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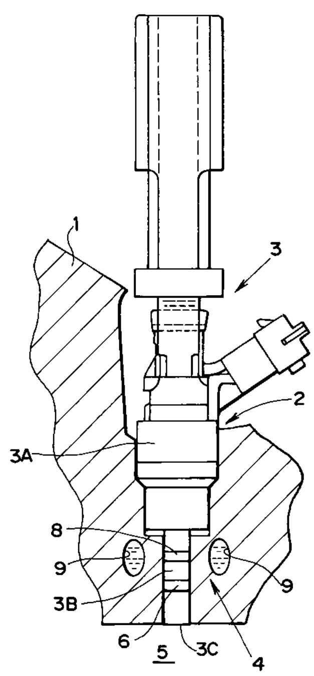
(54) **Cooling structure for fuel injection valve**

(57) An object of the present invention is to provide a cooling structure (4) for a fuel injection valve (3) that is capable of actively releasing the heat of a nozzle portion (3B) of the fuel injection valve (3) to a low temperature portion (9) of a cylinder head (1), and thus suppressing the generation of deposits on an injection hole (7) of the fuel injection valve (3). A heat conducting member (8), which is capable of thermal conduction between the nozzle portion (3B) of the fuel injection valve (3) and the low temperature portion (9) of the cylinder head (1), is provided on an outer peripheral portion of the fuel injection valve (3).

FIG. 1



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Description

[0001] The present invention relates to a cooling structure for a fuel injection valve, and more particularly to a cooling structure for a fuel injection valve which injects fuel directly into a combustion chamber.

[0002] Conventionally, a fuel injection valve for injecting fuel directly into a combustion chamber is installed through insertion into a valve installation hole in a cylinder head, and is sealed by a sealing member provided on the outer peripheral portion thereof such that combustion gas from the combustion chamber does not leak outside.

[0003] Meanwhile, heat from the combustion chamber causes the temperature of a nozzle portion positioned on the tip end side of the fuel injection valve and facing the combustion chamber to rise, whereby the small amount of residual fuel attached to an injection hole at the tip end of the nozzle portion is carbonized to produce a carbon deposit. Accumulation of this carbon deposit in the vicinity of the injection hole has an adverse effect on the injection characteristic and the injection amount.

[0004] However, the aforementioned sealing member typically has a low thermal conductivity, and since the sealing member is installed in the valve installation hole between the fuel injection valve and cylinder head with a predetermined pressing force, a problem arises in that the heat of the nozzle portion on the fuel injection valve cannot easily be conducted outside of the cylinder head through the sealing member.

[0005] In other words, to prevent the generation of carbon deposits on the injection hole, the heat of the nozzle portion of the fuel injection valve, which is caused to increase in temperature by combustion heat from the combustion chamber, must be discharged outside efficiently, but at present, a cooling structure with an adequate heat-discharging function has not yet been developed.

[Cited Document 1]

[0006] Japanese Unexamined Patent Application Publication 2001-132582

[Cited Document 2]

[0007] Japanese Unexamined Patent Application Publication 2002-138924

[0008] The present invention has been designed in consideration of the problems described above, and it is an object thereof to provide a sealing structure for combustion gas from a combustion chamber and a cooling structure for a fuel injection valve which is capable of appropriately cooling the fuel injection valve.

[0009] Another object of the present invention is to provide a cooling structure for a fuel injection valve which is capable of suppressing the generation of deposits on an injection hole of a nozzle portion of the fuel injection valve.

[0010] A further object of the present invention is to provide a cooling structure for a fuel injection valve which is capable of actively releasing the heat of the nozzle portion of the fuel injection valve to a low temperature portion of the cylinder head.

[0011] More specifically, the present invention focuses on thermal conduction between a high temperature portion (tip end nozzle portion) of a fuel injection valve and a low temperature portion of a cylinder head via a heat conducting member. A first invention is a cooling structure for a fuel injection valve which is installed in a valve installation hole of a cylinder head via a sealing member and injects fuel into a combustion chamber, characterized in that a heat conducting member capable of performing thermal conduction between the nozzle portion of the fuel injection valve and the low temperature portion of the cylinder head is provided on an outer peripheral portion of the fuel injection valve.

[0012] The aforementioned low temperature portion may be a cooling water passage provided in the cylinder head.

[0013] At low temperatures, the heat conducting member does not contact either the outer peripheral portion of the fuel injection valve or an inner wall surface of the valve installation hole, but at high temperatures, the heat conducting member is capable of contacting the outer peripheral portion and inner wall surface.

[0014] The heat conducting member may be positioned further toward the combustion chamber side than the sealing portion or further outside than the sealing portion on the opposite side to the combustion chamber.

[0015] A second invention is a cooling structure for a fuel injection valve which is installed in a cylinder head via a sealing member for sealing in combustion gas from a combustion chamber, characterized in that the fuel injection valve comprises a cylindrical nozzle portion, and is fixed in position by inserting this nozzle portion into a cylindrical valve installation hole formed in the cylinder head, whereupon fuel is injected into the combustion chamber from an injection hole provided on the tip end of the nozzle portion. Further, a heat conducting member is installed in an annular space formed between the inner wall surface of the valve installation hole and the outer peripheral surface of the nozzle portion so as to contact both the inner wall surface and outer peripheral surface.

[0016] The heat conducting member may have a greater thermal conductivity than the sealing member.

[0017] The heat conducting member may be constituted by a copper material.

[0018] The heat conducting member is a substantially cylindrical member having a larger diameter on one end side than on the other end side. An outer peripheral surface of the large diameter part is capable of contacting the inner wall surface of the valve installation hole, and an inner peripheral surface of the small diameter part is capable of contacting the outer peripheral surface of the nozzle portion.

[0019] The sealing member is provided between the valve installation hole and nozzle portion, and the heat conducting member may be positioned on the side that is further from the tip end of the nozzle portion than the sealing member.

[0020] The sealing member is provided between the valve installation hole and the nozzle portion, and the heat conducting member may be positioned on the side that is closer to the tip end of the nozzle portion than the sealing member.

[0021] In the cooling structure for a fuel injection valve according to the present invention, a heat conducting member is provided for performing thermal conduction between a high temperature portion in the vicinity of the injection hole in the nozzle portion, which is the tip end portion of the fuel injection valve, and a low temperature portion in the cylinder head, and hence even when the sealing member is interposed between the fuel injection valve and the cylinder head, the high temperature of the nozzle portion of the fuel injection valve can be actively released to the low temperature portion of the cylinder head. Thus the temperature of the nozzle portion, particularly in the vicinity of the injection hole, decreases such that carbon deposits can be reduced.

[0022] Cooling efficiency can be raised particularly when the heat conducting member is provided in the vicinity of the cooling water passage in the cylinder head.

[0023] Further, when the heat conducting member is constituted by a shape memory alloy, a material with a high coefficient of thermal expansion, or similar, the heat conducting member does not contact the outer peripheral portion of the fuel injection valve and the inner wall surface of the valve installation hole at low temperatures, but becomes capable of contacting the outer peripheral portion and inner wall surface at high temperatures. Hence the heat transfer function of the heat conducting member can be ensured, and the installation and removal operations thereof can be improved in workability and ease.

[0024] Further, when the heat conducting member is constituted by a material having a greater thermal conductivity than the sealing member, for example a copper material or the like, an even more efficient thermal conduction performance can be ensured.

Fig. 1 is a sectional view of a fuel injection valve 3 part comprising a cooling structure 4 according to a first embodiment of the present invention and installed in a valve installation hole 2 of a cylinder head 1;

Fig. 2 is a partially cut-away enlarged sectional view showing the cooling structure 4 in a nozzle portion 3B part of same;

Fig. 3 shows an annular metallic spring 12 (heat conducting member) of same, Fig. 3 (1) being a perspective view thereof, and Fig. 3(2) being a sectional view thereof;

Fig. 4 shows a temperature-sensing ring 13 (heat conducting member) of same, Fig. 4(1) being a sectional view thereof in a normal condition (at low temperature), and Fig. 4(2) being a sectional view thereof at high temperature;

Fig. 5 shows an expanding ring 14 (heat conducting member) of same, Fig. 5(1) being a sectional view thereof in a normal condition (at low temperature), and Fig. 5 (2) being a sectional view thereof at high temperature; and

Fig. 6 is a partially cut-away enlarged sectional view of a cooling structure 20 for a fuel injection valve according to a second embodiment of the present invention.

[0025] A cooling structure for a fuel injection valve according to a first embodiment of the present invention will now be described on the basis of Figs. 1 and 2.

[0026] Fig. 1 is a sectional view of a fuel injection valve 3 part installed in a valve installation hole 2 of a cylinder head 1. The fuel injection valve 3 comprises a main body portion 3A, and a cylindrical nozzle portion 3B which is the tip end portion of the main body portion 3A and has a smaller diameter than the main body portion 3A.

[0027] A cooling structure 4 for the fuel injection valve 3 according to the present invention is provided on the nozzle portion 3B part.

[0028] Fig. 2 is a partially cut-away enlarged sectional view of the nozzle portion 3B part of the fuel injection valve 3, and shows the cooling structure 4 of the fuel injection valve 3.

[0029] A combustion gas seal 6 (sealing member) of an arbitrary constitution is provided on a combustion chamber 5 side between the valve installation hole 2 and the nozzle portion 3B of the fuel injection valve 3.

[0030] The fuel injection valve 3 injects fuel into the combustion chamber 5 from an injection hole 7 in a tip end 3C of the nozzle portion 3B.

[0031] The cooling structure 4 comprises an annular copper ring 8 (heat conducting member), a cooling water passage 9, and cooling water 10 inside the cooling water passage 9.

[0032] The copper ring 8 is positioned in the cylindrical valve installation hole 2 outside of the combustion gas seal 6 on the opposite side to the combustion chamber 5, and contacts both an outer peripheral surface of the fuel injection valve 3 (nozzle portion 3B) and an inner wall surface of the valve installation hole 2.

[0033] More specifically, the copper ring 8 is a substantially cylindrical member in which the diameter of the end side thereof (large diameter part 8A) that is furthest from the tip end 3C of the nozzle portion 3B is larger than the diameter of the other end side thereof (small diameter part 8B) that is near to the tip end 3C of the nozzle portion 3B. In an annular space 11 formed between the inner wall surface of the valve installation hole

2 and the outer peripheral surface of the nozzle portion 3B, the outer peripheral surface of the large diameter part 8A contacts the inner wall surface of the valve installation hole 2, and the inner peripheral surface of the small diameter part 8B contacts the outer peripheral surface of the nozzle portion 3B.

[0034] In the cooling structure 4 constituted in this manner, the combustion gas seal 6 seals in combustion gas from the combustion chamber 5, and the copper ring 8 conducts high temperatures from the vicinity of the injection hole 7 in the nozzle portion 3B of the fuel injection valve 3 to the cylinder head 1 and the cooling water 10 inside the cooling water passage 9.

[0035] Since the copper ring 8 and cooling water passage 9 are positioned adjacent to each other via the wall surface of the cylinder head 1, heat from the vicinity of the injection hole 7 can be actively conducted to the cylinder head 1 from the fuel injection valve 3 and discharged efficiently even though the combustion gas seal 6 is positioned therebetween. In particular, by cooling the vicinity of the injection valve 7, the generation of carbon deposits can be suppressed.

[0036] In particular, by providing a constitution in which the small diameter part 8B of the copper ring 8 is disposed in the annular space 11 formed between the inner wall surface of the valve installation hole 2 and the outer peripheral surface of the nozzle portion 3B facing the tip end 3C of the nozzle portion 3B, the heat conducting path from the nozzle portion 3B to the cylinder head 1 can be formed in the vicinity of the tip end 3C of the nozzle portion 3B, and thus the heat that is transmitted to the fuel injection valve 3 can be released to the cylinder head 1 efficiently.

[0037] The combustion gas seal 6 also contacts both the inner wall surface of the valve installation hole 2 and the outer peripheral surface of the nozzle portion 3B, and although thermal conduction is also possible through the combustion gas seal 6, the constitution and material of the combustion gas seal 6 should be determined such that a good sealing property can be ensured. As a result, it is difficult to generate a high degree of thermal conductivity in the combustion gas seal 6. On the other hand, the material for the copper ring 8 may be selected with a comparative amount of freedom, and hence the copper ring 8 may be constituted by a material (a copper material, for example) having a higher degree of thermal conductivity than the material constituting the combustion gas seal 6, thereby ensuring a more efficient thermal conduction performance.

[0038] A desired structure other than the copper ring 8 may be employed as the heat conducting member of the present invention.

[0039] For example, Fig. 3 shows an annular metallic spring 12 (heat conducting member), Fig. 3(1) being a perspective view thereof and Fig. 3(2) being a sectional view thereof.

[0040] Due to its resilience, the metallic spring 12 is capable of thermal contact at a predetermined pressing force with both the fuel injection valve 3 and the valve installation hole 2 (cylinder head 1), and is also easy to remove and install.

[0041] Fig. 4 shows a temperature-sensing ring 13 (heat conducting member), Fig. 4(1) being a sectional view thereof in a normal condition (at low temperature) , and Fig. 4 (2) being a sectional view thereof at high temperature.

[0042] The temperature-sensing ring 13 is constituted by a bimetal, a shape memory alloy, or similar. At times such as the installation or removal of the fuel injection valve 3 and temperature-sensing ring 13 to or from the valve installation hole 2, the temperature-sensing ring 13 does not contact either the fuel injection valve 3 (nozzle portion 3B) or the valve installation hole 2, as shown in Fig. 4 (1) , and thus can be easily installed in and removed from the annular space 11 therebetween.

[0043] Further, only at high temperatures when the temperature of the fuel injection valve 3 must be reduced, the temperature-sensing ring 13 changes shape as shown in Fig. 4 (2) , thus enabling thermal conduction and heat discharge.

[0044] As shown in Fig. 4(2) in particular, when the temperature-sensing ring 13 changes shape at high temperatures, thermal conduction efficiency can be further improved by ensuring that the temperature-sensing ring 13 changes shape such that the number of contact points and contact surfaces with the valve installation hole 2 and fuel injection valve 3 increases.

[0045] Fig. 5 shows an expanding ring 14 (heat conducting member) , Fig. 5 (1) being a sectional view thereof in a normal condition (at low temperature), and Fig. 5(2) being a sectional view thereof at high temperature.

[0046] The expanding ring 14 uses a material having a high coefficient of thermal expansion in order to utilize the expansion and contraction of the medium.

[0047] As shown in Fig. 5(1), the expanding ring 14 contracts at times such as the installation or removal of the fuel injection valve 3 and expanding ring 14 to or from the valve installation hole 2, and therefore does not contact either the fuel injection valve 3 or valve installation hole 2. Hence the expanding ring 14[i] can be easily installed in and removed from the annular space 11 therebetween.

[0048] As shown in Fig. 5(2), at high temperatures, the expanding ring 14 expands so as to contact the valve installation hole 2 and fuel injection valve 3, thus enabling heat transfer.

[0049] Note that in the first embodiment of the present invention shown in Figs. 1 and 2, the combustion gas seal 6 is provided between the valve installation hole 2 and nozzle portion 3B, and the copper ring 8 is positioned on the side that is further from the tip end 3C (injection hole 7) of the nozzle portion 3B than the combustion gas seal 6. However, the copper ring 8 may be positioned on the side that is closer to the tip end 3C of the nozzle portion 3B than the combustion gas seal 6.

[0050] More specifically, Fig. 6 is a partially cut-away enlarged sectional view of a cooling structure 20 according to a second embodiment of the present invention. In the cooling structure 20, contrary to the cooling structure 4 (Figs. 1, 2) according to the first embodiment, the copper ring 8 and cooling water passage 9 are positioned further toward the combustion chamber 5 side than the combustion gas seal 6.

[0051] Similarly to the cooling structure 4 in Figs. 1 and 2, in the cooling structure 20 constituted in this manner, the heat of the nozzle portion 3B (injection hole 7) of the fuel injection valve 3 is transmitted efficiently to the cooling water 10 inside the cooling water passage 9 of the cylinder head 1, and thus the generation of carbon deposits in the vicinity of the injection hole 7 can be suppressed.

[0052] According to the present invention as described above, by providing a heat conducting member between the valve installation hole of a cylinder head and the nozzle portion of a fuel injection valve such that heat is actively discharged to the cylinder head side, the nozzle portion of the fuel injection valve can be cooled efficiently, and the generation of carbon deposits in the vicinity of the injection hole can be suppressed.

Claims

1. A cooling structure for a fuel injection valve which is installed in a valve installation hole of a cylinder head via a sealing member and injects fuel into a combustion chamber,

   characterized in that a heat conducting member capable of performing thermal conduction between a nozzle portion of said fuel injection valve and a low temperature portion of said cylinder head is provided on an outer peripheral portion of said fuel injection valve.

2. The cooling structure for a fuel injection valve according to Claim 1, **characterized in that** said low temperature portion is a cooling water passage provided in said cylinder head.

3. The cooling structure for a fuel injection valve according to Claim 1, **characterized in that** at low temperatures, said heat conducting member does not contact said outer peripheral portion of said fuel injection valve and an inner wall surface of said valve installation hole, but at high temperatures, said heat conducting member is capable of contacting said outer peripheral portion and said inner wall surface.

4. A cooling structure for a fuel injection valve which is installed in a cylinder head via a sealing member for sealing in combustion gas from a combustion chamber,

   characterized in that said fuel injection valve comprises a cylindrical nozzle portion, and is fixed in position by inserting said nozzle portion into a cylindrical valve installation hole formed in said cylinder head, whereupon fuel is injected into said combustion chamber from an injection hole provided on a tip end of said nozzle portion, and

   a heat conducting member is installed in an annular space formed between an inner wall surface of said valve installation hole and an outer peripheral surface of said nozzle portion so as to contact both said inner wall surface and said outer peripheral surface.

5. The cooling structure for a fuel injection valve according to Claim 4, **characterized in that** said heat conducting member has a greater thermal conductivity than said sealing member.

6. The cooling structure for a fuel injection valve according to Claim 5, **characterized in that** said heat conducting member is constituted by a copper material.

7. The cooling structure for a fuel injection valve according to Claims 4 through 6, **characterized in that** said heat conducting member is a substantially cylindrical member having a larger diameter on one end side than on the other end side, whereby an outer peripheral surface of the large diameter part contacts said inner wall surface of said valve installation hole, and an inner peripheral surface of the small diameter part contacts said outer peripheral surface of said nozzle portion.

8. The cooling structure for a fuel injection valve according to Claims 4 through 7, **characterized in that** said sealing member is provided between said valve installation hole and said nozzle portion, and

   said heat conducting member is positioned on the side that is further from said tip end of said nozzle portion than said sealing member.

9. The cooling structure for a fuel injection valve according to Claims 4 through 7, **characterized in that** said sealing member is provided between said valve installation hole and said nozzle portion, and

   said heat conducting member is positioned on the side that is closer to said tip end of said nozzle portion than said sealing member.

FIG. 1

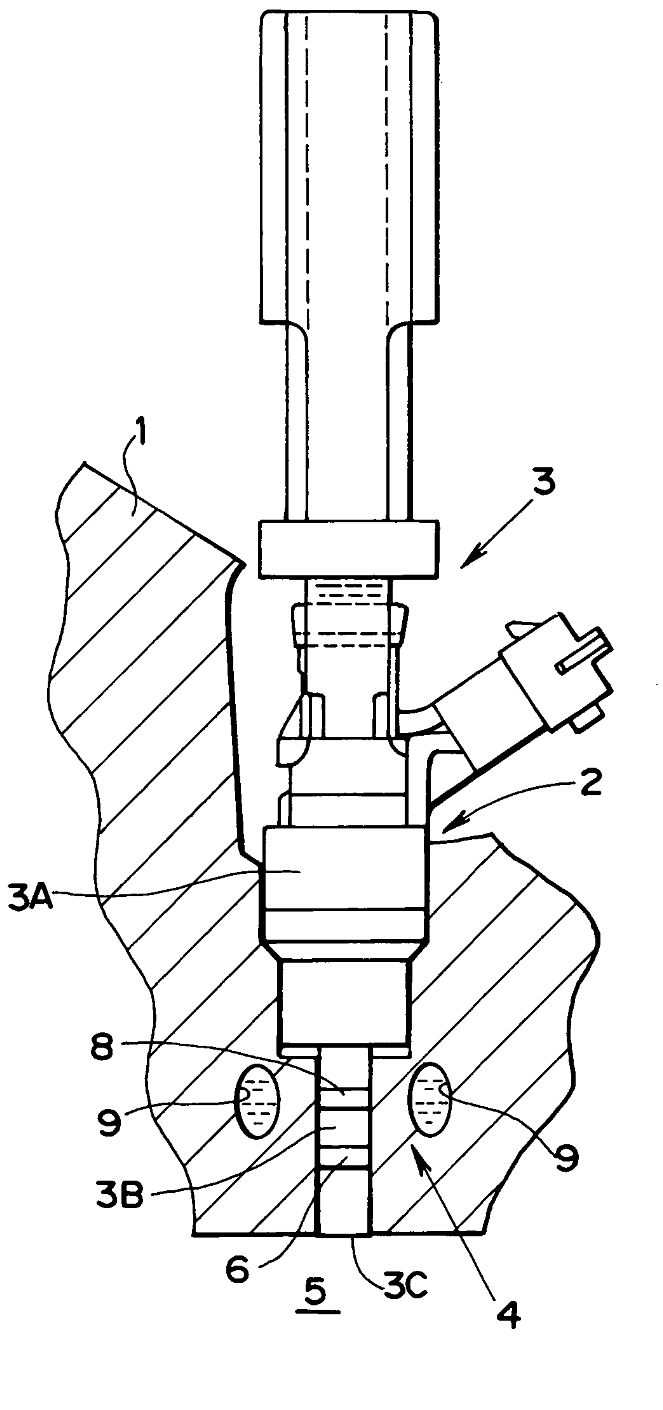

FIG.2

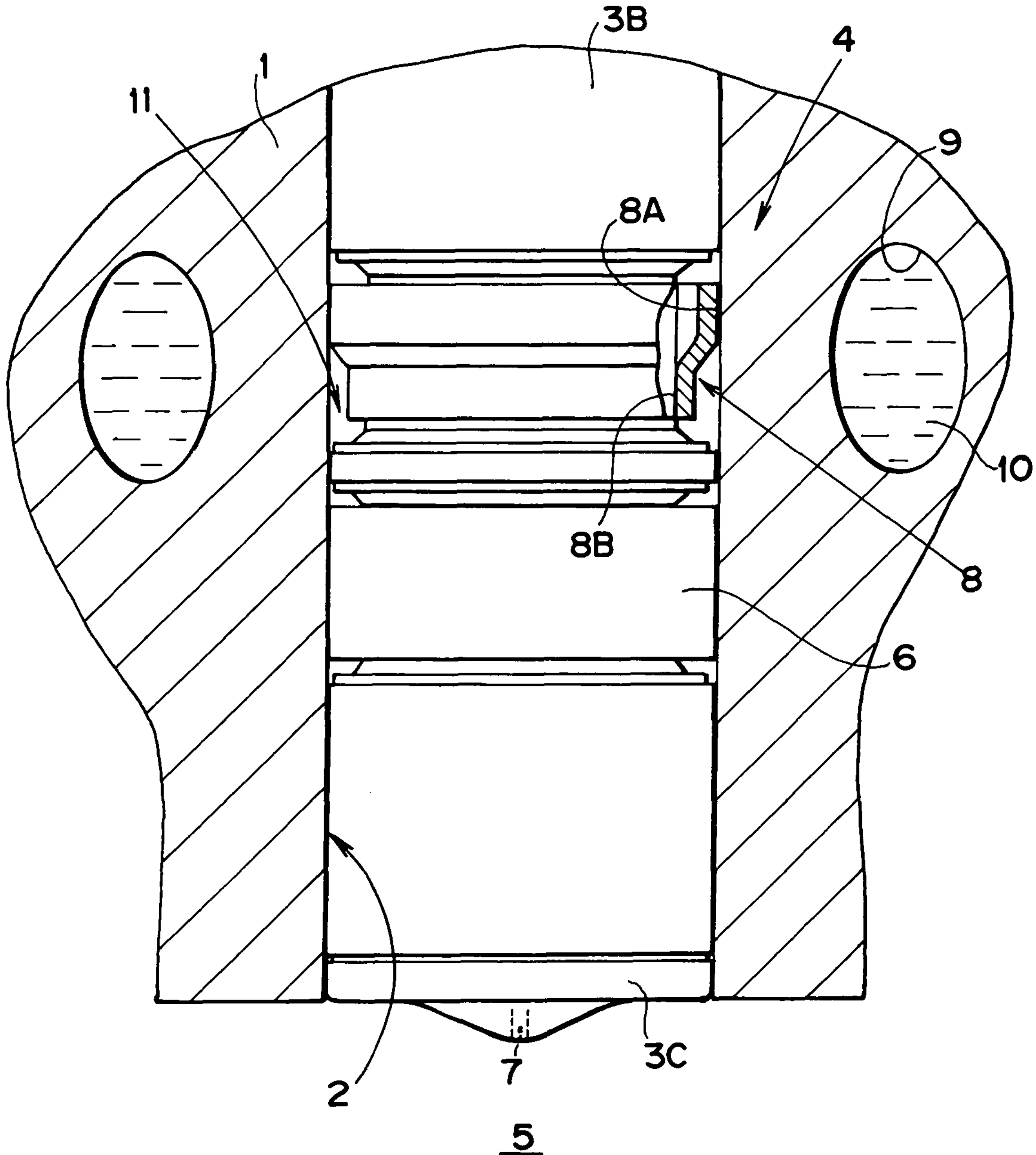

FIG. 3

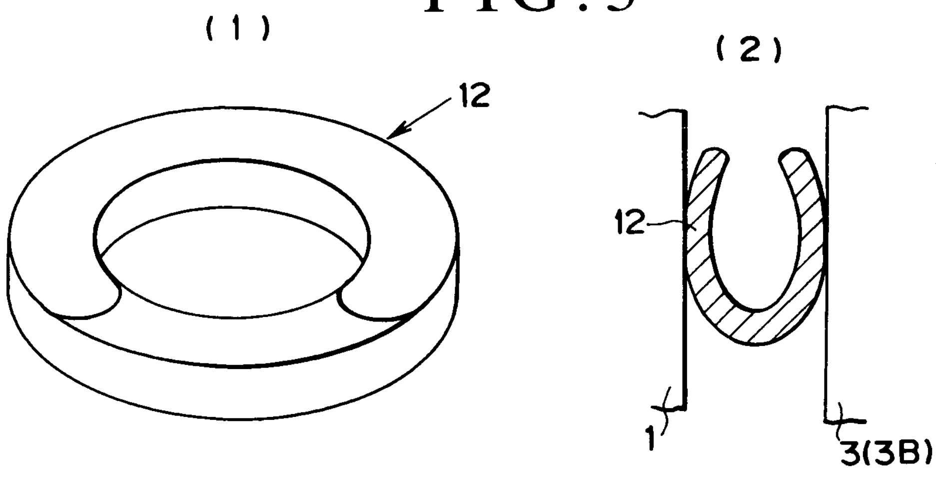

FIG. 4

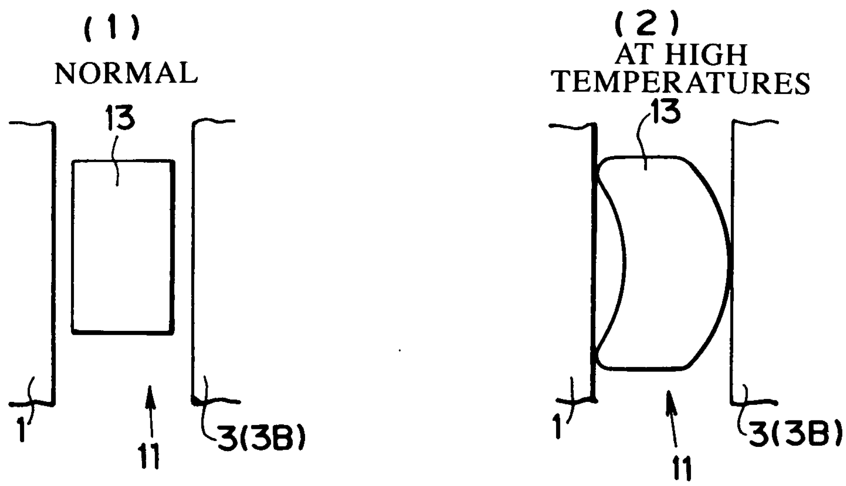

FIG. 5

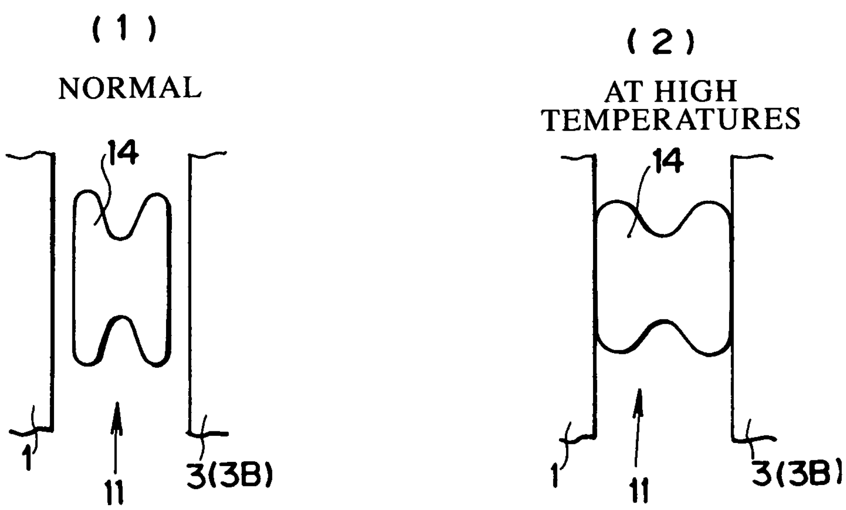

FIG.6