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(54) **Method and plug for sealing a core hole in a casting**

(57) A method for sealing a core hole of a casting with a plug, the plug being fittingly inserted into the core hole and sealingly secured therein, the plug being manufactured from a material which is recyclable with the material of the casting, in particular the same material as the casting or an alloy having a relatively high percentage of such metal, the plug being secured in the core hole at least substantially by means of deformation.

A casting manufactured from aluminum or an aluminum alloy, provided with at least one core hole, the core hole being closed by a plug secured therein, the plug being manufactured from aluminum or an aluminum alloy and being sealingly secured in the core hole at least substantially through deformation of a portion of the plug and/or the casting.

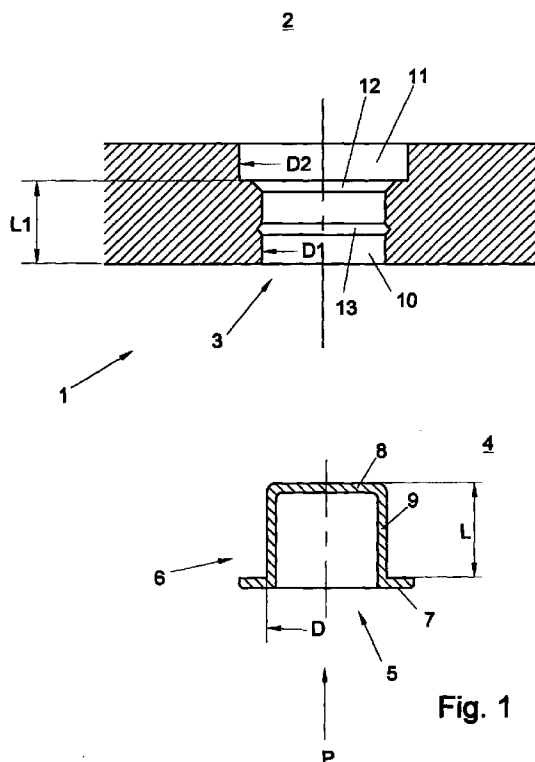


Fig. 1

EP 0 928 655 A1

Description

[0001] The invention relates to a method for sealing a core hole of a casting with a sealing plug, wherein the plug is fittingly inserted into the core hole. Such method is known from Dutch patent application 94.01864.

[0002] During the casting operation of castings having internal recesses, such as heat exchangers with water-carrying channels, cores are used which are laid in a mold. The cores are supported in one or more places in the mold, as a result of which the casting, after it is manufactured and the cores are removed, comprises a number of openings to be referred to as core holes. These openings must be closed before the casting in question can be used for, for instance, passing water.

[0003] In the known method, the plug is used which has a solid body with a circular groove in its outer face, which groove accommodates a springy sealing ring which extends out of the groove. During positioning, the plug is pressed into the core hole, while the outer longitudinal edge of the sealing ring, after positioning of the plug, cuts into the wall of the core hole and prevents the plug from being pressed out. The plug is directly secured when it is being pressed into the core hole. Hence, with such method, an inexpensive plug can be fitted in a particularly quick and effective manner.

[0004] This known method has the drawback that for obtaining a proper sealing, an O-ring should be included between the end face of the plug and a stop face in the core hole. This means that the core hole should have a special shape with at least a relatively accurately processed end face, which has a cost-increasing effect. Moreover, an O-ring should be used, which is unprofitable in terms of material usage and labor costs. A further drawback of this known method is that at the end of the service life of the casting, the plug must be removed to enable separation of the typically rubber O-ring and the steel plug from the casting, for separate residual processing thereof. This is costly and technically undesirable.

[0005] Further, it is known to screw a plug into each core hole. To that end, a core hole is bored out to a diameter suitable for threading, after which internal screw thread is provided in the bored-out hole. A plug having external screw thread is then fittingly screwed into the core hole. To obtain a proper sealing, the plug is manually provided, before it is screwed in, with a liquid packing agent or a comparable packing material. In this manner, castings can be rendered impervious to gas and/or liquid.

[0006] The use of a liquid sealing means is relatively inexpensive in terms of material usage, but has the drawback that it takes relatively much time before the packing has sufficiently dried to enable the casting to be pressure tested. Pressure testing of the casting is necessary for a proper check on the sealing action of the plug. Further, this known method has the drawback that when too little packing material is applied, or when the

packing material is applied wrongly or inaccurately, the plug can be removed for correction only with difficulty. This renders the sealing action poorly adjustable, as a consequence of which, in practice, a surplus of packing material will in each case be used in order to guarantee a proper sealing. This involves additional costs and, moreover, causes fouling of the surroundings. Moreover, drilling the core hole to an exactly suitable diameter and cutting the internal screw thread are time-consuming and accordingly costly procedures. In addition, because of inter alia the external screw thread and the desired accuracy thereof in view of the desired sealing, the plugs to be used in this known method are relatively costly. Moreover, to this method, too, it applies that after the service life of the casting, the plugs must be removed, while the sealing means used are moreover already highly environmentally polluting by themselves.

[0007] The object of the present invention is to provide a method of the type described in the preamble of the main claim, wherein the drawbacks mentioned of the known methods are avoided, while the advantages thereof are retained. To that end, a method according to the invention is characterized by the features of the characterizing part of the main claim.

[0008] The use of plugs manufactured from a material that can be recycled together with the material of the casting prevents the necessity of removing the plugs at the end of the service life for separate processing. In particular when for the plugs material is used which corresponds to the material of the casting at least to a high degree, recycling of such castings is possible in a particularly simple manner. Because the plug is secured in the core hole for sealing at least substantially through deformation, the mounting thereof is possible in a particularly quick and simple manner, while, moreover, no fouling substances such as liquid or non-liquid packing means have to be included in the core hole. This, too, is advantageous in terms of production, environment, as well as economy.

[0009] In a particularly advantageous embodiment, a method according to the invention is characterized by the features of claim 3.

[0010] Deforming the plug by means of a pressure fluid offers the advantage of obtaining a uniform distribution of the pressure over the surface area to be deformed, which pressure can be set and controlled in a particularly simple manner. Thus, in the sealing condition, an optimum fit of the plug within the core hole is in each case obtained, also if this were formed slightly irregularly. As a result, a particularly effective sealing can be obtained in a relatively fast and simple manner, without requiring that the relevant opening undergoes particular preliminary or finishing operations.

[0011] In an advantageous embodiment, a method according to the invention is characterized by the features of claim 4.

[0012] The at least partially hollow design of the plug offers the advantage that a relatively thin and readily

deformable wall part is obtained which, during or after the insertion of the plug into the core hole, can be deformed at least partially. This involves securement of at least the deformed portion of the plug behind at least a portion of the circumferential wall of the core hole. The at least partially plastic deformation offers the advantage of ensuring a permanent securement of the sealing plug. Moreover, when the plug is also deformed slightly elastically, a permanent closing force is obtained which will provide sufficient sealing action also during heat deformation of the parts of the casting. Moreover, it is possible to further adjust or increase the sealing action afterwards.

[0013] In a method according to the invention, the plug is preferably deformed in the core hole, but it will be appreciated that it is also possible to deform a portion of the material of the casting surrounding the core hole around the plug in a comparable manner, possibly in combination with deformation of the plug. Deformation of the plug can be effected in a simpler manner than deformation of the casting.

[0014] The present invention moreover relates to a casting manufactured from aluminum or an aluminum alloy, characterized by the features of claim 7.

[0015] The use of aluminum or aluminum alloys for castings of the subject type is particularly advantageous, in particular for casting channel-carrying products such as heat exchangers and the like. In those products, the water-carrying channels can be directly cast integrally therewith by means of cores incorporated into a mold, which cores, after casting, can be removed via the core holes. The use of plugs manufactured from aluminum or an aluminum alloy offers the advantages mentioned in respect of the above-described method. In this regard, aluminum offers the advantage of being relatively elastic, well- deformable, thermally sufficiently stable and having a good heat conduction. Moreover, aluminum offers the advantage of being relatively light and sufficiently corrosion resistant.

[0016] In a preferred embodiment, a casting according to the invention is characterized by the features of claim 11.

[0017] In such embodiment, a plug can be manufactured from relatively little material, which plug can readily be deformed in the core hole. To that end, a deforming tool is inserted, by the deforming portion thereof, into the space formed inside the plug, whereupon by means of the deforming tool, at least a portion of the circumferential wall can at least be radially displaced for a sealing plastic, preferably combined plastic and elastic deformation thereof.

[0018] Prior to or during the insertion of a plug according to the present invention into a core hole, an environmentally harmless, preferably natural sealing means can be provided in the core hole and/or on the plug, for instance a greasy substance which is subsequently compressed between the plug and the core hole. Thus, the sealing can be improved even further, while this

does not render integral recycling of the casting impossible.

[0019] The present invention further relates to a plug for use in a method or casting according to the invention. The invention further relates to a heat exchanger comprising a casting according to the invention and to a deforming tool for securing a plug in a core hole according to the invention, which deforming tool is characterized by the features of claim 15.

[0020] The invention moreover relates to the use of a hydromechanical expansion unit, characterized by the features of claim 18.

[0021] Further advantageous embodiments of a method, casting, plug, heat exchanger and deforming tool are given in the subclaims and will hereinafter be described in more detail and explained on the basis of a number of exemplary embodiments with reference to the accompanying drawings. In these drawings:

Fig. 1 is a cross-sectional view of a portion of a casting having a core hole and a separate plug;

Fig. 2 is a cross-sectional view of a casting according to Fig. 1, having an undeformed plug included in the core hole;

Fig. 3 is a cross-sectional view of a casting as in Fig. 2, having a sealingly deformed plug included in the core hole;

Fig. 4 is a cross-sectional view of a casting having a sealingly deformed plug included in a core hole, in an alternative embodiment;

Fig. 5 diagrammatically shows the front part of a deforming tool for use in a method and casting according to the invention;

Fig. 6 is a diagrammatic cross-sectional view of a casting as in Fig. 2, with an undeformed plug included in the core hole, together with a portion of a hydrodynamic expansion unit as deforming tool; and

Fig. 6A diagrammatically shows the plug and the deforming tool according to Fig. 6, during deformation of the plug.

[0022] In this description of the drawings, corresponding parts have corresponding reference numerals.

[0023] Fig. 1 shows a casting 1, for instance an aluminum heat exchanger, comprising a water-carrying channel 2. For forming the channel 2, a core formed from, for instance, core sand was included during casting. A core is positioned on a number of support points in a mold, whereupon a molding material is provided around the core. After removal of the casting 1 from the mold, the core is removed from the casting. The space provided in the casting by the core or cores then defines a water-carrying channel 2. At each position where the core had been supported, the wall of the casting 1 has an opening 3 connecting the channel 2 to the surroundings 4. Moreover, a number of openings 3 may further be formed through which the core is removed as one whole

or as loose core sand.

[0024] Before the heat exchanger can be put into use and the channel 2 can be filled with water, the openings 3 to be referred to as core holes should be sealed. To that end, a sealing plug 5 is used. In each core hole 3 to be sealed, such plug 5 can readily be provided.

[0025] The plug 5 comprises a body 6 having a cylindrical longitudinal wall 9, closed on a first side by a bottom face 8. From the opposite side of the longitudinal wall 9, a supporting collar 7 extends outwards. The plug 5 is substantially cylindrical and is manufactured from material comparable to that of the casting 1, in the present case from an aluminum alloy. In this regard, 'comparable material' should be understood to mean preferably a material or alloy having a high percentage, for instance more than 80%, more in particular more than 90% and preferably more than 95%, of the material or alloy of the casting or possibly a material that can at least be recycled therewith. The plug 5 is preferably manufactured from an aluminum alloy having a high extension and being insusceptible to stress corrosion between the plug and the casting, as will be explained in more detail hereinbelow. 'High extension' should at any rate be understood to mean an extension of more than 5%, for instance 10% or more. As alloy, an alloy based on Aluminum and Magnesium can for instance be used. These examples should not be construed as being limitative in any way.

[0026] Viewed in the inserting direction P for the plug 5, the core hole 3 comprises a first, cylindrical part 10 having a diameter D_1 approximately corresponding to the outside diameter D of the longitudinal wall 9 of the plug 5. Concentrically adjoining the first cylindrical part 10 is a second cylindrical part 11 having a diameter D_2 which is clearly larger than the diameter D_1 of the first cylindrical part 10. The transition 12 between the first cylindrical part 10 and the second cylindrical part 11 is formed by a frusto-conical part diverging in the inserting direction P and having a seal-increasing effect, as will be described in more detail hereinbelow. Provided in the first cylindrical part 10, in the circumferential wall thereof, is a rolled groove 13 whose function will be further described hereinbelow. The length L of the rolling plug 5 below the supporting collar 7 is slightly greater than the length L_1 of the first cylindrical part 10 together with the transition part 12.

[0027] Fig. 2 shows the rolling plug 5 in the position in which it is included in the core hole 3. It is clearly demonstrated that the supporting collar 7 abuts against the outer side of the casting 1, while the end wall 8 extends inside the second cylindrical part 11 of the core hole 3. In this position, the plug 5 is still freely movable. Subsequently, a nose portion of a forming tool 20, to be further described hereinbelow, is introduced into the space 14 within the plug 5, whereby the longitudinal wall 9 is deformed outwards, i.e. in radial direction, such that the outer wall of the longitudinal wall 9 abuts against the inner wall of at least the first cylindrical part 10, the

rolled groove 13 and a portion of the transition part 12 of the core hole 3. Thus, a combined plastic and elastic deformation of the aluminum is effected, to create an entirely watertight sealing of the core hole.

[0028] Because the portion of the longitudinal wall 9 located adjacent the bottom face 8 abuts against the wall of the frusto-conical transition portion 12, slot corrosion between the plug 5 and the casting 1 is prevented. Since a portion of the longitudinal wall 9 is deformed into the rolled groove 13, the press-out resistance and the sealing of the plug relative to the casting are increased. Moreover, this enables the influences of any temperature fluctuations between the plug 5 and the casting 1 to be taken up even more effectively, such that the sealing action of the plug is retained at all times. Because the bottom face 8 is included within the second cylindrical part 12 of the core hole 3, the plug 5 is prevented from extending into the water channel 2, which has the advantage that the influence of the plug on the flow pattern within the water channel is prevented, or at least minimized.

[0029] Fig. 4 shows an alternative embodiment of a casting 101 with a core hole 103 sealed by a plug 105. In this embodiment, the rolled groove 13 is replaced by two rolled ribs 113 extending parallel to each other, over which the rolling plug 105 is deformed. It will be understood that thus, a watertight sealing between the plug and the casting is obtained in a comparable manner. Further, it will be understood that any desired number of rolled grooves 13 and/or rolled ribs 113 can be provided, while moreover, such grooves and ribs can be dispensed with completely if deformation of the plug in the frusto-conical transition part 12 and/or the second cylindrical portion 11 is sufficient. Many variations thereto are possible.

[0030] In the exemplary embodiments shown, a hollow plug 5, 105 is used in each case. However, it is also possible to use a plug which is entirely or at least highly solid, while included in the core hole is a collar which lies ahead in the inserting direction P, against which collar the plug abuts by its bottom face during insertion. Subsequently, the plug can then be upset in the inserting direction, whereby a radial deformation of the plug will occur and the desired sealing is obtained. This requires more force and more material than in the case where the hollow plugs are used.

[0031] Fig. 5 diagrammatically shows the nose piece 21 of a deforming tool 20 for use with the hollow plugs 5, 105. This deforming tool is a rolling tool. The nose part 21 comprises for instance two rolling wheels 22' and 22'' that are fixedly disposed or rotatable about a first axis of rotation A_1 . The first rolling wheel 22' is entirely at the front of the nose piece 21, the second rolling wheel 22'' is spaced from the first rolling wheel 22'. When the nose piece 21 is inserted into the space 14, such that the first rolling wheel 22' abuts against the bottom face 8 of the plug 5, the second rolling wheel 22'' is at the level of the circumferential groove 13. The nose piece 21 is

arranged on a rotating base piece 23 for displacement in radial direction and can thereby be driven in rotational sense. The base piece 23 is rotatable about a second axis of rotation A_2 . During use, the distance between the first axis of rotation A_1 and the second axis of rotation A_2 can be set and adjusted to the diameter of the plug 5. In other words, when the nose piece 21 is inserted into the plug, it can be rotated around the axis A_2 by means of the base piece 23, and the nose piece can be displaced in radial sense such that the distance between the axes of rotation A_1 and A_2 is increased while it presses away the longitudinal wall 9 outwards to assume the condition shown in Fig. 3. After that, the nose piece 21 can be placed back and the tool can be removed.

[0032] It will be understood that in a comparable manner a tool can be used for a plug as shown in Fig. 4. Moreover, many variations thereto are directly clear to anyone skilled in the art. It is further observed that the nose piece 21 in itself also contributes to the deformation of the longitudinal wall 9. To this end, the entire nose piece may be designed for rotation about the first axis of rotation A_1 .

[0033] Fig. 6 diagrammatically shows a plug according to Fig. 2. The plug 5 comprises a hollow portion 14 into which a front end 32 of a deforming tool 31 can be inserted. This front end 32 has a substantially cylindrical shape and can be received in the space 14 with a slight play. Provided in the outer circumference of the deforming tool 31 are two spaced apart, annular grooves 34 which accommodate sealing rings 35. When the deforming tool 31 is fittingly received in the space 14, the sealing rings 35', 35" abut against the inside of the longitudinal wall 9 or can be moved thereagainst and accordingly, during deformation, enclose a chamber 39 between the two sealing rings 35', 35", the outer wall of the deforming tool 31 and the inside of the longitudinal wall 9 (Fig. 6A). From the rear of the deforming tool 31, viewed in the inserting direction, a channel 33 extends over a portion of the length of the deforming tool 31, which channel on the opposite side opens into a number of radial discharge channels 37 opening into the chamber 39. Via a connecting opening 38, the axial channel 33 is connected to pump means 40 which are connected to a storage vessel 41 for a pressure fluid, in particular water or oil. During use, the liquid can be fed under pressure by the pump means 40 from the storage vessel 41 into the chamber via the axial channel 33 and the radial channels 37, in such a manner that the cylindrical wall 9 of the plug 5 is pressed away outwards, i.e. plastically deformed into abutment against the groove B in the core hole. The use of the fluid offers the advantage of obtaining a uniform pressure distribution and an exact fit of the plug 5 in the core hole 3, also if the core hole is deformed slightly irregularly. After the plug 5 has been sufficiently deformed, the pressure can be removed from the chamber 39, for instance by drawing off the pressure medium, after which the deforming tool

31 can be pulled from the plug 5 again.

[0034] It will be understood that different pressure media can be used, for instance liquid, gas or small solid particles. Moreover, a sealing of the chamber 39 can be effected in different manners, in respect of which it may in particular be important that a sufficiently pressure-tight sealing is obtained which may or may not follow any deformation of the longitudinal wall 9. For a further, non-limitative description of a deforming tool 31 as described on the basis of Fig. 6, reference is made to hydro-expansion units known from the prior art.

[0035] During the insertion of the plug, an environmentally harmless sealing substance, for instance grease, may be provided between the plug and the casting. This results in an even better sealing, while, moreover, corrosion is prevented even more effectively. Such substance does not affect the recycling capability of the casting.

[0036] The invention is by no means limited to the embodiments described and shown in the description and drawings. Many adaptations thereto are possible. For instance, the design of a plug and an associated core hole in a casting according to the invention may be other than cylindrical, for instance frusto-conical. Also, the core hole may for instance be frusto-conical, the top thereof facing outwards, while the plug is for instance cylindrical, or at least less frusto-conical. During deformation of the plug, the longitudinal wall thereof is then moved against the conical surface of the core hole, causing the plug to be secured behind the top of the core hole. A method and casting according to the invention are in particular suitable for a heat exchanger, but other apparatus may of course also be manufactured thereby. Also, other material combinations may be used, as long as they are jointly recyclable as casting. These and many comparable variations are understood to fall within the framework of the invention.

Claims

1. A method for sealing a core hole of a casting with a plug, the plug being fittingly inserted into the core hole and sealingly secured therein, **characterized in that** the plug is manufactured from a material which is recyclable with the material of the casting, in particular the same material as the casting or an alloy having a relatively high percentage of such metal, the plug being secured in the core hole at least substantially by means of deformation.
2. A method according to claim 1, characterized in that the plug is secured in the core hole through partial plastic deformation by means of a rolling and/or upsetting operation.
3. A method according to claim 1 or 2, characterized in that the plug is secured in the core hole through partial plastic deformation by means of fluid pres-

sure, in particular hydrostatic pressure.

4. A method according to any one of claims 1-3, characterized in that the plug is of an at least partially hollow design, a wall part of the plug being plastically deformed during or after its insertion into the core hole, such that at least the deformed portion is partially retained behind a portion of the core hole, viewed from the outside of the casting. 5
5. A method according to any one of the preceding claims, characterized in that in the circumferential wall of the core hole, at least one groove-shaped recess is provided in which the plug is at least secured. 10
6. A method according to any one of the preceding claims, characterized in that the plug in the core hole is deformed such that a first portion thereof lying ahead in the inserting direction of the plug acquires a larger outer circumference than at least the portion of the circumferential wall of the core hole connecting thereto in axial sense. 15
7. A casting manufactured from aluminum or an aluminum alloy, provided with at least one core hole, the core hole being closed by a plug secured therein, characterized in that the plug is manufactured from aluminum or an aluminum alloy and is sealingly secured in the core hole at least substantially through deformation of a portion of the plug and/or the casting. 20
8. A casting according to claim 7, characterized in that the core hole is provided with an at least largely circular, groove-shaped recess in the longitudinal wall, while at least a portion of the plug extends into the recess for securing the plug. 25
9. A casting according to claim 7 or 8, characterized in that the plug, at the inwardly facing end thereof, has a section which is slightly larger than the section of the portion of the core hole connecting thereto in axial direction. 30
10. A casting according to any one of claims 7-9, characterized in that the core hole has its inwardly facing end provided with a collar portion whose sectional area increases in the direction of the inside of the casting. 35
11. A casting according to any one of claims 7-10, characterized in that the plug has a closed end wall having a circumferential wall connecting thereto, within which a space is defined for receiving a deforming tool. 40
12. A casting according to claim 11, characterized in 45

that the plug is provided with an outwardly extending supporting face adjacent the side remote from the end wall.

13. A plug for use in a method according to any one of claims 1-6 or in a casting according to any one of claims 7-12. 50
14. A heat exchanger comprising a casting according to any one of claims 7-12. 55
15. A deforming tool for securing a plug in a core hole in a casting according to any one of claims 7-12, characterized in that the tool comprises a deforming portion which can be placed in the plug and comprises deforming means arranged for outwardly deforming at least a portion of the wall of the plug.
16. A deforming tool according to claim 15, wherein the deforming means comprise at least one slightly outwardly displaceable rolling wheel or a like rolling means.
17. A deforming tool according to claim 15, characterized in that the tool comprises sealing means for forming within the plug a fluid-tight chamber between a wall part thereof and a portion of the deforming tool, means being provided for feeding into said chamber a deforming medium, in particular a liquid, for plastically deforming the plug at least partially.
18. Use of a hydromechanical expansion unit as deforming tool for securing a plug in a core hole of a casting.

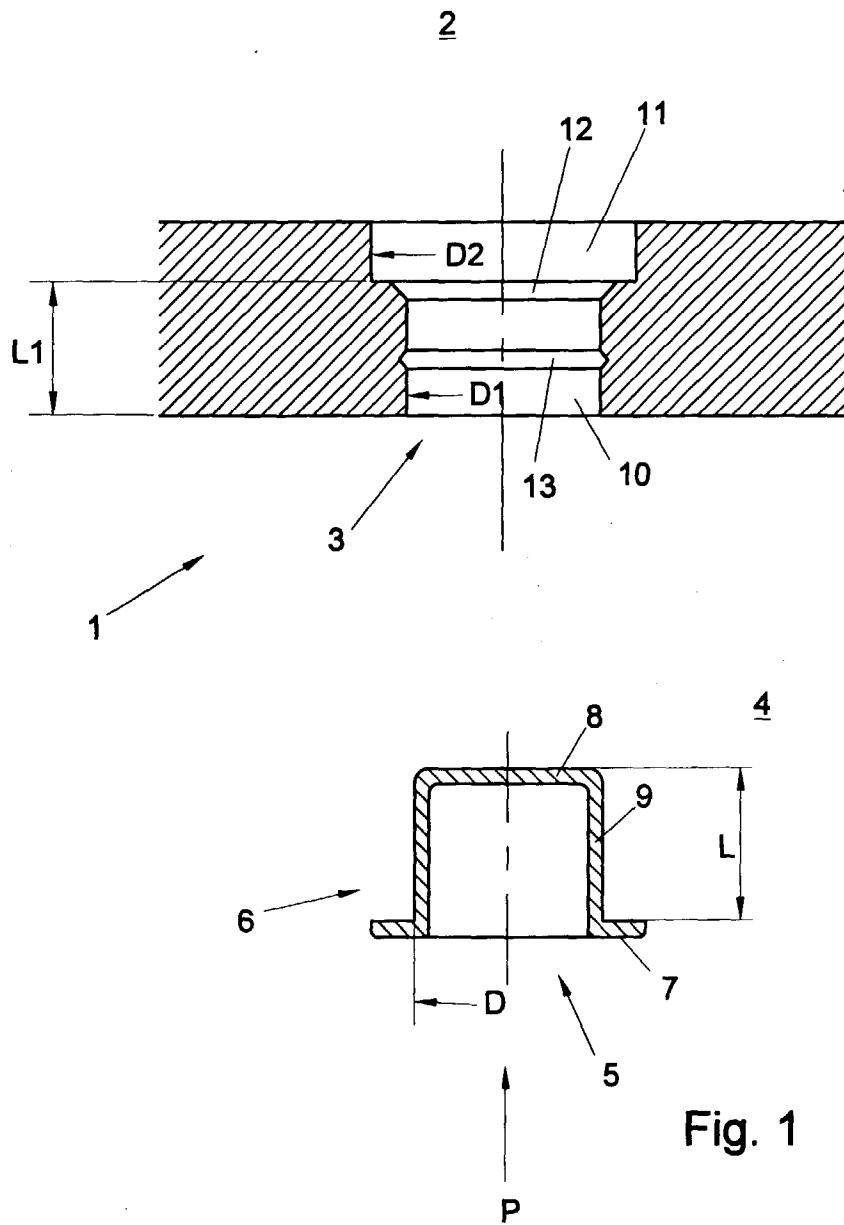


Fig. 1

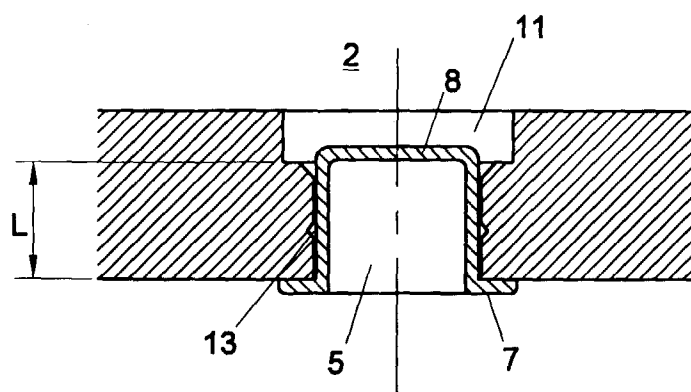


Fig. 2

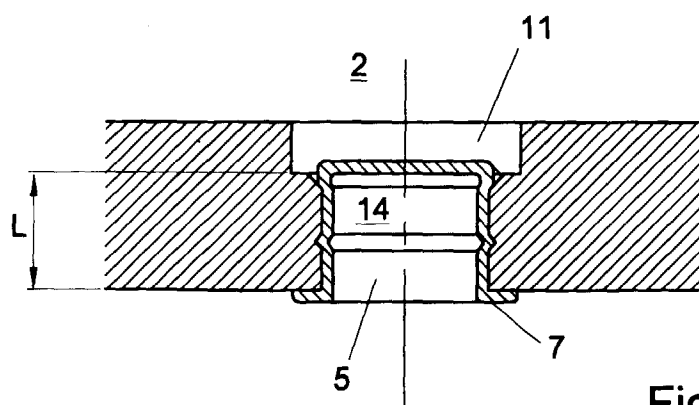
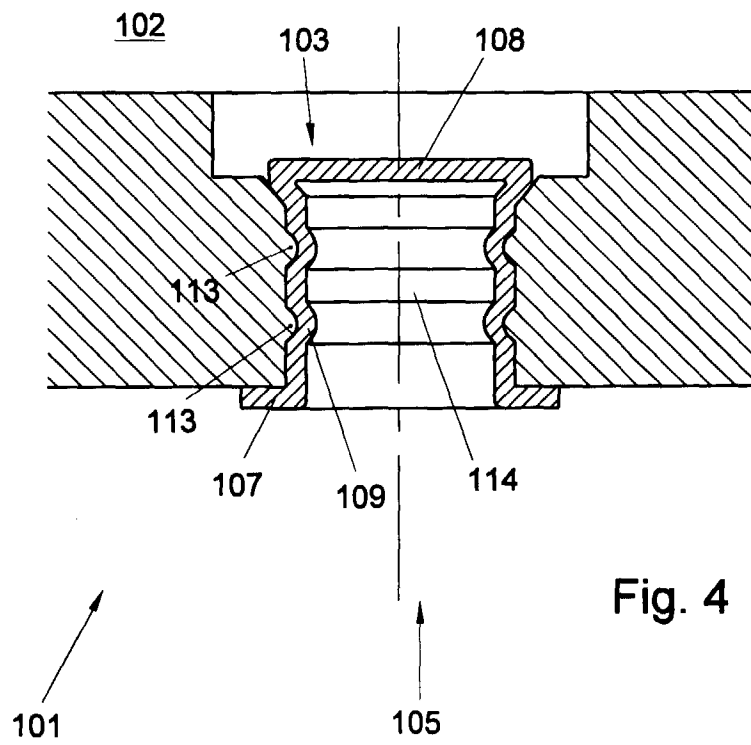
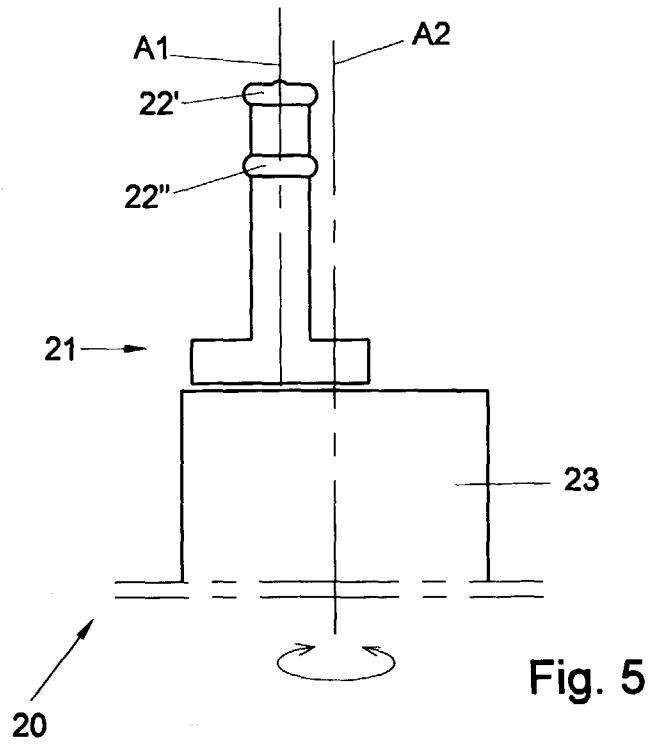


Fig. 3



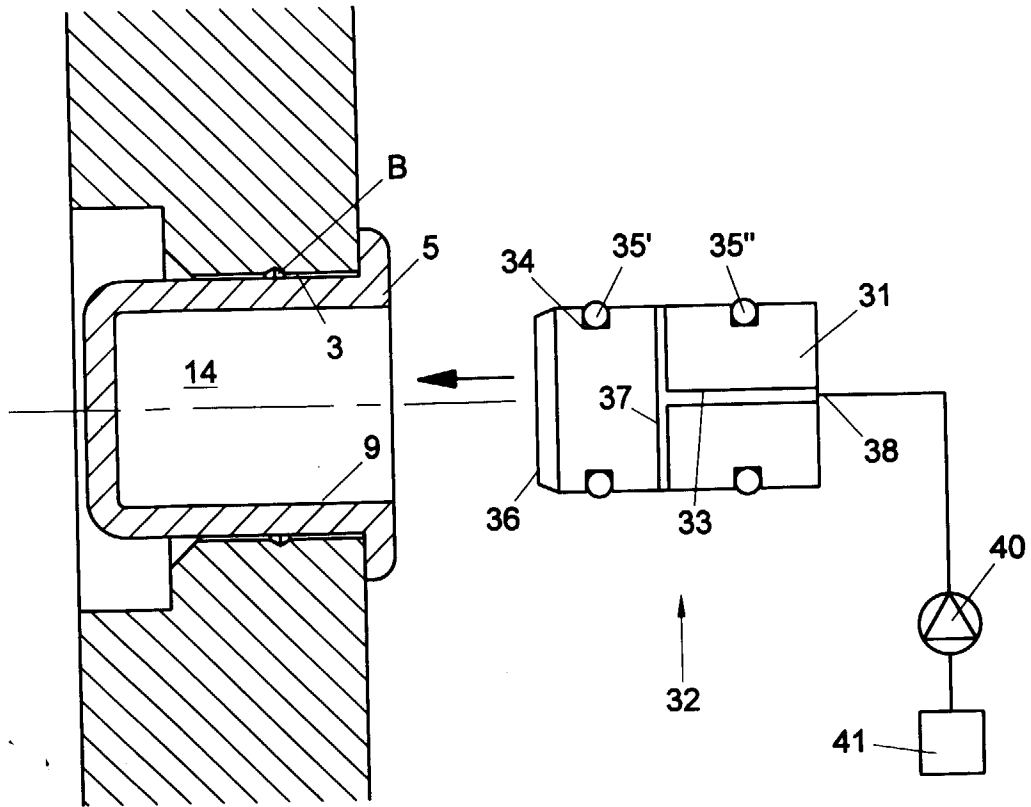


Fig. 6

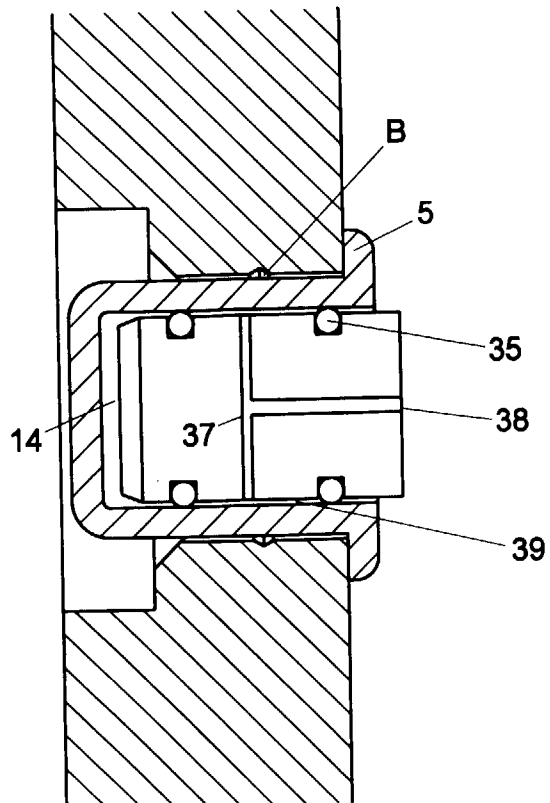


Fig. 6A



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EUROPEAN SEARCH REPORT

Application Number
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The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 9 April 1999	Examiner Peis, S
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EPO FORM 1503 03/82 (P04C01)



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EUROPEAN SEARCH REPORT

Application Number
EP 99 20 0021

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A		3	TECHNICAL FIELDS SEARCHED (Int.Cl.6)
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 9 April 1999	Examiner Peis, S
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 99 20 0021

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