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(54) FUEL PUMP AND SHOE GUIDE

(57) ABSTRACT OF THE DISCLOSURE

A method to manufacture a shoe guide (28) adapted, in use, to be in the housing (12) of a fuel pump (10) in order to guide a shoe member (26) hosting a roller (32) cooperating with a plunger (20) reciprocally moving along a main axis (X) to perform a pumping cycle, the method (100) comprising the following steps:
a) providing (110) a blank member (28B) of wrought steel;
b) angularly orienting (112) the blank (28B) relative to the pump housing (12) and axially (X) inserting (114) with interference said blank member (28B) into a cylindrical bore (29) provided in the fuel pump housing (12).

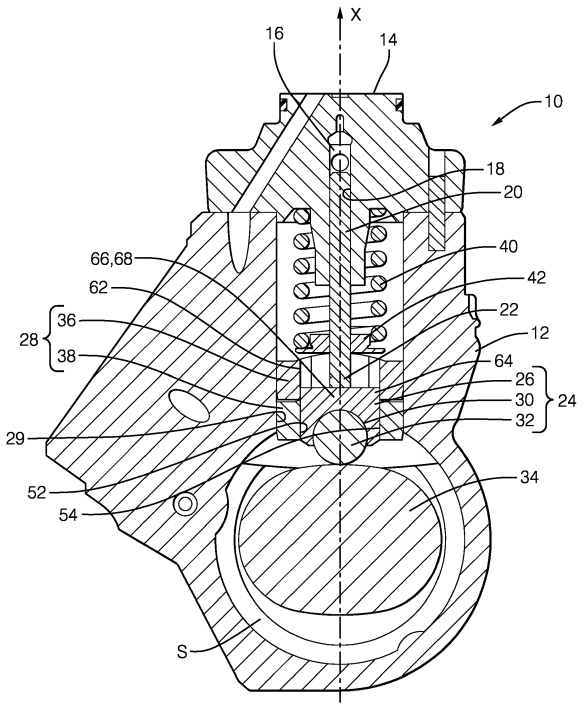

FIG. 1

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Description

TECHNICAL FIELD

[0001] The present invention relates to a shoe guide fixedly arranged in a housing of a fuel pump and, more particularly to the manufacturing process of said shoe guide enabling selection of wrought steel that has improved resistance to cavitation wear.

BACKGROUND OF THE INVENTION

[0002] A diesel fuel injection equipment of an internal combustion engine comprises a fuel pump having a housing defining a bore extending along a main axis and, a plunger cooperating with a rotating camshaft followed by a roller hosted in a shoe member, said plunger reciprocally sliding in said bore and performing a pumping cycle. In said displacements the shoe member is axially guided in a shoe guide fixed in the pump housing.

[0003] The shoe member has a rectangular cross-section and is guided in a complementary bore of the shoe guide. Said assembly is manufactured with high precision in order to respect the dimensions of the guiding faces and the micrometre tolerances, surface finish, flatness, parallelism... required to accommodate the operational conditions of the pump. Furthermore, a specific geometry of the shoe guide defining enlarged corner channels between the guiding faces and also, a guiding length comprised between 16 and 20 mm associated to said high precision machining has driven to utilise sintered steel for the shoe guide.

[0004] Functional clearances arranged between the faces of the shoe member and of the shoe guide enable diesel fuel lubrication but, considering the displacement's high frequency, cavitation occurs between said faces. The cavitation associated to the sintered steel of the shoe guide promotes undesired wear of the faces, generating particles that join the fuel flow and that may generate further damages in the injection equipment.

SUMMARY OF THE INVENTION

[0005] Accordingly, it is an object of the present invention to resolve the above mentioned problems in providing a method to manufacture a shoe guide adapted, in use, to be in the housing of a fuel pump in order to guide a shoe member hosting a roller cooperating with a plunger reciprocally moving along a main axis X to perform a pumping cycle, the method comprising the following steps:

a) providing a blank member of wrought steel having a cylindrical outer face extending along a main axis from a first end transverse face to an opposed second end transverse face and having an axial central through bore with a substantially rectangular cross-section defining four flat faces, said rectangular bore opening in both end transverse faces;

b) angularly orienting the blank relative to the pump housing and axially inserting with interference said blank member into a cylindrical bore provided in the fuel pump housing, the cylindrical outer face being press-fitted against the cylindrical inner face of the bore;

c) finishing the four faces so that the nominal dimensions and the geometrical tolerances such as surface finish, flatness parallelism of opposed faces match the functional requirement for the shoe guide to provide axial guiding to the shoe member under operating conditions of a fuel pump and wherein, the axial thickness of the shoe guide measured between the transverse faces, is between 16 and 20 mm, preferably 18 mm.

[0006] In an embodiment, the shoe guide comprises at least two distinct members stacked on the top of each other's and having together a total thickness comprised between 16 and 20 mm, preferably 18 mm, the providing step a) being:

a) providing two blank members, each blank member being of wrought steel and having a cylindrical outer face extending along a main axis from a first end transverse face to an opposed second end transverse face and having an axial central through bore with a substantially rectangular cross-section, said rectangular bore opening in both end transverse faces and

wherein, the two blanks provided at step a) are inserted in the bore of the pump housing one after the other, the secondly inserted blank being angularly oriented prior to be inserted until abutment against the firstly inserted blank.

[0007] Alternatively, the two blanks provided at step a are angularly oriented relative to each other's and properly arranged in abutment against each other so that they form a complete blank of the shoe guide prior to be inserted together in the bore of the pump housing.

[0008] Anyway, the finishing step c) is as follow:

c) finishing in a single manufacturing operation operation the faces of the first blank and of the second blank so that the alignment of said faces, the nominal dimensions and the geometrical tolerances such as surface finish, flatness, parallelism of opposed faces, match the functional requirement for providing, under operating conditions of a fuel pump, axial guiding to the shoe member.

[0009] Alternatively, the shoe guide comprises more than two distinct members, all said members being made in wrought steel and being stacked on the top of each other's and having together a total thickness comprised between and 16 mm, preferably 20 mm.

[0010] Moreover, all the distinct members have identical axial thickness.

[0011] More precisely, the finishing step comprises grinding.

[0012] The invention further extends to a shoe guide made of wrought steel and being manufactured as per any one of the preceding method claims.

[0013] Said shoe guide may comprise several distinct members each being made of wrought steel, said shoe guide comprising at least two distinct members, that are being manufactured as per any one of the method claims to.

[0014] The invention further extends to a fuel pump having a housing wherein a plunger, reciprocally moving along a bore, cooperates with a cam follower guided in a shoe guide as described above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The present invention is now described by way of example with reference to the accompanying drawings in which:

Figure 1 is an axial section of a fuel pump provided with a shoe guide as per the invention.

Figure 2 is an isometric view a member of the shoe guide.

Figure 3 is an axial section of the shoe guide of figure 1.

Figure 4 is a top view of the shoe guide of figure 1.

Figure 5 is a section of a shoe guide comprising distinct members.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0016] A diesel fuel pump 10 adapted to be arranged in a fuel injection equipment of an internal combustion engine is partially represented on figure 1. Said pump 10 has a housing 12 defining an inner space S and, a pumping head 14 fixedly arranged on a top face of said housing 12. In the pumping head 14 fuel entering into a compression chamber 16 is pressurised prior to be expelled toward fuel injectors, not shown, of the injection equipment. The compression chamber 16 is defined by the blind end of a bore 18, extending in the head along a main axis X and, by the top extremity of a plunger 20 slidably arranged in said bore 18. Opposite to the compression chamber 16, the bore 18 opens and enables the plunger 20 to protrude in the inner space S and to extend along the main axis X toward a distant end 22 where said plunger cooperates with a cam follower 24 comprising a shoe member 26 defining a hollow 30 in which is hosted a roller 32, the shoe member 26 being axially X guided in a shoe guide 28 fixed in a bore 29 provided in the housing 12 and, the roller 32 rolling, in use, on the outer face of a rotating cam 34. As shown on the figure, the shoe guide 28 comprises an upper member 36 and a lower member 38 stacked on the top of each other's and, a spring 40 is compressed between a face of the pumping head 14 and a seat 42 fixed on the plunger 20.

[0017] In use, the cam 34 rotates and urges the plunger 20 to reciprocate in the bore 18 in order to perform a pumping cycle moving between a top dead centre (TDC) position and a bottom dead centre (BDC) position represented on figure 1. The cam 34, via the follower 24, upwardly biases the plunger 20 toward TDC while the spring 36 downwardly biases it toward BDC.

[0018] Under normal operating conditions the plunger 20 reciprocates in the bore and, the shoe member 26 in the shoe guide 28, at a frequency of about 100 Hz, said mechanical displacements being lubricated by diesel fuel leaks flowing through thin functional clearances defined between the plunger and the bore or, between the shoe member and the shoe guide.

[0019] More in details, the shoe guide 28 has a body defining a cylindrical outer face 44 extending along the main axis X between an upper transverse face 46 and an opposed lower transverse face 48. In the embodiment presented the shoe guide 28 comprises the upper member 36 defining said upper face 46, arranged atop the lower member 38 defining said lower face 48. The shoe guide 28 is further provided with an axial guiding bore 50 having substantially a rectangular cross-section with two opposite long sides defining a front guiding face 52 and a rear guiding face 54, perpendicular to two opposite short sides defining a first end face 56 and a second end face 58. Furthermore, in said rectangular guiding bore 50 the four corner areas are enlarged with channels forming machining clearances 60 for grinding wheels.

[0020] The shoe member 26 is a male member complementary sliding in said guiding bore 50 with a front face 62 sliding against the front guiding face 52, a rear face 64 sliding against the rear guiding face 54 and first and second end faces 66, 68 in which open said hollow 30, sliding respectively against the first and second end faces of the shoe guide.

[0021] Although numerous embodiments exist, as an illustrated example are now shared typical dimensions of a shoe guide 28 used in an automotive application.

[0022] The cylindrical outer face 44 has a diameter of about 31 mm.

[0023] mm. The distance between the front 52 and rear 54 guiding faces is about 17

[0024] The distance between the first 56 and the second end faces is about 21 mm.

[0025] The thickness T1 between the upper 46 and lower 48 faces is about 18 mm.

[0026] The geometrical tolerances of the four faces 52, 54, 56, 58, such as surface finish, flatness, parallelism, perpendicularity are very precise within few micrometres.

[0027] The nominal clearance C between the front faces 52, 62 and also between the rear faces 54, 64 is less than a tenth of millimetres, typically about 80μm.

[0028] In an industrial environment where thousands of fuel pump 10 are manufactured every day, ensuring said high precision within constant quality requires to

firstly press-fit in the bore 29 of the housing a blank member 28B of the shoe guide 28. Said blank member 28B is already provided with finished outer cylindrical face 44 and upper 46 and lower 48 faces. The faces of the guiding bore 50 remain unfinished at this stage. The insertion operation compresses said blank 28B which slightly diminishes the dimensions of the unfinished bore then, once stabilised in place said guiding faces are finished for instance in a grinding operation.

[0029] Furthermore, to prevent wear due to fuel cavitation happening, in use, within said nominal clearance C, the blank 28B of the shoe guide 28 is obtained by forging or pressing a block of wrought steel, to the difference of the current technology using sintered material. In a sintered steel shoe guide, the steel particles that are at the surface more easily detach from the shoe guide creating undesired wear deteriorating the surface finish of the faces and, generating steel particles that flow in the fuel and that may damage other mechanical components of the injection equipment. Said surface mechanical weakness of the sintered material no longer applies to a wrought material where each steel grain is firmly linked the others.

[0030] The corner channels 60 arranged between perpendicular faces of the guiding bore 50 are necessary to enable the grinding operation of the faces of the bore, the corner edges of the grinding wheel safely rotating in said channels 60. This special cross-section with corner channels associated to the necessary guiding length of 18 mm lead to favour sintered material over wrought steel since, a 18 mm thick wrought steel blank 28B is not easily manufacturable to the precision required. In the illustrating embodiment, the shoe guide 28 comprises the stack arrangement of the upper member 36 and the lower member 38, said two members 36, 38, being identical, both being made from wrought material and having an individual thickness T2 of about 9 mm, half the total thickness T1 and stamping said complex shape with wrought steel to obtain blanks having the required dimensions is possible.

[0031] During manufacturing process method 100, said members are inserted one by one in the bore 29 of the housing and, angular orientation of said members is carefully adjusted so the blank guiding faces are correctly aligned prior to the finishing operation.

[0032] Another possibility is to firstly arrange said members 36, 38 together and to insert them together inside the bore 29. In this latter case, in order to ease the insertion step, a small difference between the outer diameters of each member is possible, the upper member 36 being inserted first would have a slightly smaller diameter by few tens of millimetres.

[0033] In another alternative embodiment represented on figure 5, the shoe guide 28 comprises more than two distinct members stacked on the top of each other, four being represented on the figure.

LIST OF REFERENCES

[0034]

S	space
X	main axis
T1	thickness of the shoe guide
T2	thickness of the upper or lower member of the shoe guide
10	fuel pump
12	housing
14	pumping head
16	compression chamber
18	bore
20	plunger
22	end of the plunger
24	cam follower
26	shoe member
28	shoe guide
28B	blank of the shoe guide
29	bore of the housing
30	hollow
32	roller
34	cam
36	upper member of the shoe guide
38	lower member of the shoe guide
40	spring
42	seat
44	outer face of the shoe guide
46	upper face
48	lower face
50	guiding bore
52	front guiding face of the shoe guide
54	rear guiding face of the shoe guide
56	first end face of the shoe guide
58	second end face of the shoe guide
60	corner channels
62	front face of the shoe member
64	rear face of the shoe member
66	first end face of the shoe member
68	second end face of the shoe member
100	Method
110	providing
112	orienting
114	inserting
116	finishing

Claims

1. Method (100) to manufacture a shoe guide (28) adapted, in use, to be in the housing (12) of a fuel pump (10) in order to guide a shoe member (26) hosting a roller (32) cooperating with a plunger (20) reciprocally moving along a main axis (X) to perform a pumping cycle, the method (100) comprising the

following steps:

a) providing (110) a blank member (28B) of wrought steel having a cylindrical outer face (44) extending along a main axis (X) from a first end transverse face (36) to an opposed second end transverse face (38) and having an axial central through bore (50) with a substantially rectangular cross-section defining four flat faces (52, 54, 56, 58), said rectangular bore (50) opening in both end transverse faces (36, 38);
b) angularly orienting (112) the blank (28B) relative to the pump housing (12) and axially (X) inserting (114) with interference said blank member (28B) into a cylindrical bore (29) provided in the fuel pump housing (12), the cylindrical outer face (44) being press-fitted against the cylindrical inner face of the bore (29);
c) finishing (116) the four faces (52, 54, 56, 58) so that the nominal dimensions and the geometrical tolerances such as surface finish, flatness parallelism of opposed faces match the functional requirement for the shoe guide (28) to provide axial guiding to the shoe member (26) under operating conditions of a fuel pump and wherein, the axial thickness (T1) of the shoe guide (28) measured between the transverse faces (36, 38) is between 16 and 20 mm, preferably 18 mm;.

2. Method (100) as claimed in the preceding claim wherein the shoe guide (28) comprises at least two distinct members (36, 38) stacked on the top of each other's and having together a total thickness (T1, T2) comprised between 16 and 20 mm, preferably 18 mm, the providing (110) step a) being:

a) providing (110) two blank members, each blank member being of wrought steel and having a cylindrical outer face (44) extending along a main axis (X) from a first end transverse face to an opposed second end transverse face and having an axial central through bore (50) with a substantially rectangular cross-section, said rectangular bore opening in both end transverse faces.

3. Method (100) as claimed in claim 2 wherein the two blanks provided (110) at step a) are inserted in the bore (29) of the pump housing one after the other, the secondly inserted blank being angularly oriented prior to be inserted until abutment against the firstly inserted blank.

4. Method (100) as claimed in claim 2 wherein the two blanks provided at step a) are angularly oriented relative to each other and correctly arranged in abutment against each other so that they form a complete blank of the shoe guide prior to be inserted (114) together in the bore (29) of the pump housing.

5. Method (100) as claimed in any one of the claims 3 or 4 wherein the finishing (116) step c) is as follow:

c) finishing (116) in a single manufacturing operation operation the faces of the first blank and of the second blank so that the alignment of said faces, the nominal dimensions and the geometrical tolerances such as surface finish, flatness, parallelism of opposed faces, match the functional requirement for providing, under operating conditions of a fuel pump (10), axial guiding to the shoe member (26).

6. Method (100) as claimed in claim 5 wherein the shoe guide (28) comprises more than two distinct members, all said members being made in wrought steel and being stacked on the top of each other's and having together a total thickness comprised between 16 and 20 mm, preferably 18 mm.

7. Method (100) as claimed in any one of the claims 2 to 6 wherein all the distinct members have identical axial thickness.

8. Method (100) as claimed in any one of the preceding claims wherein the finishing (116) step comprises grinding.

9. Shoe guide (28) made of wrought steel and being manufactured as per any one of the preceding method claims.

10. Shoe guide (28) comprising several distinct members each being made of wrought steel, said shoe guide comprising at least two distinct members (36, 38) that are being manufactured as per any one of the method claims 2 to 8.

11. Fuel pump (10) having a housing (12) wherein a plunger (20), reciprocally moving along a bore, cooperates with a cam follower (24) guided in a shoe guide (28) as claimed in any one of the claims 9 or 10.

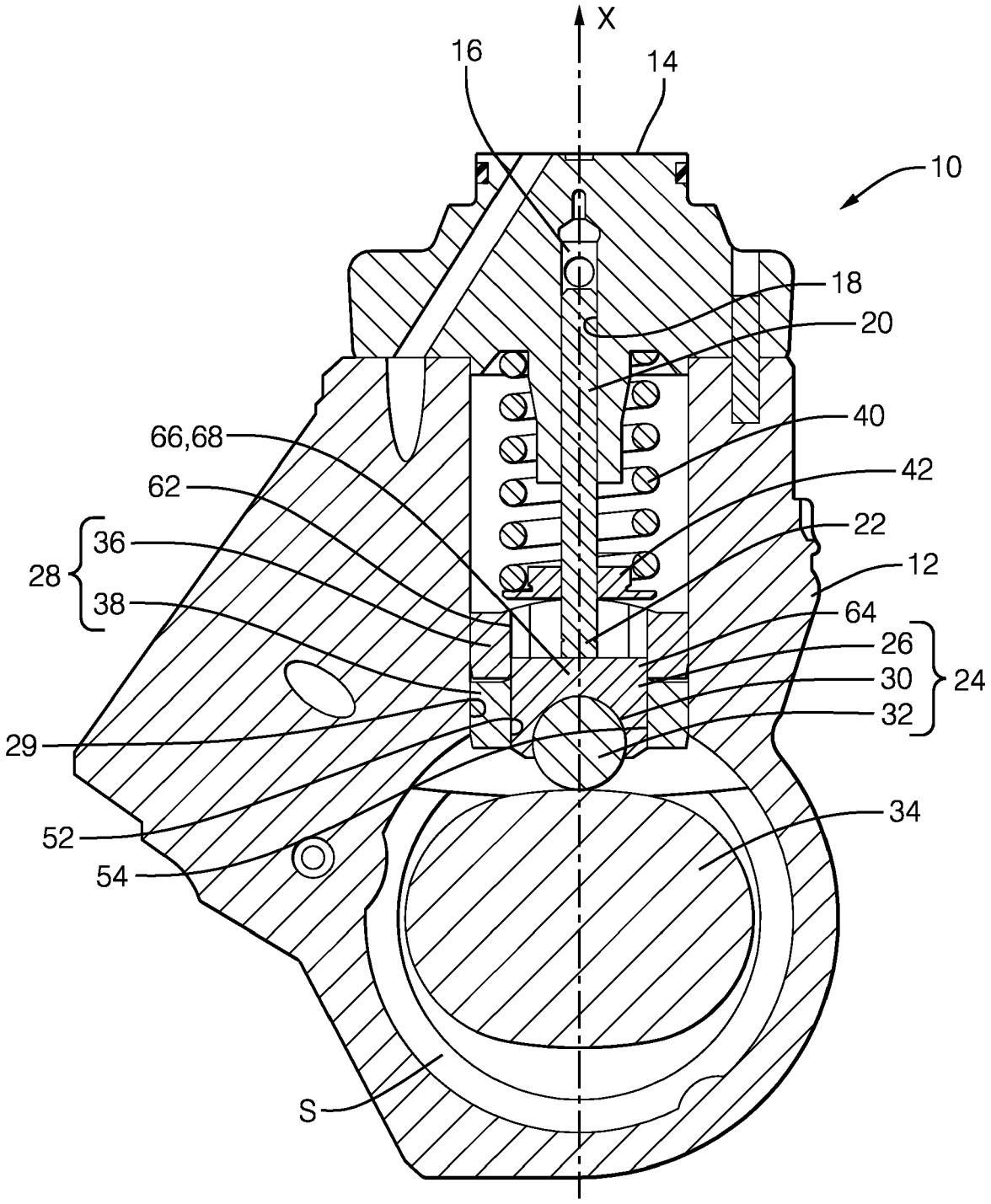
X
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FIG. 1

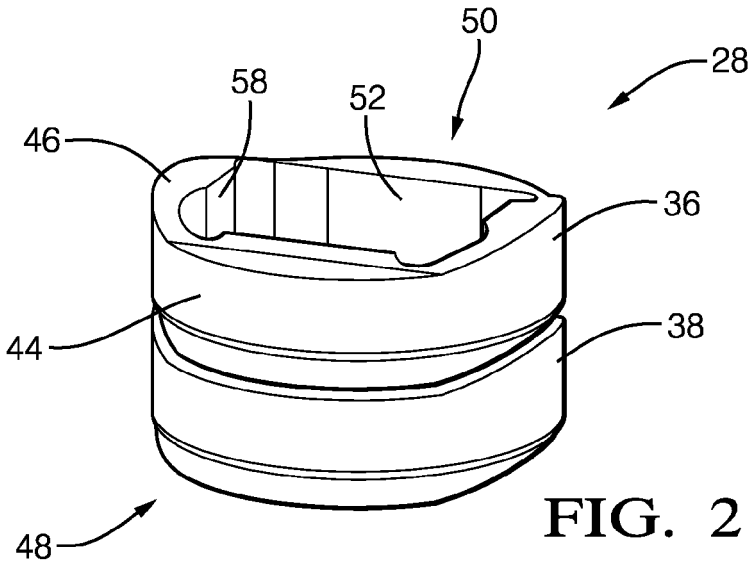

FIG. 2

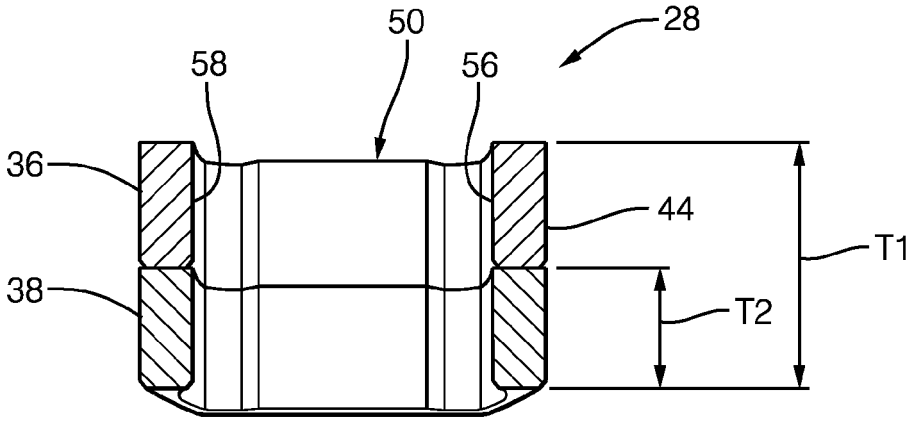

FIG. 3

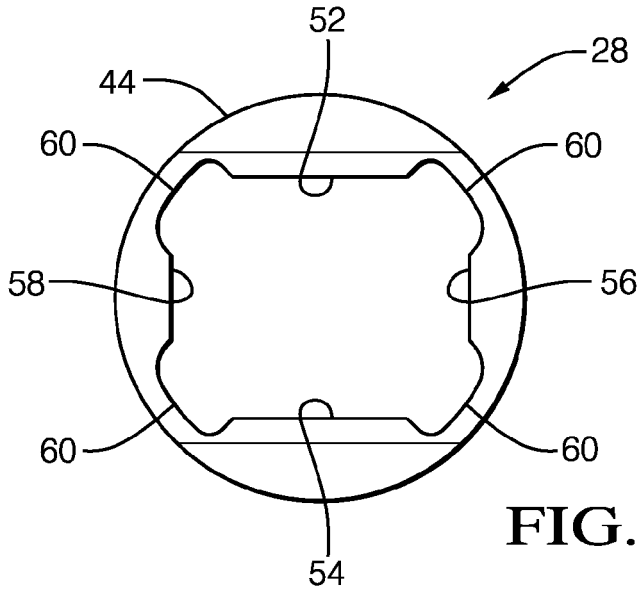

FIG. 4

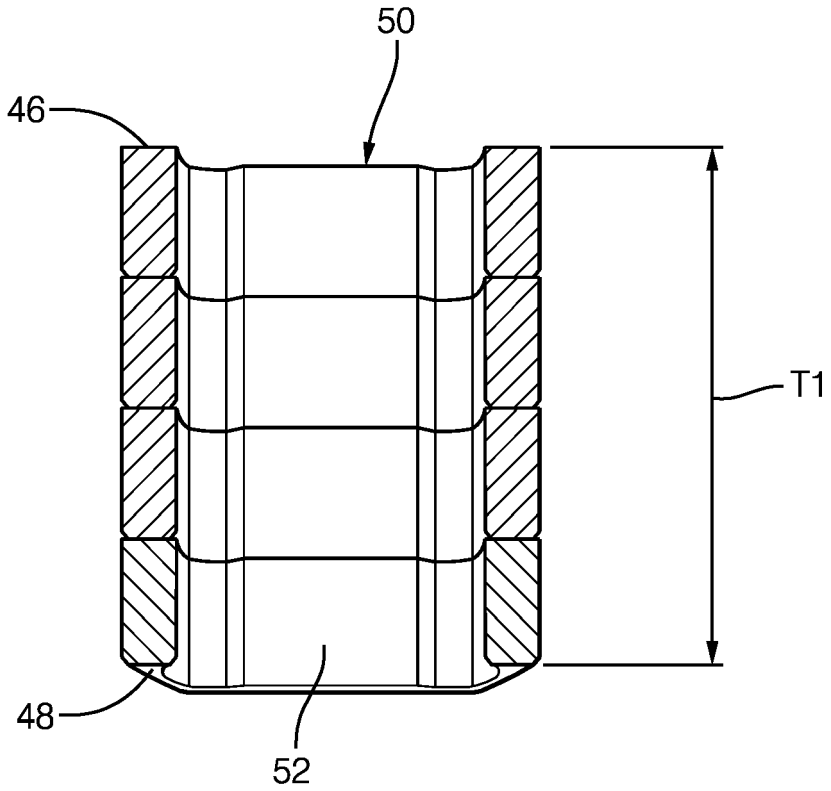

FIG. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 17 19 8714

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A	EP 1 767 772 A1 (DELPHI TECH INC [US]) 28 March 2007 (2007-03-28) * paragraph [0031] - paragraph [0034]; figures 3-6 *	1-11	TECHNICAL FIELDS SEARCHED (IPC) F02M F04B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	8 February 2018	Hermens, Sjoerd

CATEGORY OF CITED DOCUMENTS

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