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(54) Injector clamp and assembly

(57) An injector clamp (80) for securely clamping a plurality of fuel injectors (14) to an engine housing (16) is described. The clamp comprises a plurality of rigid clamp regions (82) separated by flexible clamp regions (84), each of the clamp regions (82) providing clamping means (56) for clamping an injector (14) to the engine housing (16). The injector clamp (80) further comprises a fuel passageway (22) for fluidically connecting a high pressure fuel inlet to the plurality of fuel injectors. The flexible clamp regions (84) allow the injector clamp (80) to bend to adapt to variations of height of each fuel injector (14). An injector assembly suitable for mounting in an engine housing is also described.

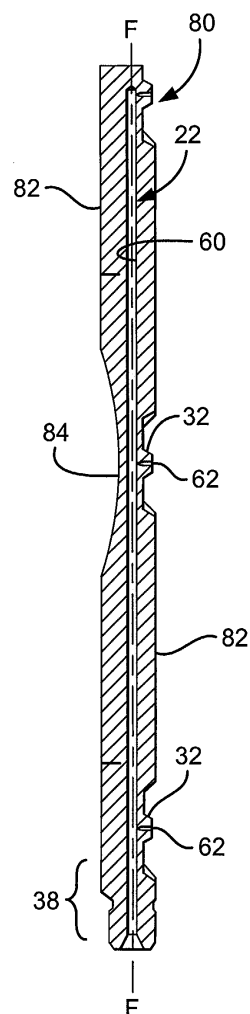


Fig.7b

Description

Technical Field

[0001] The present invention relates to an injector clamp and an injector assembly comprising a fuel injector. It relates particularly, although not exclusively, to an injector clamp and an injector assembly that securely fastens fuel injectors to cylinder heads in a diesel engine.

Background Art

[0002] European car safety regulations have recently introduced specific measures aimed at minimising pedestrian injury which car manufacturers must adhere to. One of these measures requires a large enough space within the engine compartment such that, if a pedestrian is hit head-on by a car, the bonnet of the car may deform to absorb the energy of the impact. In practice, this requirement has meant that the overall engine height has to be approximately 75 mm lower than the engines previously designed by the Applicant.

[0003] Conventional axial fuel inlets with their associated pipe bend can be the highest point on the engine, particularly when relatively long fuel injectors are utilised to fit the clamping between the top of the cylinder head and the connections to the fuel injector. The overall engine height may therefore be reduced by providing an axial connection to the fuel injectors. A known type of injector assembly is disclosed in granted European Patent no. 627 553 in which the fuel inlet is connected axially to the fuel injector. However, this type of injector arrangement has many components and may be difficult to manufacture.

[0004] An object of the present invention is therefore to produce an injector assembly of reduced height compared to injector assemblies known in the prior art, and/or which requires fewer components than known injector assemblies.

Summary of Invention

[0005] According to a first aspect of the invention there is provided a clamp for securely clamping a plurality of fuel injectors to an engine housing, the clamp comprising a plurality of rigid clamp regions separated by flexible clamp regions, each of the rigid clamp regions providing clamping means for clamping an injector to the engine housing. The flexible clamp regions advantageously allow the clamp to bend and adapt to the variation in height of each injector.

[0006] Preferably the cross-sectional area of each flexible clamp region is less than the cross-sectional area of each of the plurality of rigid clamp regions.

[0007] Preferably the clamping means comprises a fixing bore arranged to receive, in use, a fixing member.

[0008] The injector clamp may further comprise a fuel

passageway for fluidically connecting a high pressure fuel inlet to the plurality of fuel injectors. The fuel passageway preferably comprises a first substantially longitudinal bore in fluid communication with the high pressure fuel inlet and with a plurality of second bores arranged substantially perpendicular to the first bore, each of the plurality of second bores being in fluid communication with a respective outlet for supplying fuel to an associated one of the plurality of fuel injectors. Each outlet is conveniently defined in an outlet region of the clamp which is engageable with a seating provided on an associated one of the plurality of fuel injectors.

[0009] According to a second aspect of the invention there is provided an injector assembly suitable for mounting in an engine housing, the injector assembly comprising: a fuel injector connectable to an injector clamp which is laterally connectable to a high pressure fuel inlet, the injector clamp having at least one fixing member for fixing the injector clamp to the engine housing, and a fuel passageway for fluidically connecting the high pressure fuel inlet to the fuel injector, and wherein, in use, the injector clamp provides the necessary sealing force to securely clamp the fuel injector to the engine housing.

[0010] Preferably the high pressure fuel inlet is spaced laterally from, and/or perpendicular to, the major longitudinal axis of the fuel injector.

[0011] Preferably the injector clamp further comprises a locating member which is engageable with the fuel injector. The locating member may comprise a pin, a spring or roll pin, a lug, a hole, slot, flat or similar feature formed on either the injector clamp or the fuel injector. The locating member aids in locating the injector clamp when assembling the injector assembly in the engine housing.

[0012] There may be provided two fixing members, one located at either side of the injector clamp. Alternatively, there may be provided a single fixing member. The single fixing member may be located in the middle section of the injector clamp, or located at the first end (or front) section of the clamp adjacent the locating member.

[0013] Advantageously, the injector clamp may further comprise a fulcrum portion which, in use, is received by a channel or hole formed in the engine housing. The fulcrum portion allows angular movement of the injector clamp during the mounting thereof in the engine housing.

[0014] Preferably the injector clamp further comprises a clamp surface engageable with a seating formed on the engine housing. This may minimise vibration of the fuel inlet. It may also partially hold down the cam cover.

[0015] In an alternative arrangement, the injector clamp preferably comprises a first clamp portion engageable with a second clamp portion, the first clamp portion being arranged to connect to a high pressure fuel inlet and engageable with the fuel injector, and the second clamp portion being arranged to secure the first

clamp portion to the fuel injector. The first clamp portion is advantageously arranged at an obtuse angle to the second clamp portion.

[0016] Preferably the fuel passageway comprises a first bore having a first end in fluid communication with the fuel inlet, and a second end in fluid communication with a second bore, the second bore being in fluid communication with an outlet provided in the injector clamp, the outlet being engageable with a seating provided in the fuel injector. The first bore may be defined by a fuel pipe which extends through the injector clamp.

[0017] Preferably the first bore is oriented at an acute angle to the main longitudinal axis of the fuel injector. Most preferably the first bore is oriented at an angle of between approximately 60 and approximately 120 degrees to the main longitudinal axis of the fuel injector. Advantageously, the second bore is oriented substantially parallel to the main longitudinal axis of the fuel injector. However, it may be oriented at an angle to the main longitudinal axis of the fuel injector giving a lower stress on the intersection between the first and second bores than the parallel arrangement.

[0018] The injector assembly of the present invention provides the advantages of lower engine height and reduced weight, a reduced component count (and therefore lower cost), reduced engine assembly time, and ease of changing fuel injectors. The present invention is more suitable for twin overhead camshaft engine assemblies, although it is suitable for a wide variety of engines. The injector may also be oriented using a locating member, thereby simplifying injector pocket machining on the engine.

[0019] According to a third aspect of the invention there is provided an injector clamp for use with the afore-described injector assembly, the injector clamp being connectable to a fuel inlet, and wherein the injector clamp comprises: injector engaging means for engaging the clamp with a fuel injector, a fuel passageway for permitting passage of fuel from the fuel inlet to the fuel injector, and fixing means for securing the injector clamp to the engine housing.

[0020] Preferably the injector clamp further comprises a locating member engageable with the fuel injector.

[0021] The fuel inlet may be connected to a first (head) or second end section of the injector clamp.

Brief Description of Drawings

[0022] A number of embodiments of the present invention will be described, by way of example only, with reference to the accompanying drawings, in which:-

Figure 1a is a top plan view of an injector assembly according to a first embodiment of the invention;
Figure 1b is a side sectional view of the injector assembly of Figure 1a, taken along the line A-A;
Figure 2a is a top plan view of an injector assembly according to a second embodiment of the invention;

Figure 2b is a side sectional view of the injector assembly of Figure 2a, taken along the line A-A;

Figure 3a is a top plan view of an injector assembly according to a third embodiment of the invention;

Figure 3b is a side sectional view of the injector assembly of Figure 3a, taken along the line A-A;

Figure 4a is a top plan view of a plurality of injector assemblies according to a fourth embodiment of the invention;

Figure 4b is a side sectional view of one of the injector assemblies shown in Figure 4a, taken along the line A-A;

Figure 5a is a top plan view of a plurality of injector assemblies according to a fifth embodiment of the invention;

Figure 5b is a side sectional view of one of the injector assemblies shown in Figure 5a, taken along the line A-A;

Figure 6a is a top plan view of an injector assembly according to a sixth embodiment of the invention; and

Figure 6b is a sectional view of the injector assembly of Figure 6a, taken along the line C-C;

Figure 7a is a top plan view of an injector clamp according to a seventh embodiment of the invention;

Figure 7b is a side sectional view of the clamp shown in Figure 7a along the line F-F; and

Figure 7c is an underneath view of the clamp shown in Figures 7a and 7b.

Detailed Description of the Preferred Embodiments

[0023] Referring firstly to Figure 1b, there is shown an injector assembly 8 according to a first embodiment of the present invention. The injector assembly 8 comprises a fuel injector 14 and an injector clamp 10a. This injector clamp 10a (together with the other embodiments of the present invention) is arranged to sealedly connect a high pressure fuel inlet 12 to the fuel injector 14 and to clamp the fuel injector 14 into place in an engine housing 16, while at the same time minimising the height of the injector assembly 8.

[0024] In use, high pressure fuel from a common rail or accumulator volume (not shown) is fed through the fuel inlet 12 into the injector clamp 10a, and is then passed to the fuel injector 14 and injected into an engine cylinder. The fuel injector 14 shown is of a piezoelectric-type with an electrical connector 17. It will, however, be apparent to a skilled person that the injector clamp 10 according to all the embodiments of the present invention is suitable for other types of fuel injectors.

[0025] Looking at Figure 1b, the injector clamp 10a is shown in its fixed (i.e. clamped) position in the engine housing 16 wherein its longitudinal axis A-A lies substantially perpendicular to the longitudinal (i.e. major) axis B-B of the fuel injector 14. The structure of the injector clamp 10a will now be described in detail.

[0026] The injector clamp 10a comprises a substan-

tially elongated member having a substantially planar upper surface 18 and a shaped lower surface 20. A portion of the lower clamp surface 20 forms a clamping surface 21. The clamping surface 21 defines a clamping plane which lies substantially perpendicular to the major axis B-B of the fuel injector 14. There is defined in the injector clamp 10a a fuel passageway 22 for fluidically connecting the common rail or accumulator volume, via the fuel inlet 12, to the fuel injector 14.

[0027] The injector clamp 10a comprises a first end (or head) section 24 at an outlet end of the passageway 22, which is situated immediately above the fuel injector 14. The head section 24 has a single locating U-shaped slot 26 formed therein which is oriented substantially parallel to the major axis B-B of the fuel injector 14 (i.e. perpendicular to the clamping plane). The locating slot 26 receives, in use, a locating member 28 which is engageable with the top of the fuel injector 14. Also, in this embodiment, the top of the fuel injector 14 has a locating recess 30 formed therein for receiving the lower portion of the locating member 28. In this particular embodiment, the locating member 28 is a C-shaped spring or roll pin which simply springs into place in the locating slot 26 and/or locating recess 30.

[0028] Behind the locating slot 26, in the lower surface 20 of the clamp 10a, there is defined a frusto-conical outlet 32 through which a part of the fuel passageway 22 exits. The outlet 32 is engageable with a seating 34 defined in the top of the fuel injector 14. To prevent leakage of high pressure fuel, the frusto-conical outlet 32 deforms to form an interference fit with the seating 34. A cavity 36 formed between the outlet 32 and the top of the fuel injector 36 may receive a filter assembly (not shown).

[0029] A second (or inlet) end section 38 of the injector clamp 10a, at an inlet end of the passageway 22, is engageable with a fuel inlet connector 40 and the high pressure fuel inlet 12. The fuel inlet connector 40 and the high pressure fuel inlet 12 are both of conventional type. That is, the fuel inlet connector 40 is in the form of a circular cylindrical cap having a thread 42 formed in its internal surface. The end portion of the second end section 38 of the injector clamp 10a has an external thread 44 formed thereon for engaging with the internal thread 42 of the fuel inlet connector 40. A hole 46 is also formed in the base of the cap-shaped fuel inlet connector 40 for receiving the high pressure fuel inlet 12. The fuel inlet 12 is spaced laterally from the major axis B-B of the fuel injector 14.

[0030] The clamping surface 21 of the injector clamp 10a is engageable with a complimentary-shaped rear clamp seat 52 of the engine housing 16. It can be seen from Figure 1b that the lower surface 20 of the injector clamp 10a and an upper surface 78 of the engine housing 16 are shaped so as to define a cavity therebetween. It is envisaged that other constructions may be provided so that the lower surface 20 of the injector clamp 10a to the rear of the outlet 32 sits flush with the upper surface

78 of the engine housing 16.

[0031] Referring now to Figure 1a, there is shown a plan view of the injector clamp 10a. In the middle section 54 of the clamp 10a there are formed first 56a and second 56b fixing through-bores which are situated at the sides of the upper surface 18 of the clamp, one on each side of the longitudinal axis A-A. The fixing through-bores 56a, 56b extend substantially perpendicular to the clamping plane, i.e. substantially parallel to the major axis B-B of the fuel injector 14. In use, the first 56a and second 56b fixing through-bores receive respective first 58a and second 58b fixing members (such as bolts) which have threaded end sections (not shown). The threaded ends of the bolts 58a, 58b match the internal threads of threaded bores (also not shown) formed in the engine housing 16.

[0032] Returning to Figure 1b, it can be seen that the fuel passageway 22 is defined by a first bore 60 which is in fluid communication with a second bore 62. The first bore 60 extends from a recess 50 formed in the inlet end section 38 of the clamp 10a to the outlet head section 24 of the clamp 10a. The outlet end of the first bore 60 is oriented at an acute angle to the upper surface 18 of the clamp 10a. This enables the uppermost surface of the fuel inlet connector 40 to lie substantially flush with the upper surface 18 of the clamp 10a, thereby reducing the space occupied by the injector assembly 8. The second bore 62 extends from the blind end of the first bore 60 to the apex of the outlet 32 in a direction substantially parallel to the major axis B-B of the fuel injector 14, thereby allowing high pressure fuel to pass from the passageway 22 in the injector clamp 10a into the fuel injector 14.

[0033] To secure the injector clamp 10a to the engine housing 16, the locating member 28 is firstly inserted into the locating recess 30 formed at the top of the fuel injector 14 to form an interference fit. Next, the fuel injector 14 is inserted into a bore 27 (or injector pocket) formed in the engine housing 16. The injector clamp 10a is then fitted onto the fuel injector/engine housing combination so that the top of the locating member 28 is received by the slot 26, and the protrusion 32 sits in the seating 34. The bolts 58a, 58b are then passed through their respective fixing through-bores 56a, 56b formed in the clamp 10a. The clamp 10a is then engaged with the engine housing 16 by screwing the bolts 58a, 58b into the threaded-bores formed in the engine housing 16 until the clamp 10a bears firmly against the rear clamp seat 52. Finally, the fuel inlet 12 is attached to the fuel inlet connector 40, and the fuel inlet/connector combination is sealedly connected to the inlet end section 38 of the injector clamp by deforming the end of the fuel inlet connector 40 against the recess 50 formed in the inlet end section 38 of the clamp.

[0034] An alternative method of securing the injector clamp 10a to the engine housing 16 is now described. Firstly, the fuel inlet connector 40 and the fuel inlet 12 are firstly secured to the inlet end section 38 of the in-

jector clamp 10a. The fuel injector 14 is then inserted into a bore 27, or injector pocket, formed in the engine housing. The injector assembly 8 is then moved into position with the locating slot 26 in approximate alignment with the locating recess 30 formed in the top of the fuel injector 14. The locating member 28 is then inserted into the locating slot 26 and then into the fuel injector locating recess 30. The locating member 28 acts as a pivot allowing horizontal and/or vertical movement of the injector assembly 8, thereby allowing the injector assembly to be manoeuvred into its desired position in the engine housing 16.

[0035] When the injector assembly 8 is in the desired position, the bolts 58a,58b are passed through their respective fixing through-bores 56a,56b formed in the clamp 10a. The clamp 10a is then engaged with the engine housing 16 by screwing the bolts 58a,58b into the threaded bores formed in the engine housing 16 until the clamp 10a bears firmly against the rear clamp seat 52. In this manner, the fuel injector 14 is subjected to a downward compressive force F which serves to clamp it into place in the engine housing and thus provides an effective high pressure seal between the outlet 32 and the fuel injector seating 34.

[0036] It will be apparent to one skilled in the art that the methods of fitting the injector assembly 8 to the engine housing 16 are exemplary only. In some circumstances, it may be appropriate in the second method to loosely fit the bolts 58a,58b and the locating member 28 before securely fixing the injector assembly to the engine housing.

[0037] A second embodiment of the present invention is illustrated in Figures 2a and 2b, in which equivalent features to those of the first injector clamp 10a have like reference numerals.

[0038] Referring firstly to Figure 2a, the injector assembly 8 is shown in its clamped position in an engine housing 16. With reference now to Figures 2a and 2b, the injector assembly 8 comprises a fuel injector 14 and an injector clamp 10b. The injector clamp comprises a substantially elongated member 10b which longitudinal axis A-A lies substantially perpendicular to the major axis B-B of the fuel injector 14. The injector clamp 10b has a substantially planar upper surface 18 and a largely planar lower surface 20. A rear portion of the lower surface 20 at the inlet end section 38 of the clamp 10b provides a rounded clamping surface 21. The clamping surface 21 of the injector clamp 10b is engageable with a substantially planar rear clamp seat 52 of the engine housing 16.

[0039] There is defined in the injector clamp 10b a fuel passageway 22 for fluidically connecting the common rail or accumulator volume (not shown) to the fuel injector 14. Also, in common with the first embodiment, the head section 24 of the clamp 10b is situated above the fuel injector 14. Injector engaging means in the form of a frusto-conical outlet 32 define a part of the clamp 10b for engagement with the injector 14. The frusto-conical

outlet 32, through which part of the fuel passageway 22 exits, is defined in the outlet head section 24 of the clamp 10b. The outlet 32 is engageable with a seating 34 defined in the top of the fuel injector 14.

[0040] There is also provided a locating member 28, the upper part of which is received by a slot 26 formed in the head section 24 of the injector clamp 10b, and the lower part of which is engageable with the top of the fuel injector 14.

[0041] In contrast to the first injector clamp 10a where the second end section 38 thereof is engageable with the high pressure fuel inlet 12, in this embodiment the head section 24 of the clamp 10b is engageable with a fuel inlet connector 40 and a high pressure fuel inlet 12.

The fuel inlet connector 40 and the fuel inlet 12 are of the same construction as in the first embodiment of the present invention, and are attached to the outlet head section 24 of the clamp 10b as described for the first embodiment. Another difference between the first 10a and second 10b injector clamps is that, whereas in the first embodiment the main portion 60 of the fuel passageway 22 extends along the major axis A-A of the injector 10a, in the second embodiment the fuel passageway 22 is defined in the head section 24 of the clamp, along the minor lateral axis C-C thereof. As in the first embodiment of the present invention, the main portion 60 of the fuel passageway 22 may be situated at an angle to the major axis A-A of the injector 10a. Alternatively, it could be situated perpendicularly to the major axis B-B of the fuel injector 14.

[0042] In the middle section 54 of the clamp 10b there is defined a single fixing through-bore 56 which extends substantially parallel to the major axis B-B of the fuel injector 14. The fixing through-bore 56 is positioned in the centre of the upper surface 18 of the clamp 10b, rather than two fixing through-bores being provided towards the outer edge of the clamp, as in the first embodiment. In use, the fixing through-bore 56 receives a bolt 58 which has a threaded end section 59.

[0043] The injector clamp 10b is secured to the engine housing 16 as previously described. However, as there is only a single bolt 58, this arrangement is easier to fit to the engine housing 16 than the first embodiment: it can be orientated in many different positions and is thus easier to adapt to a variety of engines.

[0044] Figures 3a and 3b illustrate an alternative embodiment of the present invention, where like reference numerals are again used to denote like parts.

[0045] Referring to Figure 3a, there is shown an injector assembly 8 comprising an injector clamp 10c and a fuel injector 14 having an electrical connector 17. The injector clamp 10c is in the form of a substantially elongate member which may have been turned from round bar. The injector clamp 10c has a major longitudinal axis A-A and, although being substantially circular in cross section, is herein defined as having a profiled upper surface 18 and a similarly profiled lower surface 20.

[0046] As in the first and second embodiments of the

invention, a fuel passageway 22 is formed in the clamp 10c for transporting high pressure fuel from the common rail (or accumulator volume) to the fuel injector 14 as shown in Figure 3b. The fuel passageway 22 is defined by a first bore 60 in communication with a second bore 62. However, in this embodiment the first bore 60 is oriented substantially parallel to the upper surface 18 of the injector clamp 10c. A further difference between the first 10a and third 10c injector clamps is that the fixing through-bore 56 is formed at the front of the head section 24 of the clamp 10c. That is, in the same position as the locating slot 26 in the first clamp 10a. The front end of the clamp 10c has a cut away portion 90 such that the top of the head of the bolt 58 is lower than the upper surface 18 of the clamp 10c. Again, this restricts the height of the injector assembly 8 when it is clamped into position in the engine housing 16.

[0047] As in the first and second embodiments, the injector clamp 10c has an outlet 32 formed on its lower surface 20 which engages with a seating 34 formed in the top of the fuel injector 14. The second (or end) section 38 of the injector clamp 10c is also dimensioned and arranged to engage with a fuel inlet connector 40 and a high pressure fuel inlet 12 in the manner previously described. Thus, in this embodiment, the head section 24 is remote from the inlet end of the passageway 22 which communicates with the fuel inlet 12 (i.e. at the outlet end of the passageway 22).

[0048] In this embodiment of the invention, the end section 38 of the clamp 10c further provides a fulcrum portion 68 which is engageable with a round cavity 70 formed in the engine housing 16. The floor of the round cavity 70 defines the rear clamp seat 52.

[0049] To secure the injector clamp 10c to the engine housing 16, the fuel injector 14 is firstly inserted into a bore 27 (or injector pocket) formed in the engine housing 16. The head 24 and middle 54 sections of the injector clamp 10c are then inserted through the cavity 70 formed in the engine housing 16 until the fulcrum portion 68 of the clamp is situated in the cavity 70. The outlet 32 is then seated in the outlet seating 34 formed at the top of the fuel injector 14. When the outlet 32 has been seated, the threaded bolt 58 is inserted into the fixing through-bore 56 formed in the clamp 10c. The clamp 10c is then engaged with the engine housing 16 by screwing the fixing member 58 into a threaded bore 64 formed in the engine housing 16. In this manner, the fuel injector 14 is subjected to a downward compressive force F which serves to clamp it into place in the engine housing 16 and thus create a high pressure seal. This downward compressive force F generated at the front end of the clamp 10c causes the second end section 38 of the clamp 10c to move upwards. Conveniently, the ceiling of the cavity 70 serves to balance the resultant upward force and thus ensures the lower part of the fulcrum portion 68 remains in contact with the rear clamp seat 52.

[0050] It can be seen from Figure 3b that the floor of

the cavity 70 formed in the engine housing 16 is lower than the top of the fuel injector 14. Thus the injector clamp 10c (when in its fixed position in the engine housing 16) actually lies at an angle to the main axis B-B of the fuel injector 14. That is, the end section 38 of the injector clamp 10c is lower than the head section 24 of the clamp. As the fuel passageway 22 is defined substantially parallel to the upper surface 18 of the clamp 10c, when the clamp is fixed into this position, the first bore 60 of the fuel passageway 22 is itself oriented at an angle to the main axis B-B of the fuel injector 14. Again, as in the first embodiment of the invention, this serves to lower the height of the injector assembly 8 within the engine.

[0051] Figures 4a and 4b show a fourth embodiment of the present invention.

[0052] Figure 4b illustrates the injector assembly 8 in its fixed position in an engine housing 16. The injector assembly 8 comprises a fuel injector 14 and the injector clamp 10d. In contrast to the previously described embodiments of the invention, this clamp 10d comprises a substantially right circular cylinder having a first diameter A-A and a second diameter C-C perpendicular to the first diameter, as illustrated in Figure 4a. The clamp 10d also has substantially planar upper 18 and lower 20 surfaces. An outlet 32 is formed in the centre of the lower surface 20 of the clamp 10d which is engageable with a seating 34 formed in the top of a fuel injector 14, as previously described.

[0053] A fuel passageway 22 is formed in the clamp 10d for transporting high pressure fuel from the common rail to the fuel injector 14. The fuel passageway 22 comprises a first bore 60 and a second bore 62. The first bore 60 extends along the diameter C-C, and is oriented substantially perpendicular to the main axis B-B of the fuel injector 14. The second bore 62 is oriented substantially parallel to the main axis B-B of the fuel injector 14, and connects the first bore 60 to the apex of the outlet 32, as in the previously described embodiments.

[0054] Two fixing through bores 56a, 56b are formed at the circumference of the injector clamp 10d, diametrically opposite one another on the A-A diameter. As in the previous embodiments, the through bores 56a, 56b are oriented substantially parallel to the main axis B-B of the fuel injector 14. In use, the fixing through bores 56a, 56b receive respective bolts 58a, 58b. The bolts 58a, 58b have threaded ends 59 so that they may engage with complementary threaded bores 64 formed in the engine housing 16.

[0055] Referring now to Figure 4a, a single locating U-shaped slot (not shown) is formed along the axis C-C of the injector clamp 10d. The slot is oriented substantially parallel to the major axis B-B of the fuel injector 14 (i.e. perpendicular to the clamping plane). The locating slot receives, in use, a locating member 28 which is engageable with the top of the fuel injector 14. The top of the fuel injector 14 has a locating recess (not shown) formed therein for receiving the lower portion of the lo-

cating member 28.

[0056] In Figure 4a there are shown three identical injector assemblies 8 connected in series by way of a common high pressure fuel inlet 12 which takes the form of a pipe. The pipe may itself form the common rail of the system for storing high pressure fuel. To manufacture this arrangement, the main bores 60 are firstly formed in the injector clamps 10d. The high pressure fuel pipe 12 is then inserted through the pre-formed main bores 60 and permanently secured to the injector clamps 10d. This may be achieved by means of welding, brazing, gluing, or by pressurizing the pipe 12 such that it expands to form an interference fit within the bores 60. The second bores 62 are then formed in the injector clamps 10d by drilling in the appropriate positions.

[0057] The fixing members 28 are then inserted into the locating recesses 30 formed at the top of the fuel injectors 14. Next, the fuel injectors 14 are inserted into their respective injector pockets 27 formed in the engine housing 16. The multiple injector clamp/pipe combination is then moved into place with respect to the top of the fuel injectors 14, and the upper portions of the fixing members 28 are inserted into their U-shaped slots and the protrusions 32 are seated in their respective seatings 34. The threaded bolts 58a, 58b are then inserted into fixing through-bores 56a, 56b defined in the injector clamps 10d. The bolts 58a, 58b are then screwed into threaded bores 64 formed in the engine housing 16 until the outlets 32 bear firmly against the seatings 34 formed in the top of the fuel injectors 14. In this manner, the fuel injectors 14 are subjected to a downward compressive force F which serves to clamp them into place in the engine housing 16.

[0058] The injector clamp 10d of the fourth embodiment of the present invention is suitable for use with a common rail system, and reduces the numbers of connections required to join the injectors 14 to the common rail compared to prior art systems. The injector clamp 10d is particularly suitable for fuel injectors 14 in which a local volume is available for high pressure fuel within the injector, and therefore for which a large rail volume is not required.

[0059] A fifth embodiment 10e of the present invention is illustrated in Figures 5a and 5b. This embodiment is similar to the second embodiment in which the injector clamp 10b is secured to the engine housing 16 by a single bolt 58 positioned approximately at the centre of the upper surface 18 of the clamp.

[0060] Figure 5b shows the injector assembly 8 in its fixed position in the engine housing 16, the injector assembly 8 comprising a fuel injector 14 and an injector clamp 10e. The injector clamp 10e is in the form of a substantially elongated member having a semicircular first (or head) section 24, a rectangular middle section 54, and a tapered second end section 38 (see Figure 5a). The longitudinal axis A-A of the clamp is oriented substantially perpendicular to the major axis B-B of the fuel injector 14.

[0061] As in the second embodiment, the clamp 10e has a substantially planar upper surface 18 and a shaped lower surface 20. The rear portion of the lower surface 20 provides a clamping surface 21 which is engageable with a substantially planar rear clamp seat 52 of the engine housing 16.

[0062] There is defined in the head section 24 of the injector clamp 10e a fuel passageway 22 for fluidically connecting the common rail to the fuel injector 14. The fuel passageway 22 extends along the minor axis C-C of the clamp 10e, perpendicular to the major axis A-A thereof. As in the second injector clamp 10b, a frusto-conical outlet 32 is defined in the lower surface 20 of the clamp 10e, through which the fuel passageway 22 exits. The outlet 32 is engageable with a seating 34 defined in the top of the fuel injector 14, and thus provides a locating function. Alternatively, the locating function may be provided by a locating member as described in the previous embodiments of the present invention.

[0063] Figure 5a illustrates three identical injector clamps 10e connected in series by way of a fuel pipe 12. The fuel pipe 12 may itself form the common rail for storing high pressure fuel. The series of clamps 10e are assembled as described for the previous embodiment of the invention. Again, this injector clamp 10e is suitable for use with a common rail system, and reduces the number of connections required to join the fuel injectors 14 to the common rail (i.e. the pipe 12). The injector clamp 10e is also particularly suitable for fuel injectors having a local volume for high pressure fuel, for the reasons previously outlined.

[0064] A sixth embodiment of the present invention is illustrated in Figures 6a and 6b of the drawings. In this embodiment, the injector clamp 10f comprises a first clamp portion 74a and a second clamp portion 74b. The first clamp portion 74a is connectable to a high pressure fuel inlet 12 and a fuel injector 14. The second clamp portion 74b is engageable with the engine housing 16. These two clamp portions 74a, 74b are now described in more detail.

[0065] Referring firstly to Figure 6b, the injector assembly 8 comprises a fuel injector 14 and an injector clamp 10f and is shown in its clamped position in the engine housing 16. The longitudinal axis A-A of the injector clamp 10f lies substantially perpendicular to the major axis B-B of the fuel injector 14.

[0066] The first clamp portion 74a of the injector clamp 10f has shaped upper 18a and lower 20 surfaces. A portion of the shaped lower surface 20 forms a clamping surface 21. The clamping surface 21 defines a clamping plane which lies substantially perpendicular to the major axis B-B of the fuel injector 14. There is defined in the first clamp portion 74a a fuel passageway 22 for fluidically connecting the common rail to the fuel injector 14.

[0067] The first clamp portion 74a comprises a first (or head) section 24a and a second (or end) section 38a. The head section 24a is engageable with the top of the

fuel injector 14. There is defined in the first clamp portion 74a a fuel passageway 22 defined by a first bore 60 which is parallel to the upper surface of the first clamp portion 74a (i.e. perpendicular to the fuel injector major axis), and the second bore 62. In the lower surface 20 of the first clamp portion 74a there is defined a protruding outlet 32 of rectangular cross-section through which a drilling 62 extends, which communicates with an outlet end of the fuel passageway 22. The outlet 32 is engageable with a seating 34 defined in the top of the fuel injector 14.

[0068] The end section 38a of the first clamp portion 74a is engageable with a fuel inlet connector 40 and the high pressure fuel 12 in the manner previously described. The clamping surface 21 is substantially planar and is engageable with the top of the fuel injector.

[0069] The head section 24a of the first clamp portion 74a is receivable by a complementary shaped cut-away portion formed in the end section 38b of the second clamp portion 74b. The two clamp portions are arranged at an obtuse angle to one another. The upper surface 18b of the second clamp portion 74b is approximately level with the uppermost part of the fuel inlet connector 40 to minimise the height of the injector assembly 8.

[0070] The head section 24b of the second clamp portion 74b has a bore 26 formed therein which is oriented substantially parallel to the major axis B-B of the fuel injector 14. The bore 26 receives a locating member 28 (such as a pin) which may form an interference or press fit with the bore to retain it securely in position. The distal end of the locating member 28 is receivable in a recess 30 of complementary shape provided in the engine housing 16. The middle section 54b of the second clamp part 74b has defined therein a through-bore 56 which, in use, receives a bolt 58. In use, the head of the bolt 58 is received in a complementary shaped recess which is provided at the top of the fixing through-bore 56. This lowers the height of the injector assembly 8 as the head of the bolt 58 does not protrude from the upper surface of the assembly.

[0071] A generally U or V shaped channel 19 is formed in the second clamp portion 74b which transmits the necessary clamping force to the components and also orientates the clamp to the fuel inlet 12.

[0072] To secure the injector clamp 10f to the engine housing 16, the locating member 28 is firstly inserted into the bore 26 formed in the second clamp portion 74b. Next, the fuel injector 14 is inserted into an injector pocket 27 formed in the engine housing 16. The first injector clamp portion 74a is then connected to the second injector clamp portion 74b to form the injector clamp 10f. The injector clamp 10f is then fitted onto the fuel injector/engine housing combination so that the protrusion 32 in the first injector clamp portion 74a sits in the seating 34, and the distal portion of the locating member 28 sits in the recess 30 formed in the engine housing 16. The bolt 58 is then passed into its bore hole 56 formed in the second clamp portion 74b. The clamp 10f is then en-

gaged with the engine housing 16 by screwing the bolt 58 into the threaded bore 59 formed in the engine housing 16 until the distal end of the locating member 28 bears firmly against the engine housing 16. Finally, the fuel inlet 12 is attached to the fuel inlet connector 40, and the fuel inlet/connector combination is sealedly connected to the inlet end section 38a of the first clamp portion 74a in the manner previously described.

[0073] Referring now to Figures 7a, 7b and 7c, there is shown an injector clamp 80 which is suitable for clamping multiple fuel injectors 14 to the engine housing 16. The clamp 80 comprises a long clamp section having a plurality of rigid clamp regions 82 separated by a region 84 of reduced cross-section to provide a degree of flexibility. Each of the rigid clamp regions 82 is provided with means for clamping an injector 14 to the engine in the form of associated fixing means, such as screw-threaded bolts (not shown) which are received, in use, by slots or fixing bores 56 formed in the clamp regions 82.

[0074] The injector clamp 80 has a fuel passageway 22 defined therein. The fuel passageway 22 comprises a first bore 60 which extends substantially parallel to the main (longer) axis F-F of the clamp 80. An inlet section 38 of the injector clamp 80 is engageable with a high pressure fuel inlet of conventional type (not shown) to allow high pressure fuel to be supplied to the passageway 22. The fuel passageway 22 also comprises a plurality of second bores 62 (two of which are shown in Figure 7(b)) which are formed in the clamp 80 so as to extend substantially perpendicular to the first bore 60. Each of the second bores 62 is formed in a clamp outlet region 32 and terminates in an outlet through which fuel is delivered to an associated injector (not shown). Each outlet region 32 is of frusto-conical form and is shaped for engagement with a seating defined in an upper region of the associated injector.

[0075] In the embodiment of Figure 7, only one of the second bores 62 is located in a region of the clamp of reduced diameter (i.e. a flexible clamp region 84). The injector clamp 80 may, however, have more than one flexible region 84 to give the desired degree of freedom, depending on how many fuel injectors are required to be clamped into position. If several rigid clamp regions 82 are provided, neighbouring ones of these are separated by a flexible region 84 to provide the required flexibility over the entire clamp length.

[0076] Having described particular preferred embodiments of the present invention, it is to be appreciated that the embodiments in question are exemplary only and that variations and modifications such as will occur to those possessed of the appropriate knowledge and skills may be made without departure from the spirit and scope of the invention as set forth in the appended claims. For example, it will be appreciated that the present invention is suitable for use in an engine having a different number of injectors to that described or shown in the figures. Further, the locating feature 28 of

the sixth embodiment of the invention (i.e. injector clamp 10f) and its respective shallow recess 30 formed in the engine housing may be used with the first, second and fifth embodiments of the invention (i.e. injector clamps 10a, 10b and 10e).

Claims

1. An injector clamp (80) for securely clamping a plurality of fuel injectors (14) to an engine housing (16), the clamp comprising a plurality of rigid clamp regions (82) separated by flexible clamp regions (84), each of the rigid clamp regions (82) providing clamping means (56) for clamping an injector (14) to the engine housing (16). 5
2. An injector clamp (80) according to Claim 1, wherein the cross-sectional area of each of the flexible clamp regions (84) is less than the cross-sectional area of each of the plurality of rigid clamp regions (82). 10
3. An injector clamp (80) according to Claim 1 or Claim 2, wherein the clamping means comprises a fixing bore (56) arranged to receive, in use, a fixing member. 15
4. An injector clamp (80) according to any preceding claim, further comprising a fuel passageway (22) for fluidically connecting a high pressure fuel inlet to the plurality of fuel injectors (14). 20
5. An injector clamp (80) according to Claim 4, wherein the fuel passageway (22) comprises a first substantially longitudinal bore (60) in fluid communication with the high pressure fuel inlet and with a plurality of second bores (62) arranged substantially perpendicular to the first bore (60), each of the plurality of second bores being in fluid communication with a respective outlet for supplying fuel to an associated one of the plurality of fuel injectors (14). 25
6. An injector clamp (80) according to Claim 5, wherein each outlet is defined in an outlet region (32) of the clamp which is engageable with a seating provided on an associated one of the plurality of fuel injectors (14). 30
7. An injector assembly (8) suitable for mounting in an engine housing (16), the injector assembly comprising: a fuel injector (14) connectable to an injector clamp which is laterally connectable to a high pressure fuel inlet (12), the injector clamp having at least one fixing member (58) for fixing the injector clamp to the engine housing (16), and a fuel passageway (22) for fluidically connecting the high pressure fuel inlet to the fuel injector (14), and wherein, in use, 35

the injector clamp (10) provides the necessary sealing force to secure the fuel injector (14) to the engine housing, **characterised in that** the injector clamp further comprises a locating member (28) which is engageable with the fuel injector (14), the locating member (28) being arranged, in use, to permit horizontal and/or vertical movement of the injector assembly (8) thereby allowing the injector assembly to be manoeuvred into a desired position in the engine housing (16). 40

8. An injector assembly (8) according to Claim 7, wherein there are provided two fixing members (58a, 58b), one located at either side of the injector clamp (10a, 10d). 45
9. An injector assembly (8) according to Claim 7, wherein the injector clamp (10d, e, f) comprises a middle section (54) in which there is provided a single fixing member (58). 50
10. An injector assembly (8) according to Claim 7, wherein the injector clamp (10c) comprises a first end section (24) in which there is provided a single fixing member (58). 55
11. An injector assembly (8) according to Claim 10, wherein the locating member comprises a fulcrum portion (66) which, in use, is received by a channel (70) formed in the engine housing (16).
12. An injector assembly (8) according to any of Claims 7 to 11, wherein the injector clamp (10) further comprises a clamp surface engageable with a seating (52) formed on the engine housing (16).
13. An injector assembly (8) according to any of Claims 7 to 12, wherein the injector clamp (10) comprises a first clamp portion (74a) engageable with a second clamp portion (74b), the first clamp portion being arranged to connect to a high pressure fuel inlet (12) and engageable with the fuel injector (14), and the second clamp portion being arranged to secure the first clamp portion to the fuel injector (14).
14. An injector assembly (8) according to any of Claims 7 to 13, wherein the fuel passageway (22) comprises a first bore (60) having a first end in fluid communication with the fuel inlet (12), and a second end in fluid communication with a second bore (62), the second bore being in fluid communication with an outlet (32) provided in the injector clamp (10), the outlet (32) being engageable with a seating (34) provided in the fuel injector (14).
15. An injector assembly (8) according to Claim 14, wherein the first bore (60) is oriented at an acute angle to the main longitudinal axis (B-B) of the fuel

injector (14).

16. An injector assembly (8) according to Claim 15, wherein the first bore (60) is oriented at an angle of between approximately 60 degrees and approximately 120 degrees to the main longitudinal axis (B-B) of the fuel injector (14). 5
17. An injector assembly (8) according to any of Claims 14 to 16, wherein the second bore (62) is oriented substantially parallel to the main longitudinal axis (B-B) of the fuel injector (14). 10
18. An injector clamp (10) for use with the injector assembly (8) according to any of Claims 7 to 17, the injector clamp (10) being connectable to a fuel inlet (12), and wherein the injector clamp comprises: injector engaging means (32) for engaging the clamp with a fuel injector (14), a fuel passageway (22) for permitting passage of fuel from the fuel inlet (12) to the fuel injector (14), fixing means (58) for securing the injector clamp (10) to the engine housing (16), and a locating member (28) which is engageable with the fuel injector (14), the locating member (28) being arranged, in use, to permit horizontal and/or vertical movement of the injector assembly (8) thereby allowing the injector assembly to be manoeuvred into a desired position in the engine housing (16). 15
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19. An injector clamp (10) according to Claim 18, further comprising a first end section (24) and a second end section (38), and wherein the fuel inlet (12) is connectable to the first end section (24) of the clamp. 35
20. An injector clamp (10) according to Claim 18, further comprising a first end section (24) and a second end section (38), and wherein the fuel inlet (12) is connectable to the second end section (38) of the clamp. 40
21. An injector clamp (10) according to any of Claims 18 to 20, wherein the fuel passageway (22) comprises a first bore (60) in fluid communication with a second bore (62). 45
22. An injector clamp (10) according to Claim 21, wherein the first bore (60) is defined by a fuel pipe (72). 50

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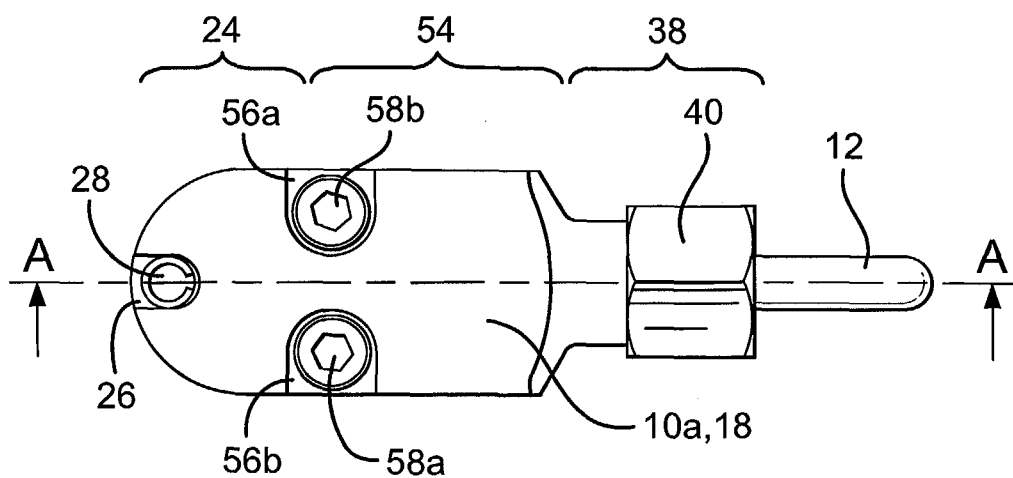


Fig.1a

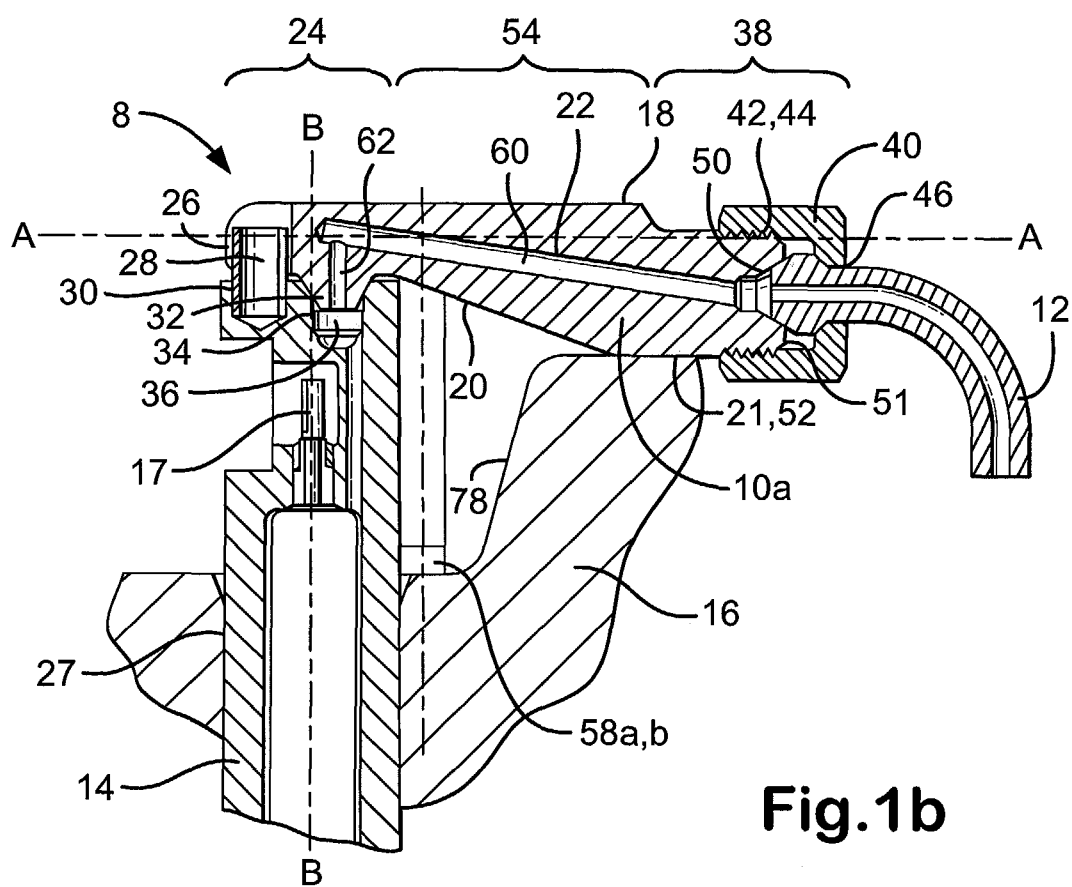
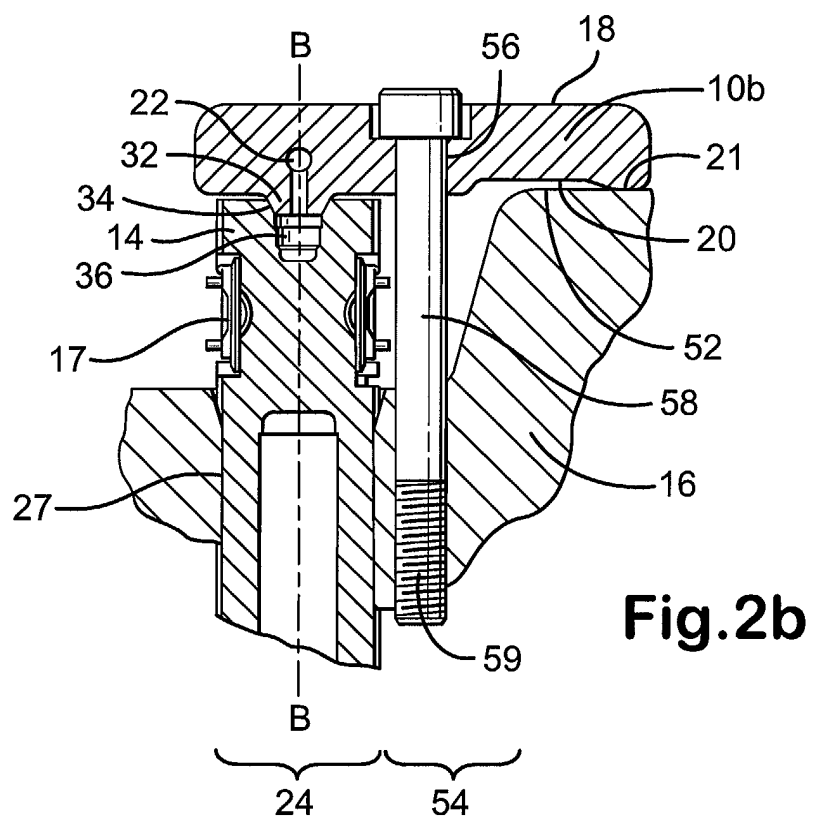
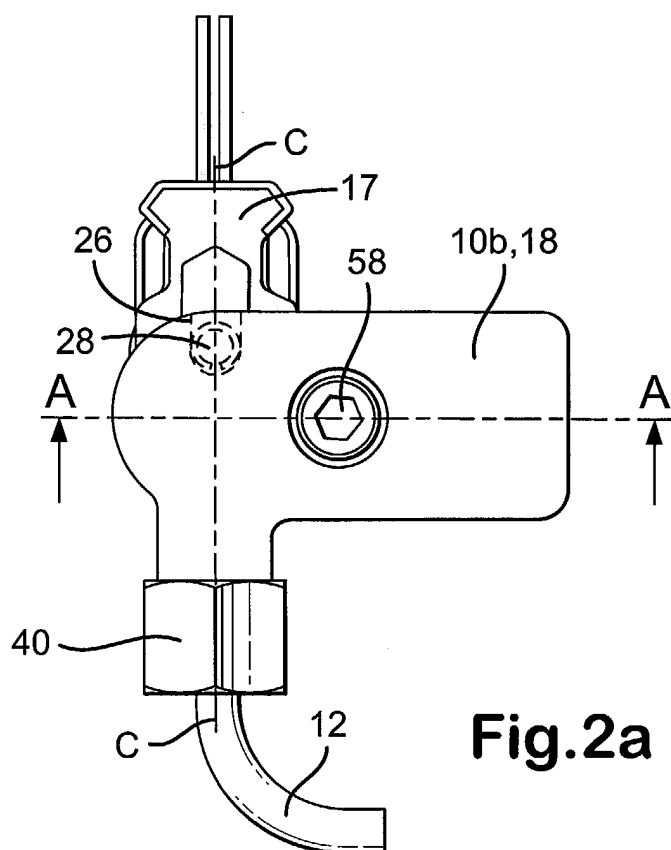
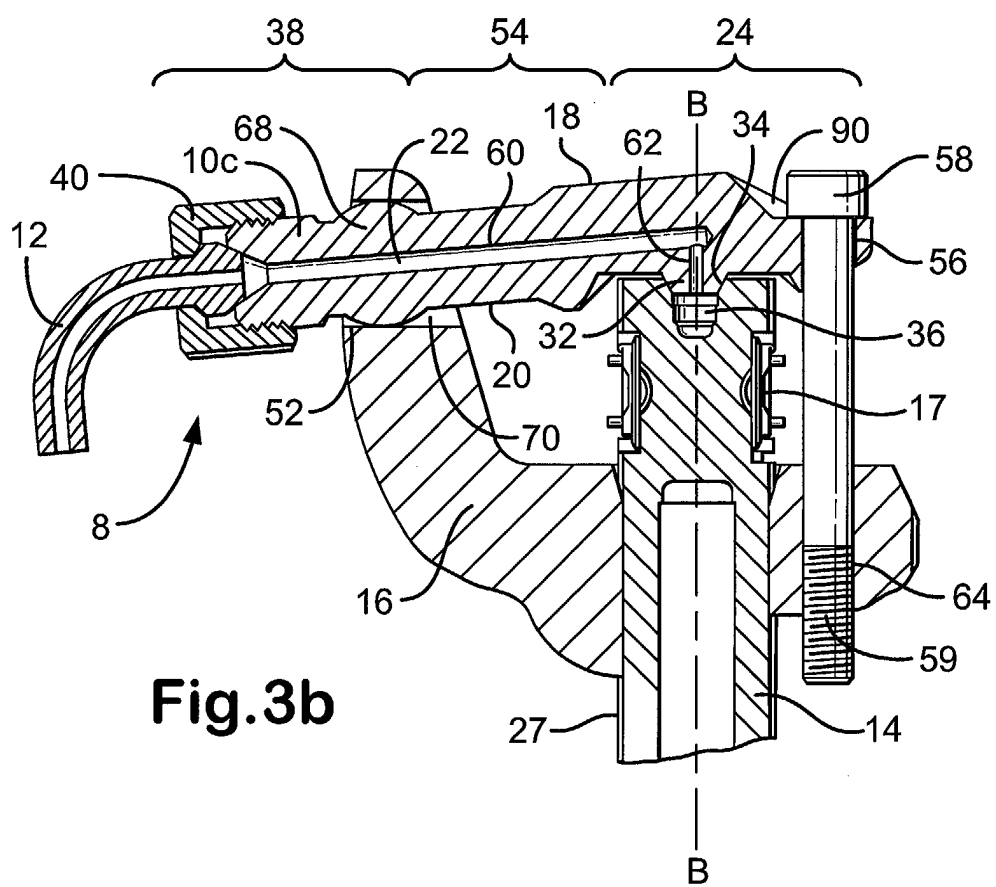
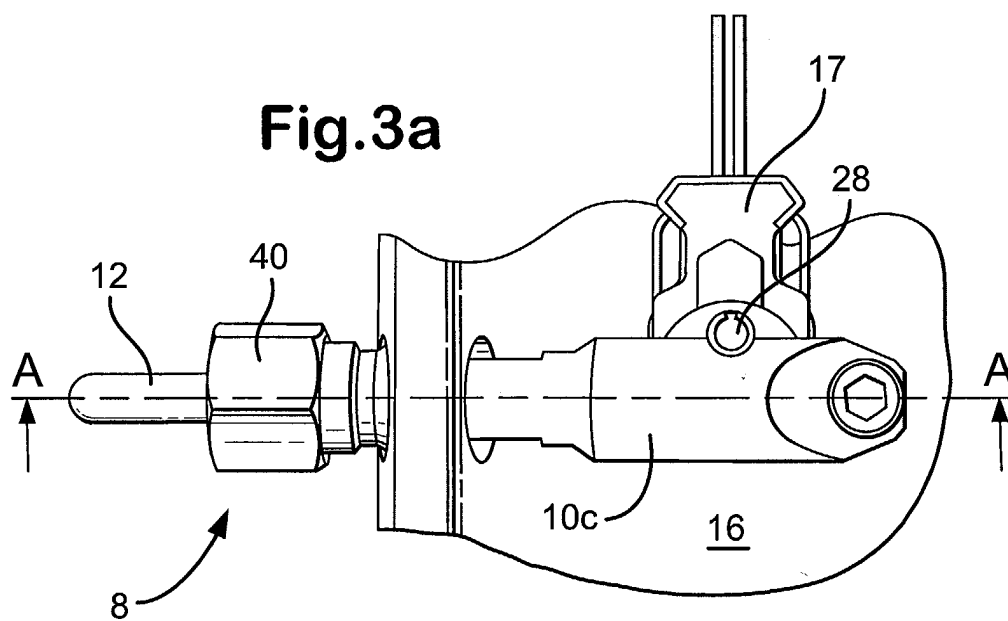


Fig.1b





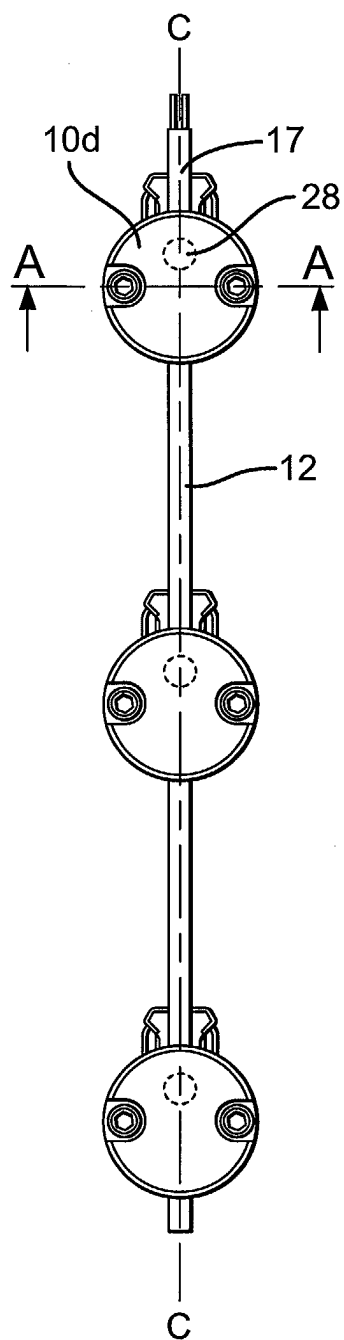


Fig.4a

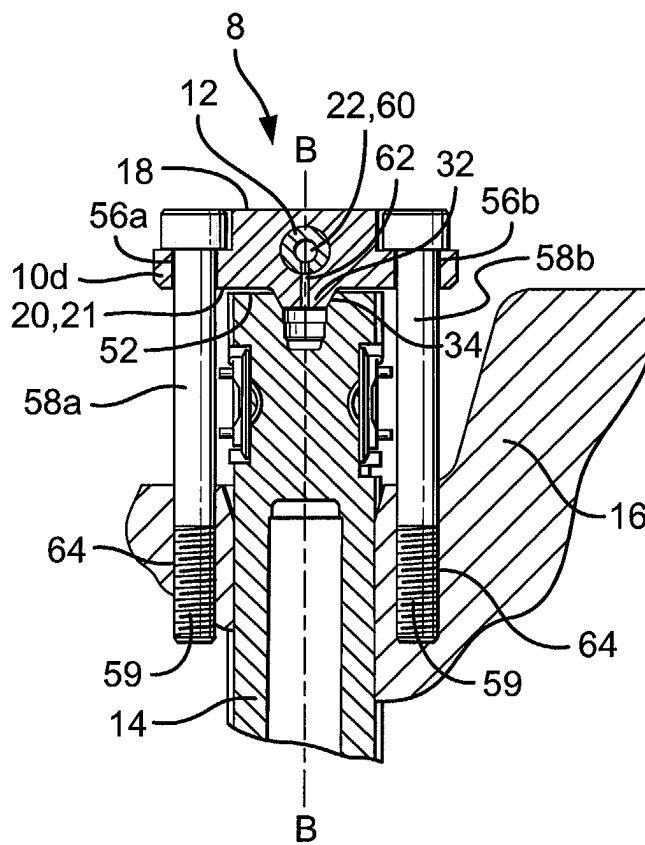


Fig.4b

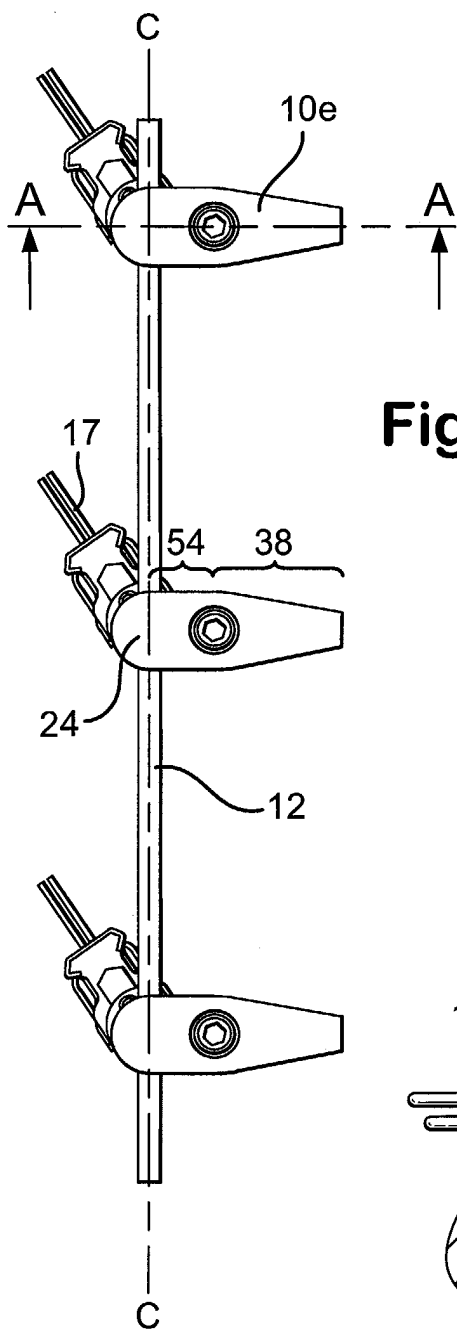


Fig.5a

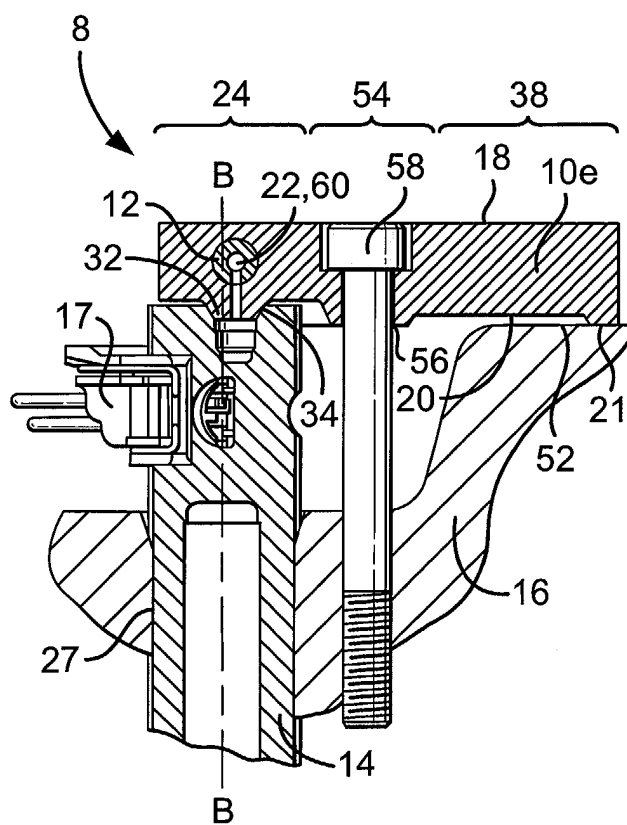


Fig.5b

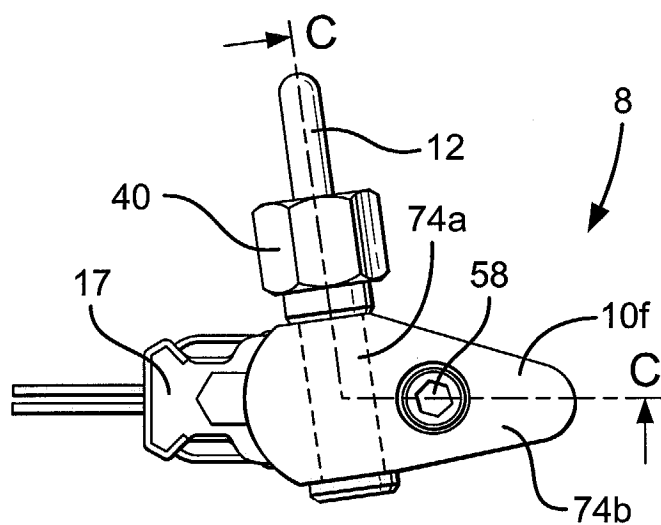


Fig.6a

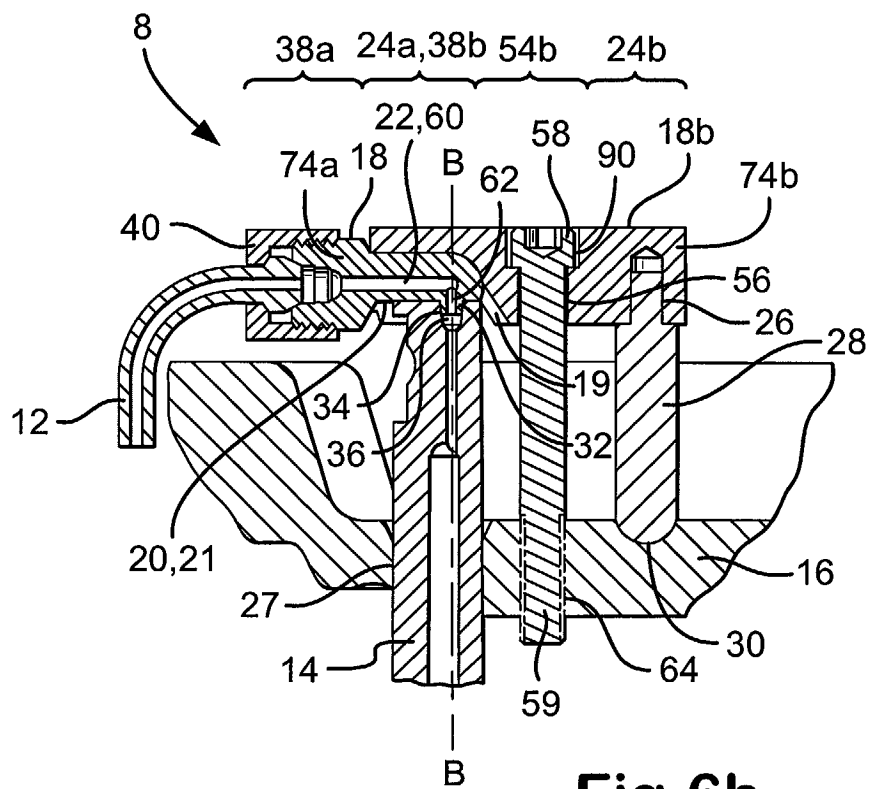


Fig.6b

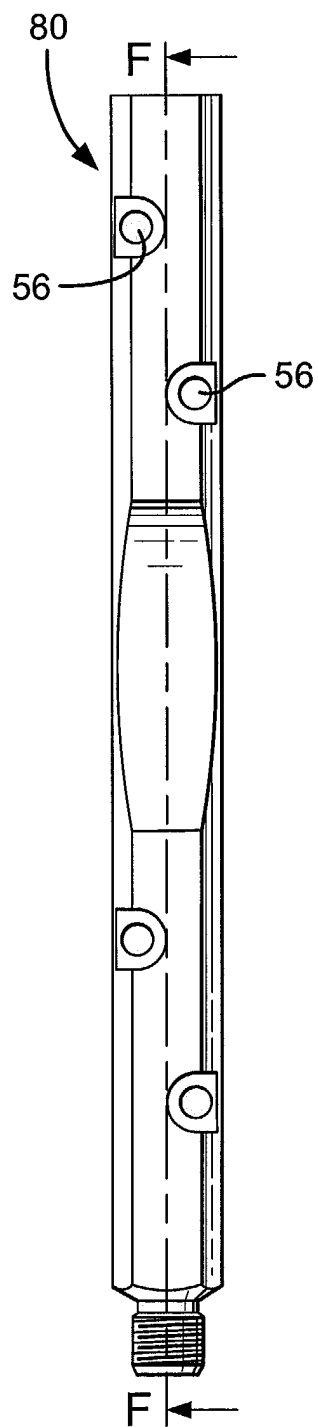


Fig. 7a

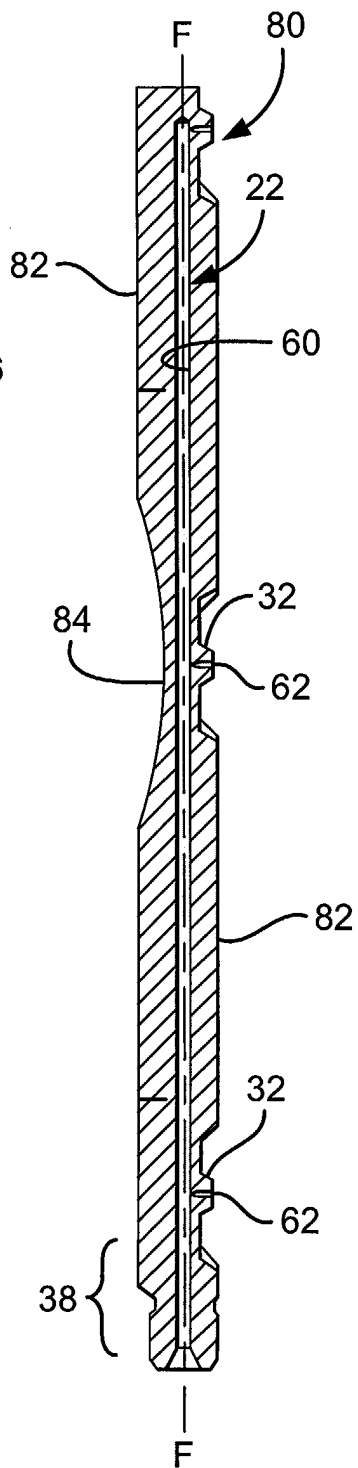


Fig. 7b

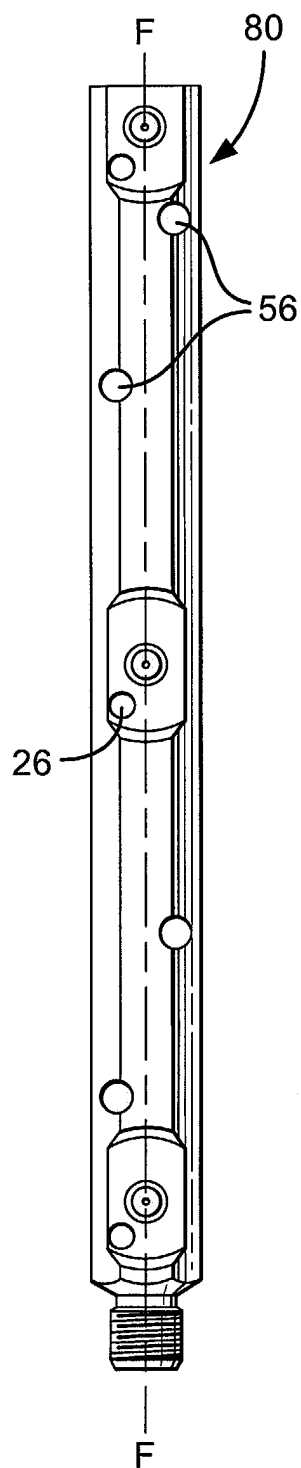


Fig. 7c