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(54) Method to remove a nose part of an injection nozzle from a cylinder head

(57) The present invention relates to a method for removing in situ of a nose part (3) of an injection nozzle from a cylinder head (1), wherein the nose part (3) has become detached from the injection nozzle and is remained behind in an injection nozzle opening (2) in the cylinder head and wherein the remaining part of the injection nozzle, other than the nose part (3) has been removed from the injection nozzle opening (2) in the cylinder head (1), wherein the method comprises forming of an internal thread (18) in the opening (16) in the nose part (3), mounting on the cylinder head (1) or supported by the cylinder head (1) of a pulling device (4), attaching a pulling spindle (6a) to the nose part (3) using the obtained thread (18) and exerted a pulling force by the pulling device (4) on the nose part (3).

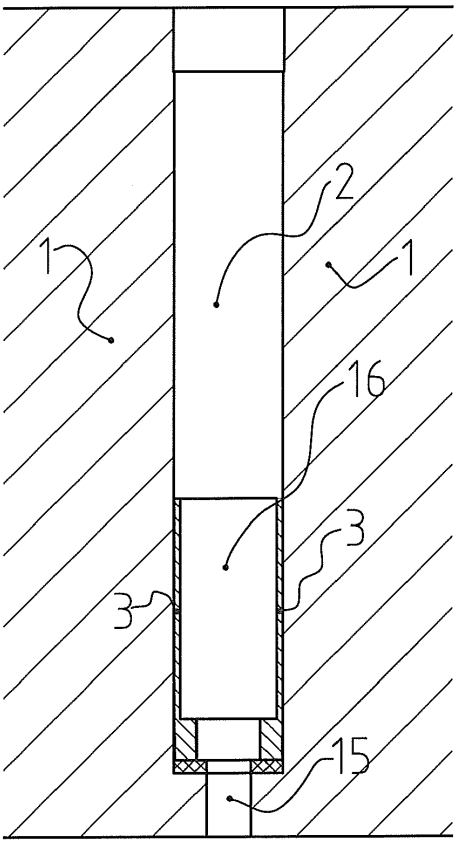

Fig. 1

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Description

[0001] The present invention relates to a method to remove a nose part of an injection nozzle from a cylinder head, wherein the nose part is broken off or has become detached of the injection nozzle and is left behind in an injection nozzle opening in the cylinder head and wherein the part of the injection nozzle, other than the nose part, has been removed from the injection nozzle opening in the cylinder head.

[0002] In combustion engines injection nozzles are inserted in cylindrical openings in the cylinder head. The injections nozzles often are mounted essentially close-fitting in the cylinder head. When an injection nozzle becomes defective and needs to be replaced, the injection nozzle housing is being pulled out of the cylinder with a pulling device.

During operation combustion gasses penetrate between the injection nozzle and the cylinder head. Small particles such as soot-particles from these combustion gasses will be deposited between the injection nozzle and the cylinder head. Through this adhesion will take place between the injection nozzle and the cylinder head. Also after some time corrosion will occur between the injection nozzle and the cylinder head causing that the injection nozzle gets more and more blocked in the cylinder head. This corrosion can be oxygen corrosion, that is being accelerated by the high temperatures, but can also be corrosion caused by stray currents. Further contamination particularly around the edges can contribute to the injection nozzle getting more and more stuck in the cylinder head. This will make the pulling of the injection nozzle out of the cylinder head considerably more difficult. Systems and methods are known to remove a defective injection nozzle from a cylinder head, in which the cylinder head is being dismounted from the engine and the injection nozzle is being removed with special tooling from the cylinder head in a special workshop, for instance from a company specialised in revising combustion engines. However it is important that pulling out of a defective injection nozzle can take place in situ on the engine, without having to dismount the cylinder head from the engine.

[0003] For removing injection nozzles from cylinder heads special pulling tools are available on the market. In this respect pulling tools, as described in WO 2007/091883 of the applicant of the present patent application deserves to be mentioned here. It is important that the injection nozzle can be pulled out of the cylinder head in its entirety without damaging the cylinder head. If this is not successful, in many cases the cylinder head has to be dismounted from the engine and attempts must be made to remove the injection nozzle, or the remains thereof, with other means.

[0004] An injection nozzle usually has a cylindrical shape where at one end a nose part has been screwed on. The nose of the injection nozzle is in the mounted position the part that is deepest down in the opening in the cylinder head. In certain cases, the nose part has a cylindrical shape with a smaller diameter than the remaining part, the upper part of the injection nozzle. In those cases the opening in the cylinder head for receiving the injection nozzle will be a stepped bore with two diameters to receive the injection nozzle and its nose part with a close fit.

[0005] In removing for instance a defective injection nozzle it may occur that the upper part of the injection nozzle is being pulled out of the cylinder head, but that the nose or part of the nose remains behind in the part of the bore with a smaller diameter. Causes for this can be the exertion of too large a pulling force during pulling the injection nozzle out of the cylinder head. When this pulling force exceeds the strength of the connection from the nose part and the upper part of the injection nozzle, it is likely that in this connection breakage will occur or deformation/loosening of the thread such that the nose part remains behind in the bore in the cylinder head. In this case the cylinder head needs to be dismounted to remove the remaining nose part from the injection nozzle out of the cylinder. In most cases this needs to take place using special tooling and in a different location notably by a specialised company. It can also be envisiged that the situation occurs by that the upper part of the injection nozzle can be unscrewed, but the nose part remains behind in the cylinder head, attached by the processes described above.

[0006] It is an aim of the present invention to provide a method for removing a nose part of an injection nozzle from a cylinder wherein the nose part has been broken off/become detached from the injection nozzle and remains behind in the injection nozzle opening in the cylinder head and the part of the injection nozzle, other than the nose part has been removed from the injection nozzle opening in the cylinder head, without the need to dismount the cylinder head.

[0007] This objective is reached by a method according to claim 1 of the present invention.

[0008] Following the method of claim 1 a thread forming tool and a guide are being arranged in the injection nozzle opening above the nose. Then with this thread forming tool using the guide an internal thread is being made in the opening of the nose part wherein this internal thread is coaxial with the nose part. The diameter of the thread is such that the wall thickness of the nose part that the outer part of the thread seen in a radial direction, is kept very small, without however running the risk that this thread is extending to beyond the nose part, what would cause damage to the cylinder head. The thread forming tool can be any suitable tool, such as a tapping tool, a rolling tool, etc. Further it is of importance that the thread is extended in axial direction as far as possible to the far end of the nose part. Preferably and if possible the thread is extended over the entire length over which the nose part is in contact with the cylinder head, respectively over which the nose part is being stuck to the cylinder head. Subsequently a pulling device is being mounted on the cylinder head and a pulling spindle of

the pulling device is being attached to the nose part using the thread that has been obtained by tapping. The remaining part of the nose after applying the internal thread, is a thin sleeve. When using the pulling device a pulling force is being exerted on this thin sleeve, this sleeve will mainly be squeezed between the external thread of the pulling spindle and the cylinder head. Through this it is possible to exert on this sleeve a pulling force that is far beyond the yield strength of the sleeve. When this occurs the material of the remaining part of the nose, that is situated between the cylinder and the thread will plastically deform and will flow. Through this the nose part can be moved slowly upwards and eventually can be removed from the cylinder head without causing damage to the cylinder head. It is of importance that the pulling force is being selected sufficiently large to create plasticity of at least a part of the sleeve, but not so large that the cylinder head is being damaged. When plasticity is being reached it requires a certain amount of time for the sleeve to follow a movement in the pulling direction, because this movement takes place as a result of the plastic flow of the material. It must be avoided that the pulling force is being increased until the nose part snaps loose. In that case it is likely that the pulling also damages the cylinder head.

[0009] In certain cases it can be necessary that the existing opening in the injection nozzle nose has to be pre-processed before the tapping of the thread can take place. It can for instance be necessary to bore out or ream the opening.

[0010] Also it can be advantageous to use a vibrating device to generate vibrations and transfer these vibrations to a nose part prior to pulling with the pulling device. Using these vibrations corrosion parts between the nose part and the cylinder can be loosened after which a smaller pulling force is required to loosen the nose part from the cylinder head.

[0011] In a preferred way the method is operated with caution in that the pulling device is set to a certain pulling force and this pulling force is being exerted for some time on the nose part. When this pulling force is set such a way that the stresses occurring at the wall of the nose part and in particularly in the thinnest part are such that this part will experience plastic flow, then the nose part will make a small movement in the direction of the exerted pulling force, and therefore in the direction of pulling out the nose part out of the opening in the cylinder head. Through this small movement the exerted pulling force will in general decrease and the pulling force can be set again and the process is repeated. Through this in a cautious way, without a risk for damage the nose part is being pulled out of the opening in the cylinder head in small steps.

[0012] The invention will now be explained by description of the preferred embodiment of the invention with reference to the drawing in which:

Fig. 1 schematically shows a part of a cylinder head with a injection nozzle opening and a remaining nose part in cross section,

Fig 2. shows a schematic view in cross section of an embodiment of a pulling device for use with the method according to the invention,

Fig. 3 schematically shows a side view of an embodiment of further parts for use with a method according to the invention,

Fig. 4 shows schematically a view in cross section of placing the sealing plug of figure 3,

Fig. 5 shows a view in cross section of tapping tool in an injection nozzle opening and a cylinder head with a remaining nose part of an injection nozzle,

Fig. 6 shows a schematic representation of a pulling device with a pulling spindle attached to the nose part, and

Fig. 7 shows a representation on a larger scale of the thread of the pulling spindle and the thread of the nose part.

[0013] In Fig. 1 a part of a cylinder head 1 with an injection nozzle opening 2 and a broken off nose part 3 in the opening 2 has been represented.

[0014] Fig. 2 shows a schematic representation of a pulling device that as whole is indicated with the reference number 4. Pulling device 4 comprises a housing 5, that can be fixed to cylinder head 1 (not shown in fig. 2) so that it is supported by the cylinder head in such a way, that pulling spindle part 6a is aligned with the opening of nose part 3. Pulling spindle 6 comprises pulling spindle parts 6a and 6b that can be coupled to each other. It is also possible that pulling spindle 6 comprises one piece such that pulling spindle parts 6a and 6b form one part. Pulling spindle part 6b comprises at an end opposite to the end coupled to pulling spindle part 6a, an external thread 8 at the exterior of the shaft. External thread 8 of the pulling spindle part 6b engages an internal thread in a hexagonal nut 9 that is rotatingly supported by housing 5. Hexagonal nut 9 can be engaged by a tool such as a torque spanner. Pulling device 4 comprises further a vibrating member 30 for generating mechanical vibrations.

[0015] Fig. 3 shows thread forming tool 10, that in this example is embodied by a tapping tool 10. Tapping tool 10 comprises a shaft 10a, that at one end comprises a tapping thread 11 and at the other end 12 is shaped such that it can be engaged by a tommy bar or a suitable socket wrenge. Further guide 13 is shown in fig. 3 for centred axial guidance of tapping tool 10 with respect to the axis of the nose part 3 of the injection nozzle. Guide 13 comprises a cylindrical sleeve 13b with a shoulder 13a at one end, wherein the cylindrical sleeve has an external diameter that corresponds to the diameter of the injection nozzle opening 2 and the cylindrical sleeve has an internal diameter that corresponds to the external diameter of the shaft 10a of tapping tool 10. Further in fig. 3 plug 14 is shown for covering opening 15 (see fig. 1) at the end of nose part 3.

[0016] The removal of nose part 3 from cylinder head

1 while using the system and the method according to the invention is as follows.

[0017] First the injection nozzle is dismantled, meaning that the loose internal parts such as springs, needle and nozzle are being removed from the injection nozzle nose. Subsequently plug 14 is inserted in opening 15 of nose part 3 that continues in cylinder head 1. Plug 14 serves to prevent chips that are being formed during tapping (see below) and possible used tapping fluid from falling into the cylinder in cylinder head 1. The position of the mounted plug 14 in opening 15 is shown in fig. 4.

[0018] Then tapping tool 10 and guide 13 are inserted in injection nozzle opening 2. Guide 13 through its shoulder 13a is supported on the upper surface of cylinder head 1 and through the external face of sleeve 13b against the wall of the injection nozzle opening 2. The inner wall of sleeve 13b guides tapping tool 10 in such a way that tapping thread 11 can tap a thread in opening 16 in nose part 3 in such a way that the obtained thread is coaxial with the external wall of nose part 3, that is in contact with the wall of the part of the injection nozzle opening that surrounds the nose part 3. Now thread 18 (see fig. 7) is being tapped in nose part 3 of the injection nozzle that is remaining in the cylinder head, using the tapping tool and the tap wrench. The tapping thread 11 of tooling 10 is chosen such, that after tapping the remaining wall thickness d (see fig. 7) of the nose part at the outer part, seen in the radial direction, of thread 18 is smaller than 3,0 mm and larger than 0,0 mm, preferably smaller than 1,5 mm and larger than 0,5 mm. After completion of the tapping of thread 18 in nose part 3, tapping tool 10 and guide 13 are being removed from injection nozzle opening 2, and chips and possible drops of tapping fluid are being sucked out of opening 16 in nose part 3, after which plug 14 can be removed.

[0019] Pulling spindle part 6a comprises at its free end external thread that corresponds to thread 18 that has been tapped in nose part 3 and pulling spindle 6a is being attached to nose part 3 using this thread and thread 18 of nose part 3. Then pulling device 4 is mounted such that it is supported by cylinder head 1 over injection nozzle opening 2 and pulling spindle 6a is being coupled to pulling spindle 6b of pulling device 4.

[0020] Then using e.g. an torque wrench on head 9, pulling device 4 is being tensioned to a predetermined level. This tension is selected such that the material from nose part 3 at least in certain places will deform plastically and plastic flow will start. Through this, injection nozzle nose 3 will move upwards over a small distance. Also material of nose part 3 can flow to spaces 20 that are being determined by the peaks of thread 18 in nose part 3 and the corresponding thread at the end of pulling spindle part 6a. Through this the pressure and the therefore the friction between nose part 3 and the wall of the cylinder head that forms the injection nozzle opening 2 can decrease and thus the movement of the injection nozzle nose in the pulling direction is facilitated. This upward movement will reduce the pulling force exerted by the pulling device on the nose part until the stress in the material is decreased such that it doesn't flow any longer.

[0021] Now the pulling force can be increased again. However a waiting time of at least 5 s is necessary before increasing the pulling force, to enable the described process of plastic flow to take place. Further once an albeit small movement of the nose part has taken place, the sticking between nose part and cylinder head is at least partly reduced, so that following movements of the nose part as a consequence of the pulling force will be easier. The process of increasing the pulling force by using the torque wrench, and subsequently waiting a few seconds (at least 5s) to enable the pulling force have it's affect, is being repeated until the nose part is completely loosened from the cylinder head.

[0022] If necessary prior to pulling the nose part 3, nose part 3 can be subjected to mechanical vibration, using vibrating member 30, to loosen up the sticking connection between nose part 3 and cylinder head 1. Prior to and/or during the vibrating a solvent fluid is being injected at the upper part of the nose part 3 to at least partly dissolve contamination between nose part 3 and cylinder head 1. By the vibration capillary cavities will be created through which this fluid can spread between nose part 3 and cylinder head 1. The generation of such vibrations and also its effects are being described in WO 2007/091883, reason for which this will not in further detail be discussed here. In persistent cases injection of the vibrations can also take place between the various pulling steps.

[0023] The invention has been described using examples of embodiments. For a person skilled in the art it will be possible to apply many modifications and variations all belonging to the invention as being determined by the appended claims.

List of reference numbers.

[0024]

1	cylinder head
2	injection nozzle opening
3	nose part
4	pulling device
5	housing of 4
6	pulling spindle
6a	pulling spindle part
6b	pulling spindle part
8	thread
9	tensioning nut

10	thread forming tool
10a	shaft of 10
11	tapping thread
12	end of 10
13	guide
13a	shoulder of 13
13b	sleeve of 13
14	plug
15	opening in end of 3 continuing in 1
16	opening in 3
18	thread in 3
20	space between threads
30	vibrating member

Claims

1. Method for removing in situ of a nose part (3) of an injection nozzle from a cylinder head (1), wherein the nose part (3) has become detached of the injection nozzle and is remained behind in an injection nozzle opening (2) in the cylinder head and wherein the remaining part of the injection nozzle, other than the nose part (3) has been removed from the injection nozzle opening (2) in the cylinder head (1), **characterized in that** the method comprising the following steps:

   a) providing in the injection nozzle opening (2) over the nose part (3) a thread forming tool (10) including a guide (13);
   b) forming of an internal thread (18) in an opening (16) in the nose part (3), of such a diameter, that the wall thickness (d) of the nose part at the outer part of the thread, seen in radial direction, is smaller than 3,0 mm and larger than 0,0 mm, preferably smaller than 1,5 mm and larger than 0,5 mm;
   c) mounting of a pulling device (4) on the cylinder head (1), respectively supported by the cylinder head (10);
   d) attaching a pulling spindle (6a) to the nose part (3) using the thread (18) obtained at step b);
   e) exerting a pulling force while using the pulling device (4) on the nose part (3).

2. Method according to claim 1, **characterized in that** prior to step a) the method comprises the step of

   a0) pre-processing the opening (16) in the nose part (3).

3. Method according to claim 1 or 2, **characterized in that** prior to step e) the method comprises the step

   e0) providing a corrosion dissolving fluid at the nose part (3) and the part of the cylinder head (1) adjacent to the nose part (3) and using a vibrating member generating vibrations that are being transferred by the pulling device (4) to the nose part (3) during a predetermined period of time.

4. Method according to one of the claims 1 to 3, **characterized in that** step e) comprises the following steps:

   e1) setting of the pulling device (4) to a pulling force of a predetermined level;
   e2) exerting the pulling force by the pulling device (4) on nose part (3) during at least 5 s.;
   e3) increasing the pulling force exerted at that moment by the pulling device (4) to the nose part (3) with a predetermined amount;
   e4) repeating of steps e2) and e3) until the nose part (3) has been removed from the injection nozzle opening (2) in the cylinder (1).

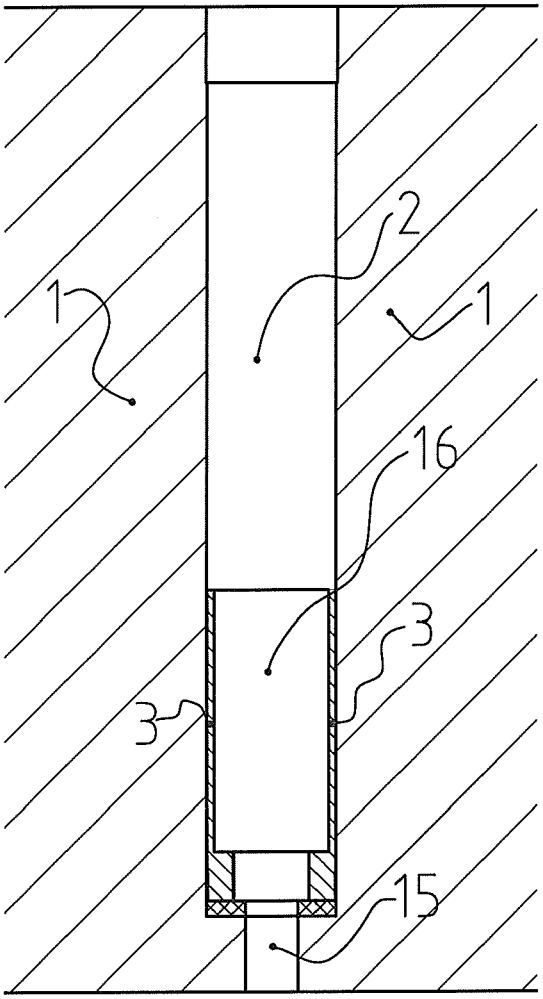


Fig. 1

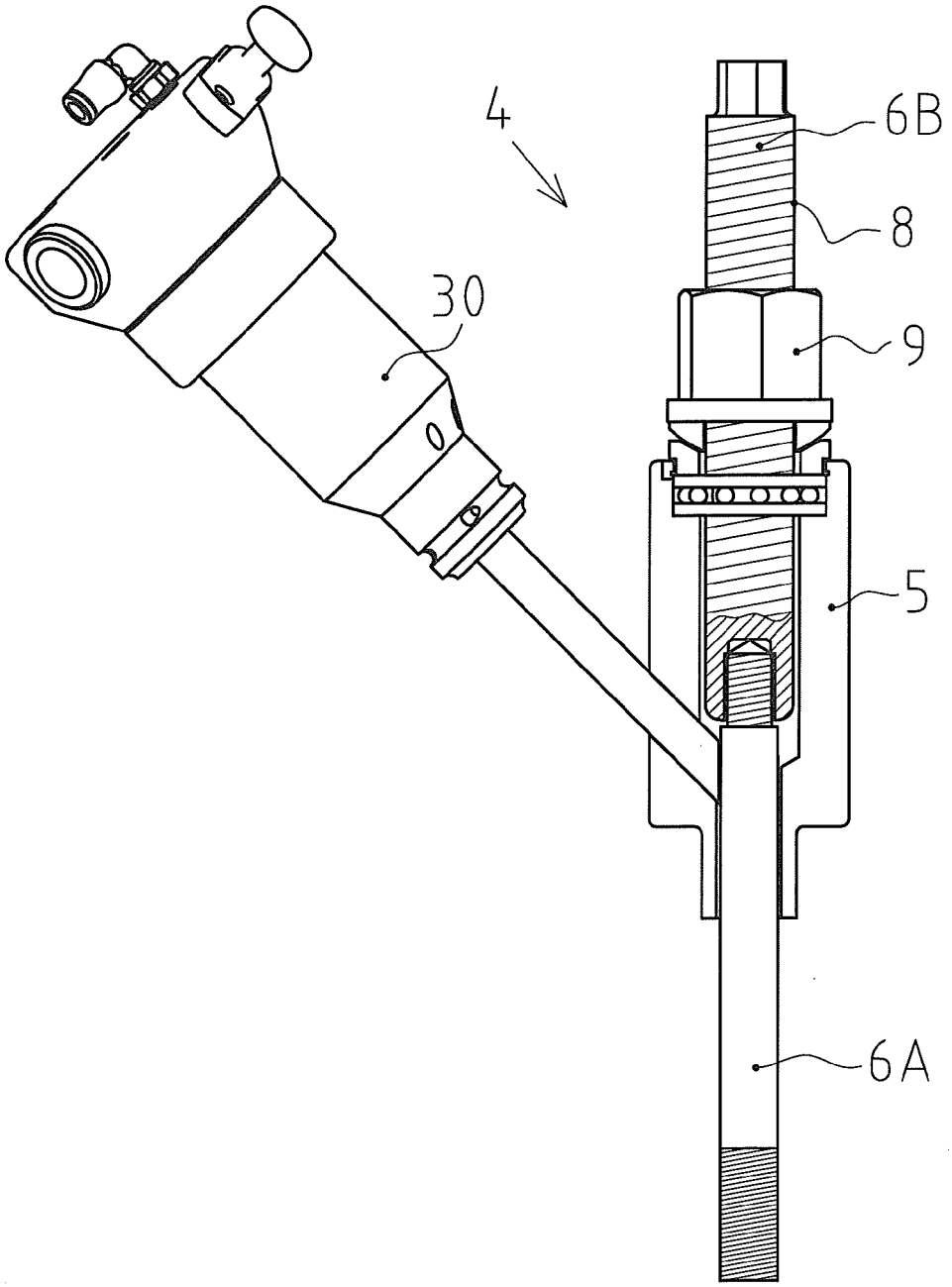


Fig. 2

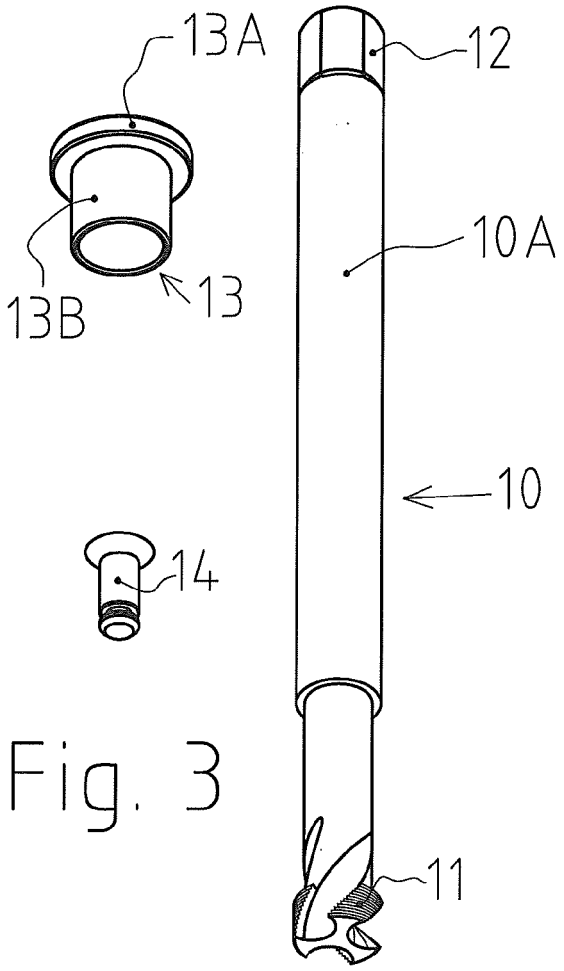


Fig. 3

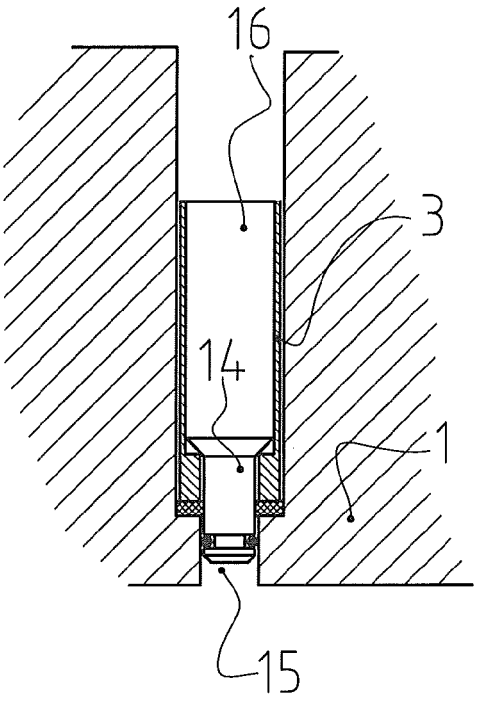


Fig. 4

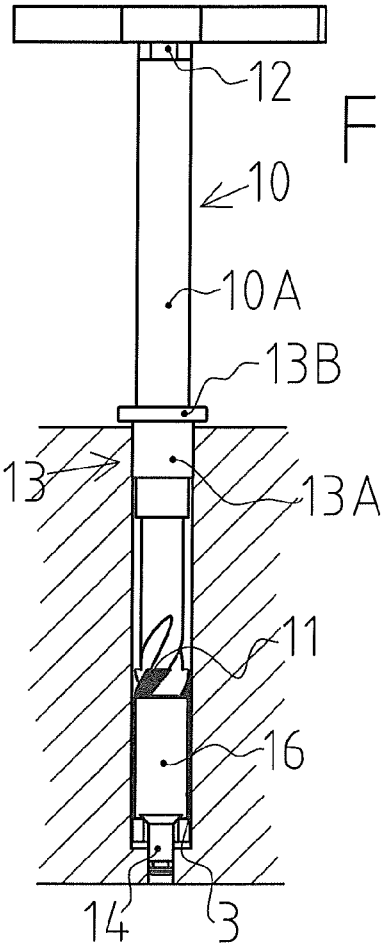


Fig. 5

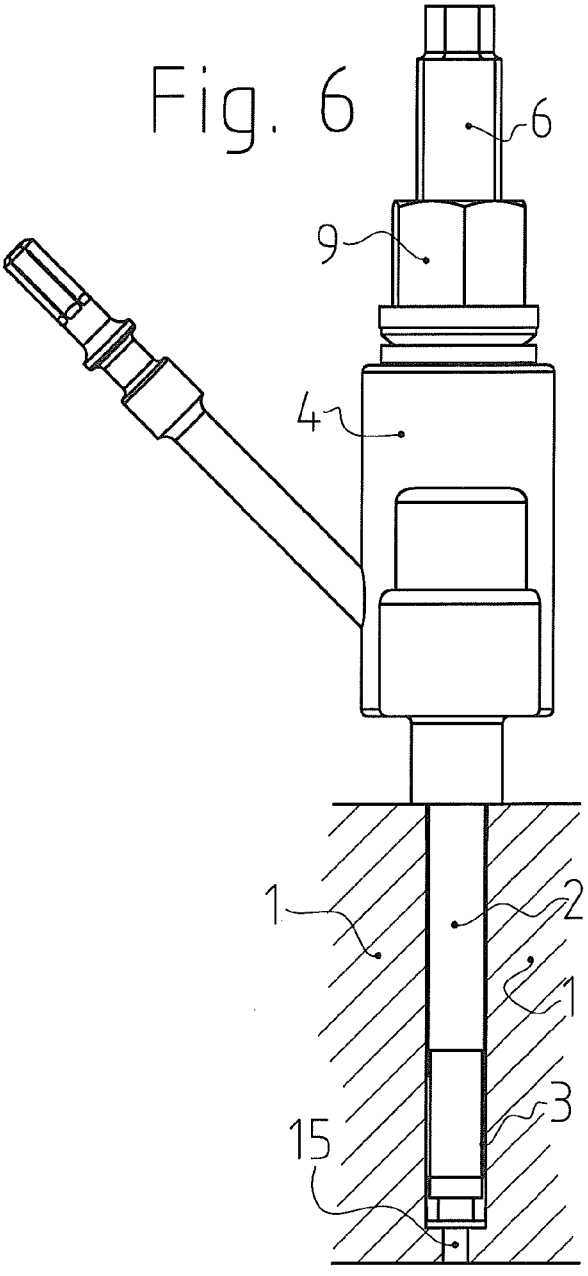
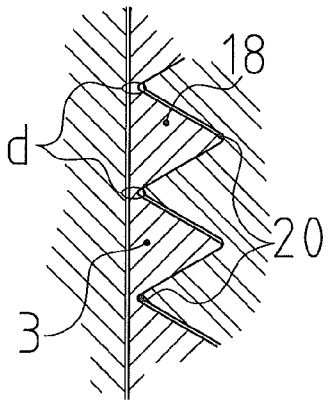


Fig. 6

Fig. 7



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EUROPEAN SEARCH REPORT

Application Number
EP 11 15 4856

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	WO 2007/091883 A1 (BAAL & PARTNERS VAN [NL]; VAN BAAL PETER GERARDUS [NL]) 16 August 2007 (2007-08-16) * abstract; figures 1-3 * -----	1-4	INV. B25B27/06 B25B27/18 B25B27/00
A	DE 20 2008 016441 U1 (HANS JOACHIM SAUER GMBH & CO K [DE]) 23 April 2009 (2009-04-23) * figure 1 * -----	1-4	

TECHNICAL FIELDS SEARCHED (IPC)

B25B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	18 May 2011	Pothmann, Johannes

CATEGORY OF CITED DOCUMENTS

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18-05-2011

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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