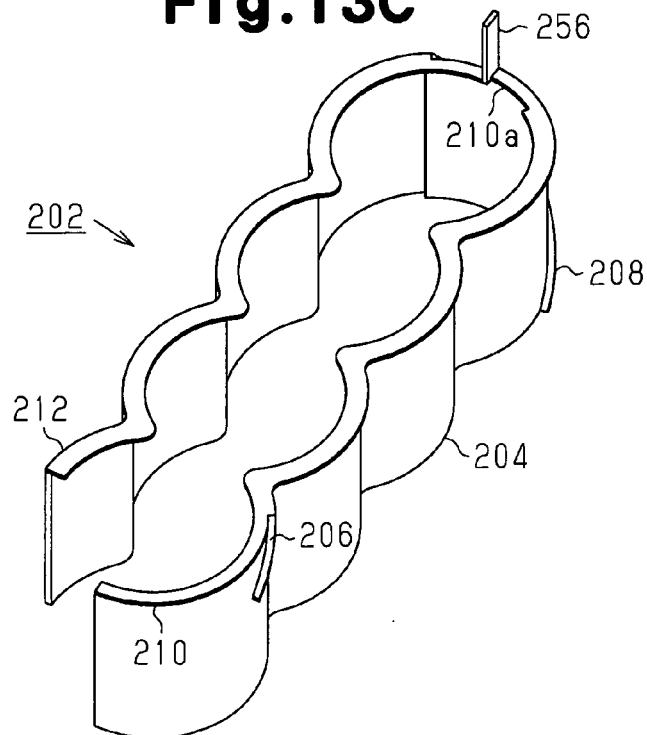


Fig.14

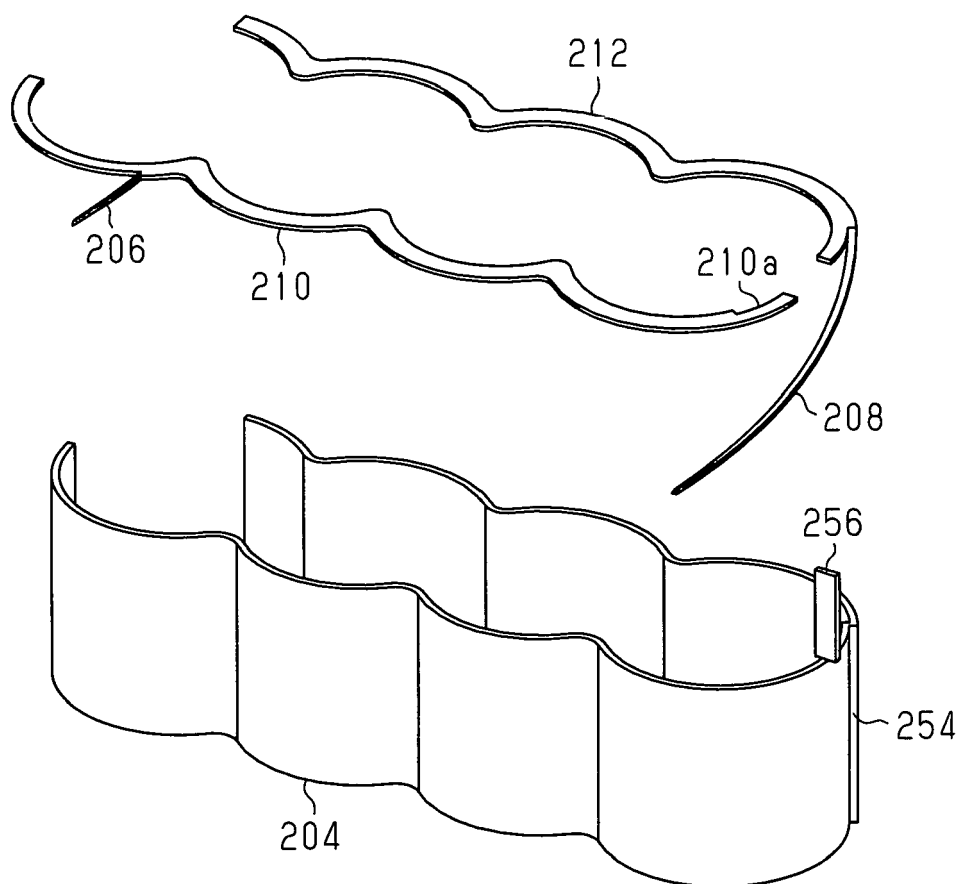


Fig.15

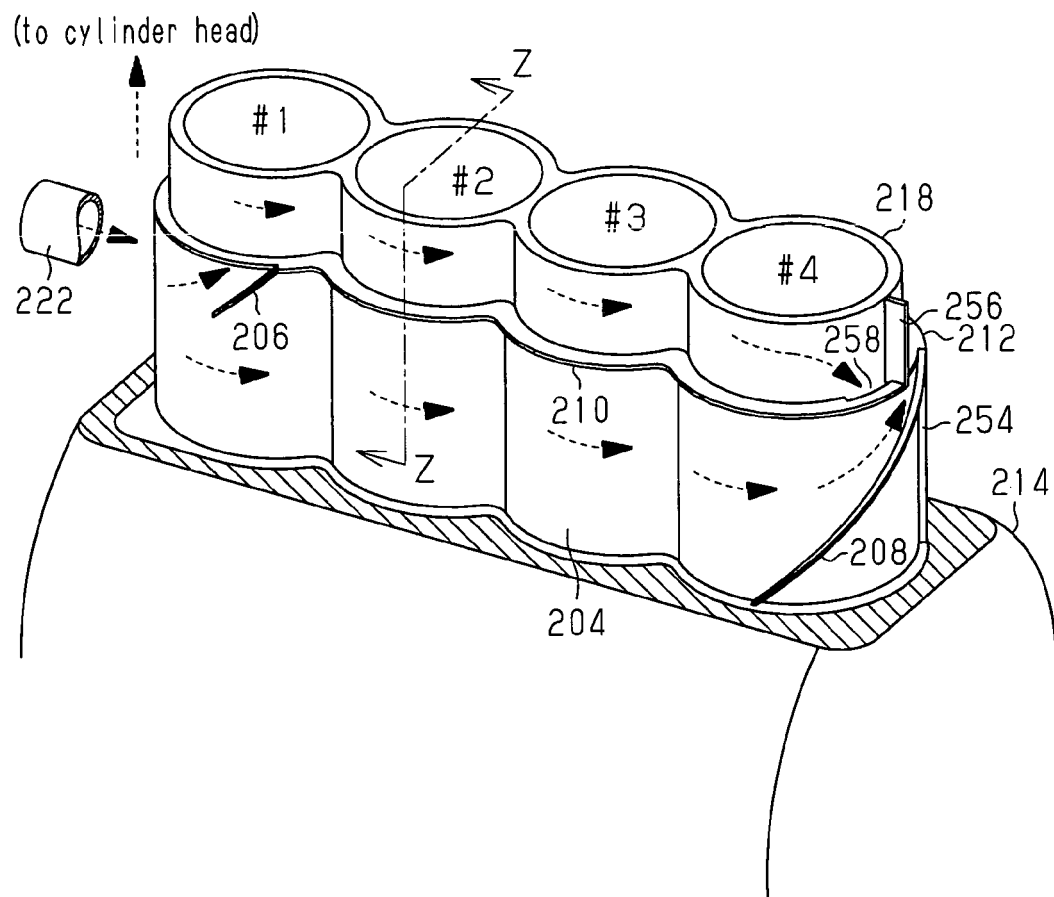


Fig.16

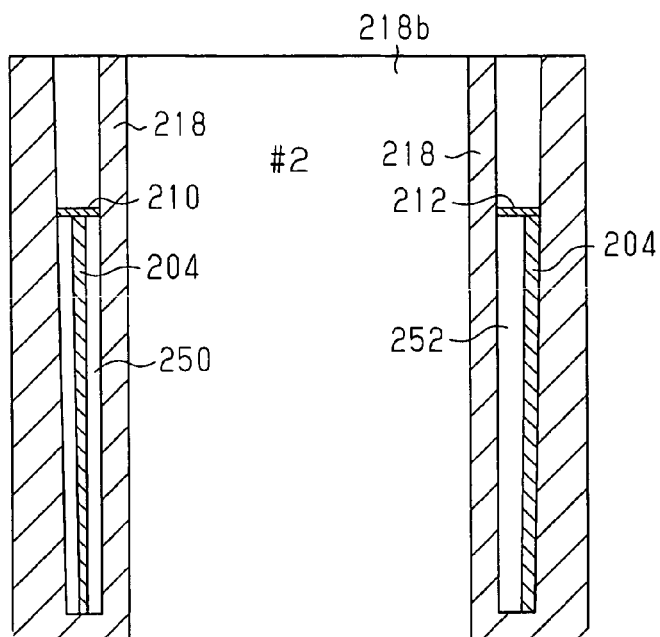


Fig.17

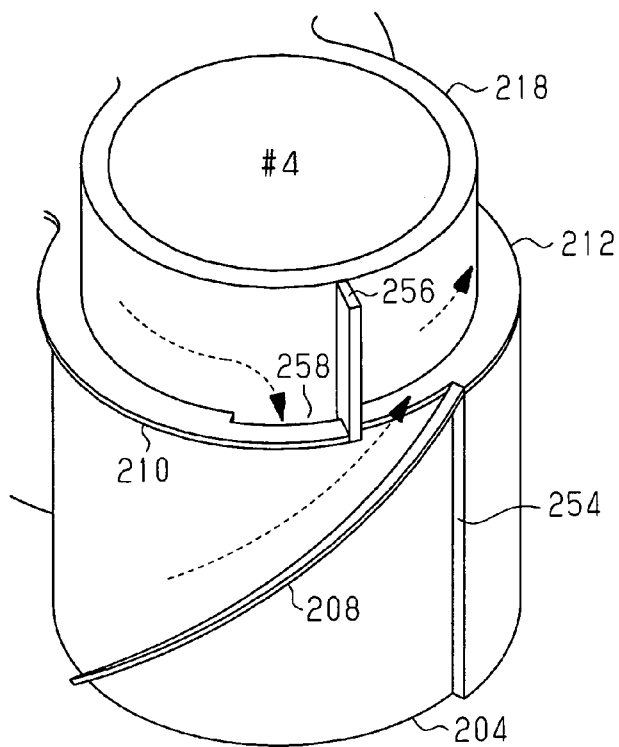


Fig.18A

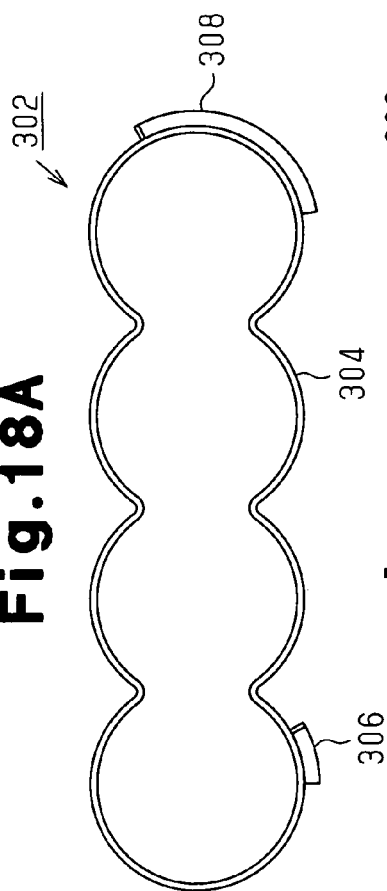


Fig.18B

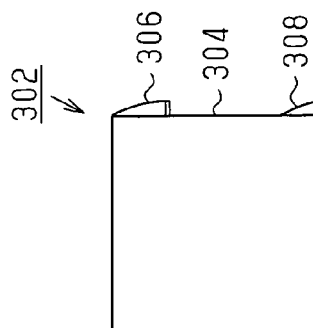


Fig.18D

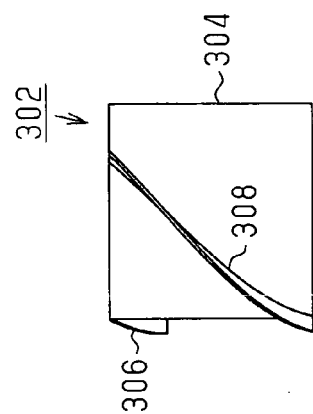


Fig.18C

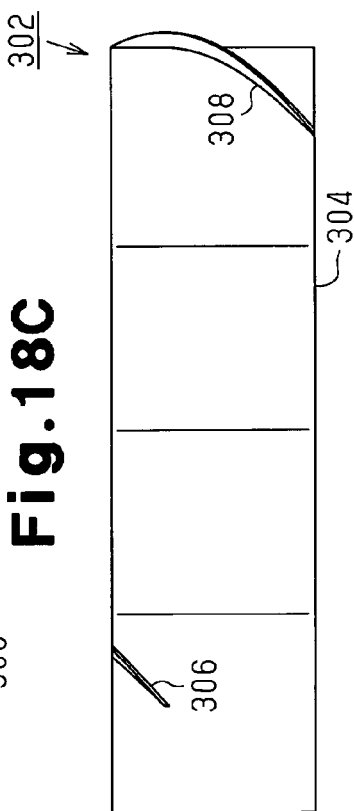


Fig.18E

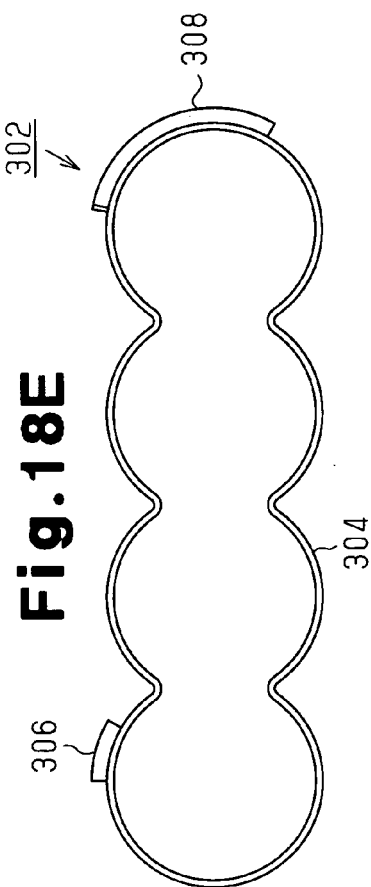


Fig.19A

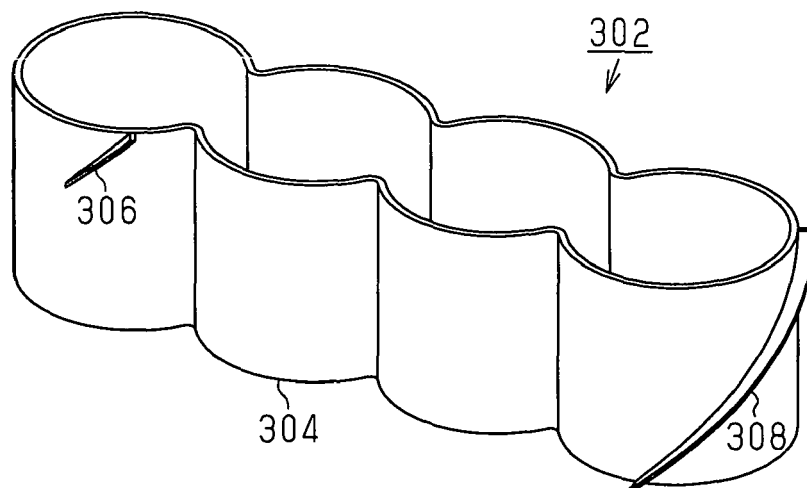


Fig.19B

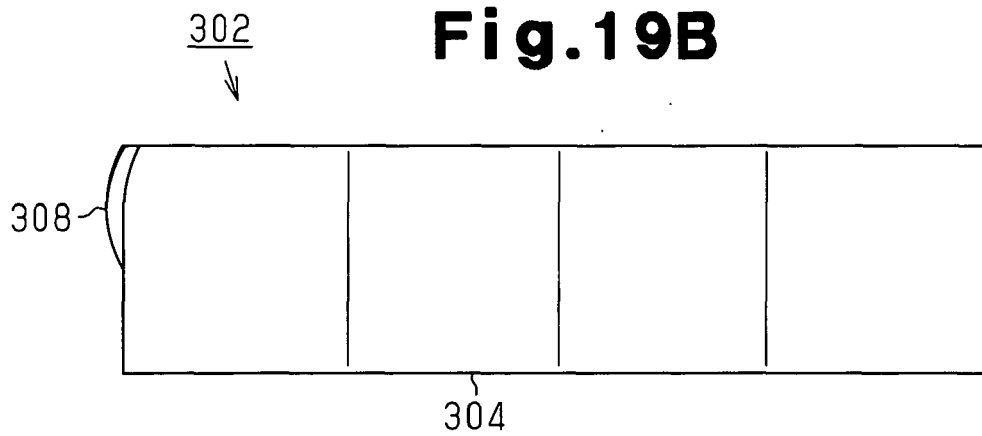


Fig.20

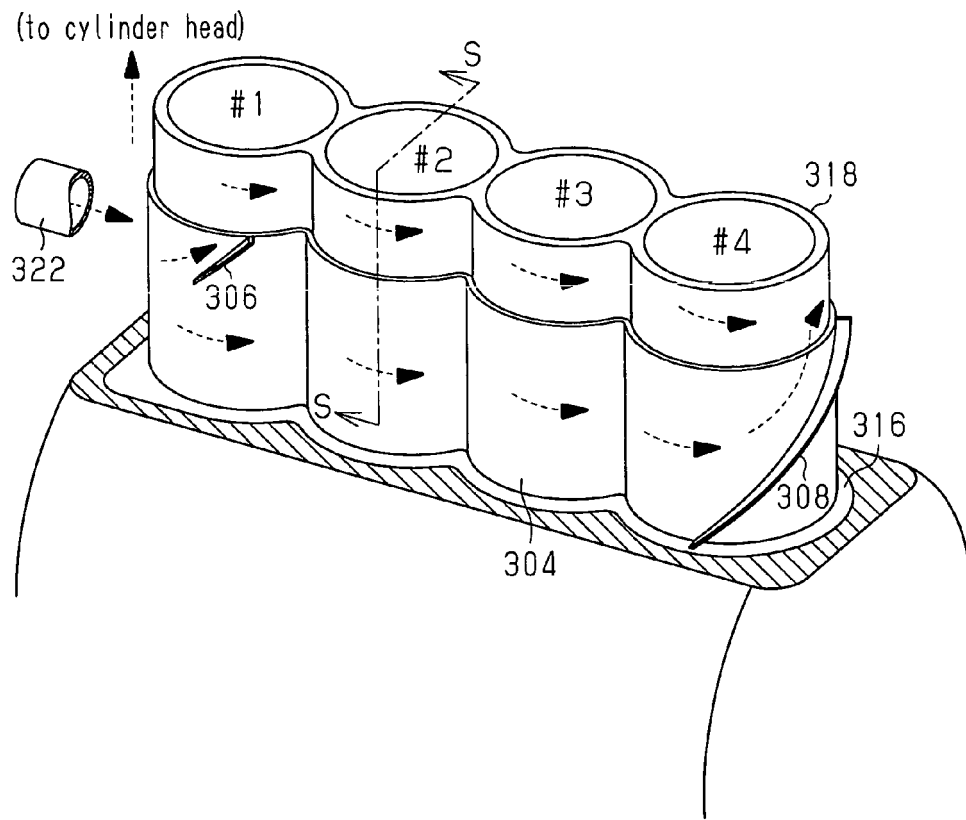
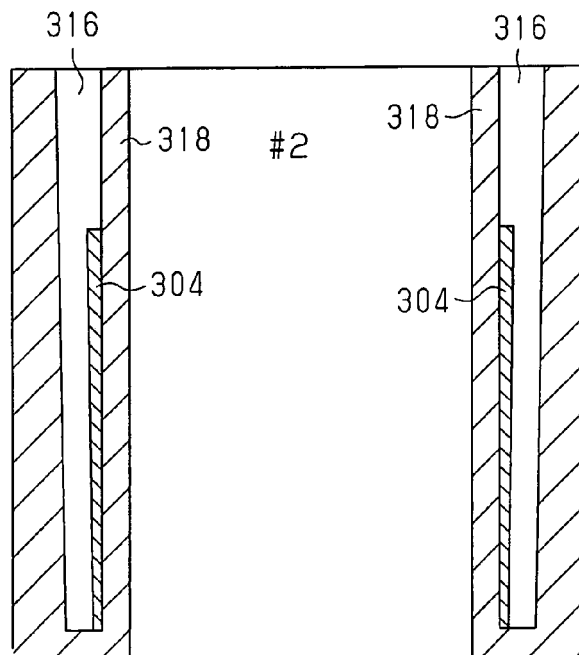


Fig.21



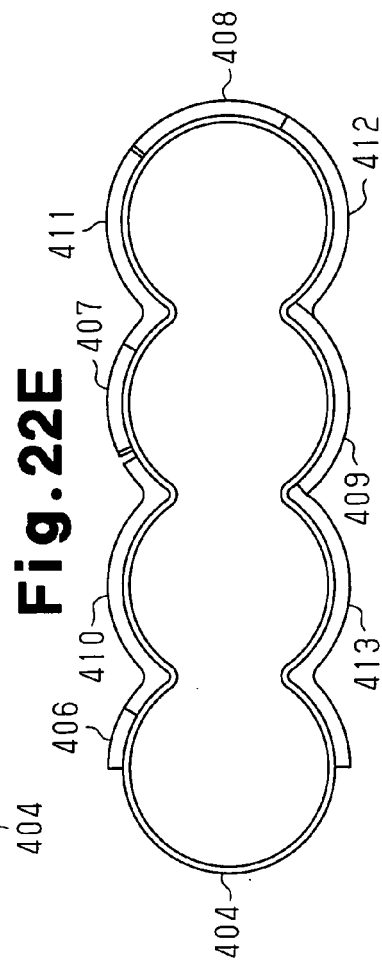
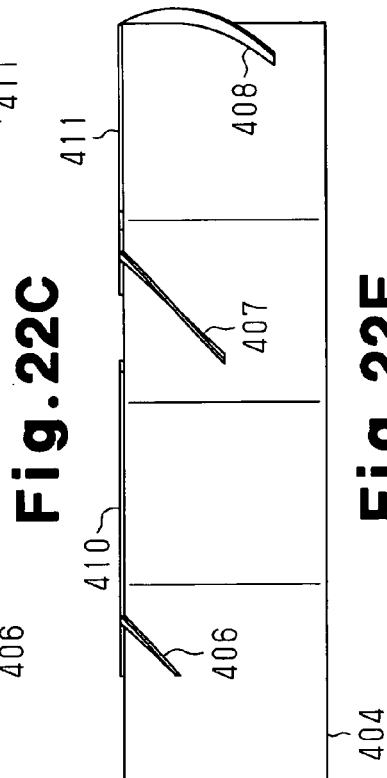
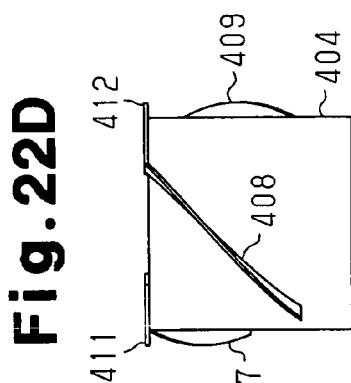
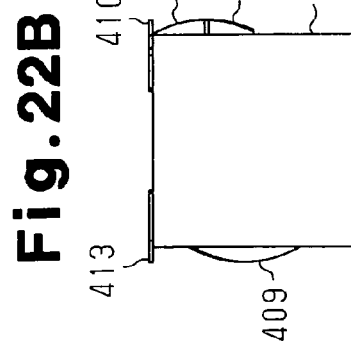
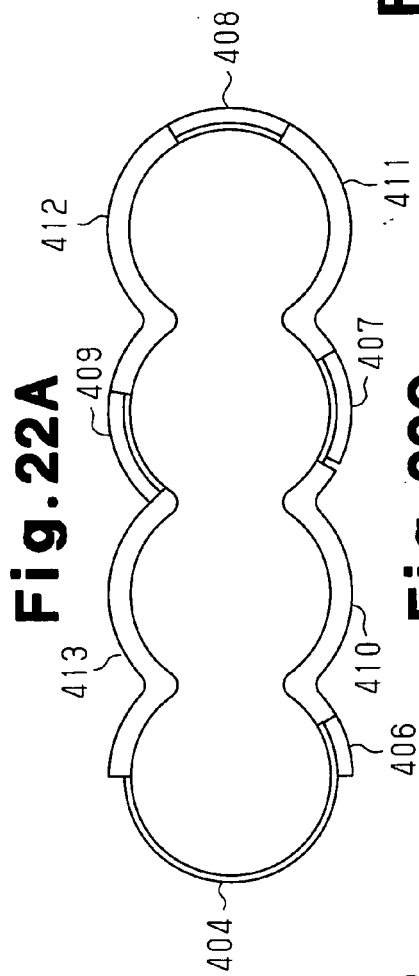


Fig. 23A

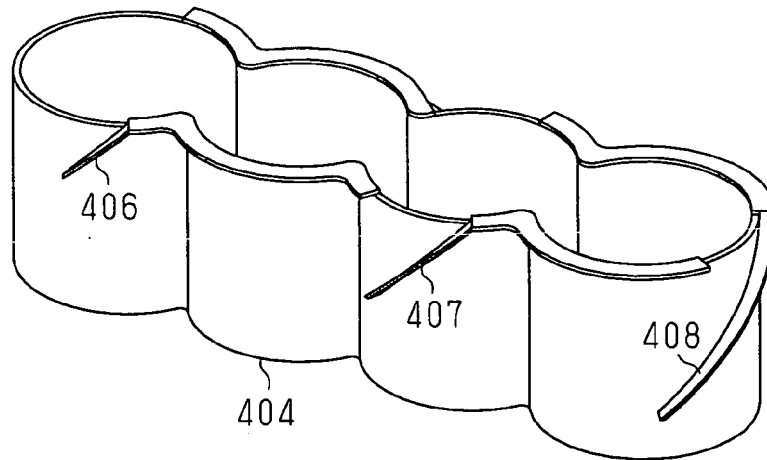


Fig. 23B

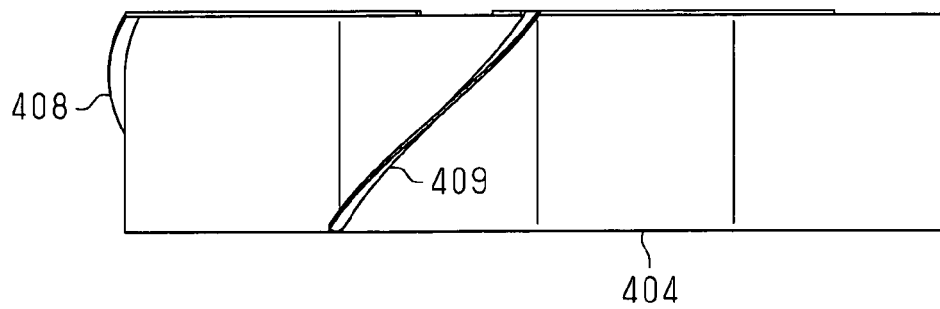


Fig. 23C

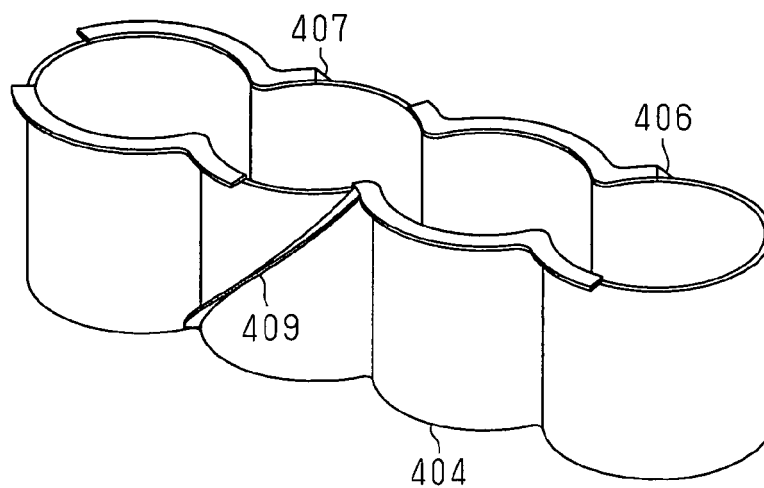


Fig.24A

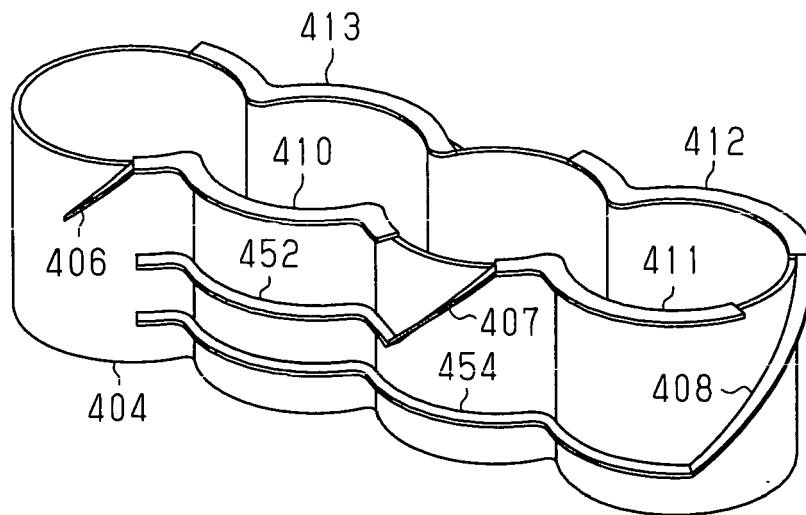
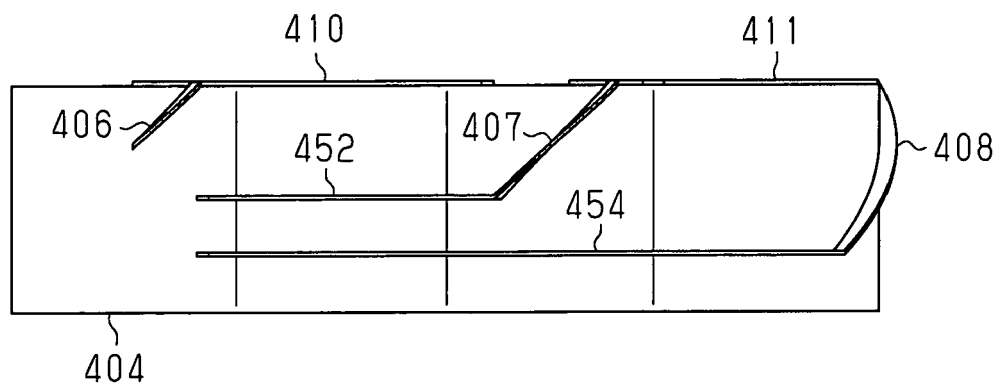


Fig.24B





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 07 02 2397

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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			F01P F02F
Place of search		Date of completion of the search	Examiner
Munich		7 April 2008	Landriscina, V
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EP 07 02 2397

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The members are as contained in the European Patent Office EDP file on
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07-04-2008

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