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Remarks:
A request for correction of the claims has been filed pursuant to Rule 139 EPC. A decision on the request will be taken during the proceedings before the Examining Division (Guidelines for Examination in the EPO, A-V, 3.).

(54) SEALING MEMBRANE FOR PIEZO ACTUATOR

(57) A sealing member (34) adapted to be arranged inside a tubular sleeve (26) extending along a main axis (X) and in which is arranged a servo actuator (28), said sealing member (34) being a metallic pan-shaped resilient membrane with a centrally holed bottom wall (36) perpendicular to said main axis (X). Also, the sealing member (34) comprises a conical peripheral wall adapted to inwardly deform in order to be press fitted with interference inside the tubular sleeve (26), the bottom wall being non-planar and the peripheral wall and the bottom wall merging in a toroid rounded outer area.

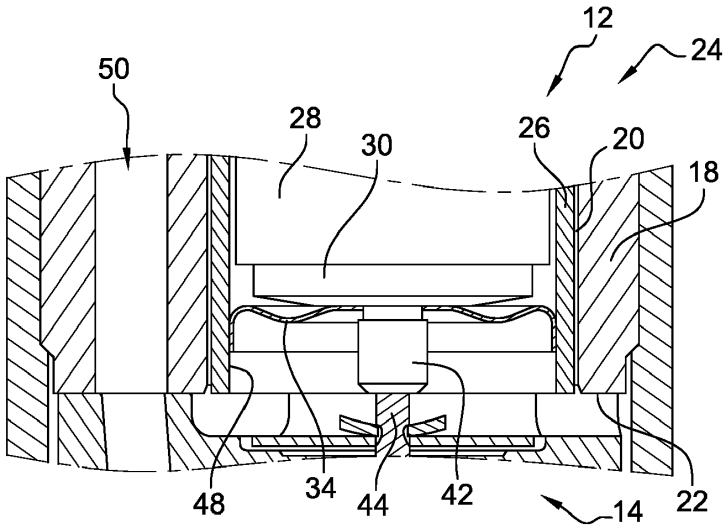


Fig. 2

EP 3 101 262 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a resilient sealing member adapted to protect a servo actuator of a fuel injector.

BACKGROUND OF THE INVENTION

[0002] In servo fuel injector, an actuator member, either piezo or magneto restrictive, cooperates with a control valve to indirectly enable or forbid fuel injection.

[0003] The actuator member is provided with a pusher member having a central shaft projection enabling cooperation with the control valve. The actuator and pusher members are arranged in a cylindrical tubular sleeve provided at an extremity with a resilient sealing member, the pusher member being in abutment against the inner face of the sealing member, the shaft projection extending through a central hole provided in said sealing member.

[0004] Protection of the actuator member against fuel contact is ensured by the sealing member since the peripheral area is in intimate contact with the inner face of the sleeve and the border of the central hole is in contact with the pusher member.

[0005] The actuator member operates at high frequency where it alternatively expends and retracts. The sealing member slightly resiliently deflects to accommodate said variations and, the repeated deflections induce fatigue stresses that may damage the sealing member.

SUMMARY OF THE INVENTION

[0006] Accordingly, it is an object of the present invention to resolve the above mentioned problems in providing a sealing member adapted to be arranged inside a tubular sleeve extending along a main axis and in which is arranged a servo actuator. The sealing member is a metallic pan-shaped resilient membrane with a centrally holed bottom wall perpendicular to said main axis.

[0007] The sealing member further comprises a conical peripheral wall adapted to inwardly deform in order to be press fitted with interference inside the tubular sleeve. The bottom wall is non-planar and, the peripheral wall and the bottom wall merge in a toroid rounded outer area.

[0008] Also, the bottom wall is provided with at least a circular waviness (58) concentric to the central hole, the waviness providing resilient characteristics to said bottom wall.

[0009] The conical angle of the peripheral wall is smaller than 20 degrees.

[0010] The axial section of said toroid rounded outer area share a first tangent with the peripheral wall and a second tangent with the bottom face, the first and second tangents being at an angle inferior to 90 degrees.

[0011] The height measured in the axial direction of the waviness of the non-planar bottom wall is calculated as per the formula:

$$\frac{D \times T}{4} < H < D \times T$$

where:

D is the larger diameter of the peripheral wall and,
T is the thickness of the walls of the sealing member, T being inferior to 0.5 mm.

[0012] Height of the waviness is preferably equal to:

$$\frac{D \times T}{2}$$

[0013] The invention also extends to a servo actuator assembly of a servo injector, the actuator assembly comprising a cylindrical actuator member inserted in a tubular sleeve provided at an extremity with a sealing member as described above, the actuator member abutting on a face of the bottom wall of the sealing member and, a shaft member integral to the actuator member projecting through the central hole of the bottom wall.

[0014] The invention also extends to a servo injector provided with an actuator assembly as described above. The actuator member can be a piezo or a magneto restrictive actuator.

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 erection view of a fuel injector, a partial cut-out in the view enabling to present an internal area where an extremity of the actuator of the injector cooperates with the stem of a control valve.

Figure 2 is a magnified view of the cut-out of figure 1 enabling a more distinctive appreciation of the extremity of the actuator arranged in a tubular sleeve closed by a sealing member, a pusher extension cooperating with the stem of the valve.

Figure 3 is an axial section of the sealing member of figure 2.

Figures 4, 5 and 6 are sequential views presenting the engagement of the sealing member of figure 3 in the tubular sleeve where the actuator is arranged.

Figures 7 to 12 are distinct embodiments of sealing member as per the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0016] In reference to figure 1 is represented a servo injector 10 generally extending along a main axis X and comprising from top to bottom in the arbitrary and non-limiting orientation of the figure a servo assembly 12, a control valve assembly 14 and a nozzle assembly 16.

[0017] The servo assembly 12 has a body 18 provided with an axial X bore 20 opening in the bottom face 22 of the body 18 and in which is arranged a actuator assembly 24 comprising a tubular sleeve 26 enclosing an actuator member 28, piezoelectric or magneto restrictive for instance, and a pusher member 30, easier to see on figure 2. In the upper part, non-represented, the actuator member 28 comprises a head member and electrical wires extending between the actuator member 28 and a connector 32 arranged on the top of the servo assembly 12. At the bottom end of the sleeve 26 is arranged a resilient sealing member 34 that is a pan-shaped resilient membrane, represented up-side-down and having a bottom wall 36 substantially transverse to the main axis X and a peripheral wall 38 in contact with the inner face of the sleeve 26. The bottom wall 36 is provided with a central hole 40 to enable a male shaft member 42 integral to the pusher member 30 to project through said hole 40 in order to cooperate with a valve 44 comprised in the control valve assembly 14. The pusher member 30 is in uninterrupted sealing contact against the upper face 46 of the bottom wall 36 and, the peripheral wall 38 is in uninterrupted sealing contact with the inner face 48 of the sleeve 26 so that fuel cannot enter the sleeve 30 and be in contact with the actuator member 28.

[0018] Throughout the injector 10, a high pressure channel 50 extends from an inlet 52 arranged at the top of the actuator assembly 12, to spray holes 54 arranged in the tip of the nozzle assembly 16.

[0019] In operation, an external control unit not represented energizes the actuator member 28 which alternatively axially expends or retracts, opening or closing the valve 44 and indirectly a needle valve not represented that enables or forbids fuel injection through the spray holes 54.

[0020] A first embodiment of the sealing member 34 is now described in reference to figure 3, the sealing member 34 being an integral part formed by deep drawing, or other forming processes, of a metal sheet of thickness T. Steel, such as spring steel, is typically utilize because of their known high mechanical fatigue resistance but other materials may be appropriate as well, said other materials requiring adequate forming processes. The sealing member 34 is axisymmetric and it comprises the bottom wall 36 provided with the central hole 40 and the peripheral wall 38. On figure 3 the sealing member 34 is represented in a stand-alone rest position, outside the sleeve 26 and, from the border 56 of the central hole 40, the bottom wall 36 radially transversely extends forming concentric circular waviness 58 having a height H measured along the main axis X. Outwardly the bottom wall 36 merges tangentially in an outer area 60 rounded as per a toroid extending to a distal end, also tangentially merging with the peripheral wall 38. The tangents on both side of the rounded outer area 60 generally make an obtuse angle A1. As visible on the figure, the peripheral wall 38 has fairly steep conical shape with an angle A2 smaller than 30 degrees; a preferred angle would be smaller than 20 degrees. Good results have been obtained with angles smaller than 10 degrees. The peripheral wall 38 extends and widens toward an external circular edge 62 having a diameter D.

[0021] Figures 4, 5 and 6 represent the sequence consisting in arranging the sealing member 34 in the tubular sleeve 26.

[0022] In figure 4, the sealing member 34 is in rest position, as it is represented in figure 3, and it faces the end of the sleeve 26 wherein are already arranged the actuator member 26 and the pusher member 30.

[0023] In figure 5, the sealing member 34, still in rest position, is presented to the sleeve, the shaft 42 of the pusher member initiates engagement in the central hole 40 and, as visible on the figure, only the bottom wall and the rounded outer area 60 can freely engage in the sleeve 26 while the peripheral wall 38 cannot has it widens to a larger section than the sleeve 26.

[0024] In figure 6, the sealing member 34 is arranged in place inside the sleeve 26. The sealing member 34 has been axially X upwardly pushed and press-fitted inside the sleeve 26 with sufficient force to elastically deform the conical shape of the peripheral wall 38 which resiliently narrows to match the cylindrical shape of the sleeve 26. As an illustration, the necessary force to press fit the sealing member 34 may not exceed few hundreds Newton's, the objective of the press fit being to ensure a continuous circumferential contact between the peripheral wall and the internal face of the sleeve, regardless of the manufacturing tolerance.

[0025] Deforming and narrowing the external portion of the peripheral wall generates internal stresses in the rounded area 60 forcing said rounded area to slightly pivots about itself moving upward the bottom wall 36 in further sealing abutment against the pusher member.

[0026] Not further detailed, once in place, to secure the sealing properties, the external edge 62 of the sealing member 34 may be fixed, for instance by laser welding inside the sleeve 26. Other known means of fixation may be utilized, such as brazing or even gluing. The shape of the sealing member 34 provides resilient characteristics, meaning that, should the sealing member 34 be disengaged from the sleeve 26 it would almost take back its rest shape with a conical peripheral wall 38, some permanent plastic deformation may still be remaining. To provide said characteristics, the dimensions of the sealing member 34 are chosen according to the following criteria:

$$\frac{D \times T}{4} < H < D \times T$$

where 0.05 mm < T < 0.3 mm
H being the height of the waviness measured along the main axis X, D being the larger diameter of the peripheral wall, or diameter of the external edge and, T being the thickness of the walls of the sealing member.

[0027] As an illustration example, when thickness T is 0.1 mm and external edge diameter D is 10 mm then, the height H of the waviness has to be comprised between 0.25 mm and 1 mm.

[0028] In reference to figures 7 to 12 are presented for non-limiting illustration purposes different sealing members 36 matching the above criteria.

[0029] Figure 7 depicts a sealing member which has a reduced total height and, to achieve similar press fit, the angle A2 of the cone is larger.

[0030] The sealing member 34 of figure 8 is thicker and the waviness height H is also reduced.

[0031] The sealing member 34 of figure 9 is thinner and the height H remains fairly small so, in order to accommodate the deformation the conical angle A2 is very small, leading to minor deformation when engaging the sealing member in the sleeve.

[0032] The sealing member 34 of figure 10 is also thin and the rounded outer area 60 has a large radius enabling a noticeable axial raise of the bottom wall 36 when engaging the member in the sleeve 26, the conical angle A2 of the peripheral wall being slightly larger than on the embodiment of figure 9.

[0033] The sealing member 34 of figure 11 is also quite thin and the bottom wall 36 presents two concentric waves 58. The rounded outer area 60 has a small radius and the conical angle A2 is more important than in the previous embodiment. The summit of the waves, of the rounded area and of the border 56 of the central hole are coplanar, the height of the central wave being smaller than the height of the external wave.

[0034] The sealing member 34 of figure 12 is also provided with two concentric waves. The thickness T is slightly more important and the conical angle A2 remains similar.

LIST OF REFERENCES

[0035]

X	main axis
T	thickness of the metal sheet of the sealing member
H	height of the waviness
D	diameter of the extremal edge of the sealing member
A1	angle between the tangents on both sides of the outer area
A2	angle of the cone
10	injector
12	servo assembly
14	control valve assembly
16	nozzle assembly
18	body of the servo assembly
20	bore
22	bottom face of the body
24	actuator assembly
26	tubular sleeve
28	actuator member
30	pusher member
32	connector
34	sealing member
36	bottom wall
38	peripheral wall
40	central hole
42	shaft member of the pusher member
44	valve
46	upper face of the bottom wall
48	inner face of the sleeve
50	high pressure channel
52	inlet
54	spray holes
56	border of the central hole
58	waviness
60	outer area
62	external edge

Claims

1. Sealing member (34) adapted to be arranged inside a tubular sleeve (26) extending along a main axis (X) and in which is arranged a servo actuator (28), said sealing member (34) being a metallic pan-shaped resilient membrane with a centrally holed bottom wall (36) perpendicular to said main axis (X), **characterized in that**
the sealing member (34) further comprises a conical peripheral wall (38) adapted to inwardly deform in order to be press fitted with interference inside the tubular sleeve (26),
the bottom wall (36) is non-planar and,
the peripheral wall (38) and the bottom wall (36) merge in a toroid rounded outer area (60).

2. Sealing member (34) as claimed in the preceding claim wherein the bottom wall (36) is provided with at least a circular waviness (58) concentric to the central hole (40), the waviness (58) providing resilient characteristics to said bottom wall (36).

3. Sealing member (34) as claimed in any of the preceding claims wherein the conical angle (A2) of the peripheral wall (38) is smaller than 20 degrees.

4. Sealing member (34) as claimed in any of the preceding claims wherein the axial section of said toroid

rounded outer area (60) share a first tangent with the peripheral wall and a second tangent with the bottom face, the first and second tangents being at an angle (A1) inferior to 90 degrees.

6. Sealing member (34) as claimed in any of the preceding claims wherein the height (H) measured in the axial (X) direction of the waviness (58) of the non-planar bottom wall (36) is calculated as per the formula:

$$\frac{D \times T}{4} < H < D \times T$$

where:

D is the larger diameter of the peripheral wall (38) and,
T is the thickness of the walls of the sealing member (34), T being inferior to 0.5 mm.

7. Sealing member (34) as claimed in claim 6 wherein height (H) of the waviness (58) is preferably equal to:

$$\frac{D \times T}{2}$$

8. Servo actuator assembly (12) of a servo injector (10), the actuator assembly (12) comprising a cylindrical actuator member (28) inserted in a tubular sleeve (26) provided at an extremity with a sealing member (34) as set in any of the preceding claims, the actuator member (28) abutting on a face of the bottom wall (36) of the sealing member (34) and, a shaft member (42) integral to the actuator member (28) projecting through the central hole (40) of the bottom wall (36).

9. Servo injector (10) provided with an actuator assembly (12) as claimed in claim 8.

10. Servo injector (10) as claimed in claim 9 wherein the actuator member (28) is a piezo or a magneto restrictive actuator.

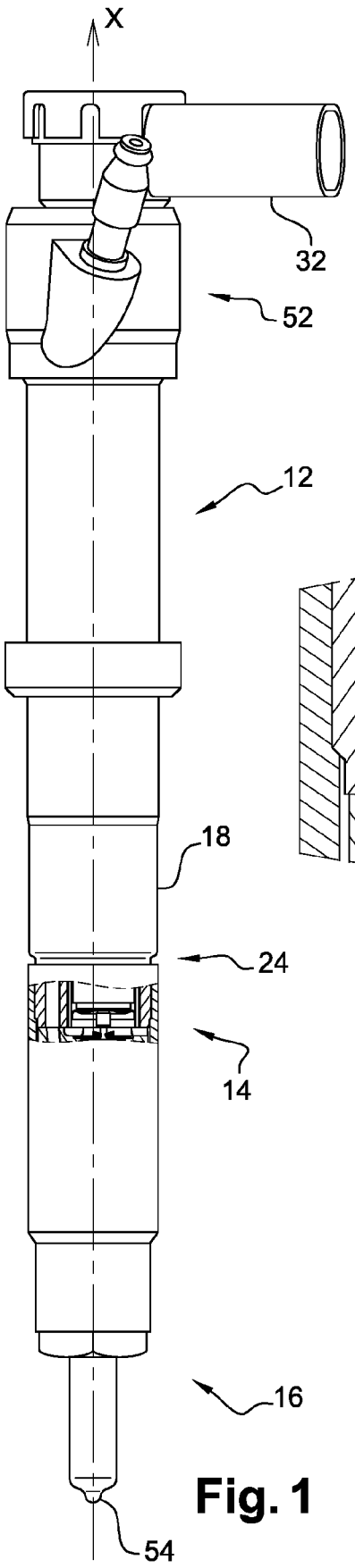


Fig. 1

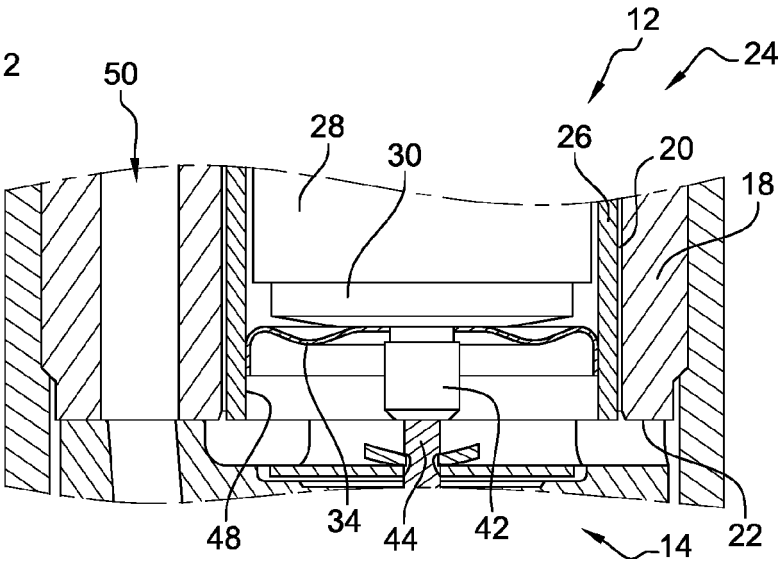


Fig. 2

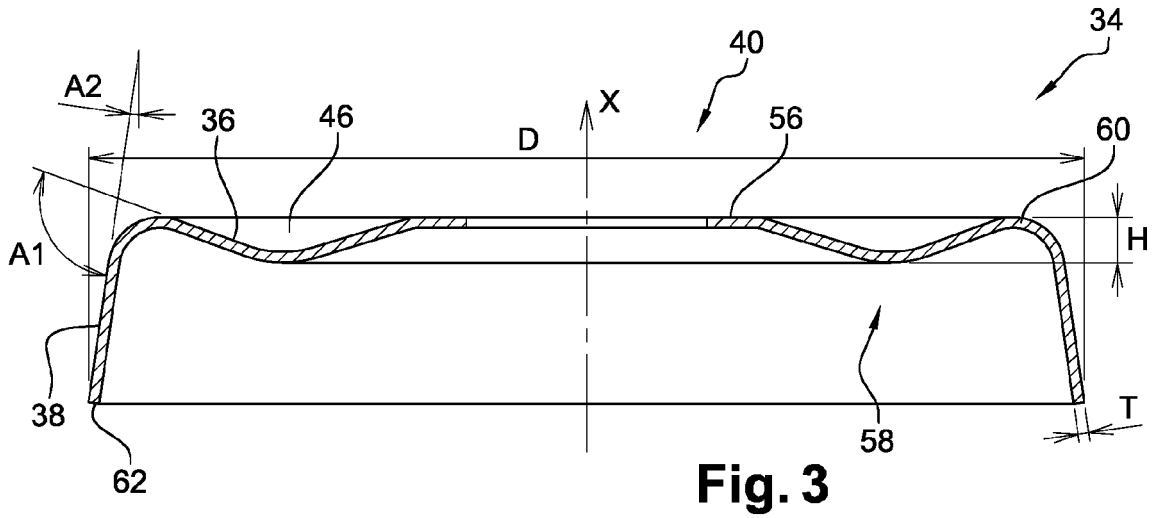


Fig. 3

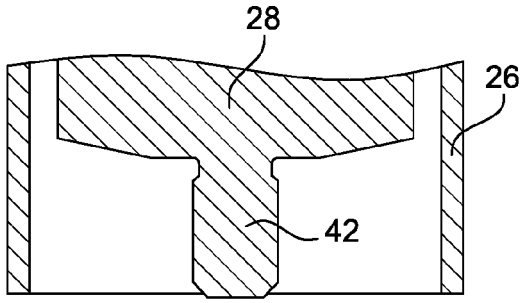
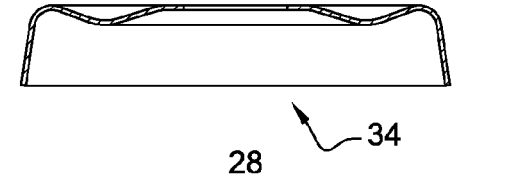


Fig. 4



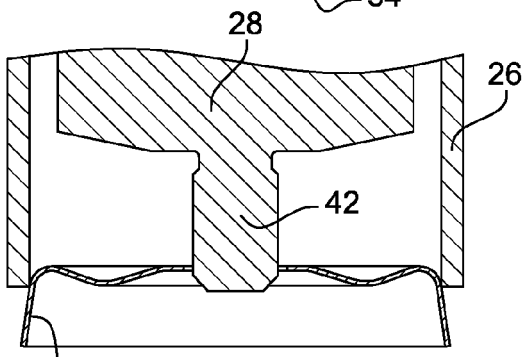


Fig. 5

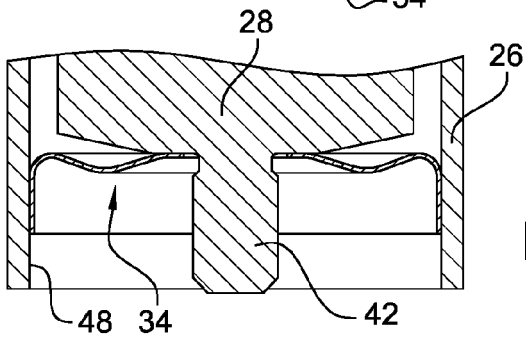


Fig. 6

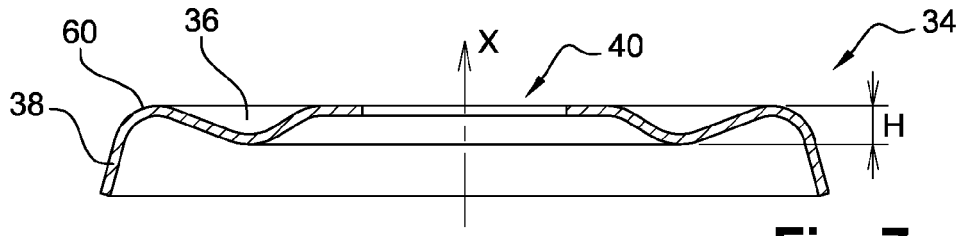


Fig. 7

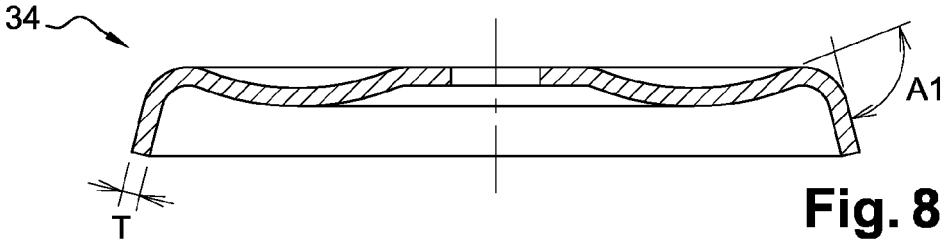


Fig. 8

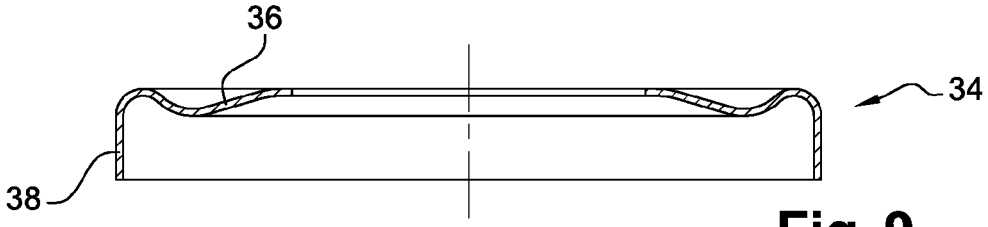


Fig. 9

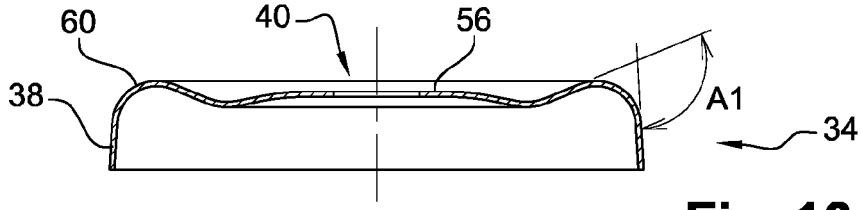


Fig. 10

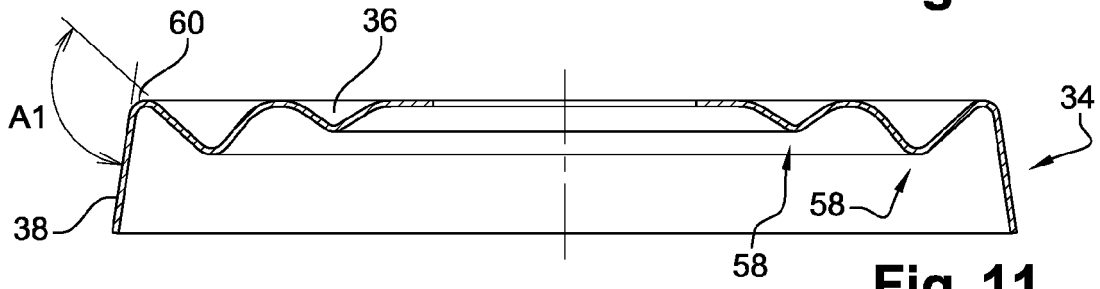


Fig. 11

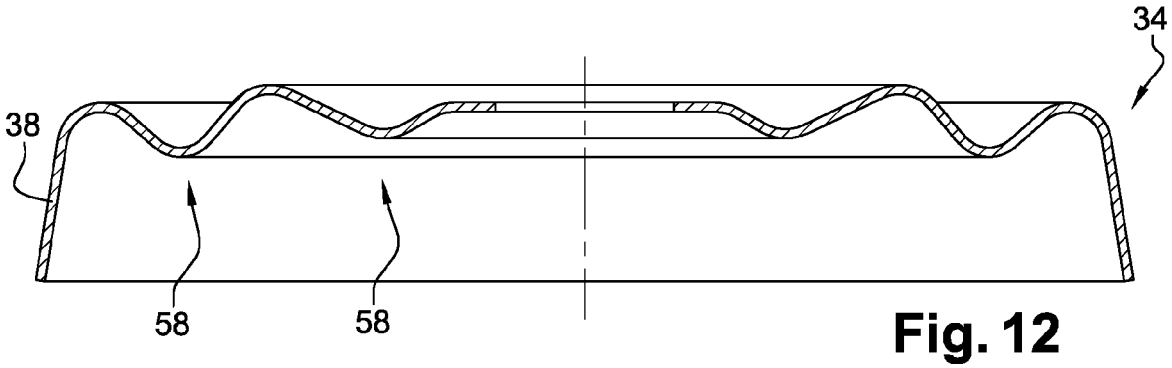


Fig. 12

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EUROPEAN SEARCH REPORT

Application Number
EP 16 17 1591

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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Y	DE 199 21 242 C1 (SIEMENS AG [DE]) 26 October 2000 (2000-10-26) * figure 1 *	2-6	
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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	26 September 2016	Morales Gonzalez, M

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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