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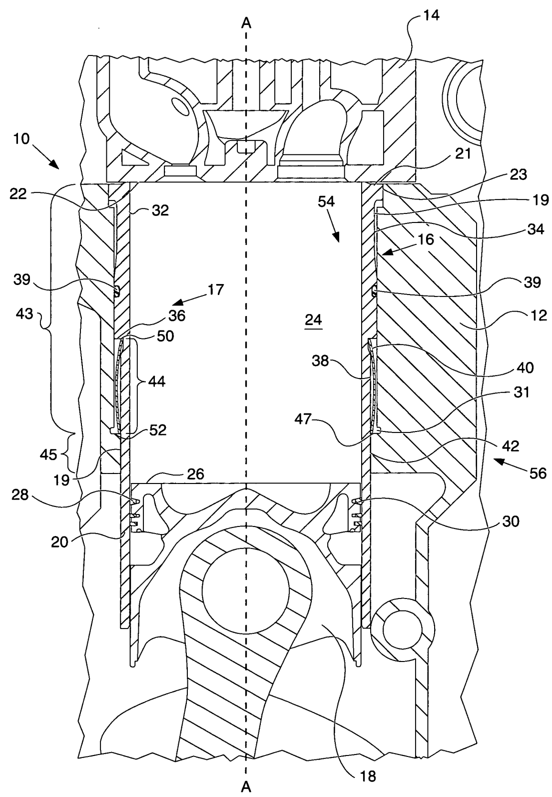
(54) **Method of lining a cylinder and a cylinder liner therefor**

(57) The disclosure relates to a method for lining an engine cylinder (16) including assembling a liner (20) and a sleeve (40) into a bore (19) such that the sleeve (40) is positioned between a liner surface (50) and a bore surface (52). A force is applied onto the liner (20) to position the liner (20) into the bore (19) thereby compressing and deforming the sleeve (40).

FIG. 1



EP 2 216 534 A1

Description

Technical Field

[0001] The present disclosure relates generally to internal combustion engines and more particularly to a method for lining cylinders of such engines.

Background

[0002] Engine liners are typical components utilized in modem engines, such as internal combustion gasoline engines and diesel engines. An engine liner includes a bore defined by a longitudinally extended inner surface to accommodate a piston disposed therein. The piston can reciprocate within the bore due to a clearance between an outer surface of the piston and the inner surface of the liner. A head of the piston and an end of the bore may define a combustion chamber, the volume of which may vary as the piston moves back and forth within the bore. Fuel injected into the combustion chamber is compressed, ignited, and combusted at different engine cycles defined by the movement of the piston. In many applications, the engine liners are disposed within an engine block. An engine head assembly is typically disposed on the engine block adjacent one end of the engine liners. As a result, the engine liners may be subject to a compression load due to the presence of the engine head assembly. Some portions of an engine liner may undergo radial deformation under the compression load. The radial deformation of the liner may distort the otherwise straight profile of the inner surface of the liner. At some locations, the diameter of the bore may be reduced due to inward deformation of the inner surface of the liner. The inward deformation of the inner surface may require an increase in the piston ring end gap to avoid piston seizure. However, the increase in the piston ring end gap may reduce the sealing effect and result in an increase in engine oil consumption and contamination, and an increase in the need for breather and filtration capacity in a crankcase ventilation system associated with the engine. Combustion efficiency may also be reduced.

[0003] A cast iron liner is described in U.S. Patent No. 7,273,029 (the '029 patent) issued to Oda et al. on 25 September 2007. The cast iron liner includes a plurality of grooves formed on an outer surface of the liner. Each of the grooves has a ring or spiral shape, extending in a circumferential direction of the liner. A plurality of such liners may be placed in a mold, and an aluminum alloy cylinder block may then be cast integrally with the liner. According to the '029 patent, such a liner design with grooves may reduce residual stress in the cylinder block, thereby preventing the cylinder block from cracking. Also according to the '029 patent, thermal expansion of such a liner can be controlled to be uniform, which may make it possible to maintain the inner surface in a cylindrical shape and minimize friction caused by a piston reciprocating within the cylinder block.

[0004] Although the liner disclosed in the '029 patent may alter thermal expansion characteristics and help maintain the cylindrical inner surface, reduce engine oil consumption, and reduce abrasion of the piston ring, the liner may be problematic in some applications. For example, the liner of the '029 patent may not adequately account for inward radial deformation due to any compressive load that may be applied at a top portion of the liner, e.g., by an engine head assembly placing a compressive force on the liner, distorting the shape of the cylindrical inner surface and causing additional abrasion of the piston ring, increased engine oil consumption, and reduced combustion efficiency.

[0005] The present disclosure is directed toward improvements in the existing technology.

Summary of the Invention

[0006] In a first aspect there is disclosed a method for lining an engine cylinder comprising assembling a liner and a sleeve into a bore such that the sleeve is positioned between a liner surface and a bore surface. A force is applied onto the liner to position the liner into the bore thereby compressing and deforming the sleeve.

[0007] In a second aspect there is disclosed an internal combustion engine comprising a bore and liner arrangement defining a central longitudinal axis (A-A). The liner has a first surface generally transverse to the central longitudinal axis (A-A) and the bore has a second surface generally transverse to the central longitudinal axis (A-A). A sleeve at least partially surrounds the liner and deformed under compression between the generally transverse first and second surfaces.

[0008] In a third aspect there is disclosed the use of a deformable sleeve to line a bore of an internal combustion engine wherein the deformable sleeve is in a compressed state between two generally opposing walls of a bore and a liner.

Brief Description of the Drawings

[0009]

Fig. 1 is an exemplary illustration of liner arrangement in accordance with the current disclosure.

Fig. 2 is a simplified cross-sectional illustration of the liner arrangement of Fig. 1 before the liner is fully assembled into the engine block.

Detailed Description

[0010] Referring to Fig. 1, there is shown a portion of an engine 10. The engine 10 may be an internal combustion engine and may be any kind of suitable engine having any number of cylinders, in a straight or a V-configuration and being adapted for any kind of fuel. The engine 10 may have a cylinder block 12 and a cylinder head 14. The cylinder block 12 and the cylinder head 14 may be relatively stiff to achieve the necessary structural integrity and may typically be formed via a casting process involving one ore more metals or metal alloys including metals such as iron or aluminium.

[0011] The engine 10 may have a cylinder 16 with a piston 18 slideably mounted therein. For designing, manufacturing, assembling and/or overhauling it may be preferred to construct the cylinder 16 from a bore 19 in the cylinder block 12 in combination with a liner arrangement 17. The liner arrangement 17 may include a liner 20 and a sleeve 40. The liner 20 may at least partially define the combustion chamber 24. The combustion chamber 24 may further be defined by a surface 22 of the cylinder head 14 and a surface 26 of the piston 18. Due to the reciprocating motion of the piston during operation the volume of the combustion chamber 24 varies throughout the combustion process.

[0012] To enable a slideably engagement of the piston 18 in the liner 20 a clearance need to be present between the piston 18 and the liner 20. However, any clearance may lead to a loss of combustion products and hence combustion pressure and performance. To reduce or prevent such losses, the piston 18 may be provided with at least one but more commonly a plurality of piston rings 28 arranged in a corresponding number of grooves 30 in the piston 18 and configured to seal a gap between the piston 18 and the liner 20. Each piston ring 28 may be configured such that an outer portion of the piston ring 28 protrudes beyond its corresponding groove 30, i.e. the outer diameter of the piston ring 28 may be greater than the outer diameter of the piston 18. The piston ring 28 may have a certain degree of movement in the corresponding groove 30 and a degree of elastic deformability so as to accommodate certain temporal and dimensional tolerances and/or variations in the diameters of the piston 18 and liner 20. The piston ring may therefore at least partially seal the clearance between the piston 18 and the liner 20. The piston 18, the liner 20 and the groove/piston ring combination (30, 28) may be configured such that the sealing properties of the combination are optimum during high pressures in the combustion chamber 24, i.e. near the top dead center of the piston 18.

[0013] A longitudinal axis A-A may extend substantially centrally through the cylinder 16, the liner and the piston 18. The longitudinal axis A-A is for reference purposes only and merely indicates a common central axis, but is not intended to indicate per se that each component has a particular symmetry relative to the longitudinal axis A-A.

[0014] As shown in Fig. 2, the arrangement of the liner 20 and bore 19 may define a cavity 31 for containing and or retaining the sleeve 40. The liner 20 may have a substantially straight inner surface 32 and a stepped outer surface 34. In some embodiments the step in the outer surface may result in two distinct liner portions 35 and 37 that are characterized by different external liner diameters. The first liner portion 35 may have a larger external diameter than the second liner portion 37. A transitional region 36 may include a first surface 50 extending between the first and second liner portions 35 and 37 in a generally transverse direction. It is to be understood that the terms transverse and transversal in this disclosure are to be interpreted as being of an angle between 0° and 180° relative to the longitudinal axis A-A but not being equal to either 0° or 180°.

[0015] In some embodiments the second liner portion 37 may have a sleeve engaging portion 38 configured to at least partially accommodate the deformable sleeve. For example the second liner portion 37 may have a particular diameter or surface characteristics to achieve a desired engagement with the sleeve 40. The surface characteristics may for example include a surface finish such as surface roughness or a particular surface shape such as an indentation, groove, projection or protrusion to engage the sleeve 40 or a portion thereof such as for example a retention portion in a positive manner.

[0016] In some embodiments the liner 20 may further be provided with a locating portion 21, such as for example a peripheral ring that may aid in correctly seating and or positioning the liner 20. The locating portion 21 may for example be configured to engage with a locating portion 23 associated with the cylinder block 12. For example, if the locating portion is a peripheral ring as shown in Figs. 2 and 3 the locating portion 23 may be a corresponding groove in the cylinder block 12. In some embodiments wherein the locating portion 23 is such a groove, the locating portion 23 may be deeper than the height of the locating portion 21 so as to prevent the locating portion 21 bottoming out in the locating portion 23 before the sleeve 40 is deformed to a preferred degree. In some embodiments the liner may also be provided with a sealing arrangement 39 around its external periphery to seal any gaps that may exist between the liner 20 and the cylinder block 12.

[0017] In some embodiments the liner 20 may further be provided with a sealing arrangement 39 for sealing a gap between the liner 20 and the bore 19. The sealing arrangement 39 may include seals to be accommodated in a retention arrangement such as one or more peripheral grooves in the outer surface 34.

[0018] The bore 19 may be defined by a bore surface 42. The bore surface 42 may be stepped. In some embodiments the step in the outer surface results in two distinct bore portions 43 and 45 that are characterized by different internal bore diameters. The first bore portion 43 may have a greater internal diameter than the second bore portion 45. A transitional region 47 may include a second surface 52 extending between the first and second bore portions 43 and 45 in a generally transverse direction.

[0019] In some embodiments the first bore portion 43 may have a sleeve accommodating portion 44 configured to at least partially accommodate the deformable sleeve. For example the first bore portion 43 may have a particular diameter or surface characteristics to achieve a desired relationship with the sleeve 40. The surface characteristics may for example include a surface finish such as surface roughness or a particular surface shape such as an indentation, groove, projection or protrusion to engage the sleeve 40 in a positive manner.

[0020] The sleeve 40 may be formed of any deformable material and may for example be metallic. The sleeve 40 may be configured such that once assembled it at least partially surrounds the liner 20 and is compressed between the transitional regions 36 and 47, i.e. in a generally axial direction. The sleeve 40 may be configured such that compression of the sleeve 40 may result in deformation of the sleeve 40. The sleeve 40 may be configured to either deform in a generally radial direction. The deformation may be generally radially outward, inward or a combination thereof such as for example a single S-curve or a plurality of S-curves. It is to be understood that radial and axial in this context are to be interpreted as at least one component of the acting forces or at least one component of change having an axial or radial direction.

Industrial Applicability

[0021] The disclosed liner arrangement 17 may be used in an internal combustion engine to provide a durable and high performance cylinder arrangement. The sleeve configuration may enable a relatively light liner to be used with no, or with at least a reduced risk of excessive liner deformation during assembly and operation as the sleeve 40 may be able to absorb some of the forces acting on the liner 20. A reduced liner deformation may in turn lower the piston ring requirements as relatively large clearances between the liner and the piston may be avoided and hence the piston rings may have less of a gap to seal as compared to conventional arrangements.

[0022] An exemplary method of lining a bore 19 will be described in more detail below.

[0023] In some embodiments the liner 20 and the sleeve 40 may be assembled into a liner-and-sleeve subassembly 54. In some embodiments the cylinder block 12 and the sleeve 40 may assembled into a cylinder block-and-sleeve subassembly 56.

[0024] Either via forming any of subassemblies 54 or 56 first or via direct assembly, the liner 20 and the sleeve 40 may be assembled into the bore 19 such that the sleeve 40 is positioned in the cavity 31 between liner 20 and the bore surface 42. The sleeve 40 may therefore be positioned between the first and second surface portions (50, 52) of the liner 20 and the bore 19. At this stage of assembly the sleeve 40 may or may not yet contact either or both of the first and second surface portions (50, 52). During further assembly a force may be applied onto the liner 20 to position the liner into the bore 19. The force may for example be generated during assembly of the cylinder head 12 onto the cylinder block 12 whereby the cylinder head surface presses 22 down onto the liner 20. The liner 20 may be held in a position corresponding to the final position of the cylinder head 14 relative to the cylinder block 12. The locating portions 21 and 23 may aid the positioning of the liner 20 in the bore 19. The force acting on the liner 20 may generally be in a longitudinal direction, i.e. parallel to or coinciding with longitudinal axis A-A. The liner 20 may transfer at least some of the applied force to the sleeve 40 via the first surface 50. Once the sleeve 40 contacts both the first and second surfaces 50 and 52, but the liner 20 has not reached its final position in the bore 19 yet, the sleeve 40 may be compressed between the generally opposed surfaces 50 and 52. The compression may be in a generally axial direction relative to the sleeve 40 and if sufficient compression is generated, the sleeve 40 may deform radially, i.e. "buckle". The deformation may be outward or inward or a combination of both. In some embodiments the deformation may be influenced and or limited by the size of the cavity 31.

[0025] Although the preferred embodiments of this disclosure have been described herein, improvements and modifications may be incorporated without departing from the scope from the following claims.

Claims

1. A method for lining an engine cylinder (16) comprising:

   assembling a liner (20) and a sleeve (40) into a bore (19) such that said sleeve (40) is positioned between a liner surface (50) and a bore surface (52);
   applying a force onto the liner (20) to position the liner (20) into the bore (19) thereby compressing and deforming the sleeve (40).

2. The method of claim 1, wherein compressing and deforming the sleeve (40) includes compressing said sleeve (40) between two generally transverse surfaces (50, 52) of said liner (20) and said bore (19).

3. The method of any of claims 1 to 2, wherein compressing and deforming the sleeve (40) includes compressing said sleeve (40) axially so as to deform said sleeve (40) radially.

4. The method of any of the preceding claims, further comprising forming a subassembly (54) of said liner (20) and said sleeve (40) before assembling said liner-and-sleeve subassembly (54) in said bore (19).

5. The method of any claims 1 to 3, further comprising forming a subassembly (56) of said cylinder block (12) and said sleeve (40) before assembling said liner (20) in said cylinder block-and-sleeve subassembly (56).

6. An internal combustion engine (10) comprising:

a bore (19) and a liner arrangement (17) defining a central longitudinal axis (A-A), the liner arrangement comprising a liner having a first surface (50) generally transverse to the central longitudinal axis (A-A), the bore having a second surface (52) generally transverse to the central longitudinal axis (A-A); and
a sleeve (40) at least partially surrounding the liner (20) and deformed under compression between the generally transverse first and second surfaces (50, 52).

7. The internal combustion engine (10) of claim 6, wherein said liner (20) has a stepped diameter with a transitional region (36) between the various diameters, at least a portion of said transitional region (36) forming said first surface (50).

8. The internal combustion engine (10) of any of claims 6 to 7, wherein said bore (19) has a stepped diameter with a transitional region (47) between the various diameters, at least a portion of said transitional region (47) forming said second surface portion (52).

9. A liner kit for an internal combustion engine (10) comprising:

a liner (20) configured to line a bore (19) of the internal combustion engine (10);
a sleeve (40) configured to at least partially surround said liner (20);
the liner (20) having a surface (50) configured to engage said sleeve (40) and to apply a generally axial force upon said sleeve (40) during assembly, said sleeve (40) being configured to deform generally radially under the influence of the applied force.

10. The liner kit of claim 9, wherein said kit further comprises a sealing arrangement (39) configured to substantially seal a gap between the liner (20) and a surface of the bore (42) and wherein said liner (20) is provided with a retention arrangement (41) configured to at least partially accommodate said sealing arrangement.

11. The cylinder kit of claim 11, wherein said liner is provided with a sleeve engaging portion (38) configured to provide a positive retention between said liner (20) and said sleeve (40).

12. Use of a deformable sleeve (40) to line a bore (19) of an internal combustion engine (10) wherein the deformable sleeve (40) is in a compressed state between two generally opposing surfaces (50,52) of the bore (19) and a liner (20).

13. The use of a deformable sleeve (40) according to claim 17 wherein said sleeve (40) is compressed in a generally axial direction.

14. The use of a deformable sleeve (40) according to claim 18 wherein said sleeve (40) is deformed in a generally radial direction.

15. The use of a deformable (40) sleeve according to any of claims 17 to 19 wherein said sleeve (40) is used to at least partially absorb some forces applied to the liner (20).

FIG. 1

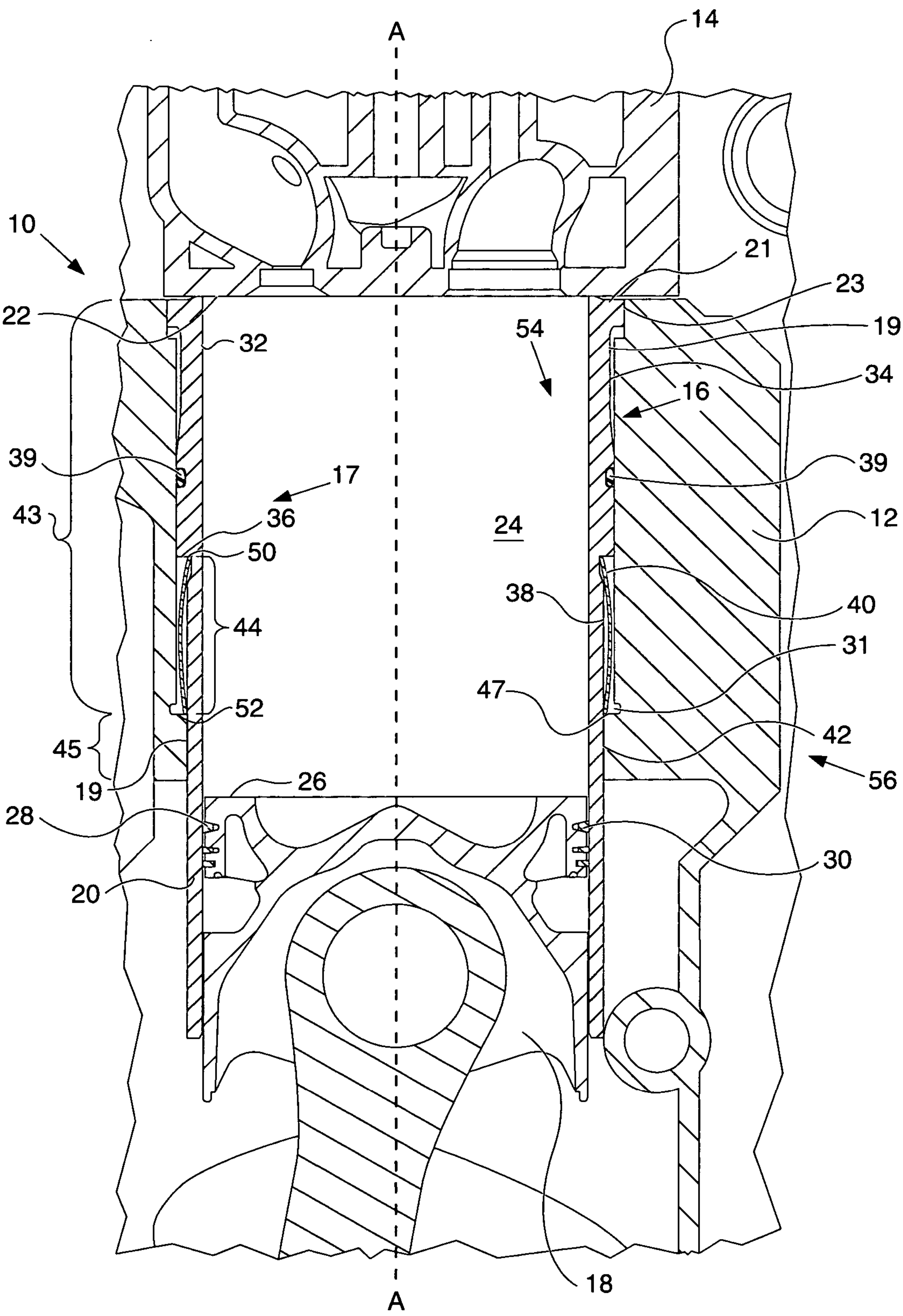

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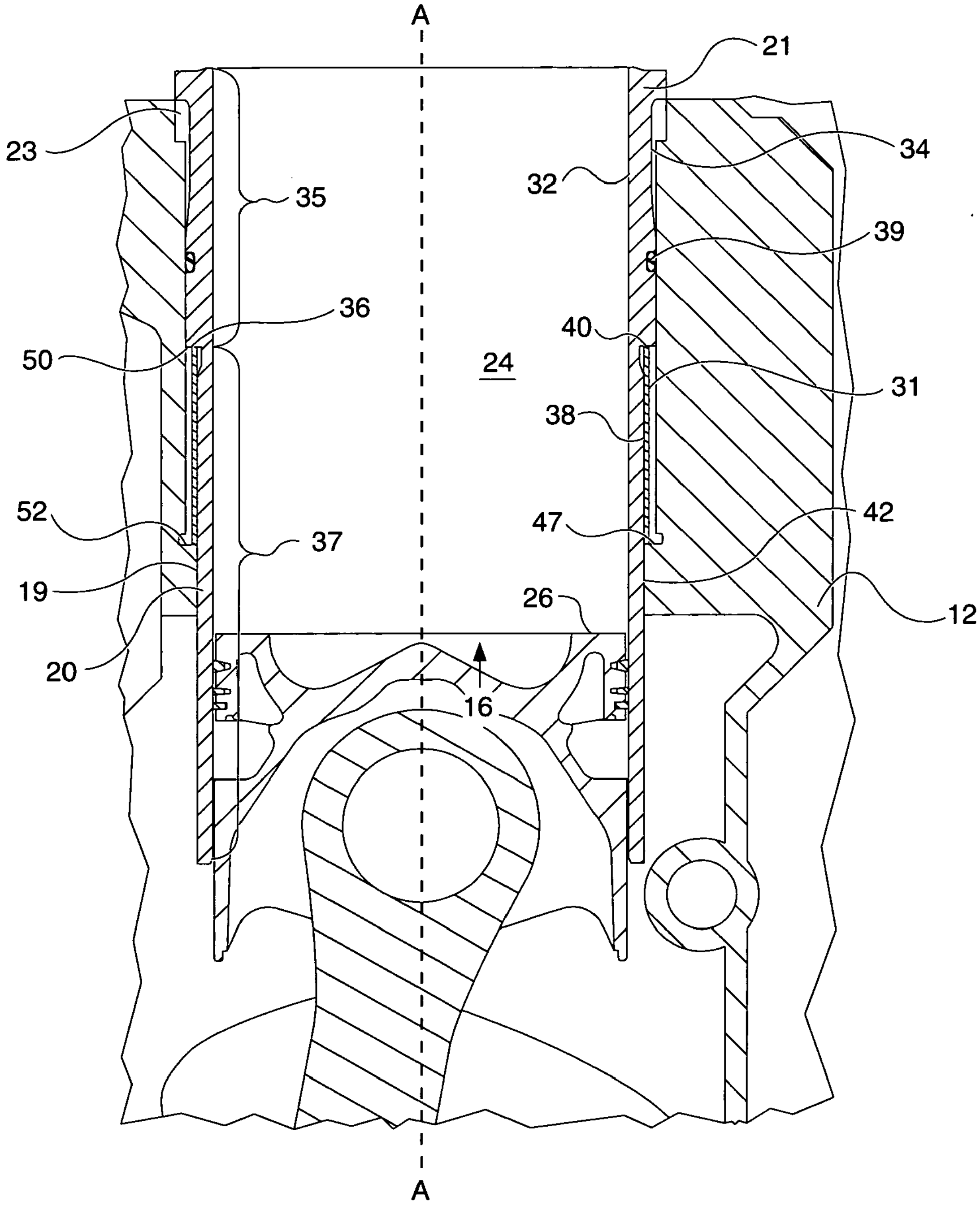
FIG. 2



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EUROPEAN SEARCH REPORT

Application Number
EP 08 02 2098

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	JP 63 036645 U (-) 9 March 1988 (1988-03-09) * figures *	1-15	INV. F02F1/16
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	24 June 2009	Matray, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 08 02 2098

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

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