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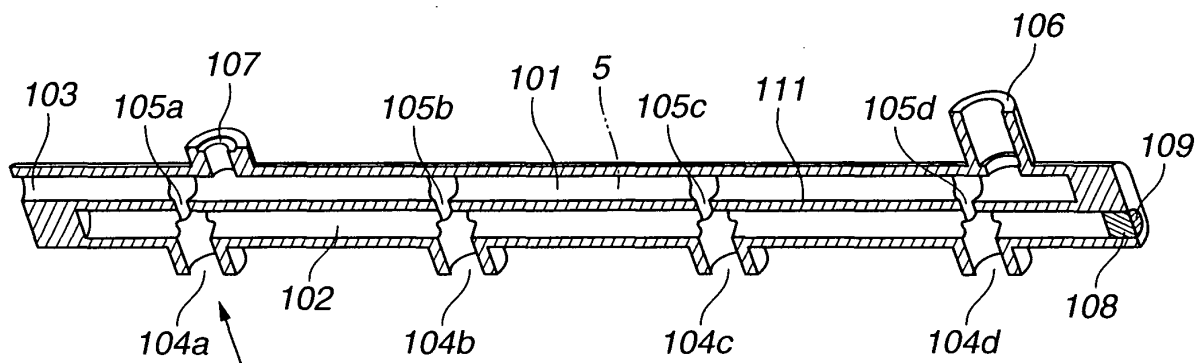
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(54) **Highly pressurized common rail for internal combustion engine**

(57) In a highly pressurized fuel piping for an internal combustion engine, a piping main body has an outer peripheral wall, a partitioning wall (111) is formed integrally with the outer peripheral wall at least two of first and second fuel flow passages (101,102), divided with the partitioning wall (111) of the piping main body, are formed within an inner space of the piping main body and extended mutually approximately in parallel to each other, a fuel introduction portion (103) is formed to com-

municate with at least one of the first and second flow passages (101,102), a plurality of inserting portions (104a-104d) are formed to communicate with at least one of the first and second flow passages (101,102), through each of which a corresponding one of the fuel injection device is insertable and a plurality of communication portions (105a-105d) are formed through which the first and second fuel flow passages (101,102) are mutually communicated.

**FIG.3**



EP 1 416 151 A2

**Description****BACKGROUND OF THE INVENTION:****Field of the invention**

[0001] The present invention relates generally to a highly pressurized fuel piping (structure) to deliver fuel supplied from a fuel tank into a plurality of fuel injection devices (for example, electromagnetically operated fuel injection valves).

**Description of the related art**

[0002] A Japanese Patent Application First Publication No. Heisei 9-296768 published on August 8, 1995 exemplifies a first previously proposed highly pressurized fuel piping. In this Japanese Patent Application First Publication identified above, a partition plate is disposed to divide a piping main body into up and down (upper and lower) fuel flow passages. Up and down (upper and lower) fuel flow passages are communicated with both ends of the piping main body. Then, an amount of fuel is supplied through the respective ends into the upper fuel flow passage and lower fuel flow passage. A delay of fuel pressure recovery is uniformized among the respective fuel injection devices. Then, the fuel is supplied from both ends into the upper fuel passage and lower fuel passage. The delay of fuel pressure recovery is uniformized between each of the fuel injection devices immediately after the fuel injections and a deviation in the fuel injection quantities from among the fuel injection devices is reduced.

[0003] A Japanese Patent Application First Publication No. Heisei 7-208298 published on August 8, 1995 exemplifies a second previously proposed highly pressurized fuel piping. In the fuel delivery piping disclosed in the above-described latter Japanese Patent Application First Publication, an inside of the piping main body is divided into upward and downward fuel flow passages, a fuel introduction portion is disposed on the downward fuel flow passage, a pressure regulator is disposed at a fuel exhaust portion which is provided at the upward fuel flow passage, the fuel introduced from the downward fuel flow passage is returned to the fuel tank via the fuel exhaust portion of the upper fuel flow passage and via a pressure regulator. Thus, delays in fuel pressure recoveries among the respective fuel injection devices immediately after the fuel injection has been carried out are uniformized and deviations among the fuel injection quantities for the respective fuel injection devices are reduced.

**SUMMARY OF THE INVENTION:**

[0004] In a generally available highly pressurized fuel piping (structure) of the internal combustion engine, a hoop stress by which an inner wall of the piping main

body is received is expressed in the following equation (1):

$$\sigma_{\max} = p(r_2^2 + r_1^2) / (r_2^2 - r_1^2) \quad (1),$$

wherein  $\sigma_{\max}$ : maximum hoop stress (a stress receiving the piping due to the fuel pressure), P: a piping fuel pressure,  $r_1$ : piping inner diameter, and  $r_2$ : piping outer diameter. In a case where the piping fuel pressure p is high, it is necessary to enlarge the piping volume in order to reduce a deviation in the fuel injection quantity and a ripple noisy sound. However, if inner diameter  $r_1$  and outer diameter  $r_2$  are enlarged, the hoop stress becomes large in a unit of square as appreciated from equation (1). Hence, in order to secure a strength of the piping, it is necessary to thicken the wall of the piping. A thick wall of the piping may cause a heavy weight of the highly pressurized fuel piping (structure) and this results in a large-size and expensive highly pressurized fuel piping (structure). In addition, the large sizing of the highly pressurized fuel piping (structure) does not satisfy an engine layout requirement. In the first previously proposed highly pressurized fuel piping described above, the partition plate merely divides the piping internal part and the fuel pressure within the piping receives only from the piping wall portion. Hence, the hoop stress is determined from the inner diameter and outer diameter of the piping main body. As described above, it is, nevertheless, necessary to thicken the piping (wall) as described above. On the other hand, in the second previously proposed highly pressurized fuel piping structure, the wall with which the piping main body is divided is formed integrally with the piping wall to receive the fuel pressure. Therefore, the hoop stress is acted upon in a relationship between the respectively divided inner and outer diameters within the piping. As described above, the hoop stress which is acted upon by a square of each of inner and outer diameters. Hence, if the diameters of a single piping becomes small, the hoop stress acted upon the whole piping becomes small. However, distances of a vicinity to the both ends of each fuel injection device and of a vicinity to the center of each fuel injection device from the portion through which fuel is introduced are different from each other from among the fuel injection devices. The velocities of the fuel supply are different. Hence, as the fuel pressure within the piping main body becomes higher, the uniformization of the delays in the fuel pressure recovery between each fuel injection device immediately after the fuel injection has been carried out becomes difficult and the uniformization (or uniformity) of fuel injection quantity becomes difficult.

[0005] It is, hence, an object of the present invention to provide a highly pressurized fuel piping for an internal combustion engine which can reduce a deviation in the fuel injection quantity even under a high fuel pressure

in a highly pressurized fuel piping and which can achieve a simple manufacturing operation at a reduced cost in addition to the reduction of the deviation in the fuel injection quantity.

[0006] According to one aspect of the present invention, there is provided a highly pressurized fuel piping for an internal combustion engine, the internal combustion engine comprising: a fuel tank; and a plurality of fuel injection devices into each of which a fuel supplied from the fuel tank is distributed, the highly pressurized fuel piping comprising: a piping main body having an outer peripheral wall and a partitioning wall formed integrally with the outer peripheral wall; at least two of first and second fuel flow passages, divided with the partitioning wall of the piping main body, formed within an inner space of the piping main body, and extended mutually approximately in parallel to each other; a fuel introduction portion formed to communicate with the first fuel flow passage; a plurality of inserting portions formed to communicate with at least one of the first and second flow passages, through each of which a corresponding one of the fuel injection devices is insertable; and a plurality of communication portions through which the first and second fuel flow passages are mutually communicated.

[0007] According to another aspect of the present invention, there is provided a method applicable to a highly pressurized fuel piping for an internal combustion engine, the internal combustion engine comprising: a fuel tank; and a plurality of fuel injection devices into each of which a fuel supplied from the fuel tank is distributed, the method comprising: providing a piping main body having an outer peripheral wall and a partitioning wall formed integrally with the outer peripheral wall; providing at least two of first and second fuel flow passages, divided with the partitioning wall of the piping main body, formed within an inner space of the piping main body, and extended mutually approximately in parallel to each other; forming a fuel introduction portion to communicate with at least one of the first and second flow passages; forming a plurality of inserting portions to communicate with at least one of the first and second flow passages, through each of which a corresponding one of the fuel injection devices is insertable; and forming a plurality of communication portions through which the first and second fuel flow passages are mutually communicated.

[0008] This summary of the invention does not necessarily describe all necessary features so that the invention may also be a sub-combination of these described features.

#### BRIEF DESCRIPTION OF THE DRAWINGS:

[0009] Fig. 1 is a schematic block diagram a fuel supply system to which a highly pressurized piping for an internal combustion engine in a first preferred embodiment according to the present invention is applicable.

[0010] Fig. 2 is a perspective view of a common rail in the first preferred embodiment according to the present invention shown in Fig. 1.

[0011] Fig. 3 is a cross sectional view cut away along a line of III - III' shown in Fig. 2.

[0012] Figs. 4A, 4B, and 4C are explanatory views for explaining a relationship between each communication portion and each inserting portion in a case of a second preferred embodiment according to the present invention.

[0013] Fig. 5 is a perspective view for explaining the common rail in the second preferred embodiment according to the present invention.

[0014] Fig. 6 is a cross sectional view cut away along a line of VI - VI' shown in Fig. 5.

[0015] Fig. 7 is a perspective view of the common rail in a third preferred embodiment according to the present invention.

[0016] Fig. 8 is a cross sectional view cut away along a line of VII - VII' shown in Fig. 7.

[0017] Fig. 9 is a perspective view of the common rail in a fourth embodiment according to the present invention.

[0018] Fig. 10 is a cross sectional view cut away along a line of X - X' shown in Fig. 9.

[0019] Fig. 11 is a schematic block diagram of another fuel supply system to which the common rail of another preferred embodiment than the first through fourth embodiment according to the present invention is applicable.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS:

[0020] Reference will hereinafter be made to the drawings in order to facilitate a better understanding of the present invention.

(First Embodiment)

[Fuel Supply System]

[0021] Fig. 1 shows a block diagram of a fuel supply system to which a highly pressurized fuel piping in a first preferred embodiment is applicable.

[0022] This fuel supply system includes a common rail 1000 as a highly pressurized piping structure of the internal combustion engine; a fuel injection system 2, and a fuel tank 10. Common rail 1000 includes a piping main body 100; a partitioning wall 111; a first fuel flow passage 101; a second fuel flow passage 102; a fuel introduction portion 103; inserting sections 104a through 104d; and communication portions 105a through 105d. First fuel flow passage 101 and second fuel flow passage 102 are formed with an inside space of the piping main body 100 divided in a vertical direction with a partitioning wall 111 and formed as a cavity space mutually juxtaposed. Fuel introduction portion 103 is disposed at one end portion

of first fuel flow passage 101 and is connected with a high pressure supplying tube 3. It is noted that fuel introduction portion 103 is formed on a left end portion of first fuel flow passage 101 and is connected to high pressure supply tube 3. However, an appropriate modification of fuel introduction portion 103 may be made according to an engine layout. For example, fuel introduction portion 103 may be formed at a right end portion of first fuel flow passage 101 or may be formed in a midway through first fuel flow passage 101 or second fuel flow passage 102.

**[0023]** Inserting portions 104a through 104d have openings to insert fuel injection devices 2a through 2d each corresponding to the respective engine cylinders. Communication portions 105a through 105d are mutually communicated with first and second fuel flow passages 101 and 102. The number of communication portions 105a through 105d are the same as the number of inserting portions 104a through 104d. However, the number of communication portions 105a through 105d may be less than the number of inserting portions 104a through 104d. In addition, a fuel pressure sensor 5 is disposed on first fuel flow passage 101 to detect a fuel pressure within an inner part of the piping main body 100.

**[0024]** Fuel injection devices 2a through 2d are inserted into inserting portions 104a through 104d. A fuel input side of each fuel injection device is disposed on second fuel flow passage 102 and a fuel output side thereof is inserted in a corresponding cylinder of engine cylinders. Each fuel injection device 2a through 2d serves to inject the fuel in the inner part of piping main body 100.

**[0025]** Fuel tank 10 accumulates the fuel, the accumulated fuel being supplied to pressure regulator 11 by means of a low pressure pump 9. Pressure regulator 11 is connected to a high-pressure pump 6 via a low-pressure supply tube 7. A low-pressure return tube 12 is connected to pressure regulator 11. Pressure regulator 11 serves to return an extra fuel to fuel tank 10 via a low-pressure return tube 12. Thus, the pressure adjusted fuel is set to high-pressure pump 6. High-pressure pump 6 is connected to first fuel passage 101 via highly pressurized supply tube 3 and fuel introduction portion 103 to raise the fuel pressure supplied from pressure regulator 11 and is supplied to first fuel flow passage 101. In addition, a relief valve 4 is disposed on first fuel flow passage 101. Relief valve 4 is connected to fuel tank 10 via a return tube 8. Relief valve 4 is opened in a case where a detected value of fuel pressure sensor is equal to or larger than a predetermined value. By returning the fuel in the piping main body 100 to fuel tank 10, the fuel pressure within piping main body 100 does not exceed the predetermined value. Relief valve 4 is installed on an upper part of first fuel flow passage 101. An appropriate modification of relief valve disposition may be made in accordance with the engine layout. For example, relief valve 4 may be disposed in a midway through on either end portion of first fuel flow passage 101 or

second fuel flow passage 102.

[common rail]

**[0026]** Fig. 2 is a perspective view of a common rail 1000. Fig. 3 is a cross sectional view cut away along a line of III - III'. In Figs. 2 and 3, the same reference numerals designate corresponding elements as those shown in Fig. 1.

**[0027]** Common rail 1000 is manufactured using an aluminum die-cast method. Specifically, using a core inserted from a horizontal direction (left or right direction) and using another core inserted from a vertical direction, first fuel flow passage 101, second fuel flow passage 102, inserting portions 104a through 104d, communicating portions 105a through 105d, an opening section of fuel exhaust portion 106, and an opening portion of a sensor attaching portion 107 are formed. A partitioning wall 111 is integrally formed with an outer peripheral wall 112 of piping main body 100 in a case where the cores are used to form first fuel flow passage 101 and second fuel flow passage 102 during the casting. First fuel flow passage 101 and second fuel flow passage 102 are partitioned by means of partitioning wall 111 within piping main body 100 and are formed mutually substantially (or approximately) parallel to each other. A left end portion of first fuel flow passage 101 is provided with an opening portion 103 opened in an elongate direction thereof. Opening portion 103 constitutes fuel introduction portion 103. In addition, a right end portion of first fuel flow passage 101 is provided with an integrally formed fuel exhaust portion 106. Fuel exhaust portion 106 is provided with an opening portion. Relief valve 4 is attached onto this opening portion of fuel exhaust portion 106. A sensor attaching portion 107 is extended in an upward direction and is integrally formed on a left side end portion of first fuel flow passage 101. Sensor attaching portion 107 is provided with an opening, this opening thereof being opened in the upward direction and communicated with first fuel flow passage 101. A fuel pressure sensor 5 is attached onto the opening portion of the sensor attaching portion 107. An opening portion 108 is provided with second fuel flow passage 102 to open in an elongate direction at the leftmost (left side end) portion. A plug 109 is fitted into the opening portion 108 so as to be closed. Inserting portions 104a through 104d are formed integrally with second fuel flow passage 102 and have opening portions. These opening portions are communicated with second fuel flow passage in a downward direction. These opening portions of inserting portions 104a through 104d are inserted with fuel injection devices 2a through 2d. Communication portions 105a through 105d are communicated with first fuel flow passage 101 and second fuel flow passage 102. Communication portions 105a through 105d are arranged at positions corresponding to inserting portions 104a through 104d.

**[0028]** If viewed from each inserting direction from in-

serting portion of 104a through 104d (in arrow-marked directions of Fig. 2 and 3), the openings of communication portions 105a through 105d are included in an opening range of inserting portions 104a through 104d.

**[0029]** Figs. 4A through 4C are views for explaining a relationship between inserting portion 104a as viewed from the arrow-marked directions of Figs. 2 and 3. As an example, Figs. 4A through 4C show a relationship between inserting portion 104a and communicating portion 105a. The relationship between the other inserting portions 104b through 104d and communicating portion 105b through 105d is the same. In Fig. 4A, inserting portion 104a is coaxial with the opening of communicating portion 105a and the opening of communicating portion 105a is smaller than inserting portion 104a. In Fig. 4B, inserting portion 104a is not coaxial with the opening of communicating portion 105a but is larger than the opening of communicating portion 105a. In Fig. 4C, the opening of the inserting portion 104 is coaxial with communicating portion 105a and has the same diameter as the opening of the inserting portion. The openings of communication portions 105a through 105d are formed in the magnitude and positional relationship to any one of Figs. 4A through 4C.

**[0030]** Since the openings of communication portions 105a through 105d are formed to be included in the opening range of inserting portions 104a through 104d, a common core is used to form simultaneously mutually corresponding communication portions 104a through 104d in a case where common rail 1000 is manufactured with the aluminum die-cast method. In a case where the openings of communication portions 105a through 105d and inserting portions 104a through 104d are coaxial and have the same diameters, it is easy to form the core. In addition, after the casting step is completed, a cutting drill is used to open an inserting portion 104a through 104d. In a case where the openings of the communication portions 105 through 105d and inserting portions 104a through 104d can simultaneously be formed at once opening operation.

**[0031]** In addition, main body attaching portions 110a through 110d are formed which extend in a vertical direction on a side surface of the piping main body 100. penetrating holes are formed through the vertical direction of main body attaching portions 110a through 110d. When common rail 1000 is attached, bolts are penetrated through penetrating holes of main body attaching portions 110a through 110d to tighten the bolts onto a cylinder block of the engine to fix piping main body 100. At this time, fuel injection devices 2a through 2d inserted into inserting portions 104a through 104d are grasped from the vertical (upper and lower) direction by means of an upper part of piping main body 100 and the cylinder at a lower side thereof.

(1 - 2) Action

**[0032]** In common rail 1000 in this embodiment ac-

cording to the present invention, the fuel from fuel tank 10 is introduced through fuel introduction portion 103 and is filled within first fuel flow passage 101 and second fuel flow passage 102 via communication portions 105a through 105d. The fuel is accumulated in first fuel flow passage 101 and second fuel flow passage 102. Thereafter, when the fuel pressure measured by fuel pressure sensor 5 becomes a desired value, a given amount of fuel is speedily injected from respective fuel injection devices 2a through 2d into the respectively corresponding cylinders in a predetermined order. In addition, immediately after the fuel injection, the fuel is supplied speedily to fuel injection devices 2a through 2d via communication passages 105a through 105d positioned on just above fuel injection devices 2a through 2d. If the fuel pressure is in excess of a predetermined value, relief valve 4 is opened and the fuel within piping main body 100 is returned within fuel tank 10 to prevent the fuel pressure from being equal to or higher than a predetermined value.

**[0033]** In addition, the hoop stress applied to the inner wall of piping main body 100 is diverged with two fuel flow passages of first and second fuel flow passages 101 and 102 provided. Although it is necessary to provide the piping thickness of 5.5 mm in order to secure a strength of the piping with the same value secured with one fuel flow passage as in the case of the previously proposed piping structure. However, in this embodiment, the hoop stress is distributed (diverged) by means of the two fuel flow passages so that the necessary strength can be reduced. The piping thickness in this embodiment was 4 mm. Thus, a light weight of common rail 1000, small sizing, and a manufacturing cost reduction can be achieved.

(1-3 Advantages)

**[0034]** In common rail 1000 in the first embodiment according to the present invention, even if the fuel pressure at a portion of common rail placed in the vicinity to each of inserting sections 104a through 104d through fuel injection is reduced, the fuel is speedily supplied into inserting portion 104a through 104d via communication portions 105a through 105d included within the opening range of inserting portion 104a through 104d. Thus, a delay in a recovery of fuel pressure between each fuel injection device 2a through 2e immediately after the fuel injection can be uniformized and deviation in each fuel injection quantity can be reduced.

**[0035]** In addition, since high pressure tube 3 and return pipe 8 are communicated with each other at first fuel flow passage 101, a ripple developed due to the fuel injection is reduced by means of an inside of second fuel flow passage 102 and partition wall 111 and the ripple to be propagated toward highly pressurized supply pipe 3 and return pipe 8 via first fuel flow passage 101 can be reduced.

**[0036]** In addition, in common rail 1000 in the first pre-

ferred embodiment according to the present invention, since the deviation in the fuel injection quantity between each of fuel injection devices 2a through 2d by means of the plurality of communication passages 105a through 105d can be reduced, the pressure regulator constituting the fuel return system is not specially needed to be installed. The number of parts are accordingly reduced. Thus, a manufacturing cost can be reduced.

**[0037]** In addition, since in the common rail in the first embodiment according to the present invention, the hoop stress can be diverged due to the presence of the plurality of fuel flow passages (first fuel flow passage 101 and second fuel flow passage 102), the required piping strength can be reduced and the thickness of the piping can be thinned. Thus, the right-weight, small-sizing, and cost-reduction can be achieved. In addition, the small sizing of common rail 1000 makes an influence of the engine lay-out condition difficult and a sufficient volume to reduce an abnormal ripple sound can be secured. Consequently, a sound prevention protector to countermeasure the ripple abnormal sound generation is especially not needed. Thus, the reduction of the number of parts and the cost reduction in manufacture can be achieved. In addition, in a case where the aluminum die-cast method is applied to manufacture common rail 1000, the thickness of piping main body 100 becomes thick, there may be a high possibility that shrinkage cavities and a deviation in densities are developed. According to common rail 1000 in the first embodiment, the thickness of piping main body 100 can be thinned and the developments in the shrinkage cavities and density deviation can be prevented from occurring.

**[0038]** Furthermore, in common rail 1000 according to the present invention, partitioning wall 111 is integrally formed with outer peripheral wall 112. Hence, the number of parts can be reduced and the manufacturing process can be simplified. Consequently, the cost of the manufacturing of common rail 1000 can be reduced.

**[0039]** Still furthermore, in common rail 1000 in the first embodiment according to the present invention, the openings of communication portions 105a through 105d are formed so as to be included in the opening range of inserting portions 104a through 104d. Hence, a common core can be used to simultaneously cast mutually corresponding communication portions 105a through 105d together with inserting portions 104a through 104d. Or alternatively, after the casting process, a cutting drill is used to open inserting portions 104a through 104d and communication portions 105a through 105d. Thus, communicating portions 105a through 105d and inserting portions 104a through 104d can easily be manufactured. Thus, the manufacturing process can be simplified and the manufacturing cost can be reduced.

(Second Embodiment)

(2-1) Structure

**[0040]** Fig. 5 shows a perspective view of common rail 2000 in a second preferred embodiment according to the present invention. Fig. 6 shows a cross sectional view cut away along a line of VI-VI' in Fig. 5. In the second embodiment, each communication portion 205a through 205d is positioned not so as to correspond to each inserting portion 204a through 204d but is formed at a position deviated from each inserting portion 204a through 204d.

(2-2) Action and Advantage

**[0041]** Communication portions 205a through 205d are not disposed on a straight above of the inserting portions 204a through 204d, in common rail 2000 in the second embodiment. Hence, a pressure ripple developed in a proximity to inserting portions 204a through 204d is caused to be diffused (irregular reflection) and can be reduced. Thus, the pressure ripple is transmitted to high pressure supply tube 3 and return pipe 8 via communication portions 205a through 205d so that the development in the abnormal sound can be prevented.

(Third Embodiment)

(3-1) Structure

**[0042]** Fig. 7 shows a perspective view of common rail 3000 in a third preferred embodiment according to the present invention. Fig. 8 is a cross sectional view cut away along a line of VII - VII' of Fig. 7. In this embodiment, fuel exhaust portions 106 and 206 are not formed which communicate in the upward direction from first fuel flow passage 301. Openings 108 and 208 are not formed on rightmost end portion of first fuel flow passage 302. An opening 308 is formed on a leftmost end portion of second fuel flow passage 302. Then, opening portion 303 is set as fuel introduction portion 303, opening portion 308 is set as fuel exhaust portion 308. Then, fuel introduction portion 303 is connected to high pressure supply tube 3. Relief valve 4 is disposed on fuel exhaust portion 308. On the contrary, opening portion 303 is set as fuel exhaust portion 303 and opening portion 308 is set as fuel introduction portion 308. Then, relief valve 4 may be disposed on fuel exhaust portion 303 and the highly pressurized supply tube 3 may be connected to fuel introduction portion 308.

(3-2) Action and advantage

**[0043]** In common rail 3000 in the third preferred embodiment according to the present invention, first fuel flow passage 301 and second fuel flow passage 302 are formed. Simultaneously, fuel introduction portion 303

and fuel exhaust portion 308 may be formed. In addition, it is not necessary to specifically form fuel introduction portions 106 and 206. Thus, the manufacturing process can be simplified and the manufacturing cost can be reduced.

(Fourth Embodiment)

(4-1) Structure

**[0044]** Fig. 9 shows a perspective view of a common rail 4000 in the fourth preferred embodiment according to the present invention. Fig. 10 is a cross sectional view cut away along a line of x - x' in Fig. 10. In the fourth embodiment, the number of communication portions 405a through 405d becomes smaller (less) than that of inserting portions 404a through 404d. In the fourth embodiment, each communication portion 405a through 405c is arranged on an approximately middle portion of each inserting portion 404a through 404d along an elongate direction of piping main body 400.

(4-2) Action and advantage

**[0045]** In common rail 4000 in the fourth preferred embodiment, the number of communication portions 405a through 405c are less than that of inserting portions 404a through 404d. However, even in this case, the presence of the plurality of communication portions 405a through 405c disposed in the proximity to inserting portions 404a through 404d permits the deviations in the fuel recoveries of fuel injection devices 2a through 2d to be reduced. An uniform injection of the fuel injection quantities for the respective fuel injection devices 2a through 2d can be achieved.

(Another Embodiment)

**[0046]** In the above-described embodiment, two fuel flow passages 101 and 102 are provided. However, three fuel flow passages (101, 102, and 102A shown in Fig. 11) and the fuel introduction portions may be formed so as to be communicated with any fuel flow passage and mutually adjoining fuel flow passages may be communicated with any other fuel flow passage. In this case, the hoop stress applied to the inner wall of common rail 1000 is furthermore diverged and the thickness of the piping can be thinned. It is noted that, in Fig. 11, reference numeral 111A denotes another partitioning wall than the partitioning wall of 111 and communication portions 105A, 105B, 105C, and 105D are formed, third fuel flow passage 102A is formed, and the other structure is generally the same as shown in Fig. 1.

**[0047]** The entire contents of a Japanese Patent Application No. 2002-317565 (filed in Japan on October 31, 2002) are herein incorporated by reference. The scope of the invention is defined with reference to the following claims.

## Claims

1. A highly pressurized fuel piping for an internal combustion engine, the internal combustion engine comprising: a fuel tank (10); and a plurality of fuel injection devices (2a through 2d) into each of which a fuel supplied from the fuel tank is distributed, the highly pressurized fuel piping comprising:
  - a piping main body (100, 200, 300, 400) having an outer peripheral wall and a partitioning wall (111, 211, 311, 411, 111A) formed integrally with the outer peripheral wall;
  - at least two of first and second fuel flow passages (101, 102, 201, 202, 301, 302, 401, 402), divided with the partitioning wall of the piping main body, formed within an inner space of the piping main body, and extended mutually approximately in parallel to each other;
  - a fuel introduction portion (103, 203, 303, 403) formed to communicate with the first fuel flow passage;
  - a plurality of inserting portions (104a through 104d, 204a through 204d, 304a through 304d, 404a through 404d) formed to communicate with at least one of the first and second flow passages, through each of which a corresponding one of the fuel injection devices is insertable; and
  - a plurality of communication portions (105a through 105d, 205a through 205d, 305a through 305d, 405a through 405d, 105A through 105D) through which the first and second fuel flow passages are mutually communicated.
2. A highly pressurized fuel piping for an internal combustion engine as claimed in claim 1, wherein each of the plurality of communication portions (105a through 105d) is arranged at positions corresponding to any one of the plurality of the inserting portions (104a through 104d) in such a manner that an opening of each of the plurality of the communication portions is included within an opening range of a corresponding one of the inserting portions as viewed from an inserting direction.
3. A highly pressurized fuel piping for an internal combustion engine as claimed in claim 2, wherein each of the plurality of communication portions is arranged coaxially (Fig. 4A) with the corresponding one of the inserting portions at the position of the piping main body corresponding to any one of the plurality of the inserting portions.
4. A highly pressurized fuel piping for an internal combustion engine as claimed in either claim 2 or claim 3, wherein the number of the communication por-

tions (105a through 105d) are equal to that of the inserting portions (104a through 104d).

5. A highly pressurized fuel piping for an internal combustion engine as claimed in claim 1, wherein the plurality of communication portions (105a through 105c) are arranged along an elongate direction of the piping main body with positional offset provided against any one of the plurality of inserting portions (104a through 104d). 5 10
6. A highly pressurized fuel piping for an internal combustion engine as claimed in either claim 2 or claim 5, wherein the number of the communication portions (105a through 105c) are less than that of the inserting portions (104a through 104d). 15
7. A highly pressurized fuel piping for an internal combustion engine as claimed in any one of the preceding claims 1 through 6, wherein the plurality of inserting portions (104a through 104d) are formed to communicate with the second fuel flow passage (102). 20
8. A highly pressurized fuel piping for an internal combustion engine as claimed in any one of the preceding claims 1 through 7, wherein at least another fuel flow passage (102A) is extended in substantially parallel to the first and second fuel flow passage and is communicated with at least one of the first and second fuel flow passages (101 or 102). 25 30
9. A highly pressurized fuel piping for an internal combustion engine as claimed in any one of the preceding claims 1 through 8, wherein the fuel introduction portion (103) is formed to an opening end of the first fuel flow passage (101). 35
10. A highly pressurized fuel piping for an internal combustion engine as claimed in any one of the preceding claims 1 through 9, wherein a fuel exhaust portion (308) is formed on an opening end (308) of the second fuel flow passage. 40
11. A method applicable to a highly pressurized fuel piping for an internal combustion engine, the internal combustion engine comprising: a fuel tank (10); and a plurality of fuel injection devices (2a through 2d) into each of which a fuel supplied from the fuel tank is distributed, the method comprising: 45 50
  - providing a piping main body (100, 200, 300, 400) having an outer peripheral wall and a partitioning wall (111, 211, 311, 411, 111A) formed integrally with the outer peripheral wall; 55
  - providing at least two of first and second fuel flow passages (101, 102, 201, 202, 301, 302, 401, 402), divided with the partitioning wall of

the piping main body, formed within an inner space of the piping main body, and extended mutually approximately in parallel to each other;

forming a fuel introduction portion (103, 203, 303, 403) to communicate with the first flow passage;

forming a plurality of inserting portions (104a through 104d, 204a through 204d, 304a through 304d, 404a through 404d, 104A through 104D) to communicate with at least one of the first and second flow passages, through each of which a corresponding one of the fuel injection devices is insertable; and forming a plurality of communication portions (105a through 105d, 205a through 205d, 305a through 305d, 405a through 405d, 105A through 105D) through which the first and second fuel flow passages are mutually communicated.

**FIG. 1**

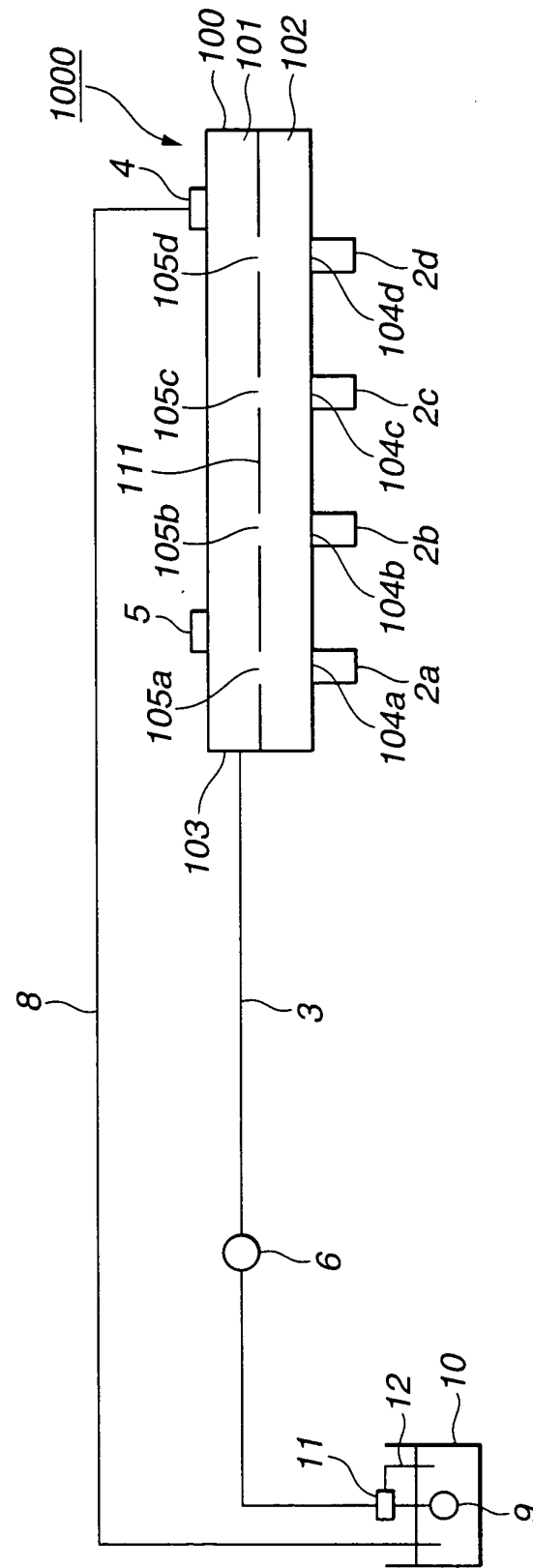


FIG.2

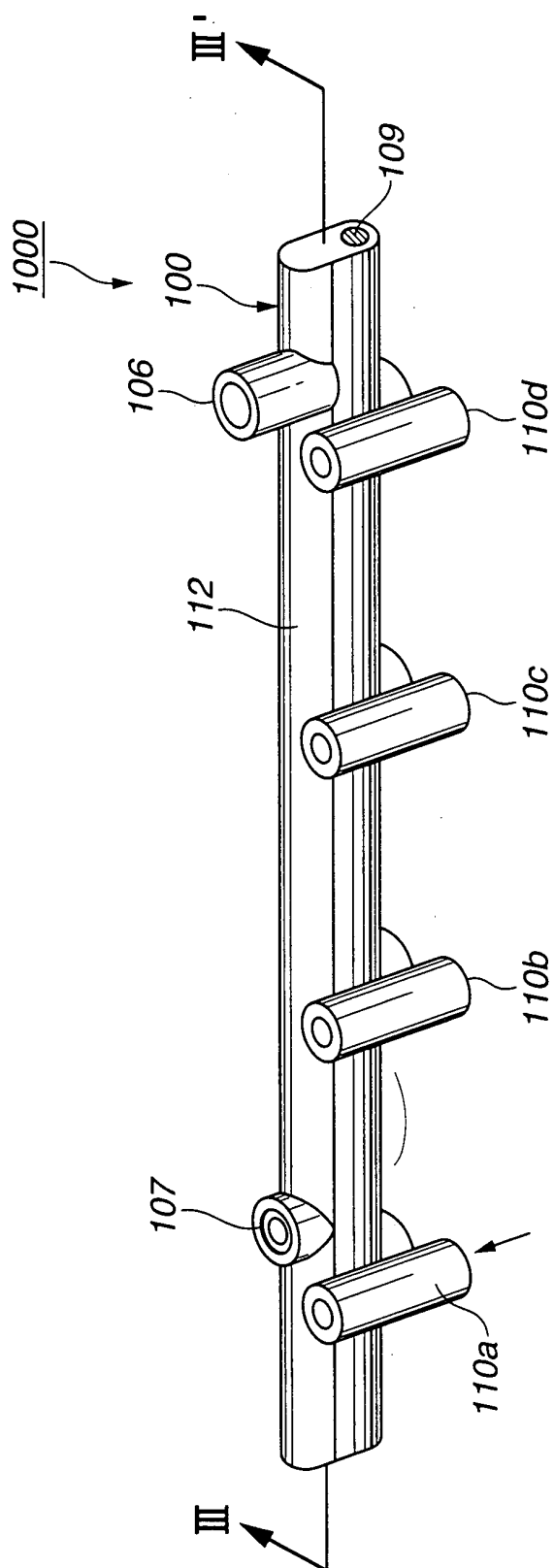
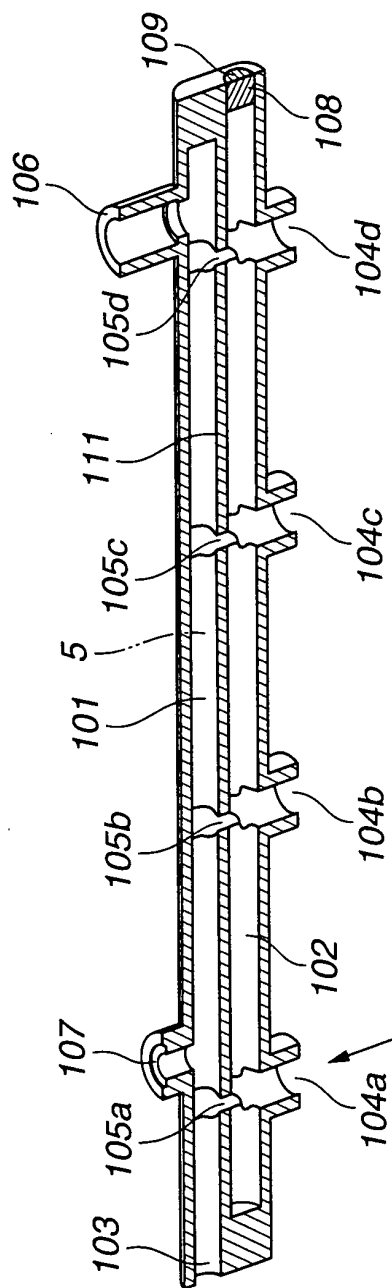
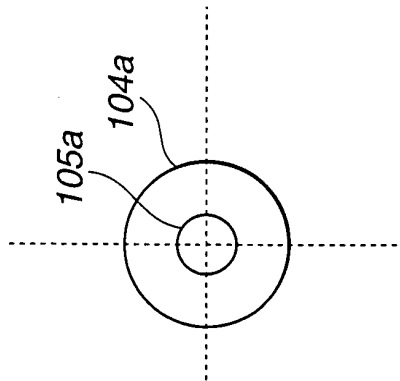


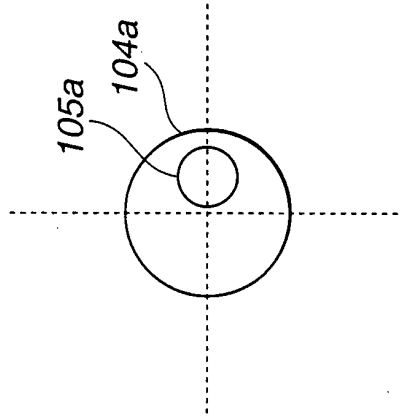
FIG.3



**FIG.4A**



**FIG.4B**



**FIG.4C**

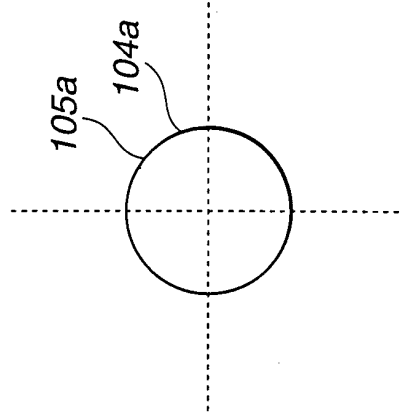


FIG.5

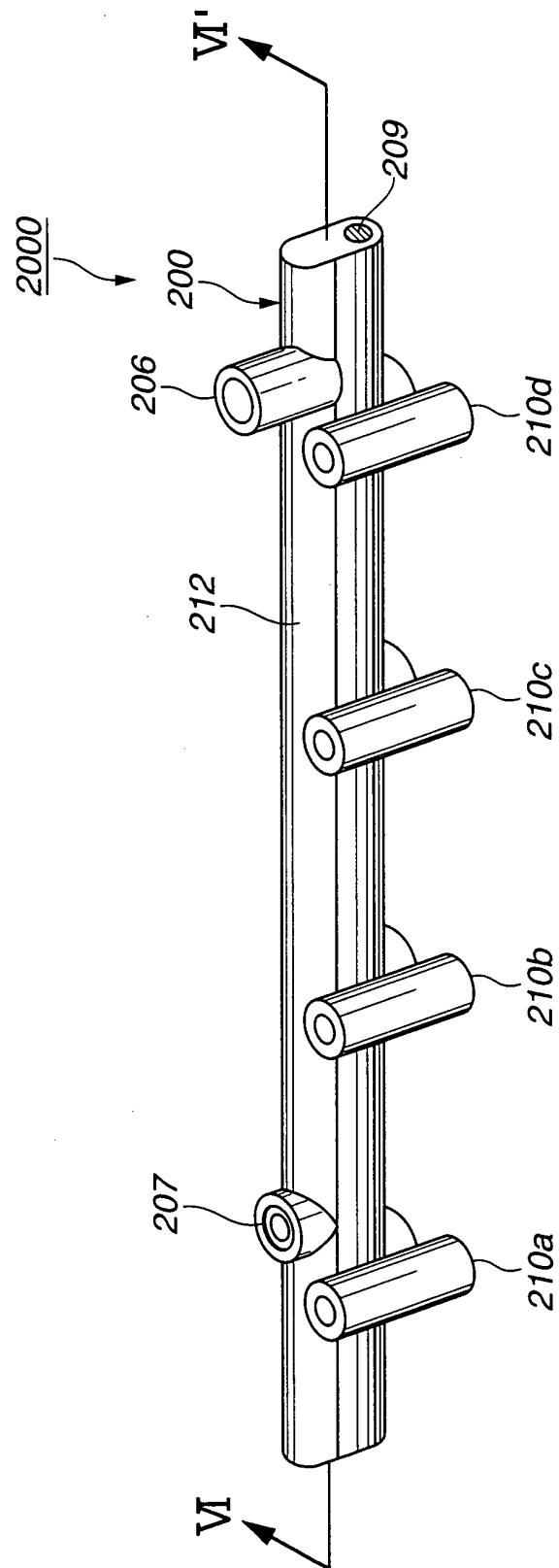


FIG.6

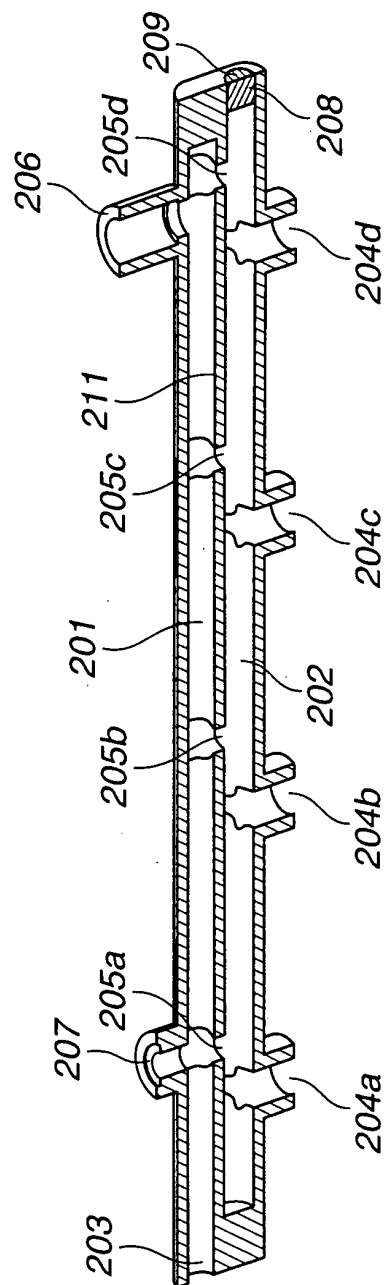


FIG.7

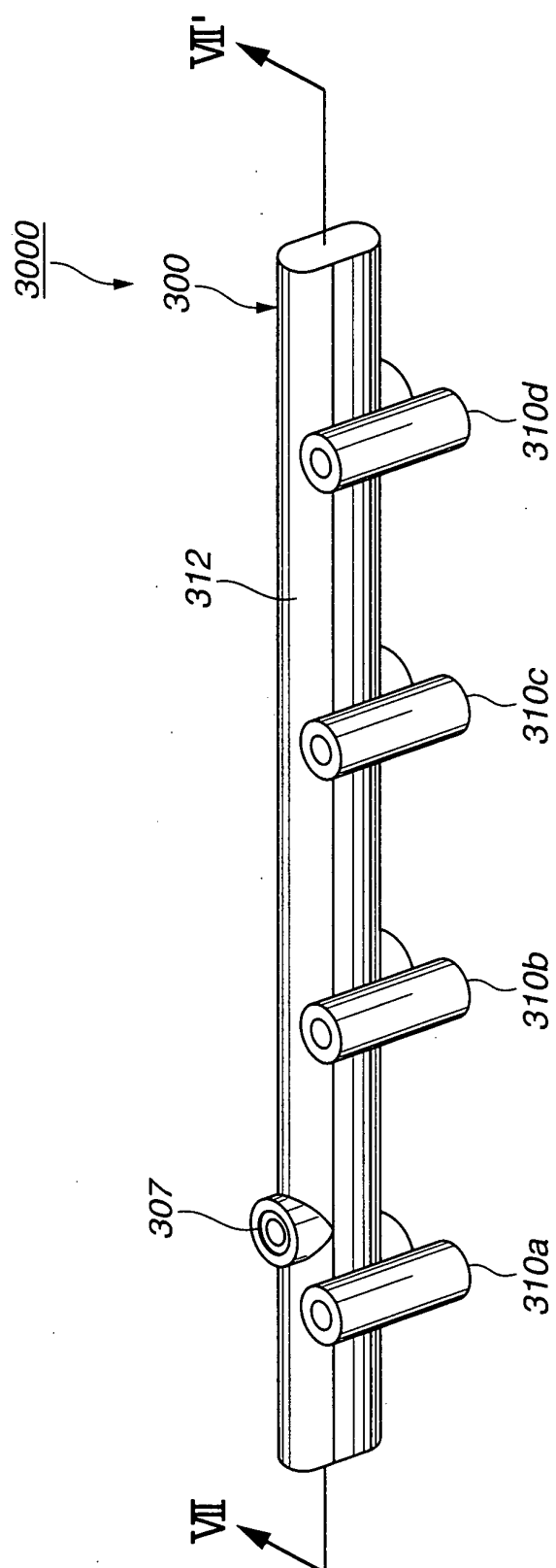


FIG. 8

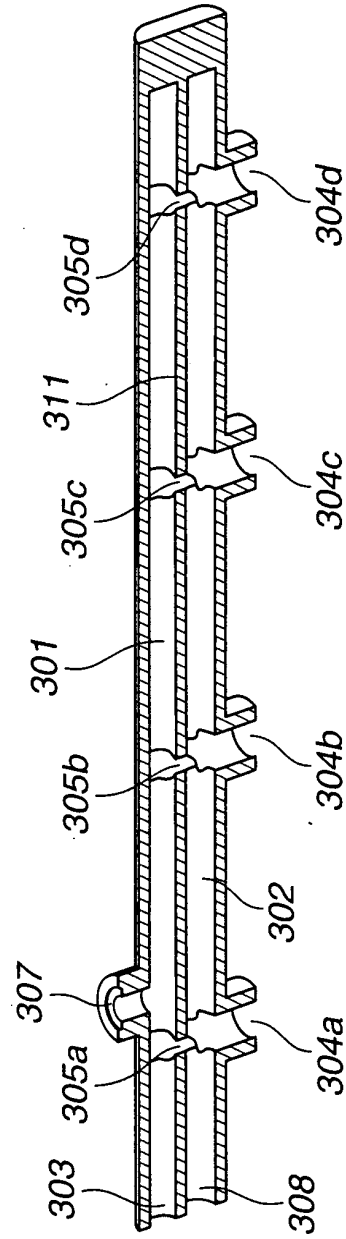


FIG. 9

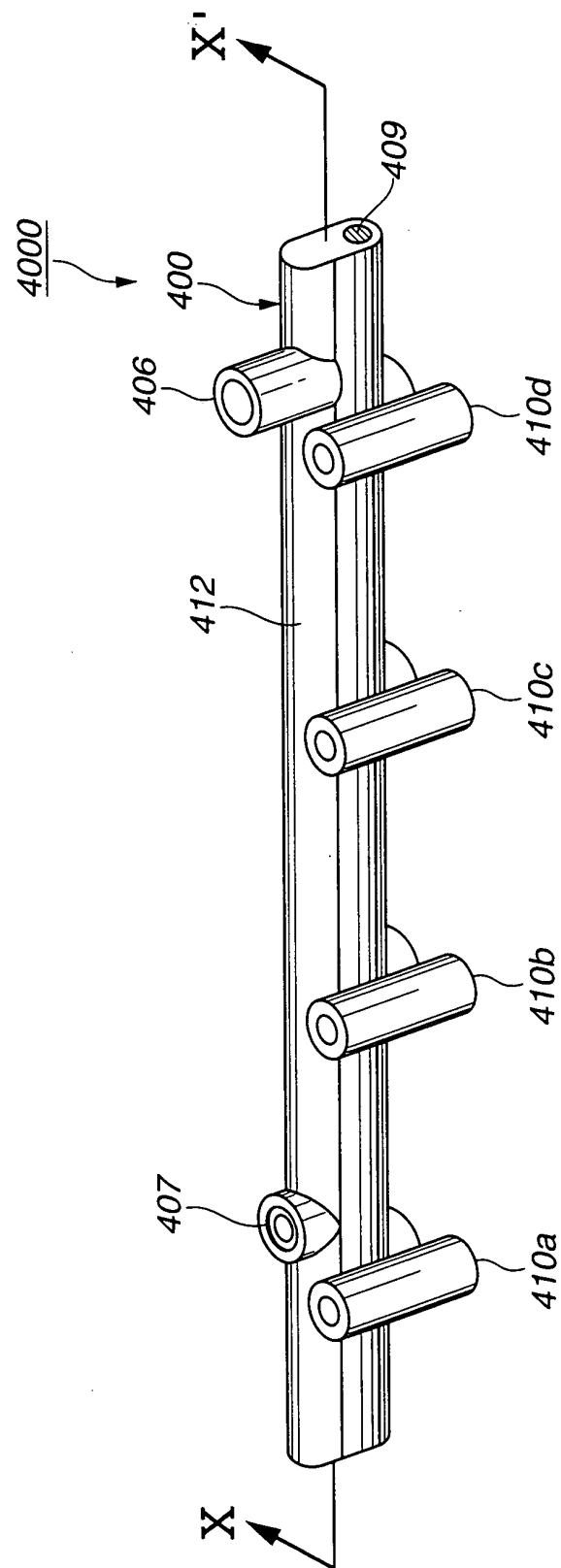


FIG.10

