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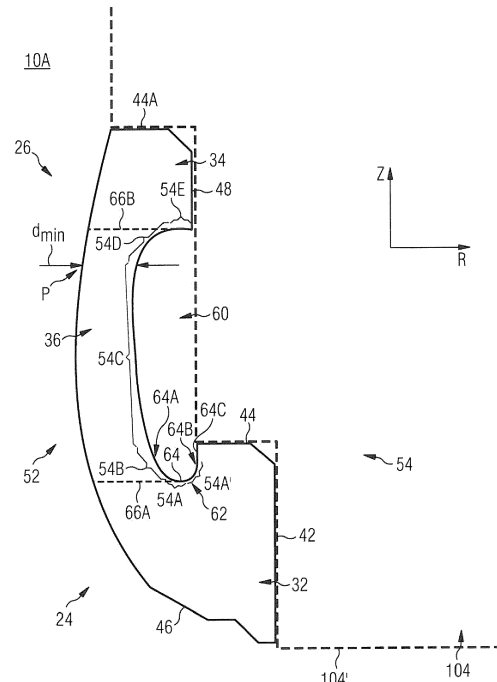
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(54) **Valve seat insert for an internal combustion engine**

(57) A valve seat insert (10A, 10B, 10C) for a cylinder head (104) of an internal combustion engine (100) comprises a ring-shaped body (20) defining a passage (22) for enabling a fluid to pass through the body (20) along an axial direction (Z) from an entrance side (24) to an exit side (26) of the valve seat insert (10A, 10B, 10C), wherein the body (20) comprises an entrance side section (32) with a first contact surface section (42), and a valve sealing surface section (46), an exit side section (34) with a second contact surface section (48), and an arch section (36) axially extending from the entrance side section (32) to the exit side section (34) and decreasing in material thickness from the entrance side section (32) towards the exit side section (34) up to a minimum thickness axial position (P) that is located in the half of the arch section (36) being close to the exit side section (34). Thereby, a more load resistant structure of the valve seat insert (10A, 10B, 10C) can be provided.

FIG 3



Description

Technical Field

[0001] The present disclosure generally relates to a valve of an internal combustion engine and, more particularly, to a valve seat insert for a valve of an internal combustion engine.

Background

[0002] Proper functionality of inlet and exhaust valves are essential for running an internal combustion engine. In particular valve spindles and valve seats are, however, subject to adverse conditions such as high temperatures and aggressive exhaust components. Despite those adverse conditions, long life times are desired. In medium speed internal combustion engines, usually valve seat inserts are used that are press-fitted or shrink-fitted into respective valve openings of a cylinder head.

[0003] In particular for exhaust valves, a valve seat insert is configured to form a circumferential cooling channel together with the sidewall of the cylinder head's opening. The cooling channel is connected to the engine cooling circuit and provides for cooling the valve seat insert as well as indirectly the bottom part of the valve spindle via its contact with the valve seat in the closed state of the valve.

[0004] The present disclosure is directed, at least in part, to improving or overcoming one or more aspects of prior systems.

Summary of the Disclosure

[0005] In an aspect, a valve seat insert for a cylinder head of an internal combustion engine comprises a ring-shaped body defining a passage for enabling a fluid to pass through the body along an axial direction from an entrance side to an exit side of the valve seat insert. The body comprises an entrance side section with a first contact surface section, an abutting surface section, and a valve sealing surface section. The body comprises further an exit side section with a second contact surface section and an arch section axially extending from the entrance side section to the exit side section and decreasing in material thickness from the entrance side section towards the exit side section up to a minimum thickness axial position that is located in the half of the arch section being close to the exit side section.

[0006] In another aspect, a valve seat insert for a cylinder head of an internal combustion engine comprises a ring-shaped body defining a passage for enabling a fluid to pass through the body along an axial direction from an entrance side to an exit side, wherein the body comprises an entrance side section with a first contact surface section for forming a first sealed contact with the cylinder head in the mounted state, an abutting surface section for defining the position when mounted at the

cylinder head, and a valve sealing surface section adapted to a valve spindle, an exit side section with a second contact surface section for forming a second sealed contact with the cylinder head in the mounted state, and an arch section delimiting a cooling channel in radial direction from the passage, wherein the cooling channel is formed, in the mounted state of the valve seat insert, between the valve seat insert and the cylinder head, and wherein the arch section decreases in axial direction from the entrance side in material thickness along at least 60 % of the arch section.

[0007] In another aspect, a retrofitting method for a combustion engine having a plurality of cylinders, each of the plurality of cylinders being associated with at least one exhaust valve comprises the step of attaching the valve seat insert as described above to an exhaust opening of a cylinder head of an internal combustion engine.

[0008] Other features and aspects of this disclosure will be apparent from the following description and the accompanying drawings.

Brief Description of the Drawings

[0009]

FIG. 1 is a schematic cross-sectional view of a combustion engine;

FIG. 2 is schematic cross-sectional view through an inlet valve and an exhaust valve of a combustion engine such as shown in FIG. 1;

FIG. 3 is an illustration of a schematic cross-section of a first embodiment of a valve seat insert;

FIG. 4 is a schematic cross-sectional view of a second embodiment of a valve seat insert mounted to a cylinder head; and

FIG. 5 is a schematic partial three-dimensional view of a third embodiment of a valve seat insert.

Detailed Description

[0010] The following is a detailed description of exemplary embodiments of the present disclosure. The exemplary embodiment described herein and illustrated in the drawings are intended to teach the principles of the present disclosure, enabling those of ordinary skill in the art to implement and use the present disclosure in many different environments and for many different applications. Therefore, the exemplary embodiments are not intended to be, and should not be considered as, a limiting description of the scope of patent protection. Rather, the scope of patent protection shall be defined by the appended claims.

[0011] The present disclosure may be based in part on the discovery that cracks in the valve seat insert formed starting from the cooling channel, and in particular from the valve seat side of the cooling channel. It was realized that the valve seat insert is subject to at least two types of stress: static stress/load caused by the press-fitting,

the underlying tolerances, and/or the required coaxial design as well as alternating stress/load caused by the combustion, specifically the combustion pressure. It is herein proposed to spatially separate those stress/load regions by a specific geometrical design of the valve seat insert. In particular, that geometric design may be achieved while maintaining prior surface shapes with the exception of the shape of the cooling channel. The proposed designs may reduce the number of the above mentioned cracks, delay their formation, or even avoid their formation at all.

[0012] The present disclosure may further be based in part on the discovery that adjusting the curvature radii of the cooling channel for a given inner surface shape may allow moving the static stress region caused by the mounting towards the exist side of the valve seat insert, i.e. to the side opposite of the valve seat side. Specifically, providing a minimum thickness of the material of the valve seat insert in an arch section of the same at a distance from an entrance side section (subject to the interaction with the valve spindle), may form a hinge-like section being the center of the static stress. This may result in an improved stress condition of the valve seat insert. For example, moving the minimum thickness close to an exit side section may maximize the spatial separation of the static stress and the alternating stress.

[0013] An exemplary embodiment of an internal combustion engine having a valve seat insert is described in the following with reference to Figs. 1 and 2. Figs. 3 to 5 illustrate exemplary embodiments of valve seat inserts.

[0014] Referring to FIG. 1, an internal combustion engine 100 includes an engine block 101 that at least partially defines a plurality of cylinders 102, a piston 110 slidably disposed within each cylinder 102, and a cylinder head 104 associated with each cylinder 102. Engine 100 further includes a plurality of inlet valves 106 and exhaust valves 108 associated with the plurality of cylinders 102. Example of engine 100 include natural gas, spark ignited, V-style turbocharged and after-cooled engines that may have, for example, 8, 12, or 16 cylinders, each cylinder having, for example, 2 inlet and 2 exhaust valves. One skilled in the art will recognize that engine 100 may be any other type of internal combustion engines such as, for example, a dual fuel powered engine. Further, engine 100 may include a greater or lesser number of cylinders 102, and cylinders 102 may be disposed in an "in-line" configuration, or in any other suitable configuration.

[0015] During operation of engine 100, inlet valves 106 and exhaust valves 108 may open and close to allow a mixture of gas and air to enter each cylinder, and to allow a flow of exhaust to exit each cylinder, respectively. For that purpose, inlet valves 106 and exhaust valves 108 include valve spindles 142 that can block respective flow through the valves.

[0016] FIG. 2 shows an enlarged (non-planar) cross-sectional view of inlet valve 106 and exhaust valve 108 of, for example, combustion engine 100.

[0017] Inlet valve 106 and exhaust valve 108 may have

a similar configuration such that only the configuration of exhaust valve 108 will be described in detail in the following. However, it should be appreciated that the same description may also apply to inlet valve 106.

[0018] Exhaust valve 108 includes a valve guide 140, a valve spindle 142, and a valve seat insert 10. Valve guide 140 may have an elongated cylindrical shape having a lower end 141, an upper end 143, and a through hole 145. Valve guide 140 may be secured to cylinder head 104 in a known manner.

[0019] Valve spindle 142 includes a bottom part 144 with a spindle seal. Valve spindle 142 is disposed in through hole 145 of valve guide 140 such that it can slide inside through hole 145 up and down. Valve spindle 142 is biased via a biasing spring 147 into a closing position in which the spindle seal contacts valve seat insert 10. Valve spindle 142 can be actuated to move down to an opening position via an actuating mechanism 112 that is connected to, e.g., a camshaft 114 of engine 100 (see FIG. 1). In alternative configurations, a common rail system may be used to actuate the valves.

[0020] Cylinder head 104 comprises a cooling channel system 148 that in particular supplies coolant to a cooling channel 12 that is formed between cylinder head 104 and an outer side of valve seat insert 10. In general, cooling channel 12 is provided with a coolant supply and release connection, located, for example, at opposing ends. The cut view of Fig. 2 does not explicitly show a connection between cooling channel system 148 and cooling channel 12 as the same is not in the plane of the cross-section.

[0021] As can be seen in Fig. 2, usually only exhaust valves 108 comprise cooled valve seat inserts 10. Specifically, the cooling of valve seat insert 10 allows cooling of bottom part 144 while exhaust valve 108 is in the closing position. In contrast, valve seat inserts for inlet valves 106 may not need to be cooled via a cooling channel system as the inlet air may provide sufficient cooling of the valve spindle. Accordingly, valve seat insert 150 shown in Fig. 2 does not form a cooling channel.

[0022] Valve seat insert 10 is mounted in an exhaust opening 104A (see also Fig. 4) of cylinder head 104 which extends from a combustion zone face into cylinder head 104 for releasing exhaust air from cylinder 102. The mounting depth of valve seat insert 10 extends, for example, along a length within the range of 40 mm to 80 mm. During that length, the respective sidewalls of exhaust opening 104A are adapted for receiving valve seat insert 10, for example, by press and/or shrink fitting.

[0023] In some embodiments, valve seat insert 10 may be cryogenic shrink fitted in exhaust opening 104A. Specifically, valve seat insert 10 may be cryogenic shrink fitted in a respective mounting section of exhaust opening 104A. For that purpose, the circumference of valve seat insert 10 may have an outer diameter with essentially the same nominal dimension of the opening diameter but with a different tolerance thereby facilitating shrink fitting of, e.g., valve seat insert 10 and into its respective exhaust opening 104A.

[0024] In Fig. 3, a valve seat insert 10A is shown in a radial cross-section. For illustration, a dashed line 104' indicates cylinder head 104 in the mounted state. Valve seat insert 10A comprises a ring-shaped body 20 that defines a passage 22 (see also Fig. 5). During operation of the internal combustion engine, exhaust gas can flow through passage 22, thereby passing through body 20 along an axial direction Z. For a cylinder symmetric configuration (axial symmetric body 20), axial direction Z may correspond to the direction of the symmetry axis (see symmetry axis S_z in Fig. 4). In Fig. 3, axial direction Z as well as a radial direction R (extending orthogonal to axial direction Z) are indicated schematically. Usually exhaust will pass from an entrance side 24 to an exit side 26 of valve seat insert 10A. In Fig. 3 as well as in the Figs. 4 and 5, entrance side 24 is located at the bottom of the drawing while exit side 26 is located at the top of the drawing.

[0025] Valve seat insert 10A may be associated with three sections. An entrance side section 32 is located at entrance side 24 and comprises a first contact surface section 42 as well as a valve sealing surface section 46. In some embodiments, an abutting surface section 44 is additionally provided in entrance side section 32.

[0026] An exit side section 34 is located at exit side 26 and comprises a second contact surface section 48.

[0027] An arch section 36 extends from entrance side section 32 to exit side section 34 and essentially forms a wall delimiting the main part of a cooling channel that is formed in the mounted state (see cooling channel 12 in Fig. 2). Arch section 36 decreases in material thickness from entrance side section 32 towards exit side section 34 up to a minimum thickness axial position P (or small region). Minimum thickness axial position P is located in the half of arch section 36 that is close to exit side section 34. In Fig. 3, the minimum thickness d_{min} is exemplarily indicated at the transition between a larger curvature radius and a smaller curvature radius on the cooling channel side at exit side 26 of arch section 36.

[0028] Minimum thickness axial position P defines a center region of a static spring-like stress in the mounted state. For example, minimum thickness axial position P is located at at least 60 %, 70 %, 80 %, or 90 % of an axial extension of arch section 36, which is measured from entrance side section 32 along axial direction Z as indicated in Fig. 3.

[0029] In Fig. 3, the left side is associated with the inner side (passage 22) of ring-shaped body 20 while the right side is associated with the outer side of ring-shaped body 20 in the radial direction. Accordingly, body 20 comprises an inner surface 52 and an outer surface 54. In the embodiment of Fig. 3 at exit side 26, inner surface 52 and outer surface 54 are connected via a, for example, radially extending surface section 44A.

[0030] Inner surface 52 extends circumferentially on the radially inner side of body 20 and comprises inter alia valve sealing surface section 46. Valve sealing surface section 46 is, for example, tilted with respect to axial di-

rection Z under an angle in the range from 40° to 80° such as, for example, 60°.

[0031] Outer surface 54 extends circumferentially on the radial outer side of body 20 and comprises first contact surface section 42, abutting surface section 44 and second contact surface section 48.

[0032] At arch section 36, outer surface 54 is concavely curved while inner surface 52 is convexly curved.

[0033] For example, at arch section 36, outer surface 54 is concavely curved with a series of curved sections 54A, 54B, 54C, whereby those curved sections increasing in radius curvature up to minimum thickness axial position P. In some embodiments, neighboring curved sections 54A, 54B, 54C transition essentially tangentially into each other as shown in Fig. 3. For example, curved section 54A may have a radius curvature of 1 mm to 3 mm such as 2 mm, curved section 54B may have a radius curvature of 5 mm to 10 mm such as 8 mm, and curved section 54C may have a radius curvature of 50 mm to 100 mm such as 70 mm.

[0034] Similarly, inner surface 52 may comprise one or more sections having curvature radii that result in a convex shape as shown in Fig. 3, for example two sections with curvature radii in the range from 20 mm to 50 mm such as 40 mm, and 80 mm to 120 mm such as 100 mm.

[0035] A further curved section 54D having a curvature radius larger than the curvature radius of curved section 54C is indicated on exit side 26 beginning at minimum thickness axial position P. Curved section 54D may have a radius curvature of 1 mm to 10 mm such as 5 mm. In the embodiment of Fig. 3, a planar section 54E connects curved section 54D with second contact surface section 48 under, for example, a rectangular angle.

[0036] In other words, at arch section 36, outer surface 54 forms a recess 60 with a gutter-like extension 62. Gutter-like extension 62 extends towards valve sealing surface section 46 and forms a bottom 64. Bottom 64 of gutter-like extension 62 defines the beginning of arch section 36 in axial direction Z as indicated in Fig. 3 by a dashed line 66A. The end of arch section 36 coincides essentially with planar section 54E as indicated by dashed line 66B.

[0037] Returning to gutter-like extension 62, an inner gutter surface section 64A is associated with arch section 36, while an outer gutter surface section 64B is associated with entrance side section 32.

[0038] As exemplarily shown in Fig. 3, in some embodiments, curved section 54A of arch section 36 is extended as curved section 54A' to form a surface section of entrance side section 32. Curved section 54A' transitions into a planar surface section 64C, which extends in, for example, axial direction Z as exemplarily shown in Fig. 3.

[0039] As shown in Fig. 3, planar surface section 64C is essentially aligned with second contact surface section 48 of exit side section 34. Accordingly, cooling channel 12 formed by recess 60 will have an asymmetric shape; in particular, cooling channel 12 will be narrower at en-

trance side 24 than at exit side 26.

[0040] The configuration shown in Fig. 3 provides for a decreasing material thickness of arch section 36 such that any deformation during mounting of valve seat insert 10A may create stress/load around minimum thickness axial position P. Accordingly, stress caused by mounting and/or a load caused by mounting will be present at the half of arch section 36 that is close to exit side section 34.

[0041] In contrast, any stress/load that is caused during operation of the valve, for example, by interaction of valve seat insert 10A with valve spindle 142 may center within entrance side section 32. Accordingly, those two types of stress are spatially separated and, accordingly, bottom 64 of gutter-like extension 62 may be subjected to reduced stress in comparison to prior art configurations.

[0042] Similarly, configuration of Fig. 3 provides more material close to bottom 64 and such increases stress resistance in that region.

[0043] The disclosed sequence of varying curvature radii along axial direction Z at recess 60 may, therefore, provide the advantages discussed above and, for example, may increase durability and proneness to wear and tear.

[0044] In contrast to the embodiment shown in Fig. 3, the embodiment of valve seat insert 10 B of Fig. 4 is slightly modified to form a gutter-like extension 62'. While the configuration such as inner surface 52 and most of outer surface 54 (e.g. the radii development in curved sections 54A, 54B, 54C) is maintained identical to the one shown in Fig. 3, bottom 64 and curved section 54A' are modified in a manner such that gutter-like extension 62' extends in the mounted state further along the radial direction R. In other words, planar surface section 64C is shifted to a larger radius R_{64C} , thereby increasing the volume of gutter-like extension 62'. This may be achieved, for example, by using different curvature radii for curved sections 54A and 54B, and/or positioning their origin differently.

[0045] As a result, in addition to the decrease in material thickness and the providing of additional material at entrance side section 32, the cooling volume of cooling channel 12 may be increased at the entrance side. Thereby, cooling performance of valve seat insert 10B may be further improved.

[0046] As shown in Fig. 3 and Fig. 4, valve seat inserts 10A and 10B may include chamfer faces, for example, between radially extending surface section 44A and second contact surface section 48 as well as abutting surface section 44 and first contact surface section 42.

[0047] In the following, the interaction of a valve seat insert with a cylinder head 104 will be described. It is referred in particular to Fig. 4 to avoid overloading of Fig. 3 with reference numerals. However, the skilled person will understand that the same applies to valve seat insert 10A as well as valve seat insert 10C shown in Fig. 5.

[0048] Exhaust opening 104A of cylinder head 104 is schematically indicated in Fig. 4 in a step-shape form.

Specifically, exhaust opening 104A narrows stepwise in an insert direction, here along axial direction Z. Specifically, exhaust opening 104A comprises a first circumferential sidewall 104B, a first radially extending face 104C, a second circumferential sidewall 104D, and a second radially extending face 104E. For example, circumferential sidewalls 104B, 104D extend in axial direction, while first and second radially extending faces 104C, 104E extend in radial direction.

[0049] First contact surface section 42 forms in the mounted state a first sealing of cooling channel 12 at entrance side 24 together with first circumferential sidewall 104B. Second contact surface section 48 forms a second sealing of cooling channel 12 at exit side 26 together with second circumferential sidewall 104D. In addition, abutting surface section 44 may contact first radially extending face 104C to limit the insertion in axial direction of valve seat insert 10B. However, in some embodiments, radially extending surface section 44A may act as abutting face by contacting second radially extending face 104E. In the latter case, some extension of cooling channel 12 into the gap formed between abutting surface section 44 and first radially extending face 104C may be given.

[0050] As disclosed for various configurations above, arch section 36 is configured for delimiting cooling channel 12 in the radial direction from passage 22. Cooling channel 12 is formed, in the mounted state of the valve seat insert between the valve seat insert and the cylinder head.

[0051] In some embodiments, first contact surface section 42 and second contact surface section 48 extend in axial direction and/or abutting surface section 44 and radially extending surface section 44A extend in radial direction.

[0052] As further can be seen in Figs. 3 and 4, body 20 may be C-shaped when seen in a radial cross-section. Then, entrance side section 32 and exit side section 34 may be considered as respective ends of the C-shape. Arch section 36 may be considered to form the middle section of the C-shape. As can be seen in the drawings, and in adaptation to the step-like configuration of exhaust opening 104A, the end associated with entrance side section 32 extends to a larger radius R_{EN} than the radius R_{EX} associated with the exit side section 34 as shown in Fig. 4.

[0053] Moreover, in some embodiments, inner surface 52 may protrude towards the center of body 20 to define a minimal opening radius R_{min} in an axial central region as illustrated in, for example, Fig. 4.

[0054] Referring to Fig. 5, a partial three-dimensional view of an exemplary valve seat insert 10C is shown to further illustrate the geometry, in particular, passage 22, entrance side 24 and exit side 26, which are associated with ring-shaped body 20. Furthermore, Fig. 5 indicates the cylinder-symmetric configuration that may be applied for valve seat inserts. However, in some embodiments, also elliptical configurations may be used.

Industrial Applicability

[0055] Valve seat inserts as described above, are usually press-fitted or shrink-fitted to the respective openings of cylinder heads. Accordingly, when a valve seat insert is forced into an opening, mechanical tension will provide for the required sealing. For example, when shrink-fitting a valve seat insert into an opening, one will first cool the valve seat insert, for example, with liquid nitrogen, when inserting the cooled valve seat insert into the opening. This is possible due to the reduced dimensions in the cooled state. In that stage, abutting surface section 44 may, for example, limit the depth of insertion. Then, the valve seat insert may be warmed to ambient temperature such that the valve seat insert is shrink-fitted into the opening. The same procedure may be applied for retrofitting a valve seat insert according to the herein disclosed embodiments, which may be used as a replacement for a mal-functioning valve seat insert.

[0056] In some embodiments, the material of the valve seat insert may be heat resistant centrifugal casting. In some embodiments, for example for engines of the series M43C, the axial dimension of the valve seat insert is in the range from 50 mm to 70 mm; accordingly the axial extension of the arch section is in the range from 20 mm to 30 mm such that the minimum thickness position is in the range from 10 mm to 28 mm, i.e. at least beyond half of the extension. Moreover, the inner radius is in the range from 50 mm to 65 mm, the entrance radius is in the range from 75 mm to 80 mm, the exit radius is in the range from 70 mm to 75 mm. The thickness of the arch section in radial direction reduces, for example, in the above embodiments from 10 mm to 7 mm.

[0057] In addition to the above described mounting, in case of wear or damaging of any type of valve seat inserts, the same may be easily replaced with valve seat inserts according to the present disclosure (e.g. performing retrofitting using the herein disclosed valve seat inserts).

[0058] As used herein, the term "internal combustion engine" may refer to internal combustion engines such as, for example, gas engines, which may be used as main or auxiliary engines of stationary power providing systems such as power plants for powering pipeline transmission, processing, or gas storage and withdrawal, as well as for generating electricity. Fuel for the internal combustion engines may include natural gas, a combination of natural gas and another fuel, for example, diesel fuel, and the like.

[0059] Examples of internal combustion engines for the herein disclosed implementation of the valve seat insert may include, for example, engines of the series M43C manufactured by Caterpillar Motoren GmbH & Co. KG, Kiel, Germany, operated in the range of 450-750 rpm, i.e. at medium speed. Such internal combustion engines may be large stand-alone engines that may provide access to the inlet and exhaust valves of the combustion engine for attachment of the valve seat inserts of the

present disclosure during maintainance.

[0060] Although the preferred embodiments of this disclosure have been described herein, improvements and modifications may be incorporated without departing from the scope of the following claims.

Claims

1. A valve seat insert (10A, 10B, 10C) for a cylinder head (104) of an internal combustion engine (100), the valve seat insert (10A, 10B, 10C) comprising:
 - a ring-shaped body (20) defining a passage (22) for enabling a fluid to pass through the body (20) along an axial direction (Z) from an entrance side (24) to an exit side (26) of the valve seat insert (10A, 10B, 10C), wherein the body (20) comprises
 - an entrance side section (32) with a first contact surface section (42), and a valve sealing surface section (46),
 - an exit side section (34) with a second contact surface section (48), and
 - an arch section (36) axially extending from the entrance side section (32) to the exit side section (34) and decreasing in material thickness from the entrance side section (32) towards the exit side section (34) up to a minimum thickness axial position (P) that is located in the half of the arch section (36) being close to the exit side section (34).
2. The valve seat insert (10A, 10B, 10C) of claim 1, wherein the minimum thickness axial position (P) defines a region of static spring-like stress in the mounted state and is located at at least 60 %, 70 %, 80 %, or 90 % of the axial extension of the arch section (36) measured from the entrance side section (32).
3. The valve seat insert (10A, 10B, 10C) of claim 1 or claim 2, wherein the body (20) further comprises an inner surface (52) extending circumferentially on the radially inner side of the body (20) and comprising the valve sealing surface section (46); and an outer surface (54) extending circumferentially on the radially outer side of the body (20) and comprising the first contact surface section (42), the second contact surface section (48), and, for example, an abutting surface section (44); and wherein, at the arch section (36), the outer surface (54) is concavely curved and/or the inner surface (52) is convexly curved.
4. The valve seat insert (10A, 10B, 10C) of any one of the preceding claims, wherein, at the arch section (36), the outer surface (54) is concavely curved with a series of curved sections (54A, 54B, 54C) having

increasing radius curvatures up to the minimum thickness axial position (P); and/or neighboring curved sections (54A, 54B, 54C) transition essentially tangentially into each other.

5. The valve seat insert (10A, 10B, 10C) of any one of the preceding claims, wherein, at the arch section (36), the outer surface (54) forms a recess (60) with a gutter-like extension (62) towards the valve sealing surface section (46), wherein a bottom (64) of the gutter-like extension (62) defines the axial beginning of the arch section (36) such that the gutter-like extension (62) comprises an inner gutter surface section (64A) and an outer gutter surface section (64B) that are associated with the arch section (36) and the entrance side section (32), respectively.
6. The valve seat insert (10A, 10B, 10C) of claim 5, wherein the outer gutter surface section (64B) comprises a curved section (54A') that extends a curved section (54A) of the inner gutter surface section (64A) and transitions into a planar surface section (64C).
7. The valve seat insert (10A, 10B, 10C) of claim 6, wherein the planar surface section (64C) extends in axial direction; and/or wherein the radial position of the planar surface section (64C) is essentially aligned with the second contact surface section (48) or shifted to a larger radius (R_{64C}), the later case increasing the volume of the gutter-like extension (62).
8. The valve seat insert (10A, 10B, 10C) of any one of the preceding claims, wherein the first contact surface section (42) is configured for forming a first sealed contact with the cylinder head (104) in the mounted state; and/or the abutting surface section (44) is configured for defining an axial position of the valve seat insert (10A, 10B, 10C) when mounted at the cylinder head (104); and/or the valve sealing surface section (46) is adapted to form a seal with a valve spindle (142) and/or extends under an angle of about 60° with respect to the axial direction (Z); and/or the second contact surface section (48) is configured for forming a second sealed contact with the cylinder head (104) in the mounted state; and/or the arch section (36) is configured for delimiting a cooling channel (12) in radial direction from the passage (22), wherein the cooling channel (12) is formed, in the mounted state of the valve seat insert (10A, 10B, 10C), between the valve seat insert (10A, 10B, 10C) and the cylinder head (104); and/or the first contact surface section (42) and/or the second contact surface section (48) extend in axial direction (Z); and/or

the abutting surface section (44) extends in a radial direction (R).

9. The valve seat insert (10A, 10B, 10C) of any one of the preceding claims, wherein, in a radial cross-section, the body (20) is C-shaped, the entrance side section (32) and the exit side section (34) form the respective ends of the C-shape, the arch section (36) forms the middle section of the C-shape, and the end associated with the entrance side section (32) extends to a larger radius (R_{EN}) than the radius (R_{EX}) associated with the exit side section (34).
10. The valve seat insert (10A, 10B, 10C) of any one of the preceding claims, wherein the inner surface (52) protrudes towards the center of the body (20) to define a minimal opening radius (R_{MIN}) in an axial central region and the recess (60) at the outer surface (54) is configured to provide for a minimal radial thickness (d_{MIN}) of the arch section (36) that is located in the axial direction (Z) closer to the first contact surface section (42) than to the second contact surface section (48).
11. The valve seat insert (10A, 10B, 10C) of any one of the preceding claims, wherein ring-shaped body (20) is cylinder-symmetric.
12. A cylinder head assembly for an internal combustion engine (100), the cylinder head assembly comprising:
 - a cylinder head (104) comprising a section for covering a cylinder (102) of an internal combustion engine (100), wherein the section comprises an exhaust opening (104A); and
 - a valve seat insert (10A, 10B, 10C) according to any one of the preceding claims fitted into the exhaust opening (104A), whereby a cooling channel (12) is formed between the arch section (36) and the cylinder head (104).
13. The cylinder head assembly of claim 10, wherein the exhaust opening (104A) narrows stepwise in an insert direction, thereby comprising a first circumferential sidewall (104B), a first radially extending face (104C), a second circumferential sidewall (104D), and a second radially extending face (104E); and/or the first contact surface section (42) forms a first sealing of the cooling channel (12) at the entrance side (24) together with the first circumferential sidewall (104B); and/or the abutting surface section (44) contacts the first radially extending face (104C), thereby defining an axial position of the valve seat insert (10A, 10B, 10C) with respect to the cylinder head (104); and/or the second contact surface section (48) forms a second sealing of the cooling channel (12) at the exit

side (26) together with the second circumferential sidewall (104D).

14. The cylinder head assembly of claim 12 or claim 13, wherein the arch section (36) is formed to provide for the cooling channel (12) being asymmetric and/or for the cooling channel (12) being more narrow at the entrance side (24) than at the exit side (26). 5

15. A retrofitting method for a combustion engine having a plurality of cylinders (102), each of the plurality of cylinders (102) being associated with at least one exhaust valve (108), the method comprising: 10

attaching the valve seat insert (10A, 10B, 10C) according to any one of claims 1 to 11 to an exhaust opening (104A) of a cylinder head (104) of an internal combustion engine (100). 15

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FIG 1

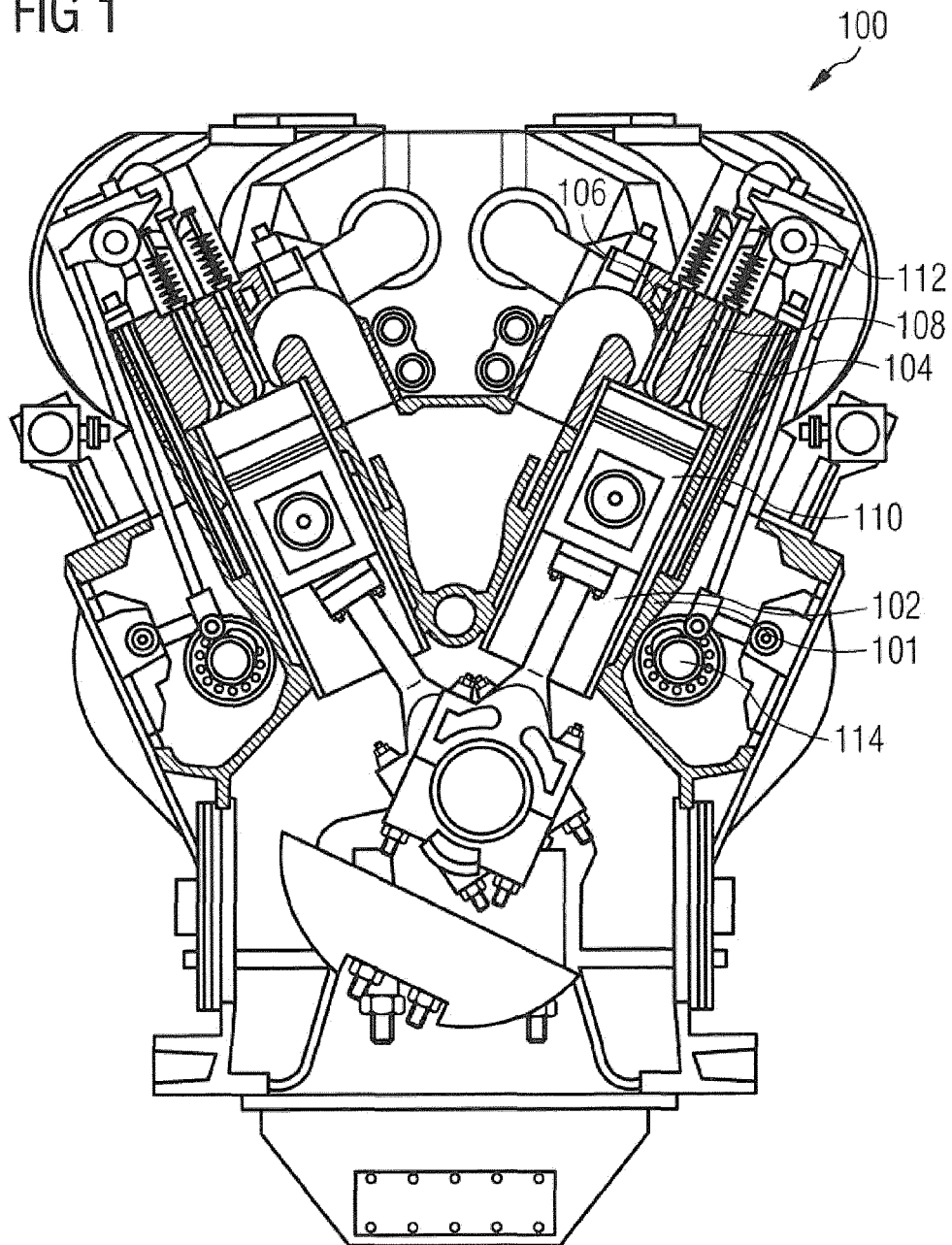


FIG 2

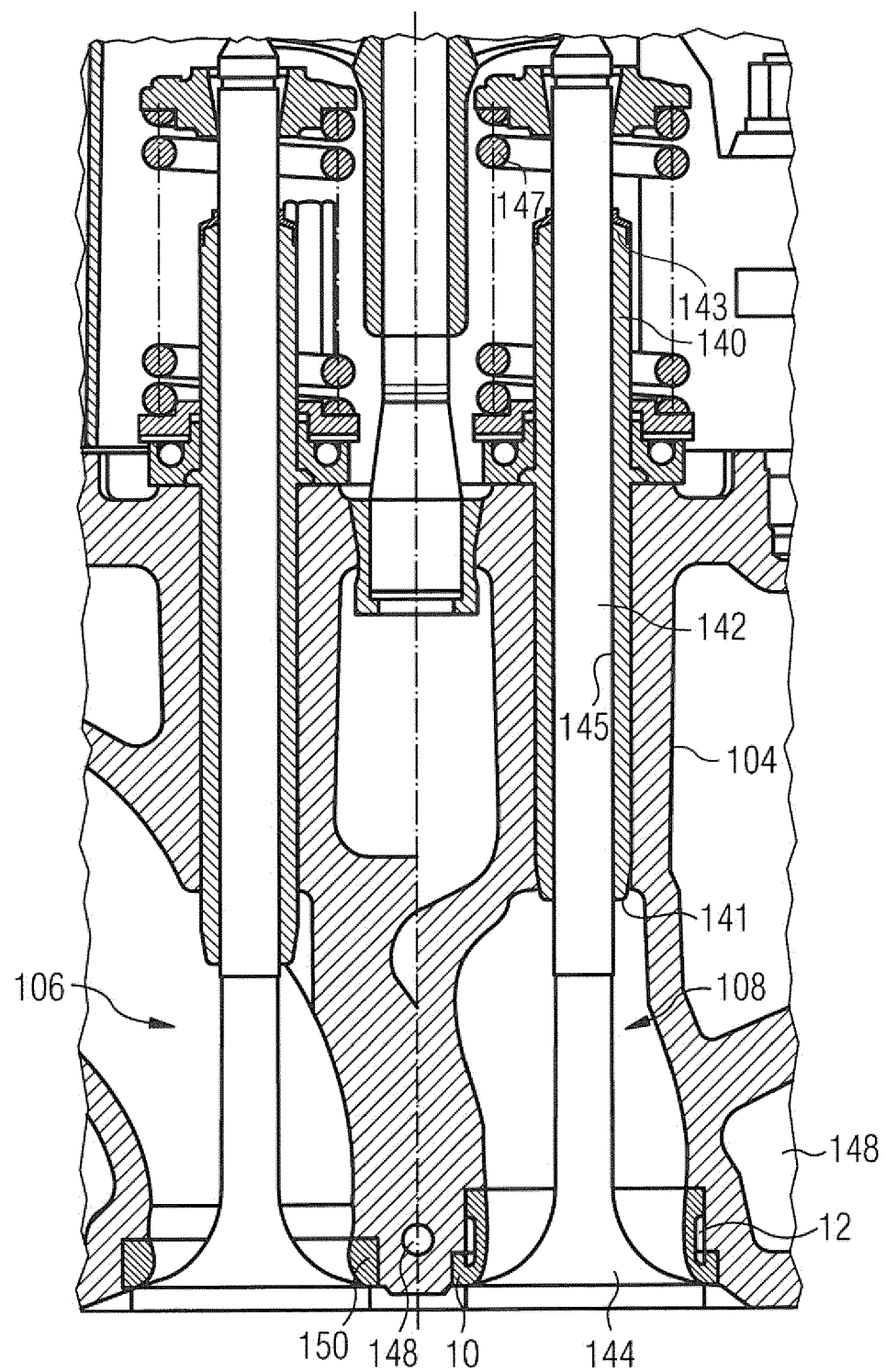


FIG 3

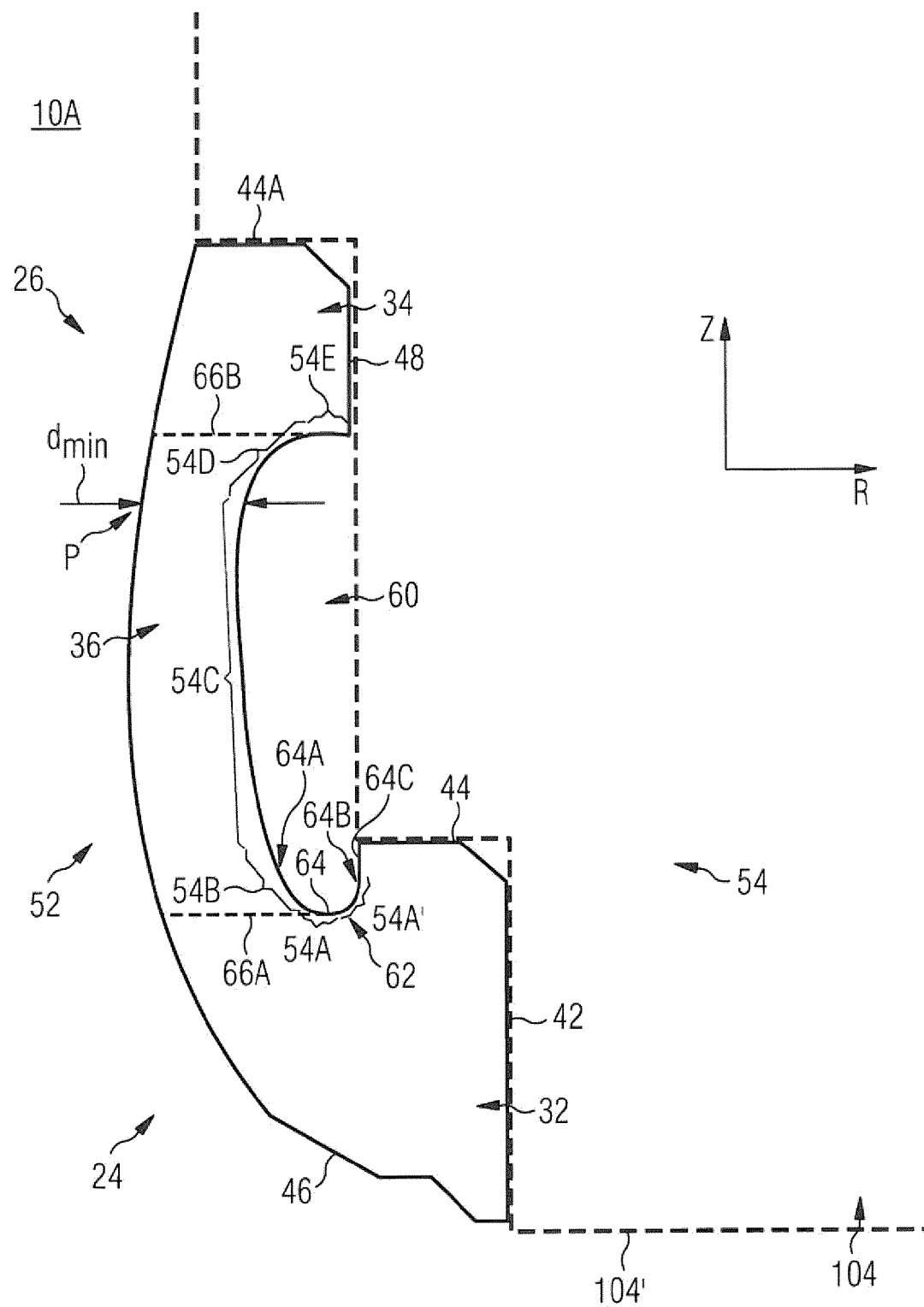


FIG 4

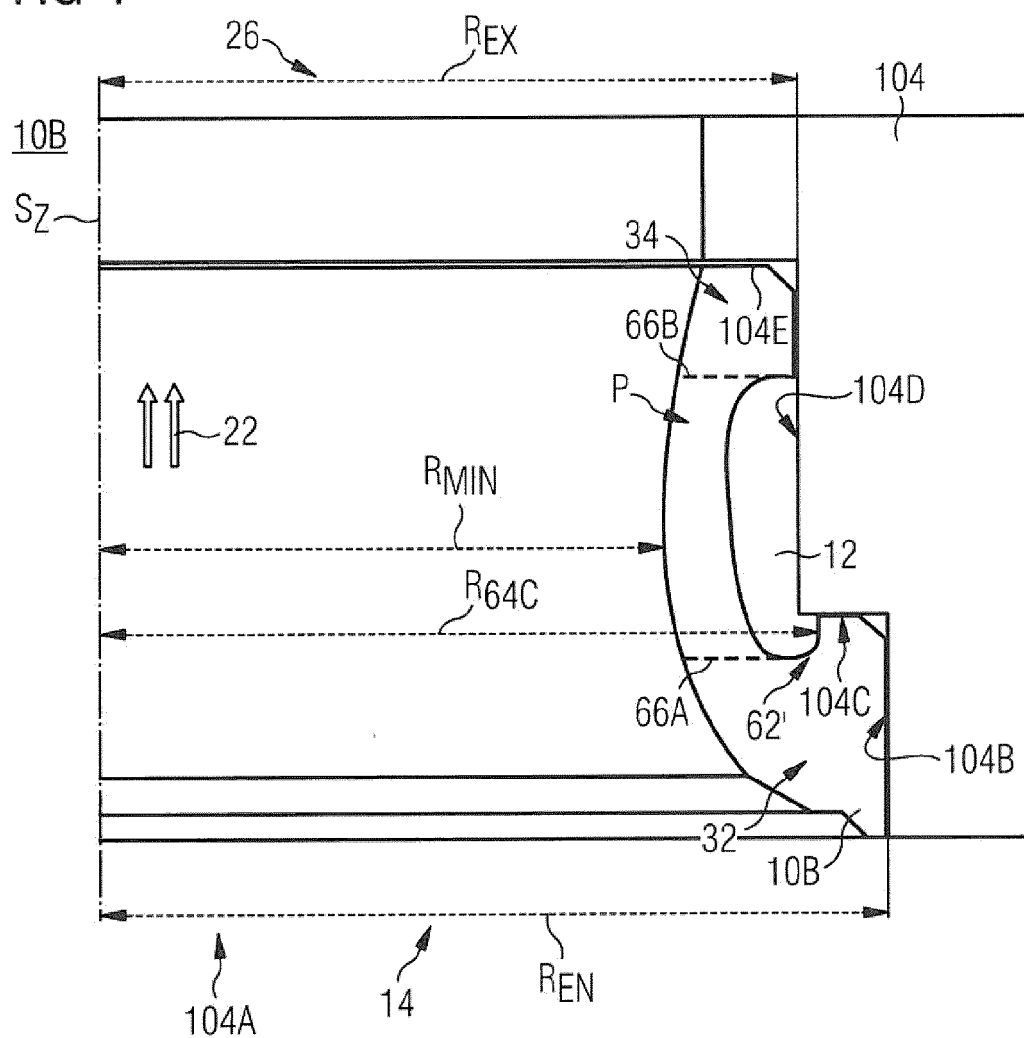
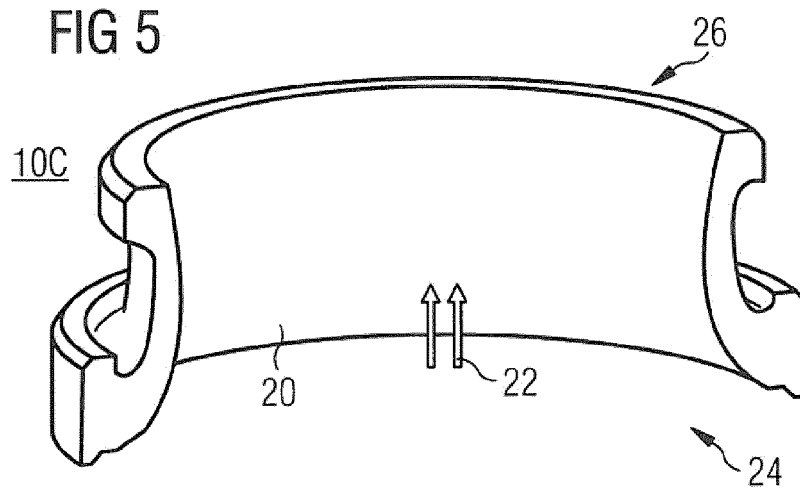


FIG 5





EUROPEAN SEARCH REPORT

Application Number
EP 14 18 6281

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			F01L
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 25 June 2015	Examiner Paulson, Bo
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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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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