(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 096 290 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
02.09.2009 Bulletin 2009/36

(51) Int Cl.:
F02F 3/14 *(2006.01)* ***F02F 3/22*** *(2006.01)*

(21) Application number: **08003822.7**

(22) Date of filing: **29.02.2008**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MT NL NO PL PT RO SE SI SK TR
Designated Extension States:
AL BA MK RS

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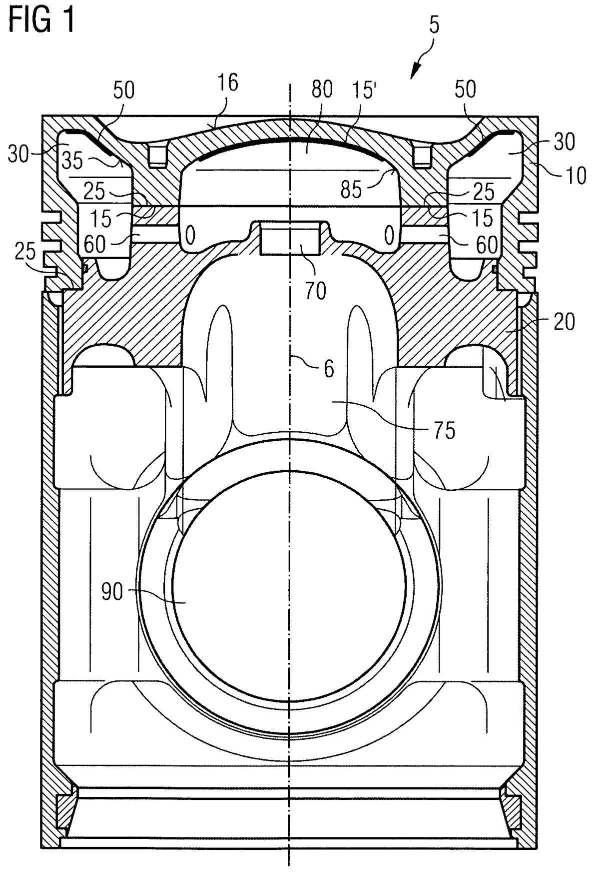
(54) **Engine piston with cooling chamber having a non-stick coating**

(57) The present disclosure refers to a piston (5) for an internal combustion engine. The piston (5) comprises at least one cooling chamber (30) preferably configured to generate a shaker cooling effect by partially filling of the cooling chamber (30) with a fluid, e.g., a coolant such oil, during use of the piston (5). The cooling chamber (30) has an inner surface (35) that is at least partly provided with a non-stick coating (50), preferably selected to inhibit or at least reduce contaminate accumulation or deposit during engine operation. The disclosure also refers to a method for manufacturing a piston (5) configured to be used in an internal combustion engine.

FIG 1



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Description

Technical Field

[0001] The present disclosure refers in general to a piston configured to be used in an internal combustion engine. More specifically, but not exclusively the disclosure relates to pistons having at least one cooling surface within a cooling chamber.

Background

[0002] Generally, pistons utilized in internal combustion engines, e.g. engines for large ships or vessels such as container ships or a tankers, often contain a cooling gallery or cooling chamber which may be designed to generate a "shaker cooling effect". The thickness of the wall separating the cooling chamber from the upper face of the piston bowl is minimized in order to maximize the cooling effect.

[0003] An example of such a piston is known, e.g., from US 6,513,477 B1. The cooling chamber of this known piston generally has a similar basic structure as compared with the piston shown in the attached drawings.

[0004] However, the known pistons may suffer in that the cooling effect may deteriorate over long use of the engine. In practice, it has been found that the cooling effect may exceptionally deteriorate over time when the internal combustion engine, such as a large diesel engine or heavy fuel oil engine, is configured to bum diesel or heavy fuel oil (HFO) or the like. In particular, it may happen that the lube oil used for lubrication and cooling purposes becomes contaminated by heavy fuel oil to be burned in the engine. Such contamination of the lube oil may be the reason for any detrimental deposits at an inner surface or cooling surface of the cooling chamber. These deposits may detrimentally influence the cooling effect within the piston.

[0005] The present disclosure is directed to overcoming this or other problems of the known pistons.

Summary of the Invention

[0006] According to one exemplary aspect of the present disclosure, a piston is disclosed that is designed for use in an internal combustion engine. The piston may include at least one cooling chamber. The cooling chamber preferably has at least one inner surface that is provided with a non-stick coating. The non-stick coating is preferably formulated so as to minimize or reduce the accumulation or deposit of contaminants on the inner surface during extended use of the piston in an internal combustion engine environment.

[0007] According to a further aspect of the present disclosure, a method for manufacturing a piston for an internal combustion engine is provided. The piston includes or defines at least one cooling chamber. The present method preferably includes the step of coating at least a portion of an inner surface of the cooling chamber with a non-stick material.

[0008] It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the disclosure.

[0009] Other features and aspects of this disclosure will be apparent to the skilled person based upon the following description, the accompanying drawings and the attached claims.

Brief Description of the Drawings

[0010] The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrates several exemplary embodiments of the disclosure and, together with the description, serve to explain the principles of the disclosure. In the drawings,

[0011] Fig. 1 is a longitudinal cross sectional view of an exemplary embodiment of a piston configured to be used in an internal combustion engine, for example a large diesel or heavy fuel oil engine, and

[0012] Fig. 2 is a longitudinal cross sectional view of another exemplary embodiment of a piston according to the present disclosure, wherein only the upper part of the piston is shown for the purpose of clarity.

Detailed Description

[0013] A first exemplary embodiment of a piston 5 according to the present disclosure is shown in a longitudinal cross sectional view in Fig. 1. This piston 5 may have a composite structure comprising an upper piston part 10 and a lower piston part 20. The upper piston part 10 has a lower end face 15 and an upper face 16. The upper face 16 may define a lower border of combustion chamber in which the piston 5 is fitted.

[0014] The lower piston part 20 has an upper end face 25 which may be configured to be connected to the piston lower face 15 of the upper piston part 10. The exemplary lower piston part 20 of Fig. 1 may have a basic structure that is generally known in the prior art. Accordingly, the lower piston part 20 may include a central bore 70 defined to connect space 75 with a cavity 80. The cavity 80 is disposed below the upper face 16 of the piston 5. Lateral bores or holes 60 may extend from the cavity 80 into a cooling chamber 30. The cooling chamber 30 may be formed as a "cooling gallery" or a cooling channel within the piston 5. In an exemplary embodiment of the piston 5, the cooling chamber is preferably ring-shaped or annular-shaped and may be arranged coaxially to a central line or longitudinal axis 6 of the piston 5. In the exemplary embodiment of Fig. 1, the cooling chamber 30 is formed as a cooling gallery, although, e.g., cooling channels may also be contemplated by the present teachings. In other exemplary embodiments the cooling chamber 30 may include one or more hollow spaces separated from each other. Axially-aligned pin bores 90 may be formed in a lower portion of the lower piston part 20. The pin bores 90 may receive a wrist pin (not shown) which serves to interconnect the piston 5 with a connection rod (not shown).

[0015] Due to the fact that all further elements and parts of the piston 5 shown in Fig. 1 may be generally known in the art, a detailed explanation of the further elements and parts can be omitted. If desired, further information concerning such known features may be found, e.g., in US 6,513,477 B1 mentioned above.

[0016] The upper piston part 10 may be joined with the lower piston part 20 along the upper and lower end faces 15 and 25, respectively, by, e.g., bolting, welding, in particular friction welding, or soldering. In case of a large piston 5 having a cooling chamber 30 for use in a large marine diesel engine or large heavy fuel oil engines, the piston 5 may be of the type "assembled piston" or "multi-part piston", and the upper piston part 10 and the lower piston part 20 are connected by bolts such that replacement of, e.g., the upper piston part 10 after a defined period of time can be carried out without problems. In the exemplary embodiment shown in Fig. 1, the upper end face 25 of the lower piston part 20 and the lower end face 15 of the upper piston part 10 may have a stepped contour in the cross-sectional view shown in Fig. 1, although other contours of the end faces 15, 25 are also possible within the scope of the present teachings.

[0017] As shown in Fig. 1, the cooling chamber 30 may be formed by the upper piston part 10 and the lower piston part 20. The inner surface 35 of the cooling chamber 30 may be partially formed by each of the upper piston part 10 and the lower piston part 20. In the exemplary embodiment of Fig. 1, a layer 50 of non-stick material may be applied to an upper portion of the inner surface 35. For example, the layer 50 of non-stick material may preferably cover the portion of the inner surface 30 that is defined by a relatively thin wall of the piston bowl of the piston 5. By applying the layer 50 of non-stick material, adhesion and/or accumulation of combustion residues, e.g., unburned carbons (HC) or "coke layers", may be inhibited, reduced or even avoided. In prior art designs, such carbon-based residues have been found to attach to the inner surface 35 of the cooling chamber 30, which reduce the heat transfer between the coolant, e.g., oil, and the residue-covered inner surface 35 of the cooling chamber 30. Thus, if unburned carbon residues or coke layers are permitted to accumulate on the inner surface 35, the temperature at the upper face 16 of the upper piston part 10'may increase during operation. This can be problematic if a critical temperature threshold is exceeded, because severe corrosion, cracking, deforming, piston seizing may occur under such conditions, which may result in permanent damage of the piston 5.

[0018] As indicated above, the non-stick material preferably has an anti-adhesive property, which inhibits or repels or at least minimizes accumulation of unburned carbon residues. The non-stick coating may be formed from any material which may reduces any detrimental deposits at some portions of the inner surface 35. The critical portions of the inner surface 35 with regard to heat transfer may be these portions which heat up beyond a threshold temperature at which coke layers may be formed. However, it is also possible to cover larger portions of the inner surface 35 or may even the complete inner surface with the non-stick material layer 50, depending on the method used for applying the non-stick material layer 50. If the non-stick material layer 50 is applied by, e.g., spraying or dip-coating, it might be appropriate to cover a larger part of or the complete inner surface 3 5 with the non-stick material.

[0019] The nano-coating layer 50 is preferably formed relatively thin, so that the heat transfer or heat transmission from the piston 5 to the coolant, e.g., oil, is not or only marginal effected. In exemplary embodiments of a piston 5, the thickness of the non-stick coating 50 may be within a range of about 2 μm to 20 μm, in particular about 4 μm to 6 μm, more particular about 5 μm. The thickness of the non-stick coating 50 may be also be about 8 μm to 12 μm, in particular about 10 μm. In another embodiment, the thickness of the non-stick coating 50 may be also be about 13 μm to 17 μm, in particular about 15 μm.

[0020] In an exemplary embodiment of the piston 5 disclosed herein, the non-stick material may be a nano-coating material such as, e.g., a sol-gel-material ("sol-gel-systems"). The nano-coating layer 50 is preferably formed relatively thin, so that the heat transfer or heat transmission from the piston 5 to the coolant is not or only marginal effected. If a nano-coating material is used to form the non-stick coating 50, the thickness of the non-stick coating 50 may be further reduced compared to other non-stick coatings.

[0021] According to the present disclosure, a nano-coating may be applied on a metal surface. The term "nano-coating" includes, e.g., a nano-coating deposited by laser and plasma assisted physical vapour deposition (PVD), a nano-coating made of a sprayed nano material, e.g. a thermally sprayed nano-material, a dip-coated nano-material, a nano-coating gel deposited by a sol-gel process, and other deposition techniques kwon in the art.

[0022] In one exemplary embodiment, a sol-gel process is employed. The sol-gel process is a wet-chemical technique that starts with a chemical solution that reacts to produce colloidal particles ("sol"). The sol then evolves toward the formation of an inorganic network containing a liquid phase ("gel"). After that the gel is dried to remove the liquid phase from the gel, thus forming a porous material. The porous material is then subjected to a thermal treatment in order to promote a polycondensation and improve the porous material's mechanical properties.

[0023] In particular, the chemical solution for producing the sol may include alkoxides or modified alkoxides of silicon, titanium, aluminum and zirconium, like for example $Si(OR)_4$, $Ti(OR)_4$, $(R1)_2$-$Zr(OR)_2$ and R1-$Al(OR)_2$. R1 is for example an alkyl or aryl moiety in the case of modified alkoxides, and OR are hydrolysable moieties, which are cleaved off as an alcohol after adding water and a catalyst to the chemical solution, such that a sol is formed. In order to obtain a gel having improved soil-repelling properties, fluorine-containing silanes, like for example $F_3C-(CF_2)_5-(CH_2)_2-Si(OC_2H_5)_3$, are added as additives to the chemical solution for producing the sol.

[0024] The obtained sol is a liquid having a low viscosity and is deposited on the surface to be coated, e.g. by spraying or dip-coating. After the sol has been deposited on the surface, the sol is subjected to a condensation reaction to form polysiloxanes in the form of a gel by heating the deposited sol.

[0025] Suitable layers of nano-coating are, e.g., H 5057, H 5083 and H 5085, obtainable from FEW Chemicals GmbH, Wolfen, Germany. The material H 5057 may be a composition of substantially TEOS/methyl/glymo-fluorosilane. The material H 5083 may be a composition of substantially A-1589/Y-9805/fluorosilane and a silicone-additive. The material H 5085 may be a composition of substantially A-1589/Y-9805/dimethyl-fluorosilane. The process temperatures and the necessary time for applying a non-stick coating 50, in particular of a nano-coating material according to one of the above-mentioned materials are well-known in the art, and, therefore, detailed explanations can be omitted.

[0026] A further exemplary embodiment of a piston 5 according to the present disclosure is shown in Fig. 2. The structure of this piston 5 is identical to the piston 5 shown in Fig. 1, with the exception that a layer of nano-coating material is not formed on the upper surface of the inner surface 85 of the cavity 80 but at an outer part of the upper inner surface 35. However, the same advantages may generally be achieved with the embodiment shown in Fig. 2 as with the piston 5 according to the embodiment shown in Fig. 1.

Industrial Applicability

[0027] Although the preferred embodiments of this invention have been described herein, improvements and modifications may be incorporated without departing from the scope of the following claims.

[0028] In practice, the upper piston part 10 and the lower piston part 20 may be manufactured or casted according to commonly known techniques. However, before the upper piston part 10 is, e.g., detachably or non-detachably connected with the lower piston part 20, e.g., by bolting, welding, in particular electron beam welding, or soldering, to form a piston with a cooling chamber 30 as shown in Figs. 1 and 2, the upper part of the inner surface 35 of the upper piston part 10 may be preferably covered with the non-stick coating 50, e.g. a nano-coating material. The area to be covered with the non-stick coating 50 may be identical to the area shown in Figs. 1 and 2. Alternatively, other or additional parts of the inner surface 35 of the cooling chamber 30 may be covered with the non-stick coating 50.

[0029] After applying the non-stick coating 50 to at least a portion of the inner surface 35 of the cooling chamber 30 of the upper piston part 10, the upper piston part 10 and the lower piston part 20 may be, e.g., detachably or non-detachably, connected with each other. While there are a number of ways to join such separate components, all of which are contemplated by the present disclosure, a preferred approach is to bolt the separately formed components with each other, or to join the components along a friction weld joint or an electron beam joint. In this exemplary embodiment, the friction weld joint or the electron beam joint is identical with the contacting area of the upper end surface 25 and the lower end surface 15. Other contemplated joining techniques include, but are not limited to, welding, bonding, brazing screw-thread joining and other mechanical and metallurgical means of uniting the separate components together to yield the closed chamber structure of the piston 5, in particular bolting together the two parts 10, 20 of the piston 5.

[0030] According to a further preferred aspect of the present disclosure, at least the lower piston part 20 may be cast from, e.g., steel, iron or aluminum , and the upper piston part 10 may likewise be cast from steel, iron or aluminum or formed by other techniques, such as forging or other casting techniques.

[0031] A piston 5 according to Figs. 1 and 2 utilized in a diesel engine or heavy fuel oil engine (not shown) will reciprocate in the direction of the central line 6. A coolant, such as oil, may flow through the bore 70 into the cavity 80. From the cavity 80, the cooling oil may then flow through the bores 60 into the cooling chamber 30. Due to the fact that the cooling chamber 30 is partially filled with the coolant during engine operation, which coolant splashes against the inner surface 35 of the cooling chamber 30, the coolant cools the inner surface 35 and absorbs heat from the upper piston part 10. Consequently, due to the heat transfer from the upper piston part 10 to the coolant, the maximum temperature of the upper piston part 10 during engine operation can be reduced. By applying the non-stick coating 50 to a portion of the inner surface 35 of the cooling chamber 30, it may be possible to inhibit, reduce, minimize or even prevent accumulation of detrimental particles such as unburned carbon residues or coke layers thereon. As a result, it is possible to prevent the maximum temperature of the upper piston part 10 from being exceeded during engine operation. As commonly known, further bores (not shown) may be provided to permit the coolant to flow out from the cooling chamber 30 and be replaced with lower-temperature coolant flowing through the bores 60. When the cooling chamber 30 is partially filled with coolant, a "shaker effect" within the cooling chamber 30 may achieved with its associated cooling effect as described above.

[0032] A piston 5 according to the present disclosure may also be referred to as a crown-cooling chamber piston having a cooling chamber which may be curved or ring-shaped, a multi-part or composite piston with a cooling chamber 30. All of these types of pistons 5 preferably include a non-stick coating 50, e.g., of nano-coating material as mentioned above disposed on at least a part of the inner surface of one or more of the cooling chambers.

[0033] A piston 5 according to the present disclosure may reduce or prevents deterioration of the cooling effect over the course of engine operation, in particular when the internal combustion engine is configured to bum heavy fuel oils or the like. As already mentioned, it may happen that the lube oil used for lubrication purposes becomes contaminated by heavy fuel oil during operation of the engine. Due to this contamination deposition of a coke layer on at least a part of the inner surface of the cooling chamber may develop. By providing a non-stick coating 50, e.g., of nano-coating material on at least a part of the inner surface 35 of the cooling chamber 30, a gradual build up or deposit of contaminants on the cooling surface may be inhibited, reduced, minimized or even avoided. In particular, according to the present disclosure, a very thin layer of ,e.g., nano-coating, preferably based on "sol-gel materials" is applied to at least a part of the cooling surface so that the build up or deposit of contaminants may be reduced and, consequently, the heat transfer will scarcely be affected due to the absence of accumulated contaminants.

[0034] In case a cooling chamber 30 is integrally cast in the piston bowl or upper piston part 10, the non-stick 50 may be applied to the inner surface 35 through at least one bore 60 or hole that opens up into the cooling chamber 30. This bore 60 or hole may be integrally provided in pistons 5 in a known manner. Such an integral bore 60 or hole often serves as a conduit through which coolant flows into the cooling chamber during operation of the piston 5.

[0035] In case the upper piston part 10 is non-detachably connected to the lower piston part 20 in order to form the cooling chamber 30, at least a part of the inner surface 35 of the cooling chamber 30 may be coated with the non-stick coating 50 before the upper piston part 10 and the lower piston part 20 are connected.

[0036] It will be apparent to those skilled in the art that various modifications and variations can be made in the disclosed piston for an internal combustion engine and the disclosed method without departing from the scope or spirit of the invention. Other embodiments of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. It is intended that the specification and examples be considered as exemplary only.

Claims

1. A piston (5) for an internal combustion engine, comprising

at least one cooling chamber (30) within the piston (5), the cooling chamber (30) having an inner surface (35), and

a non-stick coating (50) disposed on at least a portion of the inner surface (35) of the cooling chamber (30).

2. The piston (5) of claim 1, further including an upper piston part (10) and a lower piston part (20) connected to the upper piston part (10), the lower piston part (20) being configured to be connected to a connecting rod which is adapted to connect the piston (5) to a crankshaft, wherein the at least one cooling chamber (30) is provided within the upper piston part (10) and/or the lower piston part (20)

3. The piston of claim 2, wherein the upper piston part (10) is cast such that the cooling chamber (30) is formed as a hollow space or channel within the upper piston part (10) and/or the lower piston part (20), and a bore (60) is provided which opens into the hollow space.

4. The piston of claim 2 or 3, wherein the upper piston part (10) has a lower end face (15) which forms a part of the inner surface (35) of the cooling chamber (30), and the lower piston part (20) has an upper end face (25) which forms an opposing part of the inner surface (35) of the cooling chamber (30), wherein a part of the lower end face (15) of the upper piston part (10) is detachably or non-detachably connected with a part of the upper end face (25) of the lower piston part (20).

5. The piston of at least one of the preceding claims, wherein the non-stick coating (50) has the property of inhibiting or at least reducing accumulation of contaminates generated during operation of the internal combustion engine.

6. The piston of claim 5, wherein the piston (5) is configured for use in an internal combustion engine configured to bum heavy fuel oil.

7. The piston of claim 6, wherein the non-stick coating (50) is configured to inhibit or at least reduce the accumulation of any contaminates which may be produced during use of the piston (5) in an internal combustion engine which is configured to bum heavy fuel oil.

8. The piston of at least one of the preceding claims, wherein non-stick coating (50) is made from a nano-coating material.

9. The piston of claim 8, wherein the nano-coating (50) is based on a sol-gel-material.

10. The piston of claim 8 or 9, wherein the nano-coating (50) includes at least one compound selected from the group consisting of TEOS/methyl/glymo-fluorosilane, A-1589/Y-9805/fluorosilane and a silicone-additive, and A-1589/Y-9805/dimethyl-fluorosilane.

11. The piston of at least one of the preceding claims, wherein the cooling chamber (30) is configured to generate a shaker cooling effect when the cooling chamber (30) is partially filled with a fluid during use of the piston (5).

12. A method for manufacturing a piston (5) for an internal combustion engine, the piston (5) includes at least one cooling chamber (30), the method comprising:

coating at least a part of an inner surface (35) of the cooling chamber (30) with a non-stick coating (50).

13. The method of claim 12, further including the method step of connecting an upper piston part (10) and a lower piston part (20), the lower piston part (10) being configured to be connected to a connecting rod which is adapted to connect the piston (5) to a crankshaft.

14. The method of claim 12 or 13, further including the method steps of:

providing a piston (5), which includes the cooling chamber (30) formed as a hollow space or channel within the piston (5), wherein a bore (60) opens into the hollow space or channel, and
coating at least a part of the inner surface (35) of the cooling chamber (30) with the non-stick layer (50) through the bore (60).

15. The method of claim 12 or 13, further including the method steps of:

providing an upper piston part (10) having a lower end surface (15) which forms an upper part of the inner surface (35) of the cooling chamber (30),
providing a lower piston part (20) having an upper end surface (25) which forms a lower part of the inner surface (35) of the cooling chamber (30),
coating at least a part of the upper inner surface (35) of the upper piston part (10) with the non-stick coating (50), and
detachably or non-detachably connecting a part of the lower end surface (15) of the upper piston part (10) with a part of the upper end surface (25) of the lower piston part (20).

16. The method of any of claims 12-15, wherein the non-stick coating (50) is based on a nano-coating material, preferably based on a sol-gel-material.

FIG 1

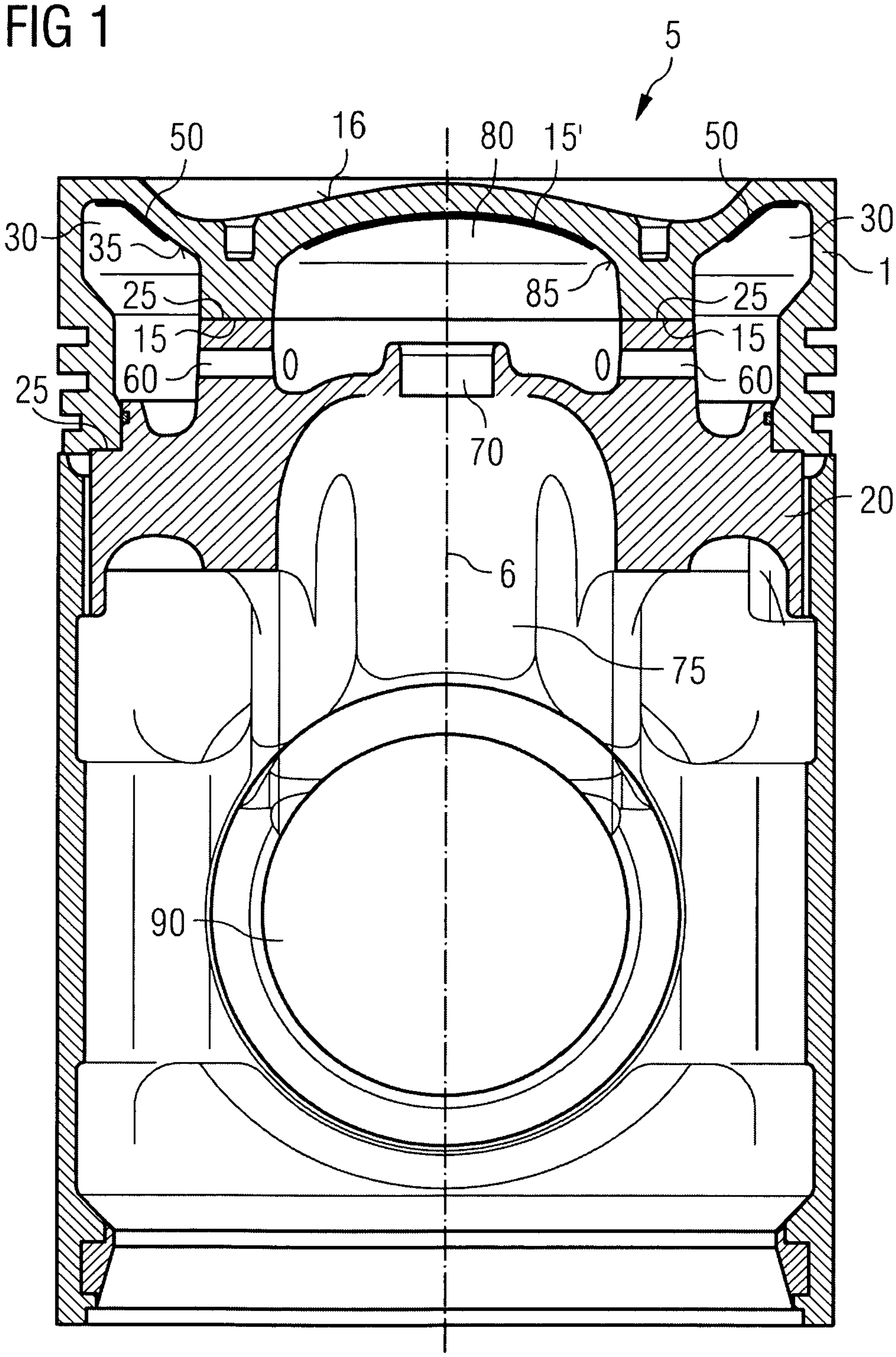
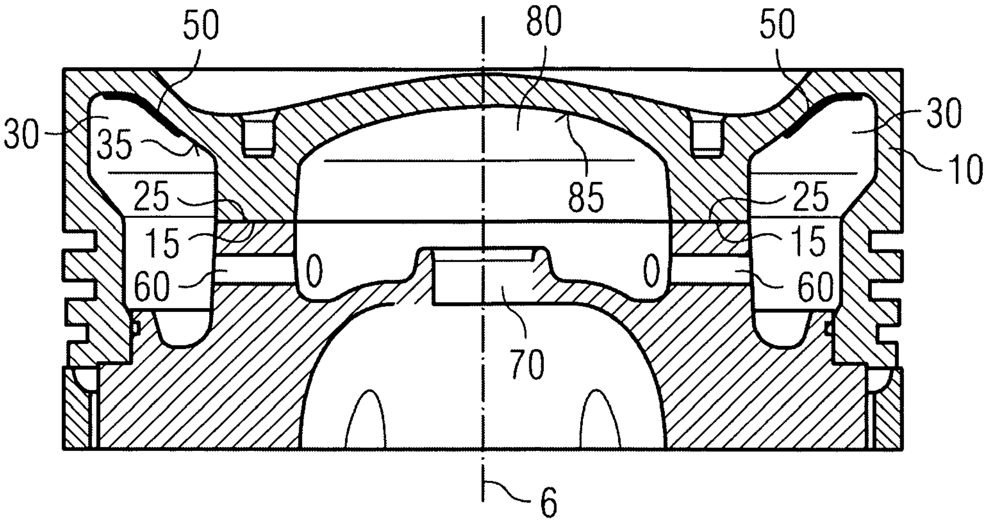


FIG 2



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EUROPEAN SEARCH REPORT

Application Number
EP 08 00 3822

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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TECHNICAL FIELDS SEARCHED (IPC)

F02F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	29 September 2008	von Arx, Hans

CATEGORY OF CITED DOCUMENTS

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29-09-2008

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