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(54) HIGH PRESSURE DIESEL FUEL PUMPS AND SHOE ARRANGEMENTS

(57) The invention relates to a high pressure diesel fuel pump comprising a pumping assembly and a drivetrain assembly, the pumping assembly comprising a pump housing and a plunger (10) mounted along a pumping axis (A-A'), the drivetrain assembly comprising a drive shaft and a cam arrangement (20) having a cam (22) and a cam follower (23) mounted within a drivetrain housing (not shown), the cam follower (23) comprising a shoe (25) and a roller (24), the plunger (10) being driven in reciprocating linear movement along the pumping axis A-A' upon rotation of the cam arrangement (20), wherein the shoe (25) comprises at least one vibration damping layer (31) disposed below a plunger-engaging surface (27). The invention also extends to an improved shoe (25) for a pumping plunger (10) of a high pressure diesel fuel pump.

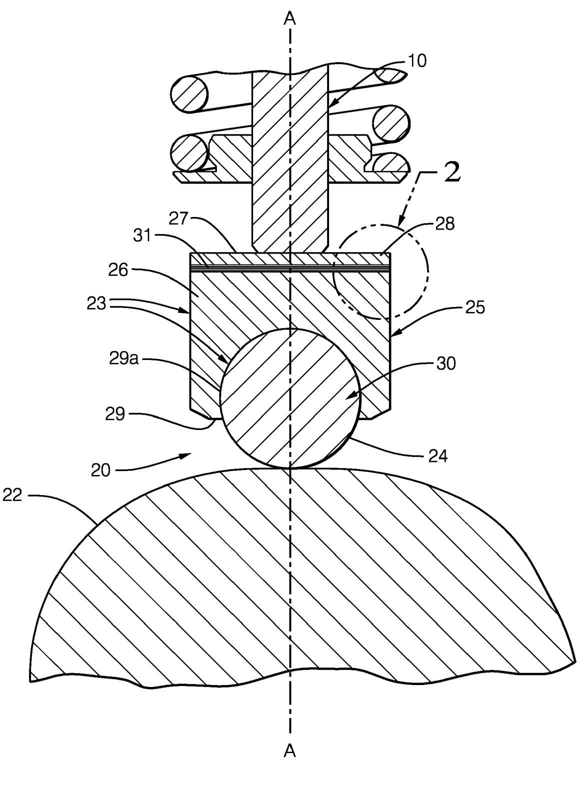

FIG. 1

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Description

BACKGROUND

Technical Field

[0001] The present invention relates generally to the field of high pressure diesel fuel pumps. More particularly, but not exclusively, the present invention concerns shoe arrangements for high pressure diesel fuel pumps.

Description of the Related Art

[0002] Known high pressure diesel fuel pumps comprise one or more plungers movable within plunger bores, to pressurise fuel within respective pumping chambers, for delivery to a fuel injection system of an engine. Each plunger is reciprocally movable along a pumping axis by a cam arrangement (driven by a drive shaft) to perform a fuel-pressurising pumping stroke and a plunger return spring to effect a plunger return stroke.

[0003] In a tappet arrangement, each of the plungers may be coupled to a cylindrical tappet member which serves to drive movement of the associated plunger within its bore. However, these arrangements can be difficult to assemble, require a relatively large accommodation space and are relatively expensive.

[0004] An alternative to the tappet arrangement comprises a roller and shoe arrangement (a cam follower or "roller-shoe" drive arrangement), in which a shoe is arranged to contact a plunger and a roller is co-operable with the shoe and the cam surface of the cam arrangement so as to impart reciprocal movement to the shoe upon rotation of the drive shaft.

[0005] Shoes are subjected to high forces in the pumping cycle and as such, need to be able to resist the stresses.

[0006] Known shoe designs comprise a single component comprising a suitable metal, typically steel. However, such shoe designs, whilst being able to cope with the forces, tend to transmit a high level of vibration to the roller and the cam and as a result, the roller and the cam components also need to be capable of withstanding and resisting said vibrations which may otherwise cause unacceptable wear and malfunction of the drive assembly. Accordingly, the known shoe designs and materials have a significant impact on the mechanical properties of the materials which can then be used for at least the roller, which are often high-cost materials.

[0007] In addition, existing shoe designs demonstrate problems with uneven load distribution, which can distort a top surface of the shoe. In turn, distortion to the shoe can cause the roller to stop rotating and thus cause pump failure by fatigue of a cam-roller interface.

[0008] One solution to address the load distribution failings of known shoe designs has been to add material to a plunger-engaging surface of the shoe to increase its stiffness. Whilst this can reduce the effects of uneven load distribution and reduce distortion, this solution does not necessarily improve the vibration issues.

[0009] Adding materials to the shoe also increases size of the shoe. Restrictions on component size are a high priority in fuel pumps where packing spaces are crowded, which means that any increase in size is generally considered to be disadvantageous. Furthermore, an increase in size of the shoe increases the mass of the shoe, which in turn increases dynamic stresses on the drive-shaft and the plunger return spring.

[0010] It is an object of the present invention to address one or more of the problems of the prior art as discussed herein or otherwise.

[0011] Therefore, it is now desired to provide an improved high pressure diesel fuel pump and roller-shoe/ cam follower arrangement that improves the effects of uneven load distribution and vibration on surrounding components.

SUMMARY OF THE INVENTION

[0012] In a first aspect of the present invention there is provided a high pressure diesel fuel pump comprising a pumping assembly and a drivetrain assembly, the pumping assembly comprising a pump housing and a plunger mounted along a pumping axis, the drivetrain assembly comprising a drive shaft and a cam arrangement having a cam and a cam follower mounted within a drivetrain housing, the cam follower comprising a shoe and a roller, the plunger being driven in reciprocating linear movement along the pumping axis upon rotation of the cam arrangement, wherein the shoe comprises at least one vibration damping layer disposed below a plunger-engaging surface.

[0013] With this arrangement, the typical stiffness of a plunger-engaging surface of the shoe can be retained, whilst minimising vibration within the shoe and the roller and cam components and distributing the pumping load over a wider area. This means that not only are the restrictions on roller material choices delimited (which can be harder and more brittle due to reduced vibration), distortion of the shoe can be significantly reduced, whilst retaining a small shoe size. Further impacts of the invention include the technology becoming less reliant on high-cost materials and less demand for the current high-precision manufacturing tolerances, which could provide other manufacturing efficiency gains and savings.

[0014] By 'vibration damping layer' what is meant is a layer capable of damping vibration/ having energy dissipation properties under cyclic stress.

[0015] The vibration damping layer(s) does/ do not form the plunger-engaging surface, but is(are) disposed below the plunger-engaging surface.

[0016] Preferably, the shoe comprises a body extending between the plunger-engaging surface and a roller-engaging surface. Preferably, the roller-engaging surface forms a cavity in a lower portion of said body to receive and retain said roller.

[0017] Preferably, the damping layer(s) comprise(s) a resin. The resin preferably comprises a thermosetting polymer. Most preferably, the polymer comprises one or more of a phenolic resin, and epoxy resin and a polyester resin.

[0018] Preferably, the damping layer(s) comprise(s) a reinforced resin. The resin may be reinforced with fibres. Preferably, the fibres may comprise one or more of cellulose fibres (such as paper or cotton), glass fibres and carbon fibres.

[0019] Preferably, the damping layer(s) comprise(s) a laminate of one or more fibre layers and one or more resin layers. The damping layer(s) may comprise(s) a laminate of cotton sheets and phenolic chemical resin layers, e.g. Tufnol ®.

[0020] The damping layer(s) may comprise(s) a thickness or depth of approximately up to 50% of a depth of the shoe (as measured from said plunger-engaging surface to the roller-engaging surface). Preferably, the damping layer(s) comprise(s) a thickness or depth of approximately from 1% to approximately 15% of a depth of the shoe (from said plunger-engaging surface to the roller-engaging surface). More preferably, the damping layer(s) comprise(s) a thickness or depth of approximately from 1 % to approximately 10% of a depth of the shoe. Most preferably, approximately 4% of a depth of the shoe.

[0021] Preferably, the damping layer(s) is(are) disposed below a plunger-engaging layer. Preferably, the damping layer(s) is(are) disposed between the plunger-engaging layer and the roller-engaging surface.

[0022] Preferably, therefore, the damping layer(s) is(are) disposed at least partially above the cavity. One or more damping layer(s) may partially surround the cavity, but most preferably, at least one damping layer is disposed above the cavity.

[0023] The damping layer(s) is(are) preferably disposed within an upper half (plunger-engaging half) of the shoe. More preferably, the damping layer(s) is(are) disposed within an upper 25% of the shoe, most preferably within an upper 15% of the shoe.

[0024] Preferably, the damping layer(s) extends across substantially the whole of the body, e.g. between side walls of the body.

[0025] Preferably, the shoe comprises a single damping layer, although multiple separate layers may be provided disposed throughout the body.

[0026] Preferably, the plunger-engaging layer comprises load distribution characteristics. Preferably, therefore, the plunger-engaging layer comprises a stiff material. The plunger-engaging layer preferably comprises a suitable metal, such as steel.

[0027] Preferably, the plunger-engaging layer comprises a thickness or depth of approximately from 1% to approximately 25% of the depth of the shoe (from said plunger-engaging surface to the roller-engaging surface). More preferably, the plunger-engaging layer comprises a thickness or depth of approximately from 1% to approximately 15% of the depth of the shoe, most preferably, approximately 5-10% of the depth of the shoe.

[0028] Preferably, the plunger-engaging layer is disposed close to the plunger-engaging surface, and most preferably forms said plunger-engaging surface.

[0029] Preferably, the plunger-engaging layer extends across substantially the whole of the body, e.g. between side walls of the body.

[0030] The shoe body may comprise any suitable material. Therefore, the shoe body may comprise any suitable metal, such as steel.

[0031] The damping layer(s) may, or may not be bonded to the plunger-engaging layer and/or the remaining body of the shoe. The damping layer(s) may be adhered to the plunger-engaging layer and/or the remaining body of the shoe using a suitable adhesive, for example, an acrylic adhesive, polyurethane adhesive, an epoxy adhesive or other contact adhesive. Preferably, the damping layer(s) are unbonded to the plunger-engaging layer and/or the remaining body of the shoe.

[0032] The roller may comprise any suitable material. Therefore, the roller may comprise a suitable metal, such as steel, or a ceramic.

[0033] In a second aspect of the present invention there is provided an improved shoe for a cam follower of a high pressure diesel fuel pump, the shoe comprising a plunger-engaging surface and a roller-engaging surface, wherein the shoe comprises at least one vibration damping layer disposed below the plunger-engaging surface.

[0034] It will be appreciated that the preferred features described in relation to the first aspect of the invention apply to the second aspect of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0035] For a better understanding of the invention, and to show how exemplary embodiments may be carried into effect, reference will now be made to the accompanying drawings in which:

Figure 1 is a partial cross-sectional side view of a plunger and cam arrangement according to an exemplary embodiment of a high pressure diesel fuel pump; and

Figure 2 is a close-up view of a portion of a shoe (as designated by 2) of a cam arrangement of a high pressure diesel fuel pump according to Figure 1.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

[0036] According to an exemplary embodiment of the invention, Figure 1 shows a high pressure diesel fuel pump (not shown) comprising a pumping assembly and a drivetrain assembly, the pumping assembly comprising a pump housing (not shown) and a plunger 10 mounted along a pumping axis A-A', the drivetrain assembly comprising a drive shaft (not shown) and a cam arrangement

20 having a cam 22 and a cam follower 23 mounted within a drivetrain housing (not shown), the cam follower 23 comprising a shoe 25 and a roller 24, the plunger 10 being driven in reciprocating linear movement along the pumping axis A-A' upon rotation of the cam arrangement 20, wherein the shoe 25 comprises at least one vibration damping layer 31 disposed below a plunger-engaging surface 27.

[0037] The shoe 25 comprises a body 26 having the plunger-engaging surface 27 and a roller-engaging surface 29.

[0038] The vibration damping layer 31 of the shoe 25 comprises a material capable of damping vibration as the shoe 25 is subjected to cyclic stress by the plunger 10. Accordingly, the damping layer 31 comprises a suitable resin and in a preferred embodiment, comprises a resin reinforced with one or more fibre types.

[0039] In an exemplary embodiment, the damping layer 31 comprises a resin comprising one or more of the following: a phenolic resin, an epoxy resin or a polyester resin, reinforced with one or more of the following: cellulose fibres (e.g. paper or cotton), glass fibres or carbon fibres. However, a laminate of fibre sheets and resin layers is anticipated to provide a good option. In particular, sheet Tufnol ® is used, which is a laminate of cotton fibre sheets and phenolic chemical resin layers.

[0040] For optimal vibration damping qualities within the context of a shoe 25, the damping layer 31 comprises a thickness or depth that is relative to a depth of the shoe body 26. In an exemplary embodiment, the damping layer 31 comprises a depth of approximately 1-15% of the depth of the shoe body 26. However, it is to be appreciated that the damping layer 31 may comprise up to 50% of the depth of the body 26 in order to have a vibration damping effect.

[0041] For optimal performance of the shoe 25, the damping layer 31 is disposed within an upper 15% of the shoe body 26 measured from the plunger-engaging surface 27. However, it is to be appreciated that the damping layer 31 may be disposed at any location above, and/or around the roller-engaging surface 29 to have a vibration damping effect.

[0042] As can be seen from both Figures 1 and 2, the vibration damping layer 31 is disposed below a plunger-engaging layer 28. In an exemplary embodiment, the plunger-engaging layer 28 forms the plunger-engaging surface 27 of the shoe body 26.

[0043] The plunger-engaging layer 28 of the shoe 25 comprises a stiff material capable of imparting load distribution across the body 26. Accordingly, the plunger-engaging layer 28 comprises a suitable material and in a preferred embodiment, comprises a suitably stiff material, for example a suitable metal, such as steel.

[0044] For optimal load distribution qualities within the context of a shoe 25, the plunger-engaging layer 28 comprises a thickness or depth that is relative to a depth of the shoe body 26. In an exemplary embodiment, the plunger-engaging layer 28 comprises a depth of approximately 1-15% of the depth of the shoe body 26. However, it is to be appreciated that the damping layer 31 may comprise up to 25% of the depth of the body 26 in order to have an acceptable load distribution effect.

[0045] The shoe body 26 comprises a suitable metal, such steel.

[0046] As can be seen in Figure 1, the roller-engaging surface 29 comprises a profiled surface 29a forming a cavity 30 to receive and compliment the roller 24 disposed therein.

[0047] In use, as the reciprocal movement of the plunger 10 impacts on the plunger-engaging surface 27 of the shoe 25, the plunger-engaging layer 28 and the damping layer 31 cooperate to (a) distribute the load across the body 26 of the shoe 25 and (b) dissipate vibrations within the shoe body 26. This is turn minimises the distortion of the shoe body 26 and the effects of the vibrations on the roller 24.

[0048] With the described shoe 25, the roller 24 need not be formed from a material that imparts as much resilience or ductility as has been previously required with prior art shoes. The roller 24 may be made from a wider range of materials since the vibration damping characteristics of the improved shoe 25 is more tolerant with otherwise harder or more brittle materials, such as ceramics.

[0049] Furthermore, with the described shoe 25, an interface between the roller 24 and the cam 22 is protected since the improved load distribution characteristics minimise distortion of the shoe 25 and the roller 24. This means that the cam 22 need not be made from such hard materials.

[0050] The resultant shoe 25 can remain small in size which is preferred in an environment with space issues.

[0051] The construction of the shoe 25 is a sandwich of one or more damping layers 31 between body 26 layers and topped with the plunger-engaging layer 28. The damping layer(s) can be bonded to the plunger-engaging layer 28 and/or the remaining body 28 of the shoe 25, although it is to be appreciated that due to the tight clearance distances between a shoe 25 and a shoe guide (not shown) in the drive housing (not shown), there would be little lateral movement of the components if they were to remain unbonded. Furthermore, due to the downward action of the plunger spring (not shown), the various components would unlikely be found to dissemble in the housing.

[0052] Where a bonded assembly of the layers of the shoe 25 is to be employed, the damping layer(s) 31 may be adhered to the plunger-engaging layer 28 and/or the remaining body 26 of the shoe 25 using a suitable adhesive, for example, an acrylic adhesive, polyurethane adhesive, an epoxy adhesive or other contact adhesive.

[0053] Although a few preferred embodiments have been shown and described, it will be appreciated by those skilled in the art that various changes and modifications might be made without departing from the scope of the invention, as defined in the appended claims.

Claims

1. A high pressure diesel fuel pump comprising a pumping assembly and a drivetrain assembly, the pumping assembly comprising a pump housing and a plunger (10) mounted along a pumping axis (A-A'), the drivetrain assembly comprising a drive shaft and a cam arrangement (20) having a cam (22) and a cam follower (23) mounted within a drivetrain housing, the cam follower (23) comprising a shoe (25) and a roller (24), the plunger (10) being driven in reciprocating linear movement along the pumping axis A-A' upon rotation of the cam arrangement (20), wherein the shoe (25) comprises at least one vibration damping layer (31) disposed below a plunger-engaging surface (27).

2. The pump according to claim 1, wherein the shoe (25) comprises a body (26) extending between the plunger-engaging surface (27) and a roller-engaging surface (29).

3. The pump according to claim 2, wherein the roller-engaging surface (29) forms a cavity (30) in said body (26) to receive and retain said roller (24).

4. The pump according to any one of claims 1-3, wherein the damping layer(s) (31) comprise(s) a resin.

5. The pump according to claim 4, wherein the resin comprises a thermosetting polymer comprising one or more of a phenolic resin, an epoxy resin and a polyester resin.

6. The pump according to any one of claims 4 or 5, wherein the resin is reinforced with fibres comprising one or more of cellulose fibres, glass fibres and carbon fibres.

7. The pump according to claim 6, wherein the damping layer(s) (31) comprise(s) a laminate of one or more fibre layers and one or more resin layers.

8. The pump according to any one of claims 1-7, wherein the damping layer(s) (31) comprise(s) a thickness or depth of approximately up to 50% of a depth of the shoe (25) (measured from said plunger-engaging surface (27) to the roller-engaging surface (29)).

9. The pump according to any one of claims 2-8, wherein the damping layer(s) (31) is(are) disposed between a plunger-engaging layer (28) and the roller-engaging surface (29) above the cavity (30).

10. The pump according to any one of claims 1-9, wherein the or all damping layers (31) are disposed within a plunger-engaging half of the depth of the shoe (25) (from said plunger-engaging surface (27)).

11. The pump according to any one of claims 9-10, wherein the plunger-engaging layer (28) comprises load distribution a stiff material.

12. The pump according to claim 11, wherein the plunger-engaging layer (28) comprises a thickness or depth from 1% to 25% of the depth of the shoe (25) (measured from said plunger-engaging surface (27) to the roller-engaging surface (29)).

13. The pump according to any one of claims 9-12, wherein the plunger-engaging layer (28) forms said plunger-engaging surface (27).

14. The pump according to any one of claims 9-13, wherein the damping layer(s) (31) is(are) bonded to the plunger-engaging layer (28) and/or the remaining body (26) of the shoe (25).

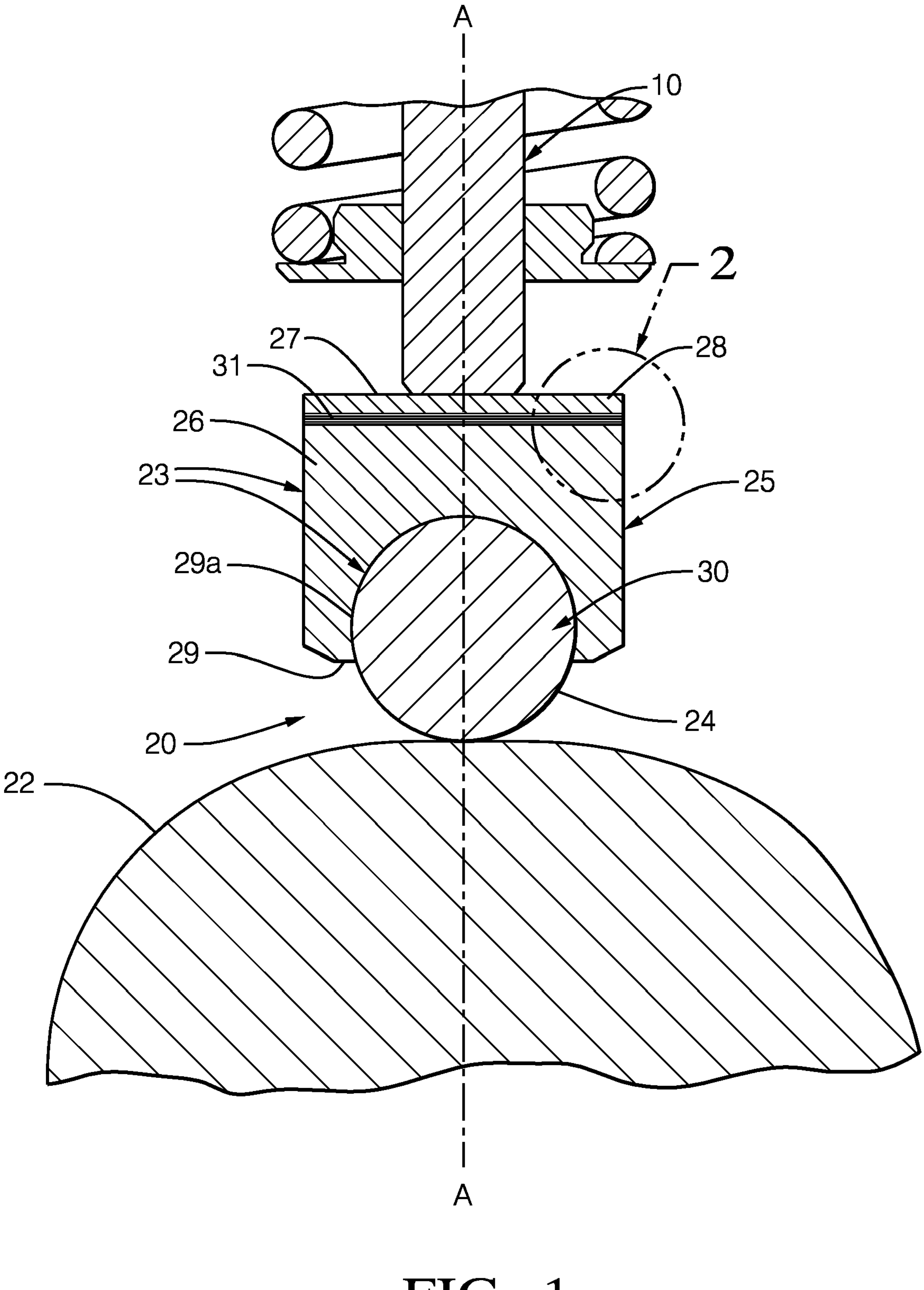

FIG. 1

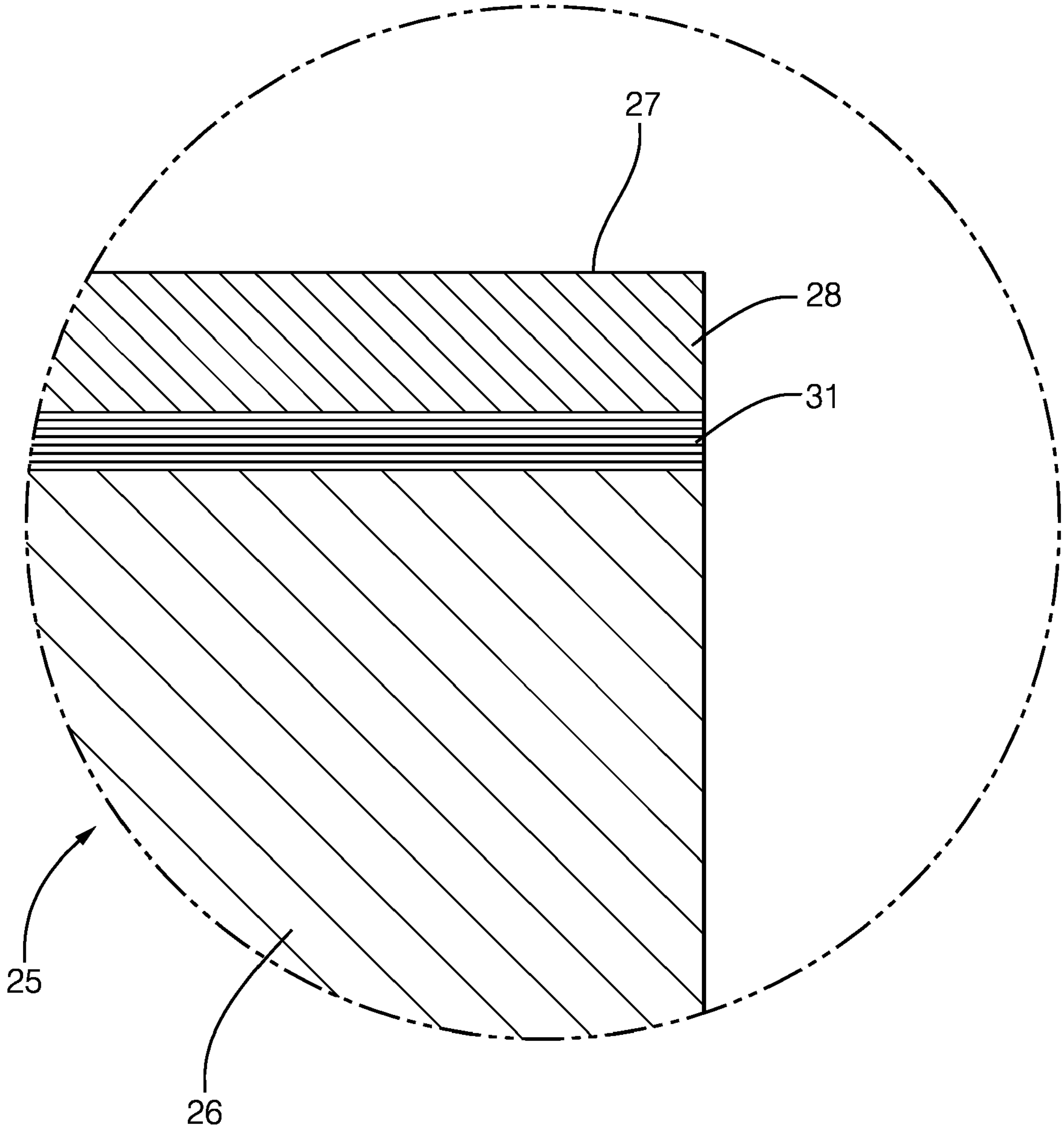

FIG. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 16 15 3707

DOCUMENTS CONSIDERED TO BE RELEVANT

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

F02M
F04B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	25 May 2016	Hermens, Sjoerd

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 16 15 3707

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25-05-2016

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