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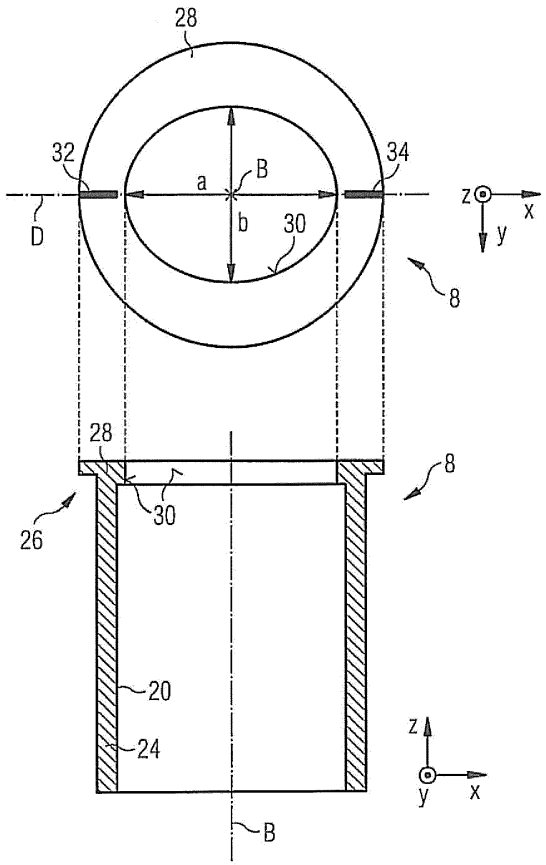
(54) Cylinder liner with deposit wiping face

(57) The present disclosure relates to a cylinder liner (8) for guiding a piston (10) of an internal combustion engine (1), and to a method for assembling the internal combustion engine (1). The cylinder liner (8) may comprise a sleeve (24) for guiding the piston (10) therein. The cylinder liner (8) may further comprise a circumferential wiper contact face (30) for scraping off deposits from the piston (10) during operation. The wiper contact face (30) may at least partially protrude towards a longitudinal axis (B) of the sleeve (24) relative an inner face of the sleeve (24). The wiper contact face (30) may have an oval shape.

FIG 2



EP 2 905 454 A1

Description

Technical Field

[0001] The present disclosure relates to a cylinder liner of an internal combustion engine, and, more particularly, to a wiper edge, or a wiper ring of a cylinder liner for scraping off deposits from a piston during operation of the internal combustion engine.

Background

[0002] During combustion in internal combustion engines such as diesel, gasoline and/or gaseous fuel engines, soot and other particulate matter are generated. Those particulate matters may accumulate at a piston skirt of a reciprocating piston, and may scratch along an inner face of a cylinder liner during operation of the internal combustion engine.

[0003] For scraping off deposits from the piston skirt, a so-called wiper ring (also referred to as cuff-ring) may be provided in an annular groove of the cylinder liner. Alternatively, a wiper edge may be integrally formed with the cylinder liner.

[0004] For example, US 2012/0304954 Al of Caterpillar Inc. discloses a cuff-ring. Here, a cylinder liner for an engine includes a hollow cylindrical sleeve, with an inner surface and an outer surface. The cylinder liner may further comprise an annular cuff-ring groove with a radiused fillet region, on the inner surface proximate a first end of the hollow sleeve. A cuff-ring may be positioned in the cuff-ring groove.

[0005] The present disclosure is directed, at least in part, to improving or overcoming one or more aspects of prior systems.

Summary of the Disclosure

[0006] In one aspect of the present disclosure, a cylinder liner for guiding a piston is disclosed. The cylinder liner may comprise a sleeve for guiding the piston therein. The sleeve may extend along a longitudinal axis, and may include an inner face. The cylinder liner may further comprise a circumferential wiper contact face for scraping off deposits from the piston during operation. The wiper contact face may at least partially protrude towards the longitudinal axis relative to the inner face. The wiper contact face may have an oval shape viewed in direction of the longitudinal axis.

[0007] In another aspect of the present disclosure, a wiper ring for mounting to a cylinder liner used for guiding a piston is disclosed. The wiper ring may comprise a wiper contact face for scraping deposits from the piston during operation. The wiper contact face may have an oval shape.

[0008] In yet another aspect of the present disclosure, a cylinder unit for an internal combustion engine is disclosed. The cylinder unit may comprise a piston having a major piston extension, and a cylinder liner as exemplary disclosed herein. An oval shape of the wiper contact face may be defined by a major extension and a minor extension, the major extension being greater than the minor extension. The major extension may be greater than the major piston extension, and/or the minor extension may be smaller than the major piston extension.

[0009] In yet another aspect of the present disclosure, an internal combustion engine is disclosed. The internal combustion engine may comprise a crankshaft extending along a crankshaft axis, and at least one cylinder unit as exemplary disclosed herein. The cylinder unit may be arranged such that the major extension of the oval shape of the wiper contact face runs parallel to the crankshaft axis.

[0010] In yet another aspect of the present disclosure, a method for assembling an internal combustion engine is disclosed. The method may comprise providing an engine block with a cylinder liner extending along a longitudinal axis, and providing a piston with a piston pin extending along a piston pin axis. The method may further comprise providing a crankshaft extending along a crankshaft axis, and inserting the piston into the cylinder liner from a cylinder head side. The piston may be oriented such that the piston pin axis is perpendicular to a common plane of the longitudinal axis and the crankshaft axis. The method may further comprise, after having inserted the piston, rotating the piston about the longitudinal axis for about 90° such that the piston pin axis runs parallel to the crankshaft axis, and connecting the piston to the crankshaft.

[0011] Other features and aspects of this disclosure will be apparent from the following description and the accompanying drawings.

Brief Description of the Drawings

[0012]

Fig. 1 is a schematic drawing of a sectional cut view through a section of an internal combustion engine;
Fig. 2 is a schematic drawing of a cylinder liner with a wiper edge in a top view and a cut view;
Fig. 3 is a schematic drawing of a wiper ring installed in a cylinder liner in a top view and a cut view;
Fig. 4 is a schematic drawing of an engine block with cylinder liner in a top view and a cut view of for illustrating an assembly step;
Fig. 5 is a schematic drawing of an engine block with cylinder liner in a top view and a cut view of for illustrating a further assembly step; and
Fig. 6 is a schematic drawing of an engine block with cylinder liner in a top view and a cut view of for illustrating yet a further assembly step.

Detailed Description

[0013] The following is a detailed description of exem-

plary embodiments of the present disclosure. The exemplary embodiments described therein 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.

[0014] The present disclosure is based at least in part on the realization that a wiper edge of a cylinder liner for scraping off deposits from a piston during operation may complicate assembly of an internal combustion engine. In particular, fitting complications may arise in case a piston is inserted into the cylinder liner from a cylinder head side, since the wiper edge reduces a fitting clearance to the piston. As a result, in practice, it may be almost impossible, or even impossible, to insert the piston into the cylinder liner from the cylinder head side in some specific configurations with wiper edges. Accordingly, it may be necessary to insert the piston from the crankshaft side of the engine. However, this may increase the assembly effort.

[0015] Herein, a wiper edge configuration is disclosed, which facilitates inserting the piston into the cylinder liner from the cylinder head side. The generally disclosed wiper edge configuration is applicable for cylinder liners with integrated wiper edges, and for cylinder liners with separate wiper rings.

[0016] Referring to Fig. 1, a section of an internal combustion engine 1 comprising an engine block 2 with a cylinder unit 5 including a piston assembly 4 arranged in a cylinder liner 8 is depicted. Engine 1 further comprises a crankshaft 6, which is connected to piston assembly 4.

[0017] Engine block 2 comprises at least one cylinder bore 3 into which cylinder liner 8 is installed.

[0018] A piston 10 of piston assembly 4 is connected to a piston rod 12 via a piston bolt 14, which is also part of piston assembly 4. Piston bolt 14 is mounted inside piston 10, and extends along a piston pin axis A. To axially secure piston bolt 14, for example, circlips may be provided, one of which being referred to by reference numeral 15. Piston 10 includes a piston crown 16 at a top end facing a cylinder head (not shown in Fig. 1). A piston skirt 18 of piston 10 faces cylinder liner 8, particularly an inner cylindrical face 20 of cylinder liner 8. At least one piston ring 22 may be provided in annular grooves of piston skirt 18.

[0019] Piston 10, particularly piston skirt 18, may have a nominal diameter within a range from 30 mm to 1000 mm. For example, pistons for car engines may have a nominal diameter between 60 mm to 110 mm, and pistons for large internal combustion engines for marine vessels or power plants may have a nominal diameter from 130 mm to 900 mm, or even greater. Nominal piston diameter is a common term in the field of engine design. A value of the nominal piston diameter is equal to a value of nominal cylinder liner diameter of a corresponding cylinder liner. In practice, the terms are used to define pairs of pistons and cylinder liners/cylinder bores.

[0020] Regarding a cross section of piston 10 in a plane perpendicular to longitudinal axis B (horizontal cross section), piston 10, particularly piston skirt 18, is not perfectly circular. Instead, piston skirt 18 is at least in certain areas shaped in an oval form. In conjunction with this design, the terms "piston major extension" and "piston minor extension" are used herein.

[0021] Piston major extension extends along a piston major axis of the oval shape in a horizontal cross section, whereas piston minor extension extends along a piston minor axis of the oval shape in a horizontal cross section. As is clear from the wording, piston major extension is greater than piston minor extension. However, piston major extension is slightly less piston nominal diameter.

[0022] Typically, but not necessarily, piston major extension may be greater than piston minor extension within a range from 0.1 % to 1.0 %, particularly between 0.3 % and 0.8 %. That defined ovality may depend, for example, on the position of the specific plane along a piston height of piston 10. In other words, along the piston height of piston 10, an ovality of the oval shape of piston skirt 18 may change within above-mentioned ranges.

[0023] Further, piston 10 may be composed of an aluminum alloy, cast iron, or steel. As the material of piston 10 influences a thermal expansion of piston 10 during operation, the material may also have an influence on the ovality of the oval shape of piston skirt 18.

[0024] Connecting rod 12 of piston assembly 4 is connected to crankshaft 6 such that piston assembly 4 is reciprocatingly arranged in cylinder liner 8. During operation, piston assembly 4 reciprocates between a top dead center (TDC) and a bottom dead center (BDC) along a longitudinal axis B.

[0025] Crankshaft 6, which is only shown in part in Fig. 1, is rotatably mounted in engine block 2, and extends along a crankshaft axis C (also referred to as engine axis in literature). In configurations including more than one cylinder, further piston assemblies may be connected to crankshaft 6.

[0026] In the shown configuration of Fig. 1, piston pin axis A and crankshaft axis C run parallel to one another, and perpendicular to longitudinal axis B.

[0027] As already outlined, cylinder liner 8 is provided in cylinder bore 3. Said cylinder liner 8 comprises a sleeve 24, for example a cylindrical sleeve, extending along longitudinal axis B, and including inner face 20 for guiding piston 10 during travel from TDC to BDC, and vice versa.

[0028] At an upper section 26 of cylinder liner 8, a wiper edge portion 28 is provided. Wiper edge portion 28 circumferentially extends around inner cylindrical face 20, and is integrally formed with cylindrical sleeve 24.

[0029] For scraping off deposits from piston skirt 18, particularly from a so-called top land of piston skirt 18, wiper edge portion 28 includes a wiper contact face 30.

Said wiper contact face 30 protrudes towards longitudinal axis B relative to inner face 20. In other words, wiper contact face 30 is arranged closer to longitudinal axis B than inner face 20 of cylinder liner 8. In some configurations, wiper contact face 30 may only partially protrude towards longitudinal axis B relative to inner face 20.

[0030] In some embodiments, wiper edge portion 28 may be not integrally formed with cylindrical sleeve 24. Instead, a separate wiper ring may be provided in an annular groove of cylindrical sleeve 24 as is described in conjunction with Fig. 3.

[0031] Turning to Fig. 2, a configuration of cylinder liner 8 including wiper edge portion 28 that is integrally formed with cylindrical sleeve 24 similar to Fig. 1 is shown. For the purpose of clarity, engine block, piston assembly etc. are not depicted in Fig. 2.

[0032] As can be seen in the top view of cylinder liner 8, which is depicted above the cross sectional view of cylinder liner 8, wiper contact face 30 has a defined non-circular oval shape viewed in direction of longitudinal axis B.

[0033] It is noted that for the purpose of clarity, herein, oval shape is shown as an ellipse in the Figs. However, this elliptic shape is only one conceivable embodiment of an oval shape as one skilled in the art will appreciate. For example, an oval shape may have only one symmetry axis, or, in some embodiments, may not even have one symmetry axis. It is further noted that the indicated oval shape of wiper contact face 30 is overemphasized, and may be not even perceptible to a human eye.

[0034] Specifically, the oval shape of wiper contact face 30 is defined by a major extension a along a major axis D and a minor extension b along a minor axis, whereas major extension a is greater than minor diameter b. For example, major extension a may be greater than minor extension b within a range from 0.1 % to 1 % of minor extension b, particularly within a range from 0.3% to 0.8 % of minor extension b. In practical terms, in case minor extension a may be 100 mm, major extension b may be within a range from 100.1 mm to 101 mm, particularly 100.3 mm to 100.8 mm.

[0035] As the oval shape may be not perceptible by a fitter inserting cylinder liner 8 in cylinder bore 3 of engine block 2, a mark on cylinder liner 8 may be provided such that the fitter can install cylinder liner 8 in a desired orientation relative to engine block 2. That mark may be perceptible as a point of reference for the fitter, and may indicate, at least indirectly, major axis (D) of the oval shape of wiper contact face 30. As an example, two marks 32 and 34 are schematically indicated in Fig. 2.

[0036] In some embodiments, marks 32 and/or 34 may be formed as grooves, removable pen strokes, and/or removable tape.

[0037] Wiper contact face 30 has a surface which may be at least partially smooth, honed, and/or knurled.

[0038] Referring to Fig. 3, a configuration of cylinder liner 8' including a separate wiper ring 36 is depicted. Again, engine block, piston assembly etc. are not depicted in Fig. 3 for the purpose of clarity.

[0039] Wiper ring 36 is installed in an annular groove 38 formed in upper section 26' of cylindrical sleeve 24' for wiping deposits from the top land of piston skirt 18 (see Fig. 1). For example, wiper ring 36 may be shrink-fitted in annular groove 38.

[0040] As can be seen in the top view of cylinder liner 8', which is - similar to Fig. 2 - depicted above the cross sectional view of cylinder liner 8' in Fig. 3, wiper contact face 30' has a defined non-circular oval shape viewed in direction of longitudinal axis B. Again, wiper contact face 30' particularly has an elliptic shape viewed in direction of longitudinal axis B. Alternatively, wiper contact face 30' may have - similar to wiper contact face 30 (see Fig. 2) - any other oval shape which is not circular.

[0041] Further, as wiper ring 36 is installed in annular groove 38, an outer circumferential face of wiper ring 36 may have a circular shape viewed in direction of longitudinal axis B.

[0042] Similar to cylinder liner 8 shown in Fig. 2, wiper ring 36 may include marks such as marks 32' and 34' to indicated the eccentricity axis of the elliptic shape of wiper contact face 30', which otherwise may be not perceptible to a human eye. Again, marks 32' and/or 34' may be formed as grooves, (removable) pen strokes, and/or removable tape.

[0043] Moreover, wiper contact face 30' has a surface which may be at least partially smooth, honed, and/or knurled.

Industrial Applicability

[0044] The cylinder liner with separate or integrally formed wiper contact face as generally disclosed herein is applicable in any internal combustion engine.

[0045] In the following, assembly problems which may arise in conventional systems are discussed in more detail. Thereafter, assembly of the system disclosed herein is described.

[0046] In conventional systems, a major piston extension may at least complicate insertion of a piston into a cylinder liner with a conventional circular wiper contact face. Specifically, the major extension of the piston may be almost the inner diameter of a conventional circular wiper contact face, which requires an exact alignment between piston and cylinder liner if inserting the piston into the cylinder liner from a cylinder head side. In configurations, in which the major piston extension is greater than the inner diameter of the conventional circular wiper contact face, insertion of the piston from the cylinder head side is not possible at all. Instead, the piston may have to be elaborately inserted into the cylinder liner from a crankshaft side.

[0047] Referring to Figs. 4 to 6, assembly of the system disclosed herein is described. Figs. 4 to 6 show engine block 2 with two installed cylinder liners 8 in a top view, and in a cut view along sectional plane E-E. Figs. 5 and 6 further schematically show piston 10 during insertion

into cylinder liner 8 from the cylinder head side.

[0048] In the shown configuration, major axis D (see, for example, Fig. 2) of the oval shape of wiper contact face 30, which is that axis in which major extension a of wiper contact face 30 extends, runs parallel with crankshaft axis C.

[0049] Fig. 4 shows an assembly state of internal combustion engine 1, in which cylinder liner 8 is already installed in engine block 2 such that major diameter a of wiper contact face 30 extends parallel to crankshaft axis C.

[0050] Referring to Fig. 5, piston 10 is inserted into cylinder liner 8 from a top side (the cylinder head side) of engine block 2.

[0051] As already outlined, piston 10 has - at least sectionally - an oval shape. Moreover, the ovality may be not equal along the piston height. Particularly, in the shown embodiment of Figs. 4 and 5, piston 10 has a major piston extension c at a lower section of piston skirt 18. Alternatively, a piston may have a major piston extension in a middle section of the piston. For example, the middle section may extend between 20 % and 80 % of the piston height, and the lower section may extend between 0 % and 20 % of the piston height.

[0052] In the shown configuration, major piston extension c is smaller than major extension a of wiper contact face 30. Additionally, major piston extension c may be greater than minor extension b of wiper contact face 30. It is further noted that at piston crown 16, piston skirt 18 has a crown extension d, which is smaller than major piston extension c, and also smaller than minor extension b of wiper contact face 30.

[0053] As major extension a of wiper contact face 30 is greater than major piston extension c of piston 10, insertion of piston 10 into cylinder liner 8 from the cylinder head side is facilitated in a specific orientation that is schematically shown in Fig. 5. In particular, during insertion, piston 10 is oriented such that piston pin axis A is perpendicular to a common plane of longitudinal axis B and crankshaft axis C. In other words, during insertion, the major axes of both piston 10 and wiper contact face 30 are parallel to one another.

[0054] Moreover, to facilitate insertion of piston 10 into cylinder liner 8, a minimum fitting clearance is required. Composition of engine block 2, cylinder liner 8, and piston 10 may influence the fitting clearance. For example, a piston composed of steel for operating in an engine block and a cylinder liner composed of cast iron, respectively, may have a fitting clearance between 0.2 ‰ to 0.6 ‰ of a nominal piston diameter, particularly between 0.3 ‰ to 0.5 ‰ of the nominal piston diameter. In case a piston is composed of an aluminum alloy, and an engine block and a cylinder liner are composed of cast iron, respectively, a fitting clearance may be between 0.5 ‰ to 1.4 ‰ of a nominal piston diameter, particularly between 0.6 ‰ to 1.3 ‰ of the nominal piston diameter. As a further example, a piston composed of an aluminum alloy for operating in an engine block and a cylinder liner composed of an aluminum alloy, respectively, may have a fitting clearance between 0.05 ‰ to 0.3 ‰ of a nominal piston diameter, particularly between 0.1 ‰ to 0.2 ‰ of the nominal piston diameter.

[0055] In some embodiments, the minimum fitting clearance may be situated between major piston extension c and major extension a of wiper contact face 30. Alternatively or additionally, the minimum fitting clearance may be situated between major piston extension c and the minor extension a of wiper contact face 30.

[0056] Turning to Fig. 6, which shows an assembly state in which piston 10 has passed wiper contact face 30, and was a rotated for about 90° about longitudinal axis B such that piston pin axis A runs parallel to crankshaft axis C.

[0057] As a result, piston 10 now has an orientation, in which insertion of piston 10 would have been not possible, since major piston extension c is greater than minor extension b of wiper contact face 30. However, it is emphasized that major piston extension c may be not necessarily greater than minor extension b of wiper contact face 30.

[0058] Further, as piston pin axis A and crankshaft axis C run parallel, piston 10 is connectable to crankshaft 6 via piston rod 12 of piston assembly 4 as is depicted in greater detail in Fig. 1.

[0059] In case an installed piston 10 needs to be removed from cylinder liner 8, for example, for maintenance, above mentioned assembly steps may be performed in a reversed order.

[0060] Naturally, the above assembly steps and/or disassembly steps may be analogously performed with cylinder liner 8' including wiper ring 36, although it may be generally possible to install wiper ring 36 in cylinder liner 8' after insertion of piston 10. However, if disassembling, wiper ring 36 may be not necessarily removed if pulling piston 10 out of cylinder liner 8' in direction of the cylinder head side if rotating piston 10 for about 90° about longitudinal axis B before pulling the same out.

[0061] During operation of internal combustion engine 1, wiper contact face 30 scrapes off deposits from the upper section of piston skirt 18, which is facilitated since piston crown extension d is smaller than minor diameter b of wiper contact face 30.

[0062] The scraping effect of wiper contact face 30 may be not equal along the upper section of piston skirt 18, because a clearance between wiper contact face 30 and the upper section of piston skirt 18 is not equally sized all around wiper contact face 30. Instead, regions of the upper section of piston skirt 18 facing wiper contact face 30 at stronger curved sections, which are connected by major extension a, have a larger clearance relative to regions of the upper section of piston skirt 18 facing wiper contact face 30 at moderately curved sections, which are connected by minor extension b. Generally, the smaller the clearance, the greater the scraping effect.

[0063] During operation of internal combustion engine 1, piston 10, and, therefore, piston skirt 18 is pressed

against specific regions of inner face 20. That phenomenon results from the presence of a so-called piston side force. Said piston side force may mainly result from an angle confined between longitudinal axis B of piston 10 and a longitudinal axis of piston rod 12, which constantly changes its spatial position and orientation relative to longitudinal axis B of piston 10 during operation.

[0064] Accordingly, it is desirable that regions of piston skirt 18 that are pressed against inner face 20 is wiped such that, if at all, only small deposits quantities deposit at those regions to reduce scratching of those deposits along inner face 20. The disclosed cylinder liner 8, and, hence, wiper contact face 30 may take this into account, since the endangered regions of piston skirt 18 are arranged close to wiper contact face 30 (see Fig. 6). Particularly, the endangered regions of piston skirt 18 are those regions, which face the moderately curved sections of wiper contact face 30. Here, the clearance between piston skirt 18 and wiper contact face 30 is relatively small due to the design of wiper contact face 30 and the internal combustion engine assembly disclosed herein.

[0065] As used herein, terms relating to spatial relationships, for example parallel and perpendicular, and values and value ranges recited herein may be used in a context allowing for certain tolerances. Those tolerances are determined in that the functional feature associated with the value or relationship may be still fulfilled. For example, perpendicular and parallel as used herein may not necessarily mean perpendicular and parallel in a strict mathematical sense, but may allow tolerances of up to $\pm 3°$, or even more in specific configurations.

[0066] Furthermore, as used herein, the terms "oval" and "oval shape" are used to indicate a non-circular shape. In other words, the oval shape has an ovality unequal zero, whereas ovality is calculated as quotient of two times the difference between major extension and minor extension, and the sum of major extension and minor extension.

[0067] 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.

Claims

1. A cylinder liner (8) for guiding a piston (10), the cylinder liner (8) comprising:

   a sleeve (24) for guiding the piston (10) therein, the sleeve (24) extending along a longitudinal axis (B), and including an inner face (20); and
   a circumferential wiper contact face (30) for scraping off deposits from the piston (10) during operation, the wiper contact face (30) at least partially protruding towards the longitudinal axis (B) relative to the inner face (20), and having an oval shape viewed in direction of the longitudinal axis (B).

2. The cylinder liner (8) of claim 1, wherein
   the wiper contact face (30) is integrally formed with the sleeve (24); or
   the cylinder liner (8') further comprises a wiper ring (36) including the wiper contact face (30), and the inner face (20') further comprises an annular groove (38) in a plane perpendicular to the longitudinal axis (B), the wiper ring (36) being installed in the annular groove (38).

3. The cylinder liner (8) of claim 1 or 2, wherein the wiper contact face (30) has at least partially a smooth, honed, and/or knurled surface.

4. The cylinder liner (8) of any one of the preceding claims, wherein
   the sleeve (24) includes an upper section (26), and the wiper contact face (30) is arranged at the upper section (26); and/or
   the sleeve (24) is cylindrical.

5. The cylinder liner (8) of any one of the preceding claims, wherein the oval shape of the wiper contact face (30) is defined by a major extension (a) and a minor extension (b), the major extension (a) being greater than the minor extension (b) within a range from 0.1 % to 1 % of the minor extension (b), for example within a range from 0.3 % to 0.8 % of the minor extension (b).

6. The cylinder liner (8) of any one of the preceding claims, further including a mark (32, 34) for providing a point of reference indicating a major axis (D) of the oval shape of the wiper contact face (30).

7. A wiper ring (36) for mounting to a cylinder liner (8') used for guiding a piston (10), the wiper ring (36) comprising a wiper contact face (30') for scraping deposits from the piston (10) during operation, the wiper contact face (30') having an oval shape.

8. The wiper ring (36) of claim 7, wherein the shape of the wiper contact face (30') is defined by a major extension (a') and a minor extension (b'), the major extension (a') being greater than the minor extension (b') within a range from 0.1 % to 1 % of the minor extension (b'), for example within a range from 0.3% to 0.8 % of the minor extension (b').

9. The wiper ring (36) of claim 7 or 8, further including a mark (32', 34') for providing a point of reference indicating a major axis (D) of the shape of the wiper contact face (30').

10. A cylinder unit (5) for an internal combustion engine (1), the cylinder unit (5) comprising:

a piston (10) having a major piston extension (c); and
a cylinder liner (8) according to any one of claims 1 to 6, wherein the oval shape of the wiper contact face (30) is defined by a major extension (a) and a minor extension (b), the major extension (a) being greater than the minor extension (b);
wherein the major extension (a) is greater than the major piston extension (c), and/or the minor extension (b) is smaller than the major piston extension (c).

11. The cylinder unit (5) of claim 10, wherein the piston (10) and the wiper contact face (30) are configured to provide a minimum fitting clearance therebetween within a range from 0.1 ‰ to 1.3 ‰ of a nominal piston diameter of the piston (10).

12. An internal combustion engine (1) comprising:

a crankshaft (6) extending along a crankshaft axis (C); and
at least one cylinder unit (5) according to claim 10 or 11, wherein the cylinder unit (5) is arranged such that the major extension (a) of the oval shape of the wiper contact face (30) runs parallel to the crankshaft axis (C).

13. The internal combustion engine (1) of claim 12, further comprising a piston (10) with a piston pin (14) extending along a piston pin axis (A), wherein the piston (10) is arranged such that the piston pin axis (A) runs parallel to an eccentricity axis (D) of the oval shape of the wiper contact face (30).

14. A method for assembling an internal combustion engine (1), the method comprising:

providing an engine block (2) with a cylinder liner (8) extending along a longitudinal axis (B);
providing a piston (10) with a piston pin (10) extending along a piston pin axis (A);
providing a crankshaft (6) extending along a crankshaft axis (C);
inserting the piston (10) into the cylinder liner (8) from a cylinder head side, the piston (10) being oriented such that the piston pin axis (A) is perpendicular to a common plane of the longitudinal axis (B) and the crankshaft axis (C);
after having inserted the piston (10), rotating the piston (10) about the longitudinal axis (B) for about 90° such that the piston pin axis (A) runs parallel to the crankshaft axis (C); and
connecting the piston (10) to the crankshaft (6).

15. The method of claim 14, wherein the cylinder liner (8) is configured according to any one of claims 1 to 6, and is provided in the engine block (2) such that a major extension (a) of the oval shape of the wiper contact face (30) runs parallel to the crankshaft axis (C).

FIG 1

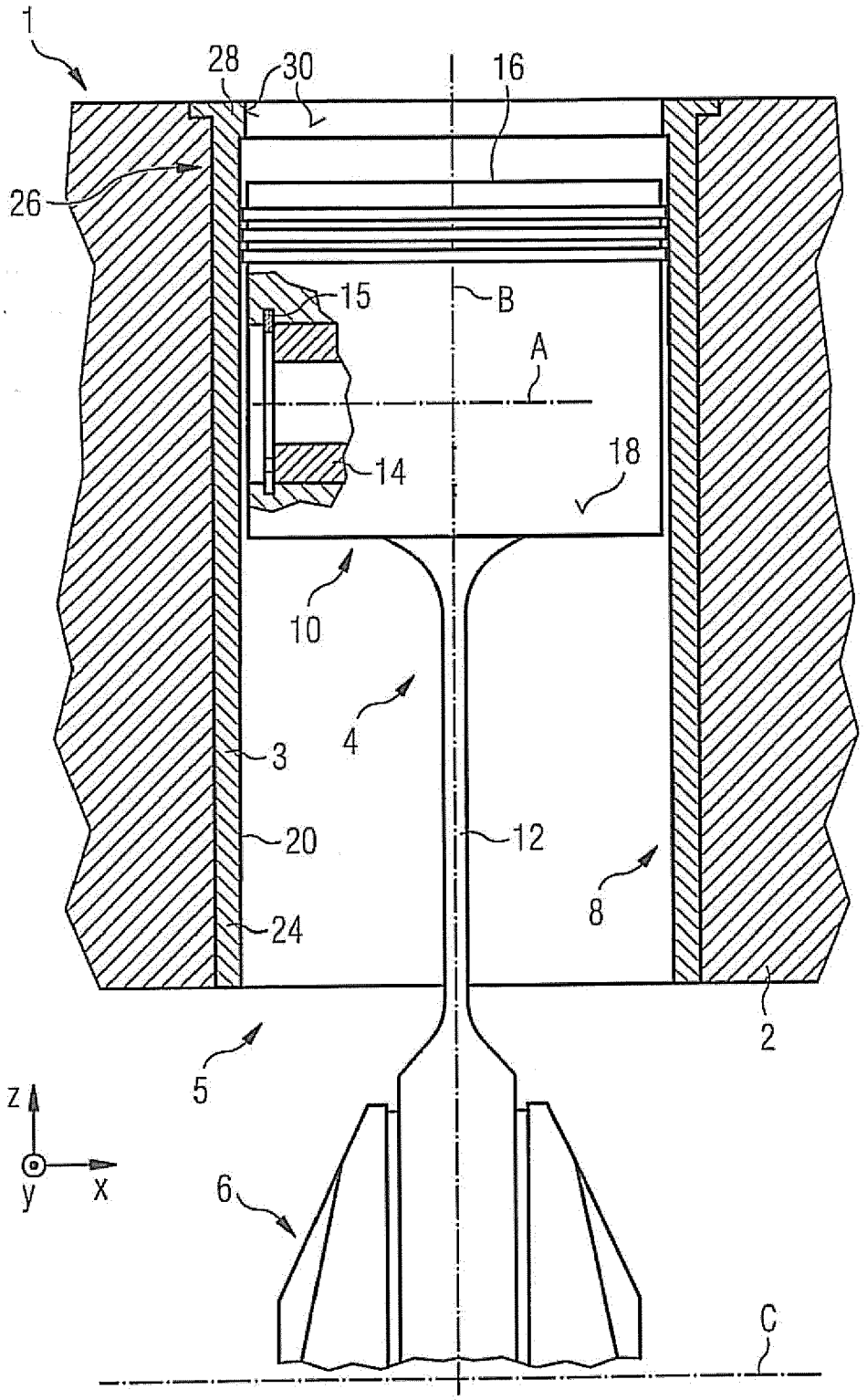


FIG 2

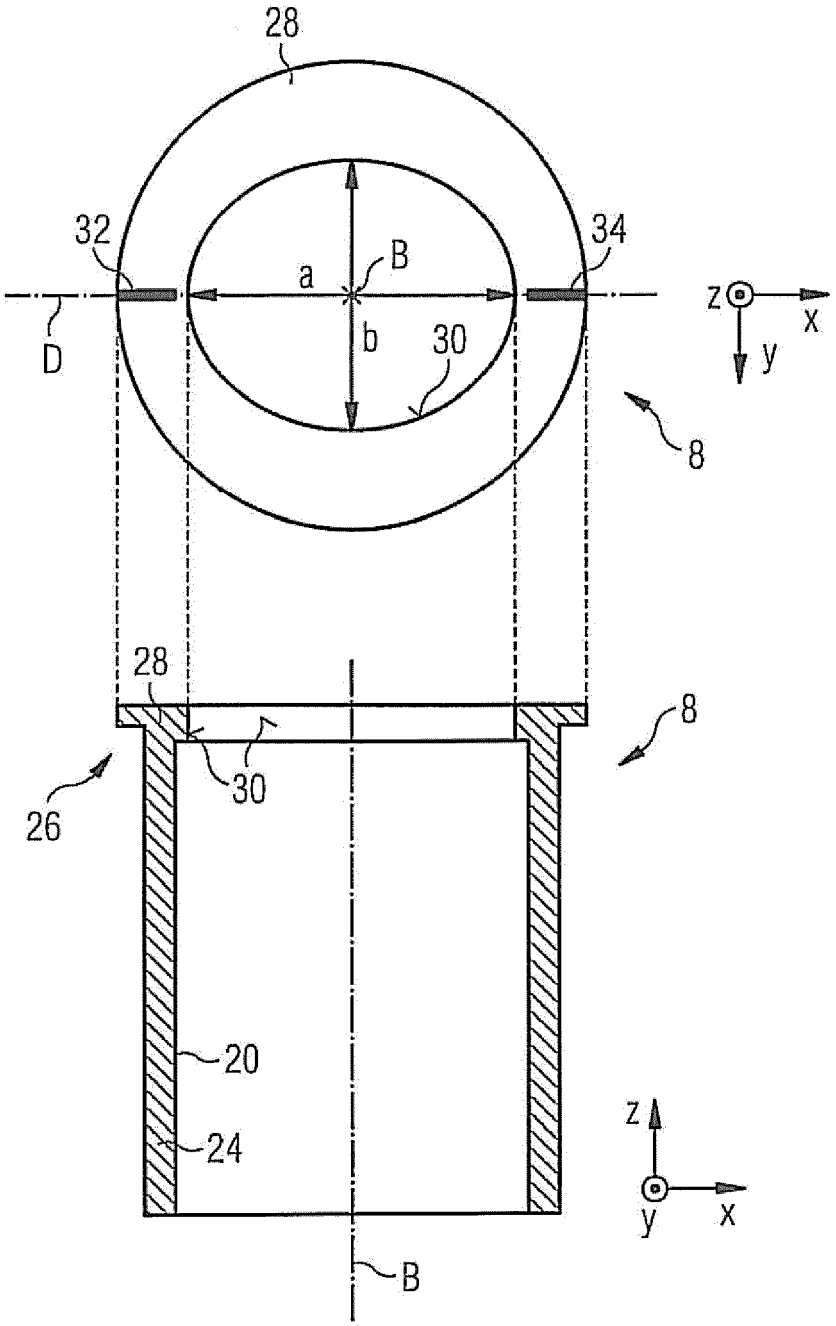


FIG 3

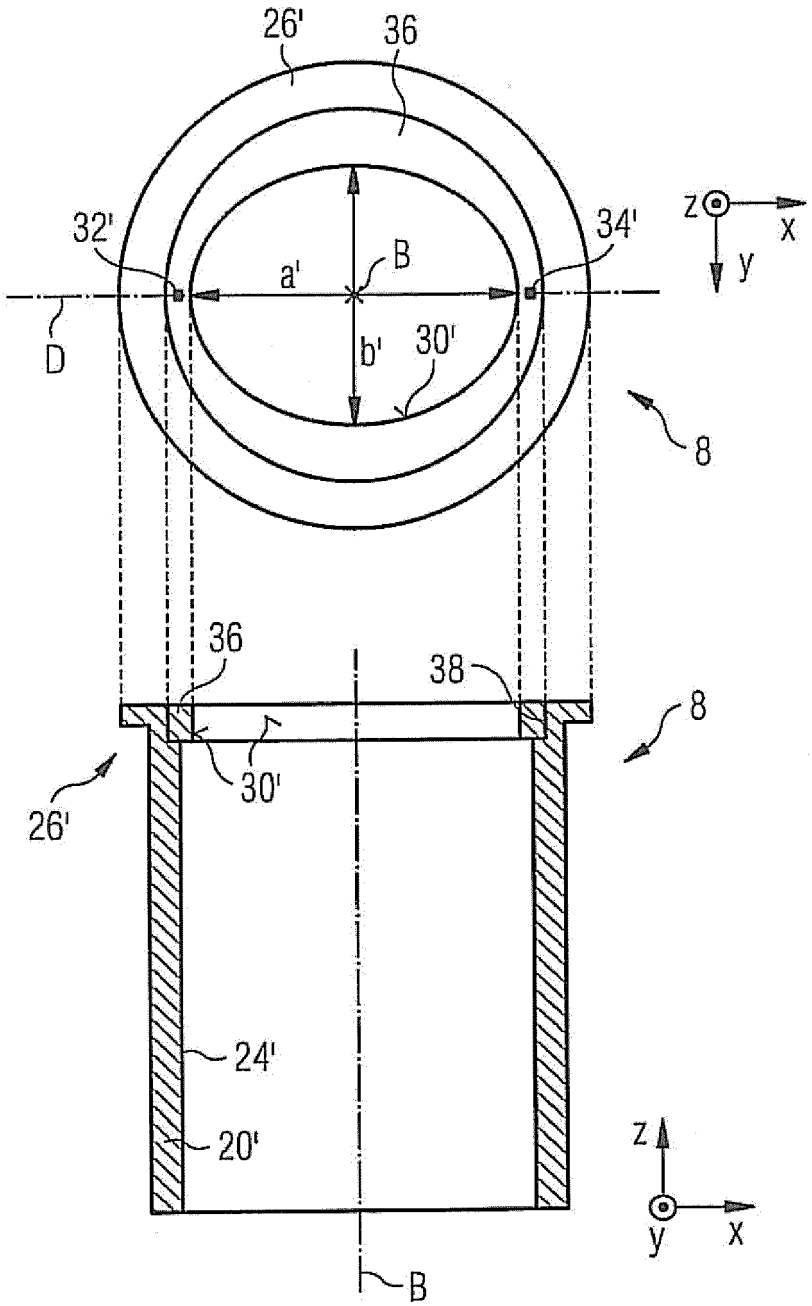


FIG 6

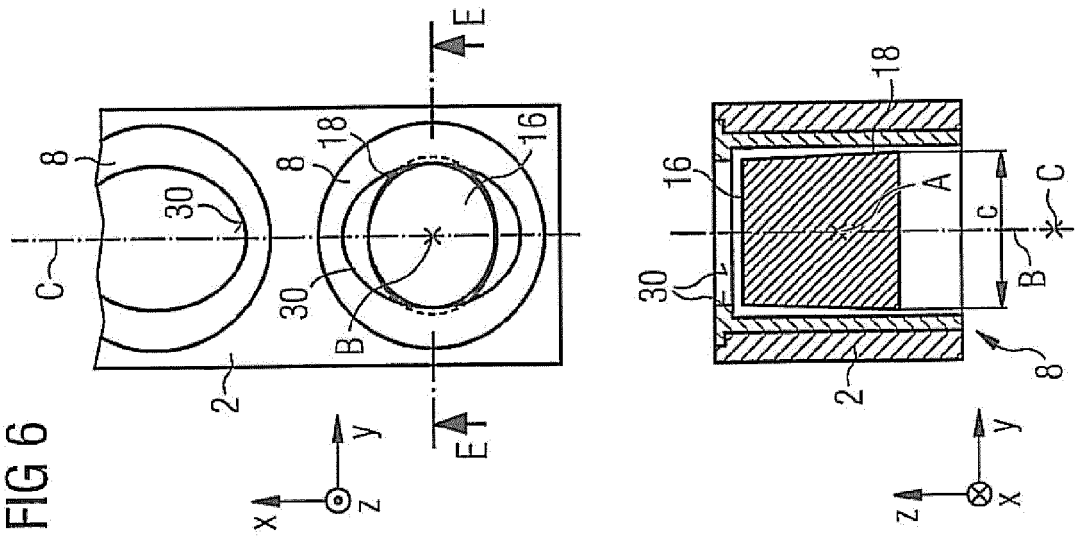


FIG 5

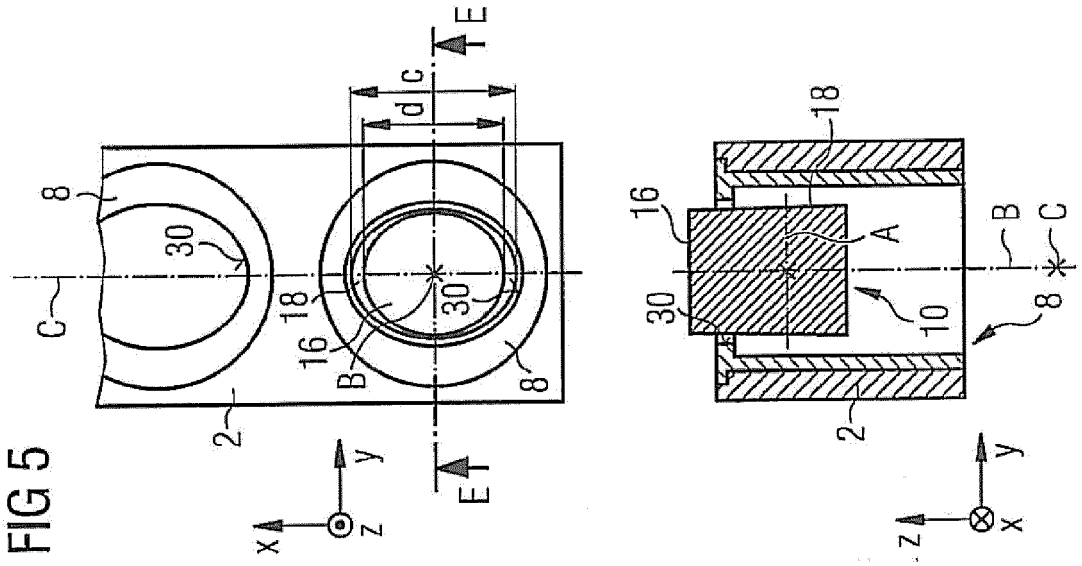
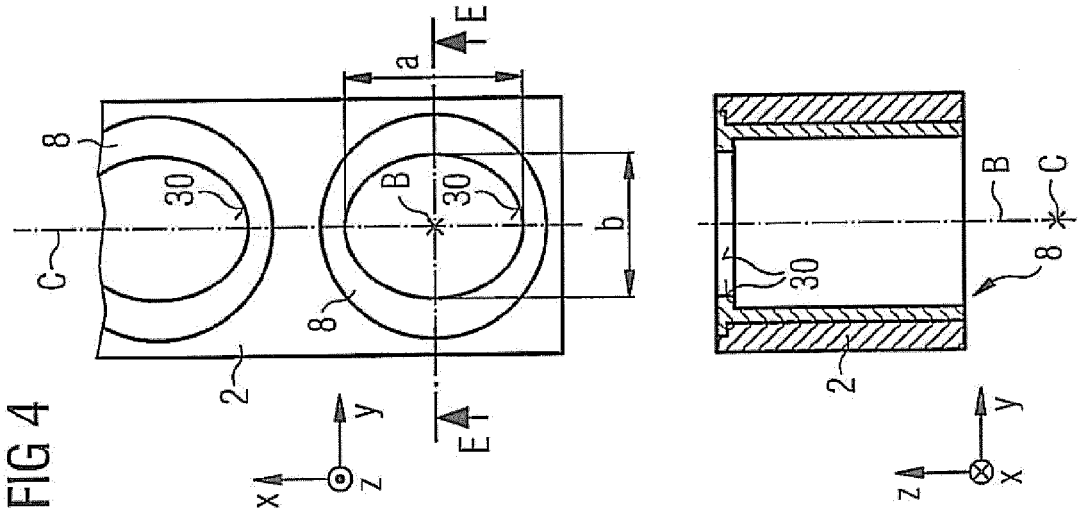


FIG 4



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EUROPEAN SEARCH REPORT

Application Number
EP 14 15 4562

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	DE 10 2011 012507 A1 (KS KOLBENSCHMIDT GMBH [DE]) 30 August 2012 (2012-08-30) * paragraphs [0024] - [0027] * * pages - * -----	1-14 2	INV. F02F1/00
Y	CN 202 645 749 U (WUHU EIDSON AUTOMATION EQUIPMENT CO LTD) 2 January 2013 (2013-01-02) * figures * -----	2	
A	DE 42 29 092 C1 (MAN & W DIESEL AG) 9 September 1993 (1993-09-09) * column 2, lines 45-61 * -----	3	
A	US 2009/095248 A1 (KUMAR YOGESH [IN] ET AL) 16 April 2009 (2009-04-16) * abstract * * figures * -----	3	
			TECHNICAL FIELDS SEARCHED (IPC) F02F

The present search report has been drawn up for all claims

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The Hague	13 June 2014	Matray, J

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102011012507 A1	30-08-2012	NONE	
CN 202645749 U	02-01-2013	NONE	
DE 4229092 C1	09-09-1993	NONE	
US 2009095248 A1	16-04-2009	NONE	

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Patent documents cited in the description

- US 20120304954 A1 **[0004]**