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(54) Abstract Title
A method of manufacturing a common rail

(57) A method of manufacturing a common rail 1a which can be connected to at least one branch pipe includes the steps of forming a lower hole 3a in a portion of a main tubular rail in the vicinity of a branch hole 5a, eg via an end mill, and generating residual compressive stress in a circumferential part of the end portion of a branch pipe by applying a pressing force, eg via a punch 4. A fine defect occurring in a lower part of the hole, such as a fine crack or a fine slit, is then cut off, eg via a drill. The common rail may be a high-pressure fuel manifold used in an accumulator fuel injection system for a diesel internal combustion engine.

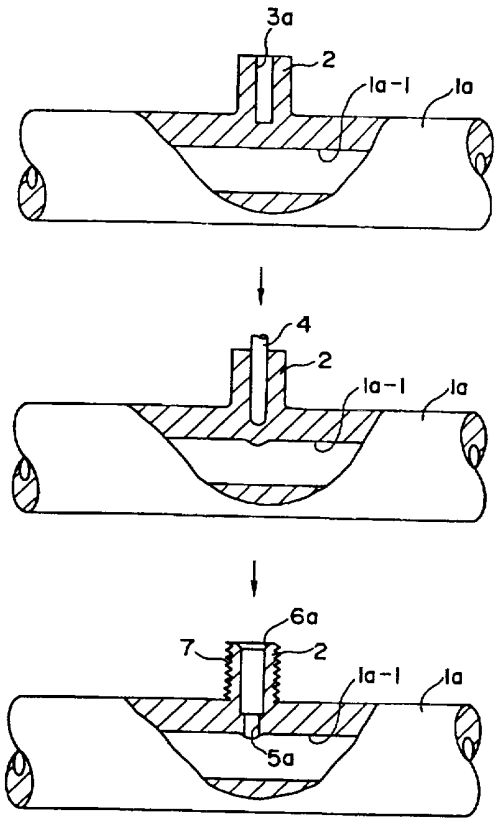

Fig. 1

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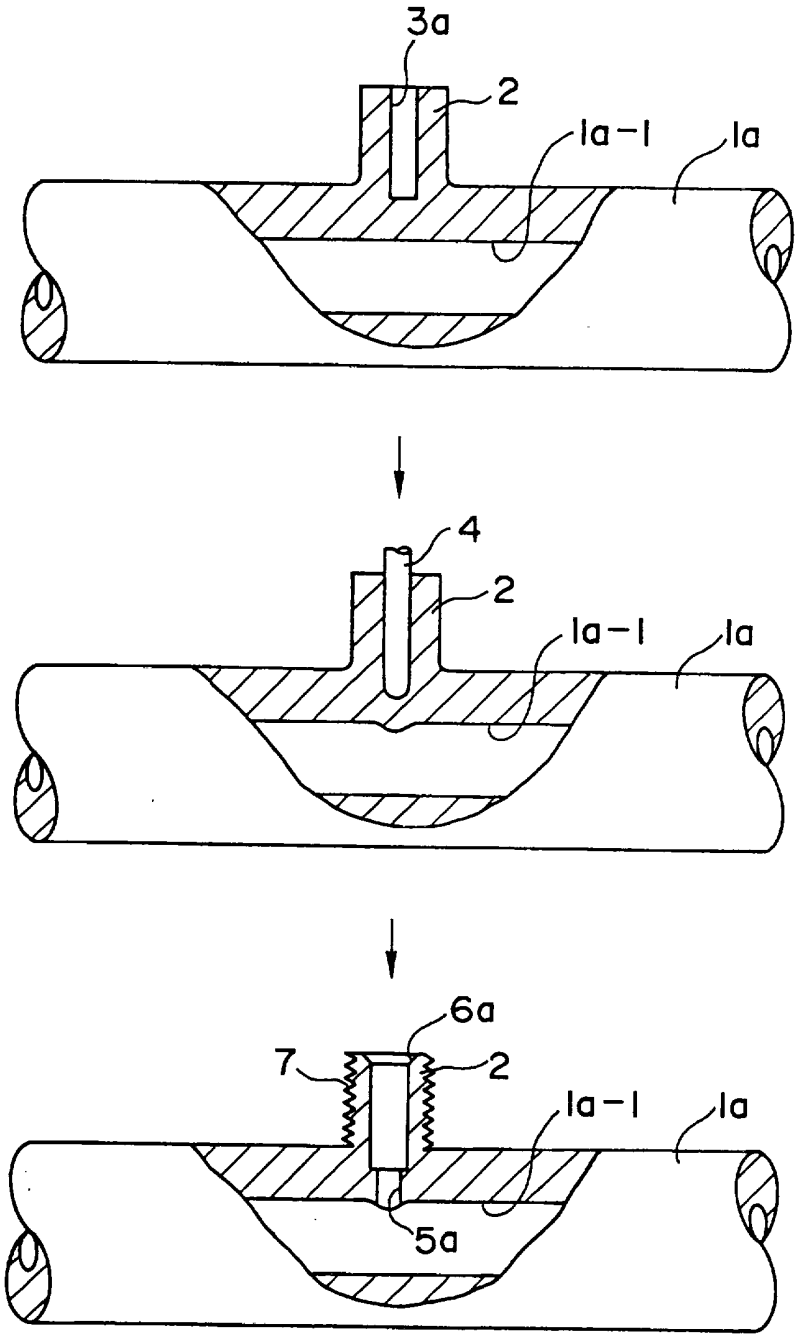

Fig. 1

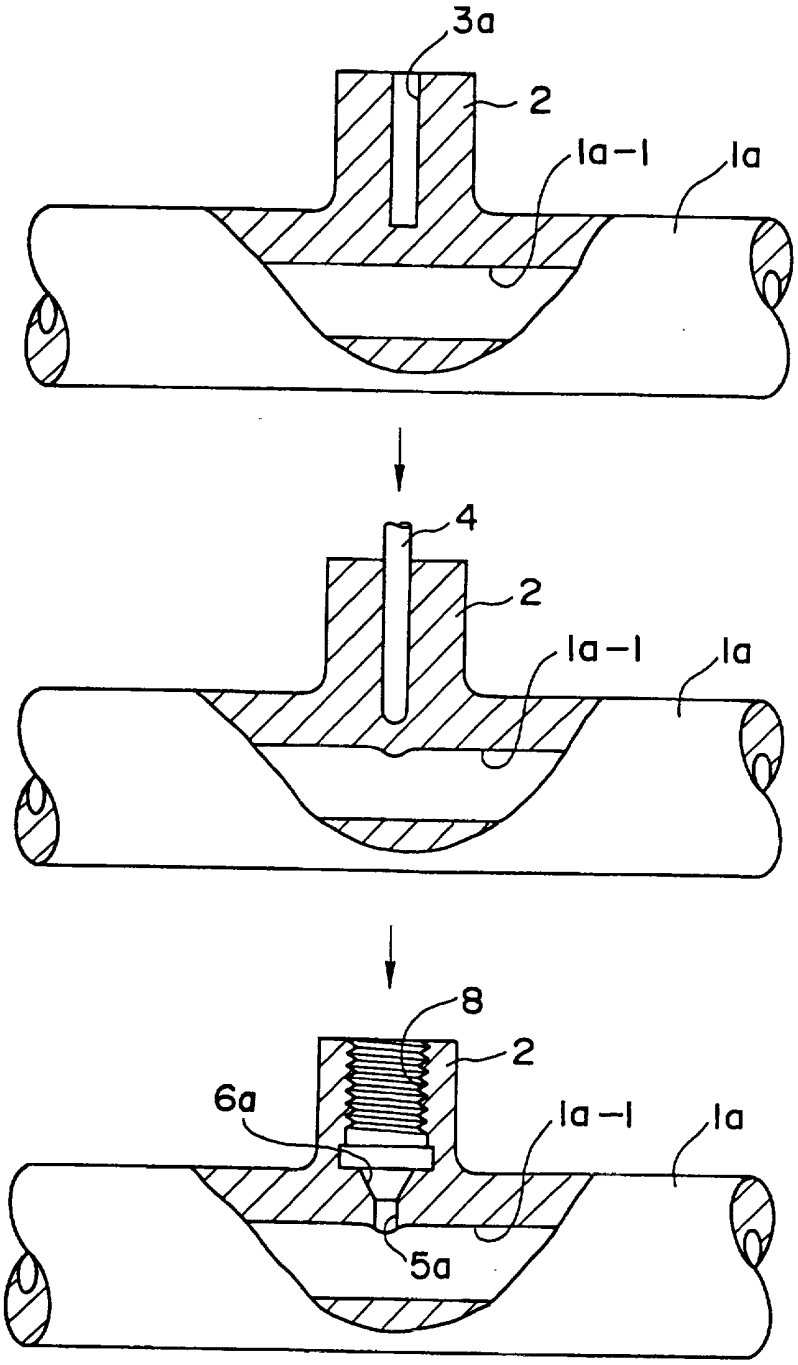

Fig. 2

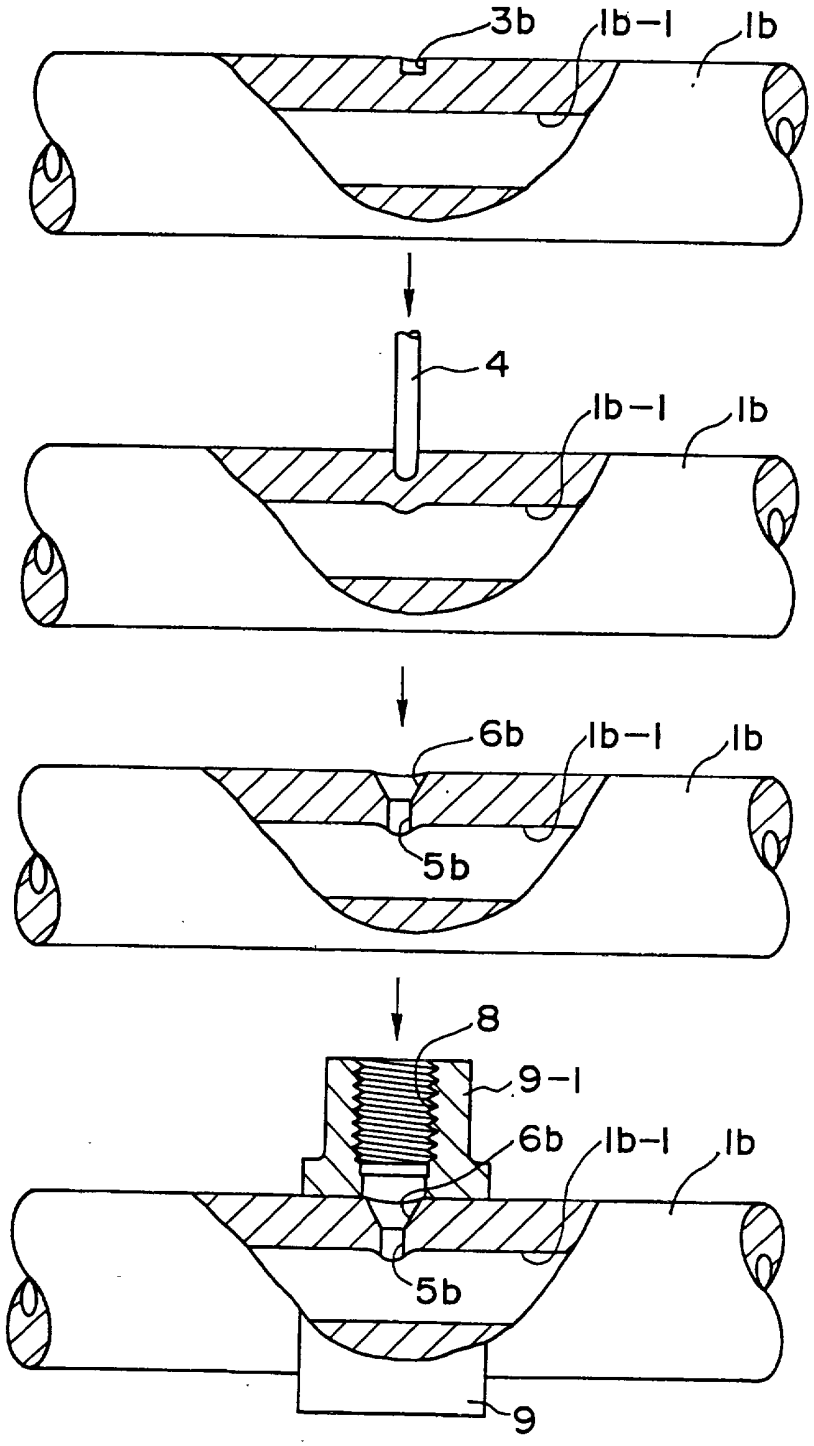

Fig. 3

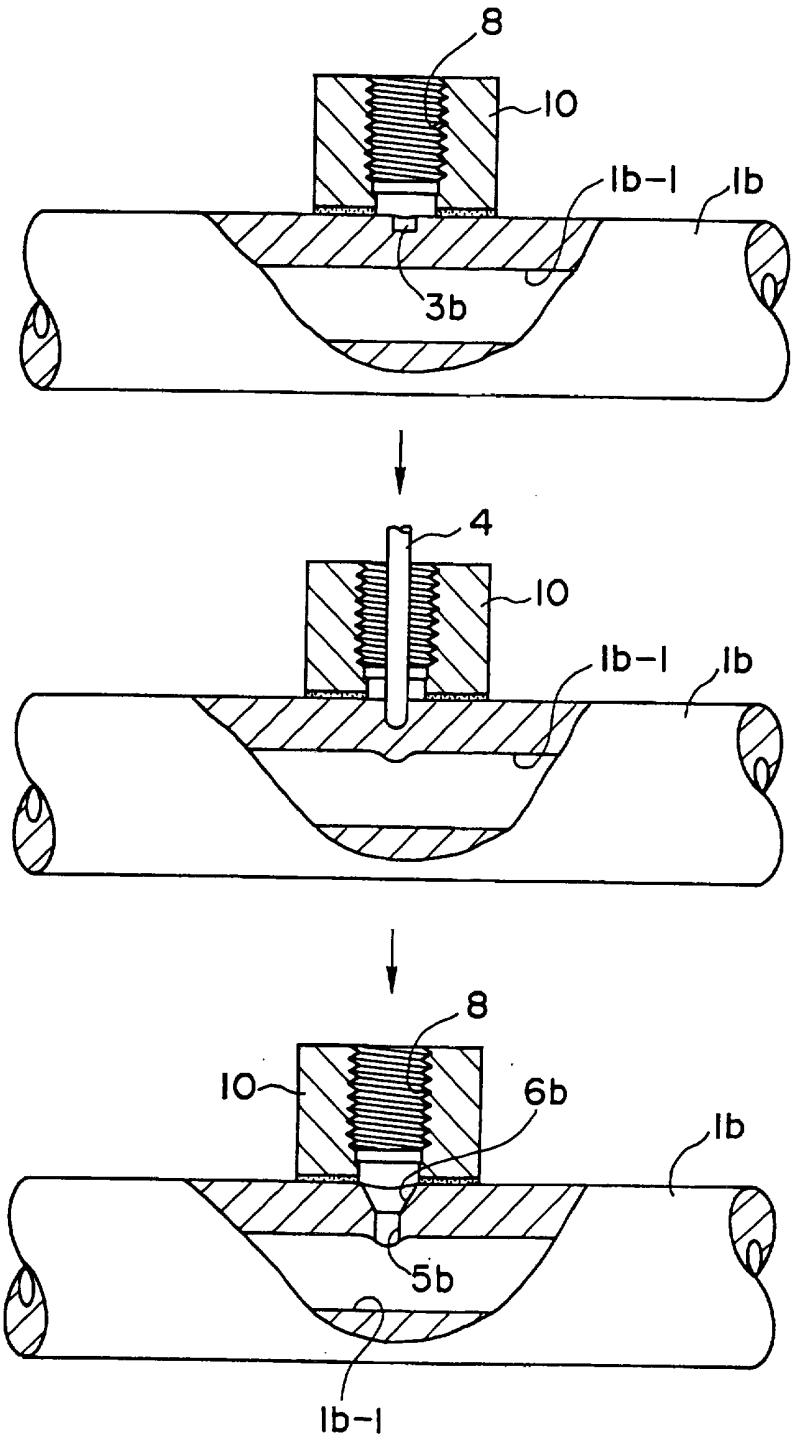

Fig. 4

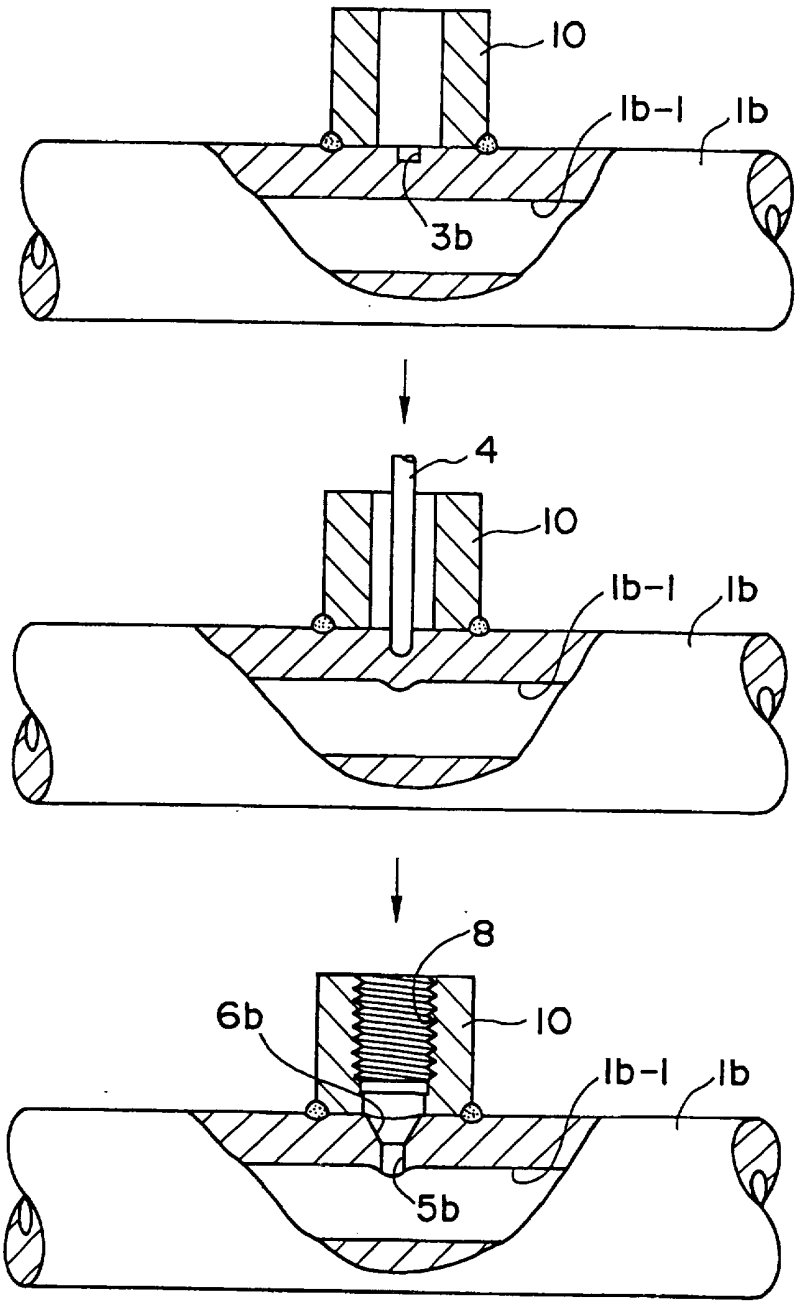

Fig. 5

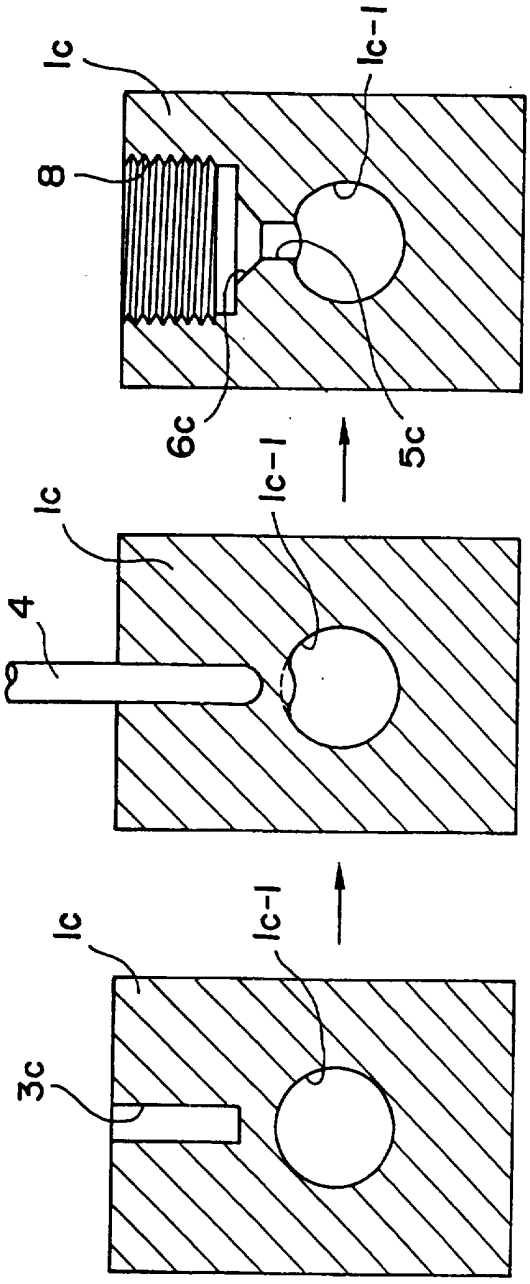

Fig. 6

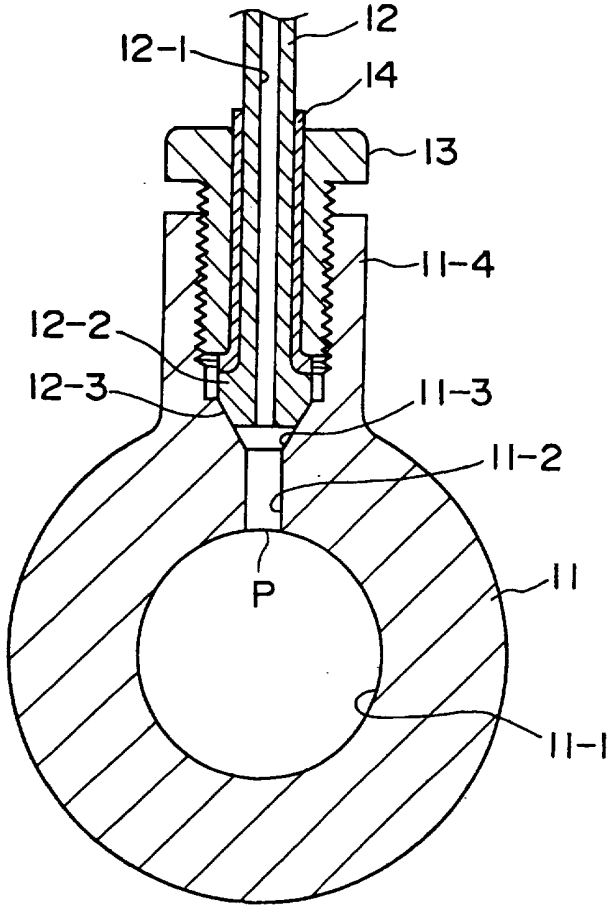

Fig. 7

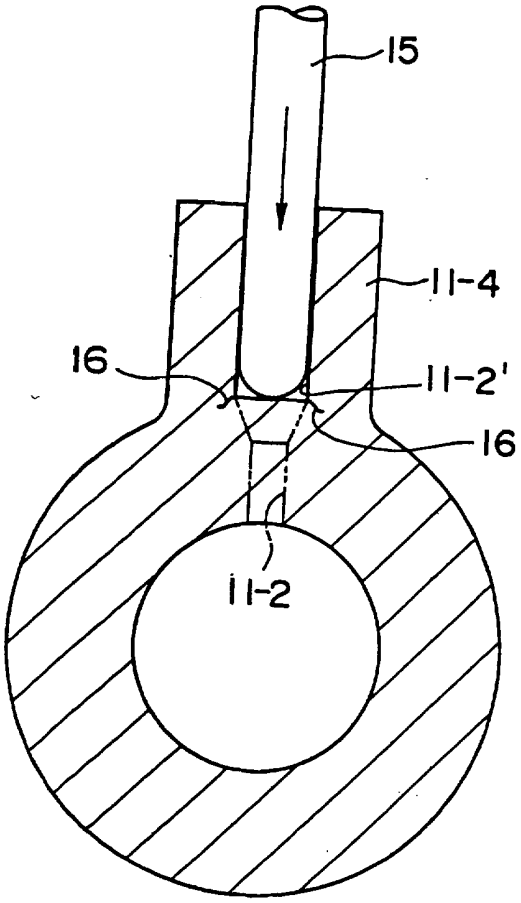

Fig. 8

PROIR ART

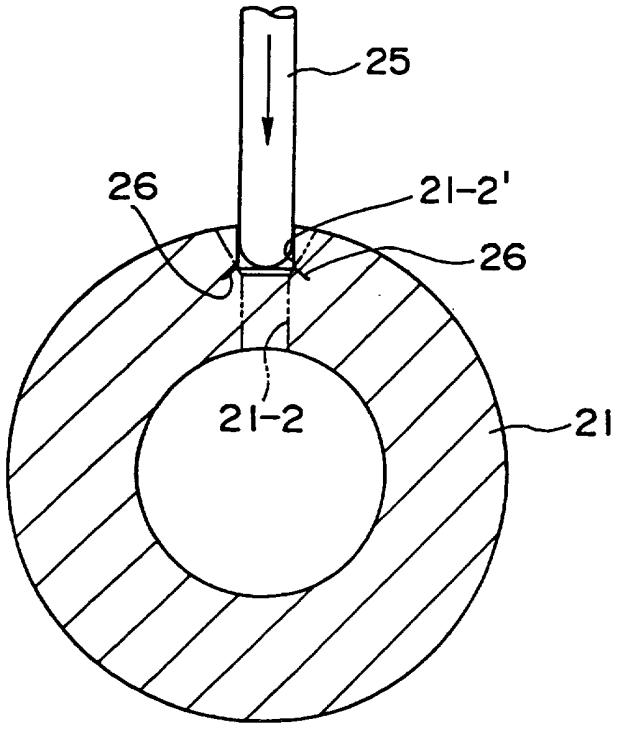

Fig. 9

PROIR ART

TITLE OF THE INVENTION:

METHOD OF MANUFACTIRING COMMON RAILS

BACKGROUND OF THE INVENTION:

Field of the Invention:

This invention relates to a method of manufacturing a common rail, such as a high-pressure fuel manifold or a block rail used generally in an accumulator fuel injection system for a diesel internal combustion engine.

Description of the Related Art:

A common rail of this kind a structural system of which is as shown, for example, in Fig. 7 is known which includes a main tubular rail 11 made of a cross-sectionally circular pipe, plural bosses 11-4 provided on an axially extending wall of the rail 11 so that the bosses are spaced from one another, a branch hole 11-2 formed in each of the bosses 11-4, communicating with a flow passage 11-1 in the main tubular rail 11 and having a pressure receiving seat surface 11-3 opened outward, a branch pipe 12 fitted in the branch hole, and having a joint head 12-2 provided with a pressure seat surface 12-3 engaged with the pressure receiving seat surface 11-3 of the main tubular rail 11, and an external tightening screw type nut 13 fitted around the branch pipe 12 in advance, the nut 13 being screwed into the relative boss 11-4 to thereby fasten and join the branch pipe 12 to the main tubular rail 11 by a pressure of the nut 13 exerted on a bent surface of a neck portion of the joint head

12-2. Referring to the drawing, a reference numeral 12-1 denotes a flow passage in the branch pipe 12, and 14 a tightening sleeve washer.

However, in the case of the common rail shown in Fig. 7 which is formed by providing the branch hole 11-2 in the boss 11-4 made integral with the main tubular rail 11 formed of a cross-sectionally circular pipe, a large tensile stress occurs in an inner circumferential portion P of a lower end of the branch hole 11-2 due to an internal pressure of the main tubular rail 11, and an axial force exerted on the pressure receiving seat surface 11-3 when the joint head 12-2 of the branch pipe 12 is pressed. Consequently, cracks starting from the inner circumferential portion P of the mentioned lower end readily occur, and there is the possibility that the leakage of a fluid occurs.

To solve such problems, the inventor of the present invention previously proposed a common rail capable of reducing a maximum value of the stress occurring in the inner circumferential portion of the lower end of the branch hole, and thereby improving the internal pressure fatigue strength thereof. This common rail is a common rail including a main tubular rail having therein an axially extending flow passage, at least one boss formed on an axially extending circumferential wall of the main tubular rail so as to be integral therewith, a branch hole formed in the boss and having a pressure receiving

seat surface communicating with the flow passage and opened outward, a branch pipe fitted in the branch hole and having a flow passage communicating with the flow passage in the rail, and a pressure seat surface which is formed on a joint head formed at an end portion of the branch pipe, and which is engaged with the pressure receiving seat surface, and a tightening nut fitted around the branch pipe in advance, the nut being screwed into the boss to fasten and join the branch pipe to the main tubular pipe by a pressure occurring due to the screwing force and exerted on a bent surface of a neck portion of the joint head; or a common rail including a main tubular rail having therein an axially extending flow passage, at least one branch hole provided in an axially extending circumferential wall of the main tubular rail, a branch pipe joined to a circumferential surface portion of the branch hole and having a flow passage communicating with the flow passage of the rail, an outwardly opened pressure receiving surface of the branch hole with which the pressure seat surface formed on the joint head provided at the end portion of the branch pipe is engaged, a separately formed metal joint fixed to the main tubular rail, and a tightening nut fitted around the branch pipe in advance, the metal joint and tightening nut being screwed on each other to press a bent surface of a neck portion of the joint head, whereby the branch pipe and main tubular rail are fastened and joined to each other; or a common rail including a block rail having

a flow passage in an axially extending inner portion thereof, at least one joint hollow provided in an axially extending circumferential wall of the block rail, a branch hole provided in the joint hollow, communicating with the flow passage and having an outwardly opened pressure receiving seat surface, a branch pipe inserted in the branch hole, having therein a flow passage communicating with the flow passage in the block rail, and a pressure seat surface which is formed on a joint head provided at an end portion thereof, and which is engaged with the pressure receiving seat surface, and a tightening nut fitted around the branch pipe in advance, the joint hollow and tightening nut being screwed on each other to press a bent surface of a neck portion of the joint head, whereby the branch pipe and block rail are fastened and joined to each other, in all of which common rails residual compressive stress is made to exist in a circumferential part of the end portion of the branch pipe which is opened into the flow passage in the main tubular rail or block rail. Namely, making residual compressive stress exist in the circumferential part of the end portion of branch pipe which is opened into the flow passage in the main tubular rail or block rail causes the stress, which occurs in the inner circumferential part P of a lower end of the branch hole due to the internal pressure of the main tubular rail or block rail and an axial force exerted on the pressure receiving seat surface when the joint head of the branch pipe

is pressed, to be offset by the same residual compressive stress, whereby a maximum value of the tensile stress occurring in the inner circumferential part P of the lower end of the branch hole is lowered.

The methods of generating and leaving residual compressive stress in the circumferential part of the end portion of the branch pipe which is opened into the flow passage in the main tubular rail or block rail in these common rails include a method of applying a pressing force to the interior of the flow passage in the main tubular rail or block rail from the outside by a pressing system, or a system for applying a pressure to the interior of the main tubular rail or block rail, or a pipe expansion system for applying a pressure from the interior of the main tubular rail or a block rail in the radial direction thereof, or a pipe expansion system for applying a pressure from the interior of the branch hole in the radial direction thereof. However, when a method including the steps of forming a bottomed lower hole 11-2' in a boss 11-4 integral with a main tubular rail, and applying a pressing force into the lower hole 11-2' from the outside in the axial direction of the boss by an external pressure system using a punch 15, so as to generate residual compressive stress in a circumferential part of the end portion of a branch hole 11-2 which is opened into a flow passage in the main tubular rail as shown, for example, in Fig. 8 is employed as the method, which is one of these methods, of

applying a pressing force from the outside to the interior of the main tubular rail by a pressing system, a fine defect 16, such as a fine crack occurs in some cases in a circumferential part of a bottom portion of the lower hole or in a circumferential part of a free end portion of the punch 15 by which a pressing force has been applied to the lower hole, due to tensile stress occurring in a bottom portion of the bottomed lower hole 11-2. As shown in Fig. 9, when a method including the step of applying a pressing force from the outside to a bottomed lower hole 21-2' provided in a circumferential wall of a main tubular rail 21, by an external pressure system using a punch 25 so as to generate residual compressive stress in a circumferential part of the end portion of a branch hole 21-2 which is opened into a flow passage in the main tubular rail is employed, a fine defect 26, such as fine crack occurs in some cases in the circumferential part of the bottom portion of the lower hole or in a circumferential part of a free end portion of the punch 25 by which the pressing force has been applied to the lower hole, due to tensile stress occurring in the bottom portion of the bottomed lower hole 21-2'. When such a fine defect occurs to cause an internal pressure to be applied to the lower hole, a decrease in the fatigue strength of the branch hole occurs, which has a fear of causing the breakage of the common rail. Therefore, it is necessary that the occurrence of the fine defect be prevented.

SUMMARY OF THE INVENTION:

The present invention has been made in view of the above circumstances and provides a method of manufacturing common rails, capable of solving the problem of occurrence of a fine defect ascribed to a fine crack occurring in the mentioned lower hole, and improving an internal pressure fatigue strength thereof by lowering a maximum value of stress occurring in the branch hole, and free from a fine defect ascribed to a fine crack in the branch hole.

According to an aspect of the present invention, the method of manufacturing common rails has the steps of forming at least one boss on an axially extending circumferential wall of a main tubular rail having a flow passage in an axially extending inner portion thereof, forming a branch hole, which communicates with the mentioned flow passage and has an outwardly opened pressure receiving seat surface, in the boss, engaging a pressure seat surface, which is formed on a joint head provided at an end portion of a branch pipe having a flow passage communicating with the flow passage in the main tubular rail, with the pressure receiving seat surface, and screwing a tightening nut, which is fitted around the branch pipe in advance, into the boss to thereby fasten and join the branch pipe to the main tubular rail by a pressure occurring due to the screwing force and exerted on a bent surface of a neck portion of the joint head, and includes the steps of forming in the boss in advance a bottomed

lower hole for the branch hole; generating residual compressive stress in a circumferential part of the end portion of the branch hole which is opened into the flow passage in the main tubular rail, by applying a pressing force from the outside to the lower hole in the axial direction of the boss by an external pressure system; and then cutting off a fine defect (a fine crack or a fine split) occurring in the lower hole.

According to another aspect of the present invention, the method of manufacturing common rails has the steps of forming at least one branch hole in an axially extending circumferential wall of a main tubular rail having a flow passage in an axially extending inner portion thereof; forming on an inner circumferential surface of the branch hole an outwardly opened pressure receiving surface to which a branch pipe having a flow passage communicating with the flow passage in the main tubular rail is joined; engaging a pressure seat surface, which is formed on a joint head provided on an end portion of the branch pipe, with the pressure receiving seat surface; and screwing on each other a separately formed metal joint fixed to the main tubular rail and a tightening nut fitted around the branch pipe in advance, to thereby fasten and join the branch pipe to the main tubular rail by a pressure occurring due to the screwing force and exerted on a bent surface of a neck portion of the joint head, and includes the steps of forming a bottomed lower hole in advance in the portion of the main tubular rail which

is in the vicinity of the branch hole, generating residual compressive stress in a circumferential part of the end portion of the branch pipe which is opened into the main tubular rail by applying a pressing force from the outside to the lower hole in the axial direction thereof by an external pressure system, and then cutting off a fine defect (a fine split or a fine crack) occurring in the lower hole.

According to still another aspect of the present invention, the method of manufacturing common rails has the steps of forming at least one joint hollow in an axially extending circumferential wall of a block rail having a flow passage in an axially extending inner portion thereof, forming in the joint hollow a branch hole communicating with the flow passage and having a pressure receiving seat surface, forming a pressure seat surface on a joint head provided at an end portion of a branch pipe having a flow passage communicating with the flow passage in the block rail, engaging the pressure seat surface with the pressure receiving surface, screwing a tightening nut, which is fitted around the branch pipe in advance, into the joint hollow, and fastening and joining the branch pipe to the block rail by a pressure occurring due to the screwing force and exerted on a bent surface of a neck portion of the joint head, and includes the steps of forming a bottomed lower hole in advance in the portion of the block rail which is in the vicinity of the branch hole, generating residual compressive stress in

a circumferential part of the end portion of the branch pipe which is opened into the block rail, by applying a pressing force from the outside to the lower hole in the axial direction thereof by an external pressure system, and then cutting off a fine defect (a fine split or a fine crack) occurring in the lower hole.

The method used in the present invention of generating and leaving residual compressive stress in a circumferential part of the end portion of the branch hole which is opened into the main tubular rail or block rail will now be described. As an example of this method, a method of generating and leaving residual compressive stress by applying a pressing force from the outside to a lower hole in the axial direction of the relative boss by a pressing system can be used, including the steps of forming in the first place on a pre-processing stage (cutting stage) a bottomed lower hole in a boss of a main tubular rail by cutting an inner portion of the boss, for example, by an end mill, and then pressing a bottom portion of the lower hole by using a punch or a rod with the main tubular rail, for example, a rail body fixed in a lower mold, or simultaneously carrying out such a pressing operation and the punching of a branch hole. As the method of cutting off the fine defect occurring in the lower hole after this process has been carried out, a method of cutting a bottomed lower hole in a boss, in the case where the boss is made integral with the main tubular rail, to a larger

diameter, for example, by an end mill so as to cut off a fine defect, and thereby form a branch hole of a predetermined diameter is used. In the case of a separately formed boss, a fine defect can be cut off by forming an outwardly opened pressure receiving seat surface in a branch hole made in a main tubular rail itself, or the branch hole may be cut to a larger diameter as necessary.

According to the present invention described above, the occurrence of stress, when a high-pressure fuel is accumulated in a flow passage during the use of a common rail, in a circumferential part P of the lower end of a branch hole which is opened into a main tubular rail or a block rail can be minimized effectively by generating residual compressive stress in the mentioned circumferential part. In addition, a normal branch hole having neither a fine split nor a fine crack in its inner circumferential surface is obtained by cutting off a fine defect occurring due to the application of residual compressive stress, and an internal pressure fatigue strength of a branch pipe-connected portion can be improved.

BRIEF DESCRIPTION OF THE DRAWINGS:

Preferred embodiments of the present invention will be described in detail on the basis of the following figures, wherein:

Fig. 1 is a partially cutoff schematic diagram showing an embodiment of the method of manufacturing a common rail having

a boss integral with a main tubular rail according to the present invention;

Fig. 2 is a partially cutoff schematic diagram showing another embodiment of the method of manufacturing a common rail having a boss integral with a main tubular rail according to the present invention;

Fig. 3 is a partially cutoff schematic diagram showing an embodiment of the method of manufacturing a common rail using a ring-shaped metal joint;

Fig. 4 is a partially cutoff schematic diagram showing an embodiment of the method of manufacturing a common rail using a sleeve;

Fig. 5 is a partially cutoff schematic diagram showing another embodiment of the method of manufacturing a common rail using a sleeve;

Fig. 6 is a sectional view showing an embodiment in which the present invention is applied to a method of manufacturing a block rail;

Fig. 7 is a longitudinal sectional view showing an example of a branch pipe connecting structure in a common rail of the related art to which the present invention is directed;

Fig. 8 is a longitudinal sectional view showing an example of a method of the related art of generating and leaving residual compressive stress in a circumferential part of the end portion of a branch hole in a common rail which is opened into a flow

passage in a main tubular rail; and

Fig. 9 is a longitudinal sectional view showing another example of a method of the related art of generating and leaving residual compressive stress in a circumferential part of the end portion of a branch hole in a common rail which is opened into a flow passage in a main tubular rail.

DESCRIPTION OF THE PREFERRED EMBODIMENTS:

Referring to Figs. 1 to 6, reference numerals 1a, 1b denote a main tubular rail, 1c a block rail, 2 a boss, 3a, 3b, 3c bottomed lower holes, 4 a punch, 5a, 5b, 5c branch holes, 6a, 6b, 6c pressure receiving surface, 7 an outer thread, 8 an inner thread, 9 a ring-shaped metal joint (retainer), and 10 a cylindrical sleeve.

The main tubular pipes 1a, 1b as common rails are formed of a forged product or a stretched pipe member of a material S45C having a comparatively thick-walled tubular portion of, for example, 28 mm in diameter and 9 mm in wall thickness, and inner axial portions of the main tubular rails are subjected to a machining process using a boring gun drill, whereby flow passages 1a-1, 1b-1 are formed therein. In the case of a common rail having a boss integral with a main tubular rail is provided with at least one boss 2 on an axially extending circumferential wall thereof. A block rail 1c as a common rail is formed of a forged product of a material S45C having a comparatively thick-walled tubular portion and a rectangular cross section

of, for example, 80 mm in length and 50 mm in width, and an inner axial portion of the cross-sectionally rectangular member is subjected to the formation of a flow passage 1c-1 therein in the same manner as the main tubular rail, whereby at least one joint hole is provided in a longitudinally extending circumferential wall thereof.

In the case of a common rail having a boss integral with a main tubular rail, a bottomed lower hole 3a of a suitable depth is formed first in the boss 2 of the main tubular rail 1a by cutting an inner portion of the boss 2, for example, by an end mill on a pre-processing stage (cutting stage) as shown in Fig. 1. When the main tubular rail 1a is then fixed in a mold (not shown) on a pressing stage, a pressing force is applied to an inner bottom portion of the boss 2 by a punch 4 having a diameter slightly smaller than an inner diameter of the bottomed lower hole 3a in the boss 2 and fixed to a press. Although a level of the pressing force applied to the inner bottom portion during this time is not limited, it may be so high that permits the part of the inner circumferential surface of the flow passage 1a-1 in the main tubular rail which is positioned just under the inner bottom portion of the boss projects slightly. Owing to the pressing force of this punch 4, the inner circumferential surface of the flow passage 1a-1 projects slightly, and, when the pressing force is applied to the inner bottom portion of the boss, a plastically deformed portion and an elastically

deformed portion occur, residual compressive stress occurring due to deformation ascribed to a difference in the quantities of return at the time of removal of the pressing force.

After the application of a pressing force of the punch 4 is then carried out, a fine defect is cut off by cutting the bottomed lower hole 3a to a larger diameter by a drill having a diameter larger than the inner diameter of the bottomed lower hole 3a, and a branch hole 5a communicating with the flow passage 1a-1 in the main tubular rail 1a and having a circular outwardly opened circumferential surface communicating with the flow passage 1a-1 and serving as a pressure receiving surface is formed, the external thread 7 being also formed in an outer circumferential surface of the boss. The external thread 7 may also be formed earlier on the pre-processing stage.

Fig. 2 illustrates a method of manufacturing an internal thread type common rail. In this method, a bottomed lower hole 3a having a diameter substantially equal to that of a branch hole 5a, which is to be formed later, and a suitable depth is also formed in a boss 2 of a main tubular rail 1a by boring the boss by, for example, an end mill, in the same manner as in the case of the manufacture of the common rail of Fig. 1. On a subsequent pressing stage, the main tubular rail 1a is fixed in a mold (not shown), and a pressing force is applied to an inner bottom portion of the boss by a punch 4 having a diameter which permits the punch to be inserted into the bottomed lower

hole 3a in the boss 2, whereby residual compressive stress is generated in a circumferential part of the end portion of the branch hole 5a which is opened into the flow passage in the main tubular rail. The branch hole 5a communicating with the flow passage 1a-1 in the main tubular rail 1a and having a pressure receiving surface 6a formed of a circular and outwardly opened circumferential surface communicating with the flow passage 1a-1 is then provided in the boss 2, and an internal thread 8 is formed in an inner circumferential surface of the bottomed lower hole 3a in the boss. Therefore, in the case of this method of manufacturing common rails, a fine defect occurring in the bottom portion of the bottomed lower hole 3a is cut off by a cutting process applied to the pressure receiving surface 6a. The internal thread 8 may also be formed earlier on a pre-processing stage.

In the method shown in Fig. 3 of manufacturing common rails, using a ring-shaped metal joint, a bottomed lower hole 3b having a diameter substantially equal to that of a branch hole 5b, which is to be formed later, and a suitable depth is provided in a main tubular rail 1b with a ring-shaped metal joint (retainer) 9 removed which is provided in its inner circumferential surface with a threaded wall 9-1 to be screwed on a tightening nut to be fitted around a branch pipe. Then, on a pressing stage, a pressing force is applied to an inner bottom portion of the bottomed lower hole 3b by a punch 4 having a diameter which

permits the punch to be fitted in the bottomed lower hole 3b, whereby residual compressive stress is generated in a circumferential part of the end portion of the branch hole 5b which is opened into the flow passage in the main tubular rail. The branch hole 5b communicating with a flow passage 1b-1 in the main tubular rail 1b and having a pressure receiving surface 6b formed on a circumferential surface communicating with this flow passage 1b-1 and having a circular outwardly opened circumferential surface communicating with the same flow passage is then formed in the bottomed lower hole 3b, a ring-shaped metal joint 9 being then fixed to the main tubular rail 1b. Namely, in the case of this method of manufacturing common rails, a fine defect is removed by cutting the bottomed lower hole 3b so as to form the circular and outwardly opened pressure receiving surface 6b therein.

The method of manufacturing common rails, using a sleeve and shown in Fig. 4 includes the steps of fixing a cylindrical sleeve 10 as a metal joint, which is provided therein with an internal thread 8 engaged with a tightening nut inserted into a branch pipe, at a base end portion thereof to an outer circumferential wall of a main tubular rail 1b by direct soldering, providing a bottomed lower hole 3b having a diameter substantially equal to that of a branch hole 5b to be formed later, and a suitable depth in a central part of the portion of an outer circumferential surface of the main tubular rail

1b which is surrounded by this cylindrical sleeve 10, generating residual compressive stress in a circumferential part of the end portion of the branch hole 5b which is opened into the flow passage in the main tubular rail, by applying a pressing force to an inner bottom portion of the bottomed lower hole 3b by a punch 4 having a diameter which permits the punch to be fitted into the bottomed lower hole 3b, and then forming the branch hole 5b which communicates with the flow passage 1b-1 in the main tubular rail 1b, and which has a pressure receiving surface 6b formed on a circular outwardly opened circumferential surface communicating with the same flow passage, in the bottomed lower hole 3b. Namely, in this method of manufacturing common rails, a fine defect occurring in the bottomed lower hole 3b is removed as well in the same manner as in the method shown in Fig. 3, by forming the circular outwardly opened pressure receiving surface 6b in the bottomed lower hole 3b by cutting the same.

The method of manufacturing common rails, using a sleeve shown in Fig. 5 is an example of a method of fixing the same cylindrical sleeve as shown in Fig. 4 to a main tubular rail 1b by welding, including the steps of fixing a base end portion of the cylindrical sleeve 10 as a metal joint to an outer circumferential wall of the main tubular rail 1b by welding the former directly to the latter; providing a bottomed lower hole 3b, which has a diameter substantially equal to that of a branch

hole 5b to be formed later and a suitable depth, in a central part of the portion of the outer circumferential surface of the main tubular rail 1b which is surrounded by the cylindrical sleeve 10; generating residual compressive stress in a circumferential part of the lower end portion of the branch hole 5b which is opened into the flow passage in the main tubular rail, by applying a pressing force to an inner bottom portion of the bottomed lower hole 3b by a punch 4 having a diameter which permits the punch to be fitted in the bottomed lower hole 3b; forming the branch hole 5b which communicates with the flow passage 1b-1 in the main tubular rail 1b, and which has a pressure receiving surface 6b formed on a circular outwardly opened circumferential surface communicating with the same flow passage; and providing in an inner circumferential surface of the sleeve 10 with an internal thread 8 which is engaged with a tightening nut fitted around the branch pipe. Therefore, in this method of manufacturing sleeve-welded type common rails, a defect occurring in the bottomed lower hole 3b is removed by forming the circular outwardly opened pressure receiving surface 6b on the bottomed lower surface 3b by a cutting process in the same manner as in the method shown in Fig. 4.

Although all of the common rails in the embodiments shown in Figs. 1 to 5 have a structure in which the axis of the flow passage in the main tubular rail and that of the branch hole cross each other at one point, the present invention can also

be applied to a common rail in which the axis of a branch pipe is shifted in the radial direction of the main tubular rail.

In the case of a block rail, a bottomed hole 3c of a suitable depth is formed first in the block rail 1c on a pre-processing stage (cutting stage) by cutting the same with, for example, an end mill as shown in Fig. 6. Then, on a pressing stage, the block rail 1c is fixed in a mold (not shown), and a pressing force is applied to an inner bottom portion of a boss by a punch 4 which has a diameter slightly smaller than an inner diameter of the bottomed lower hole 3c, and which is fixed to a press. Although the level of this pressing force is not specially limited, it may be substantially so high that makes the portion of an inner circumferential surface of a flow passage 1c-1 in the block which is just under the bottomed lower hole 3c project slightly. Owing to the pressing force of this punch 4, the inner circumferential surface of the flow passage 1c-1 of the block rail projects slightly, and a plastically deformed portion and an elastically deformed portion occur when the pressing force is applied to the inner bottom portion of the boss, residual compressive stress occurring due to deformation ascribed to a difference in the quantities of return at the time of removal of the pressing force.

After the pressing force is applied to the inner bottom portion of the boss by the punch 4, a fine defect is removed by forming the bottomed lower hole 3c in a joint hole of a larger

diameter by cutting the former hole with, for example, a drill having a diameter larger than an inner diameter of the bottom lower hole 3c, and a branch hole 5c communicating with the flow passage 1c-1, and having a pressure receiving surface 6c formed on a circular outwardly opened circumferential surface communicating with the same flow passage is formed, an internal thread 8 being formed in an inner circumferential surface of the joint hole. The internal thread 8 may also be formed in advance on a pre-processing stage.

According to the present invention described above, it becomes possible to minimize effectively the occurrence of stress in an inner circumferential part P of a lower end of the branch hole while a high-pressure fuel is accumulated in the flow passage during the use of the common rail, by making residual compressive stress exist in the circumferential part of the end portion of the branch hole which is opened into the flow passage in the main tubular rail or a block rail, obtain a normal branch hole which does not have a fine defect, such as a fine crack in its inner circumferential surface, by cutting off the fine defect which has occurred due to the exertion of the residual compressive stress, and improve the internal pressure fatigue strength of a branch-connected portion of the common rail. Therefore, the common rail obtained has a high durability, prevents the leakage of a fluid ascribed to the occurrence of a crack and a split, and can fulfill a reliable

and stable function thereof.

What is claimed is:

1. A method of manufacturing common rails, having the steps of forming at least one boss made integral with an axially extending circumferential wall of a main tubular rail having a flow passage in an axially extending inner portion thereof, forming a branch hole, which communicates with the flow passage, and which has an outwardly opened pressure receiving seat surface, in the boss, engaging a pressure seat surface, which is formed on a joint head provided at an end portion of a branch pipe having a flow passage communicating with the flow passage in the main tubular rail, with the pressure receiving seat surface, and screwing a tightening nut, which is fitted around the branch pipe in advance, into the boss to thereby fasten and join the branch pipe to the main tubular rail by a pressure occurring due to the screwing force and exerted on a bent surface of a neck portion of the joint head, comprising the steps of forming in the boss in advance a bottomed lower hole for the branch hole; generating residual compressive stress in a circumferential part of the end portion of the branch hole which is opened into the flow passage in the main tubular rail, by applying a pressing force from the outside to the lower hole in the axial direction of the boss by an external pressure system; and then cutting off a fine defect (a fine crack or a fine slit) occurring in the lower hole.

2. A method of manufacturing common rails according to Claim 1, wherein the main tubular rail comprises a forged product or a stretched tubular member having a thick-walled tubular portion.

3. A method of manufacturing common rails according to Claim 1 or 2, wherein the main tubular rail has a machined flow passage in an axial inner portion thereof.

4. A method of manufacturing common rails according to Claim 1 or 2, wherein the boring of the bottomed lower hole is done by an end mill, a pressing force being then applied to the lower hole by a punch of a press, the lower hole being thereafter cut off by a drill.

5. A method of manufacturing common rails, having the steps of forming at least one branch hole in an axially extending circumferential wall of a main tubular rail having a flow passage in an axially extending inner portion thereof; forming on an inner circumferential surface of the branch hole an outwardly opened pressure receiving seat surface to which a branch pipe having a flow passage communicating with the flow passage in the main tubular rail is joined; engaging a pressure seat surface, which is formed on a joint head provided on an end portion of the branch pipe, with the pressure receiving seat surface; and screwing on each other a separately formed metal joint fixed to the main tubular rail and a tightening nut fitted around the branch pipe in advance, to thereby fasten and join

the branch pipe to the main tubular rail by a pressure occurring due to the screwing force and exerted on a bent surface of a neck portion of the joint head, comprising the steps of forming a bottomed lower hole in advance in the portion of the main tubular rail which is in the vicinity of the branch hole, generating residual compressive stress in a circumferential part of the end portion of the branch pipe which is opened into the main tubular rail by applying a pressing force from the outside to the lower hole in the axial direction thereof by an external pressure system, and then cutting off a fine defect occurring in the lower hole.

6. A method of manufacturing common rails according to Claim 5, wherein the main tubular rail comprises a forged product or a stretched tubular member having a thick-walled tubular portion.

7. A method of manufacturing common rails according to Claim 5 or 6, wherein the main tubular rail has a machined flow passage in an axial inner portion thereof.

8. A method of manufacturing common rails according to Claim 5 or 6, wherein the boring of the bottomed lower hole is done by an end mill, a pressing force being then applied to the lower hole by a punch of a press, the lower hole being thereafter cut off by a drill.

9. A method of manufacturing common rails, having the steps of forming at least one joint hollow in an axially extending

circumferential wall of a block rail having a flow passage in an axially extending inner portion thereof, forming in the joint hollow a branch hole communicating with the flow passage and having a pressure receiving seat surface, forming a pressure seat surface on a joint head provided at an end portion of a branch pipe having therein a flow passage communicating with the flow passage in the block rail, engaging the pressure seat surface with the pressure receiving seat surface, screwing a tightening nut, which is fitted around the branch pipe in advance, into the joint hollow, and fastening and joining the branch pipe to the block rail by a pressure occurring due to the screwing force and exerted on a bent surface of a neck portion of the joint head, comprising the steps of forming a bottomed lower hole in advance in the portion of the block rail which is in the vicinity of the branch hole, generating residual compressive stress in a circumferential part of the end portion of the branch pipe which is opened into the block rail, by applying a pressing force from the outside to the lower hole in the axial direction thereof by an external pressure system, and then cutting off a fine defect occurring in the lower hole.

10. A method of manufacturing common rails according to Claim 9, wherein the block rail comprises a forged product having a thick-walled tubular portion.

11. A method of manufacturing common rails according to Claim 9 or 10, wherein the block rail has a machined flow passage in

an axial inner portion thereof.

12. A method of manufacturing common rails according to Claim 9 or 10, wherein the boring of the bottomed lower hole is done by an end mill, a pressing force being then applied to the lower hole by a punch of a press, the lower hole being thereafter cut off by a drill.

Application No:	GB 0003402.5	**Examiner:**	Gareth Prothero
Claims searched:	1 to 12	**Date of search:**	21 August 2000

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Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): F2G (G1, G7)

Int Cl (Ed.7): F02M 55/00, 55/02; F16L 41/08, 41/10, 41/12, 41/14, 41/16

Other: Online: WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	GB 2322921 A (USUI KOKUSAI) see whole document.	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.