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Fuel injector and valve seat therefor.

An electromagnetic fuel injector (10) has a housing (12) with a solenoid (24) disposed therein. The solenoid (24) operates an armature valve member (60) relative to a valve seat (58) in a valve seat disc (48) to meter fuel through the valve seat (58) and to the orifices (38) of an orifice director plate (36) disposed below the valve seat disc (48). The valve seat disc (48) is constructed of a thin sheet material which is punched to form a fuel passage (54) therethrough. The punching operation results in a raised annular ridge (56) about the perimeter of the pas-

sage (54). The raised annular ridge (56) forms a valve seat (58) which may be further reduced in height by machining. The machining has the additional benefit of placing a valve seating surface on the valve seat (58) for fluid-tight sealing with the valve member (60). A fuel injector (10) having a valve seat disc (48) constructed using this method can have a reduced sac volume between the valve seat (58) and the orifices (38) of the orifice director plate (36) resulting in improved injector performance.

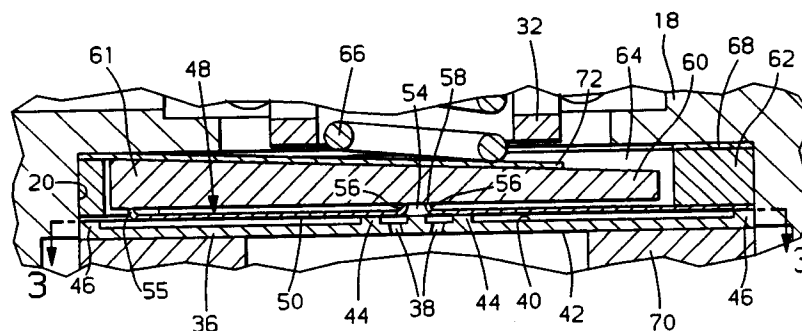


FIG. 2

The present invention relates to a method of manufacturing a valve seat and to an injector, such as a fuel injector.

Electromagnetic fuel injectors are used in internal combustion engines to regulate the discharge of precise quantities of fuel per unit time for optimised engine performance. Such fuel injectors, as well as other solenoid valve structures, have incorporated a solenoid armature located between the pole piece of the solenoid and a fixed valve seat, whereby the armature operates as a valve member. An example of an electromagnetic fuel injector of such type is disclosed in US-A-4,572,436, in which an armature valve controls the delivery of fuel through passages in an orifice plate.

While the injector disclosed in US-A-4,572,436 has performed with good results, it is desirable, from the standpoint of flow control, to utilise an orifice director plate downstream of the fuel passages. Satisfactory performance has not always been achieved with such injector designs, due to the substantial volume, known as the sac volume, formed between the armature valve and the director plate orifices. Under conditions of high manifold vacuum and temperature, the sac volume of fuel is evacuated between fuel pulses, causing a flow shift as the sac volume is refilled during a subsequent injection event.

The present invention seeks to provide an improved method of manufacturing a valve seat and an improved injector.

According to an aspect of the present invention, there is provided a method of manufacturing a valve seat as specified in claim 1.

According to another aspect of the present invention, there is provided an injector as specified in claim 3.

The present invention can provide a fuel injector and method of manufacturing the same, which has a small sac volume and which minimises flow shift to increase engine performance.

A preferred embodiment provides an electromagnetic fuel injector with a disc armature for use in an internal combustion engine. The fuel injector of this embodiment includes housing means with an axial bore therethrough and having an orifice director plate fixed at one end and a solenoid at the other end in spaced-apart relationship to the orifice plate by means of a spacer ring to form a valve chamber therebetween. The valve chamber is provided with a circular valve seat disc, positioned adjacent to the orifice plate and having an annular valve seat surface and a fuel passage extending through the surface. Flow through the fuel passage in the valve seat disc is controlled by an armature valve member through the axial movement of the armature valve between the valve seat surface and the working surface of the solenoid assembly.

Minimisation of the fuel volume, or sac volume, between the valve seat surface and downstream director plate orifices is achieved through a valve seat disc of unique construction having a minimal thickness provided using a thin sheet material in which a hole is punched to produce the fuel passage. A raised annular edge extending about the passage results from the punching process. The edge is preferably machined to produce a valve seating surface having a significantly reduced height in relation to prior art machined distributor plates. The result of the thin valve seat disc and reduced valve seat height is a minimised sac volume upstream of the orifice director plate which limits flow rate variation caused by the evacuation between fuel pulses.

In some embodiments of the present invention, it is possible to provide an improved electromagnetic fuel injector which includes features of construction rendering it easy and inexpensive to manufacture and which is reliable in operation in a fuel injection system of an internal combustion engine.

An embodiment of the present invention is described below, by way of illustration only, with reference to the accompanying drawings, in which:

Figure 1 is a cross-sectional view of an embodiment of fuel injector;

Figure 2 is an enlarged partial cross-sectional view of the lower portion of the injector of Figure 1;

Figure 3 is an enlarged partial sectional view of the lower portion of the injector of Figure 1;

Figure 4 is a partial cross-sectional view in plan of a director plate of the injector of Figures 1 and 2 taken along line 3-3 of Figure 2;

Figure 5 is a schematic view of one step in the construction of a valve seat disc of the injector of Figure 1; and

Figure 6 is a cross-sectional view of a portion of the valve seat disc of Figure 5.

Referring to Figure 1, there is shown an electromagnetic fuel injector 10 which includes a body 12 having a stepped throughbore 14 forming an upper inner wall 16, a radially inwardly projecting step 18 positioned intermediate of the ends of the throughbore 14, and a lower inner wall 20 having a threaded portion 22. A solenoid assembly 24 is slidably received within the upper inner wall 16 and is positioned within body 12 by the upper surface of step 18. The solenoid assembly 24 includes a coil 26 encased in an insulating material 28 and a centre pole piece 30 having an annular lower portion 32 extending axially below the coil, as viewed in the drawing. The centre pole piece 30 also includes an upper flange 34 which engages the upper inner wall 16 of body 12 to close the upper end of the throughbore 14.

Disposed within and closing the lower inner wall portion 20 is an orifice director plate 36. As illustrated in Figures 2 and 3, the director plate 36 has flow directing orifices 38 extending therethrough from a first, upstream side 40, to a second, discharge side 42. Annular lands 44, 46 are formed on the upstream side 40 of the director plate 36 and supportingly engage the downstream side 50 of a valve seat disc 48 disposed adjacent to the director plate. The valve seat disc 48 has a fuel passage 54 extending therethrough from the upstream side 52 to the downstream side 50, to permit fuel flow to the orifices 38 of the director plate 36. Extending about the upstream side of the valve seat disc fuel passage 54 is a raised seat 56 having a valve seating surface 58 for engagement with a valve member 60 which operates to meter the flow of fuel therethrough. A raised valve support 55 having a height which corresponds to the height of the valve seat 56 protrudes from one side of the valve seat disc and supports the distal end 61 of the valve member 60 in planar alignment with the valve seating surface 58 of the valve seat. A spacer ring 62 is located upstream of valve seat disc 48 and forms a fuel chamber 64 above the valve seat disc 48. Spacer ring 62 surrounds armature valve 60 which is disposed within fuel chamber 64 for reciprocal movement between a valve closed position in which the valve, urged by spring 66, closes passage 54 in valve seat disc 48 and a valve open position in which solenoid assembly 24 is energised to draw the valve 60 away from valve seat 58 to allow fuel from chamber 64 to flow through passage 54 to the fuel orifices 38 in director plate 36. A shim 68 of non-magnetic material lies upstream and adjacent to spacer ring 62 to establish an air gap between armature valve 60 and the annular lower portion 32 of solenoid pole piece 30. Orifice director plate 36, valve seat disc 48, spacer ring 62, and non-magnetic shim 68 are held in position within lower inner wall 20 by a threaded cylindrical retainer 70 which urges the components against the downstream side of inwardly projecting step 18.

Preferably, as shown in Figure 2, non-magnetic shim 68 has an inwardly extending spring member 72 which is suitably fixed to the upper surface of the armature valve 60 so as to effect positional indexing of the valve 60 and controlled reciprocal motion in the valve while establishing a fixed minimum air gap between the opposed working surfaces of the annular lower portion 32 of the centre pole piece 30 and the armature valve 60.

The solenoid coil 26 is adapted to be supplied with electrical power via a pair of terminal leads 74. The fuel chamber 64 receives fuel through a plurality of radial inlet passages 76 surrounded by a filter 78. In this arrangement, during engine operation,

the injector 10 can be supplied with pressurised fuel, through inlet passages 76, which flows to fuel chamber 64 upstream of valve seat disc 48. Upon energization of solenoid 24, armature valve 60 is lifted from its seated position over passage 54 allowing fuel to flow through the passage and to the orifices 38 in director plate 36 where the fuel exits the injector.

During normal injector operation, a significant portion of the fuel pressure drop occurs across the orifices 38 in the director plate 36. During engine operating conditions of high manifold vacuum and high temperature, fuel held in the sac volume, between the valve seat 58 and the orifices 38 of the fuel director plate 36, may be evacuated between fuel pulses resulting in a large pressure drop across the metering valve upon valve opening. As a result, the flow rate of the injector is increased until the sac volume is refilled, thereby re-establishing the pressure drop across the orifices 38. The increased flow rate causes a shift in fuel metering which can adversely affect engine performance. Minimisation of the sac volume to alleviate or minimise flow shift is achieved in the injector through the use of valve seat disc 48 which has a very low passage length (L) due to the low seat height and thin disc of which it is constructed.

As shown in Figures 5 and 6, the valve seat disc 48 comprises a thin sheet of material having high rigidity and resistance to a fuel environment, such as stainless steel. Sheet thickness may be of the order of 0.25mm. As shown in Figure 5, the sheet is punched, and reamed if necessary, to form fuel passage 54 having the desired diameter. The diameter of the passage 54 is typically of the order of 1.5-4.0mm depending upon flow requirements. The punching process establishes a raised annular ridge 82 around the perimeter of passage 54. The disc may be subjected to a hardening process following which the annular ridge 82 is machined to reduce its height and to flatten the surface, thereby forming valve seating surface 58. The resultant valve seat disc 48 has a low seat height which, when combined with the minimal thickness of the sheet, minimises the sac volume by greatly reducing the length (L) of the fuel passage 54. In addition, formation of the fuel passage 54 by punching establishes a curved passage outlet at the downstream side 50 of the valve seat disc 48. The curved passage outlet increases the diameter of fuel passage 54, thereby facilitating usage of the multi-orifice director plate of Figure 4 due to improved distribution of fuel.

An alternative construction of the valve seat disc which is contemplated, dispenses with the machining procedure to flatten and reduce valve seat height. As the thickness of the sheet material used to form the valve seat disc becomes increas-

ingly smaller, further reduction in seat height subsequent to the punching step will result in negligible reductions in sac volume. As such, it is contemplated that the valve seat disc may be installed in the injector assembly without being reduced by the machining process. Flattening of the raised annular ridge 82 to establish valve seating surface 58 will be through cycling the injector to induce repeated engagement of the valve 60 with the annular ridge 82. Cycling of the valve will continue until a valve seating surface 58 is established.

As illustrated in Figures 3 and 4, additional volume may be removed from the sac volume by utilising a raised land 84 between the director plate orifices. Valve support 55, which supports the distal end of the valve member to maintain the valve in a planar relationship to the valve seating surface, may be constructed by turning up one edge of the disc. This edge can be machined concurrently with the machining of the valve seat in order to establish a seating plane between the support 55 and the valve seating surface 58. In the case when the valve seat is not machined, such a valve support will not be used. In such cases other supporting means, known in the art, are to be used.

Thus, the electromagnetic fuel injector disclosed includes an armature valve operable with a valve seat, formed in a valve seat disc, to meter the flow of fuel to the orifices of a director plate. The valve seat disc is constructed from a thin sheet of material which is punched to form a fuel passage having a raised valve seat of minimal height. The resulting sac volume between the metering valve seat and the orifices of the director plate is minimised to reduce fuel shifts during engine operation commonly associated with sac evacuation.

The disclosures in United States patent application no. 968,935, from which this application claims priority, and in the abstract accompanying this application are incorporated herein by reference.

Claims

1. A method of manufacturing a valve seat from a sheet comprising the steps of punching the sheet (48) to form a passage (54) therethrough and a raised annular ridge (58) around the perimeter of the passage, the raised annular ridge forming a raised valve seat extending around the passage.
2. A method according to claim 1, comprising the step of machining the raised valve seat to reduce its height and to form a valve seating surface thereon.
3. An injector comprising a valve seat disc (48) including a raised valve seat (56) with a fuel passage (54) therethrough and a valve seating surface (58) extending around the fuel passage, a valve member (60) biased to engage the valve seating surface to interrupt fuel delivery through the fuel passage, a valve actuator (24) adapted to displace the valve from the valve seating surface to allow fuel delivery through the passage, the valve seat disc being formed from a sheet punched to form the fuel passage therethrough and the raised valve seat, the raised valve seat being machined to reduce its height and to form the valve seating surface thereon.

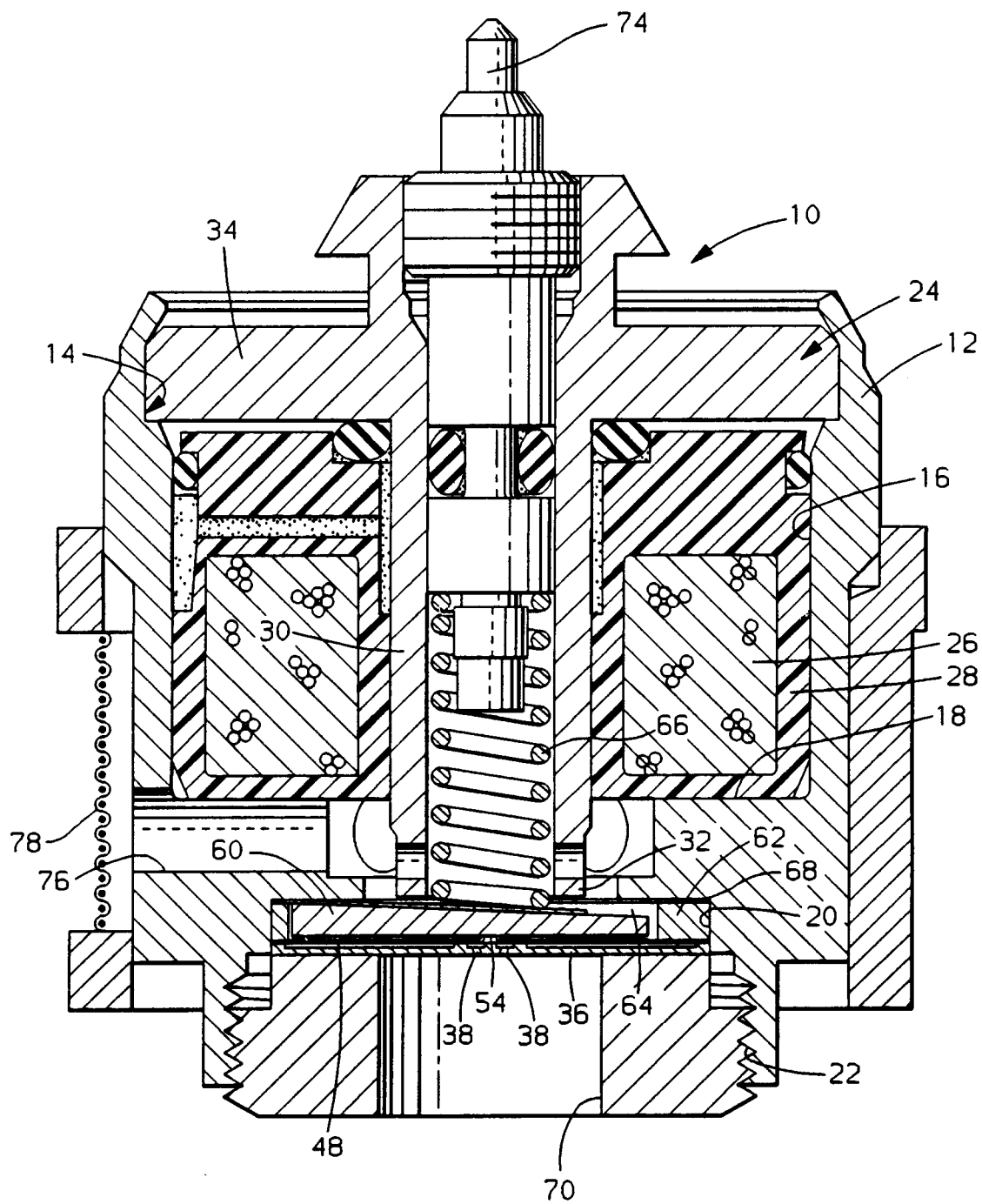


FIG. 1

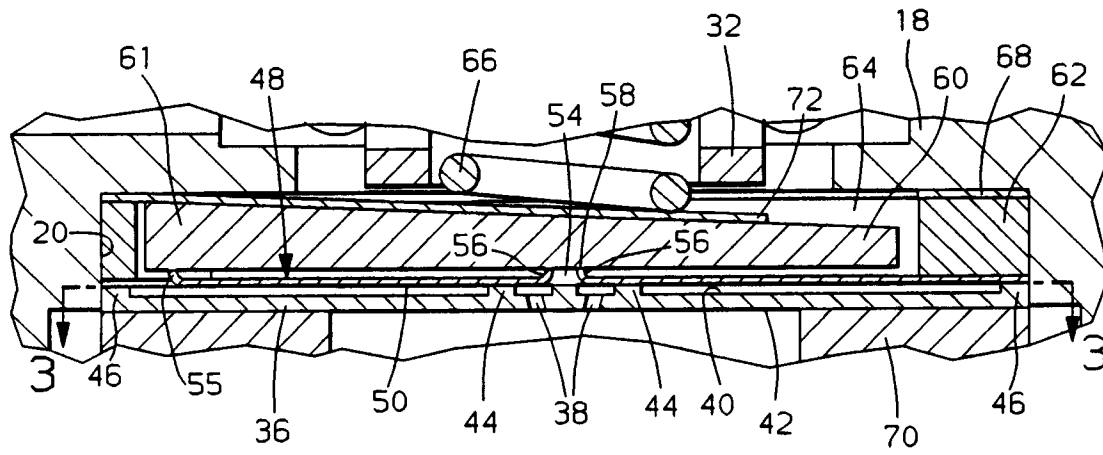


FIG. 2

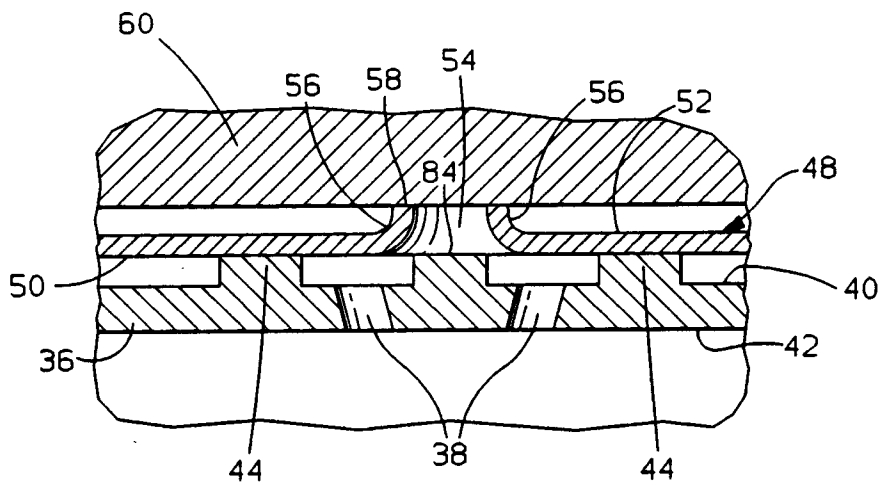


FIG. 3

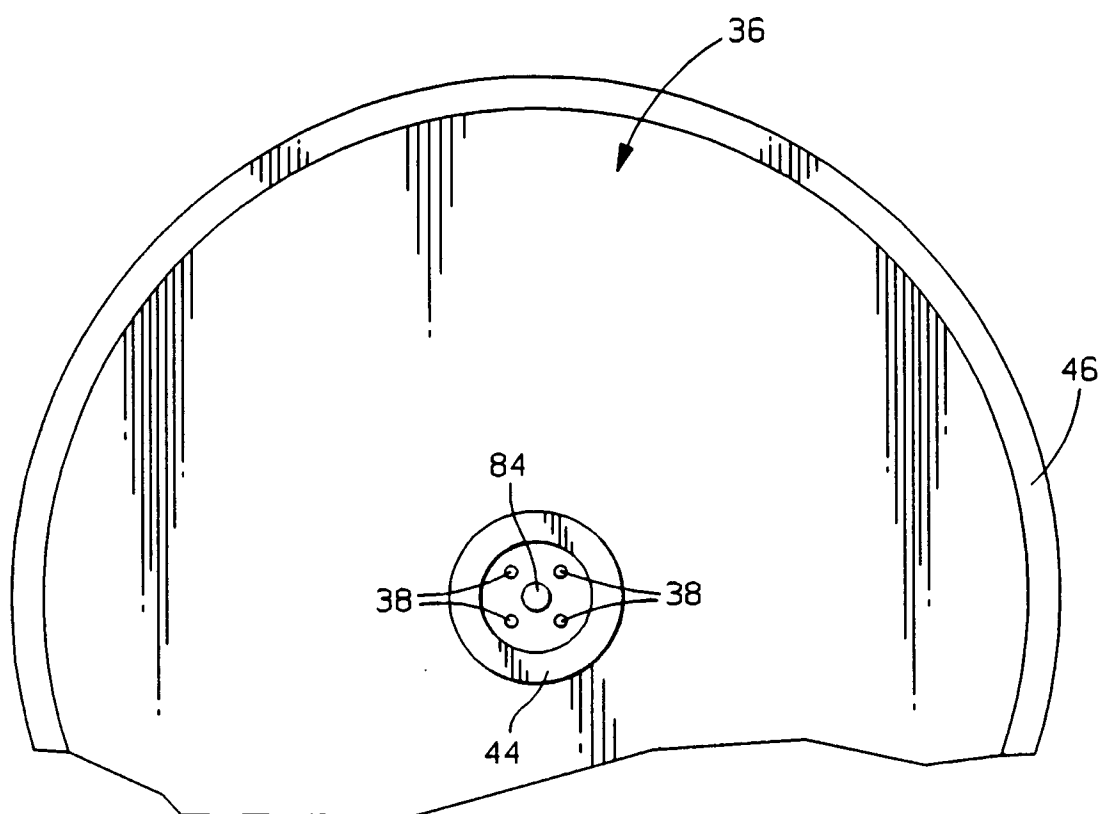


FIG. 4

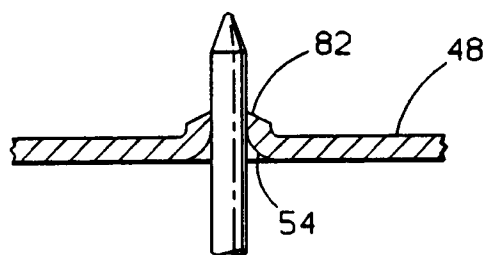


FIG. 5

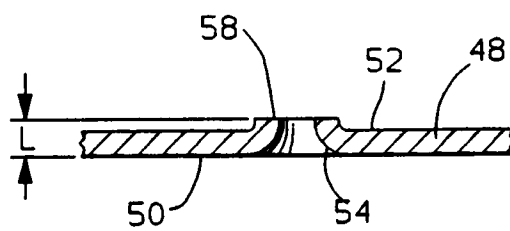


FIG. 6



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 93 20 2920

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X A	DE-C-859 395 (BOXAN) * the whole document * ---	1,2 3	F02M61/16 F02M51/06
X	DE-A-29 47 169 (SCHULZ & CO KG) * page 5, paragraph 2 * * page 7, paragraph 3; figures 1-4 * ---	1	
A	PATENT ABSTRACTS OF JAPAN vol. 4, no. 187 (M-48)23 December 1980 & JP-A-55 133 827 (TOYO SEIMITSU PRESS) 18 October 1980 * abstract * ---	1	
A	PATENT ABSTRACTS OF JAPAN vol. 10, no. 277 (M-519)19 September 1986 & JP-A-61 099 781 (RINNAI CORP) 17 May 1986 * abstract * ---		
A	US-A-4 967 959 (WIECZOREK) * the whole document * ---	3	TECHNICAL FIELDS SEARCHED (Int.Cl.5)
A	DE-A-33 13 837 (ATLAS FAHRZEUGTECHNIK) * figure 1 * ---	3	F02M B21D B23P
A	DE-C-828 329 (TILLIET) * figure 1 * -----	3	
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 21 December 1993	Examiner Friden, C
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- & : member of the same patent family, corresponding document			