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(71) Applicant: **Delphi Technologies, Inc.**
Troy, MI 48007 (US)

(72) Inventors:
- **Hardy, Martin P.**
Gillingham
Kent ME7 3QZ (GB)
- **Balfour, Graham**
Hampton
Middlesex, TW12 2NG (GB)
- **Gris, Christian**
Blois, Cedex 41042 (FR)

(74) Representative: **Hopley, Joanne Selina et al**
David Keltie Associates,
Fleet Place House,
2 Fleet Place
London EC4M 7ET (GB)

(54) Injector mounting arrangement

(57) An injector mounting arrangement for use in an engine includes a fuel injector (14) mounted upon an engine cylinder housing (10) and a clamping arrangement (24) including a clamping member (26; 42) for applying a clamping load to the injector (14) so as to clamp the injector (14) to the cylinder housing (10). The clamping member (26; 42) defines, together with the cylinder housing (10), a clamp/cylinder interface region and, together with the injector (14) or a part (34) carried thereby, a clamp/injector interface region. The injector mounting arrangement is characterised by the provision of a decoupling material (30, 130, 430) in at least one of the clamp/cylinder interface region and the clamp/injector interface region to decouple, respectively, the clamping member (26, 42) from the cylinder housing (10) and/or the clamping member (26; 42) from the injector (14) so as to damp or substantially prevent transmission of injector generated noise to the cylinder housing (10).

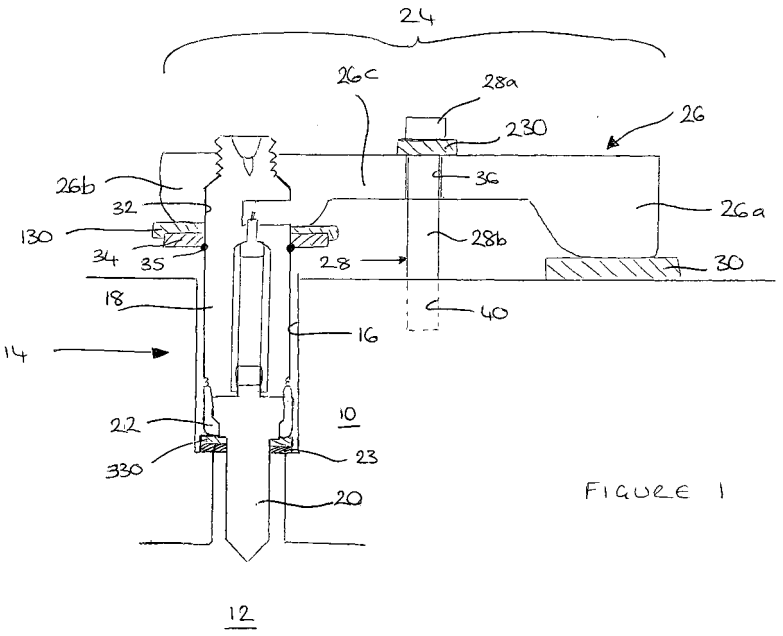

FIGURE 1

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Description

Technical Field

[0001] The present invention relates to an injector mounting arrangement comprising at least one fuel injector for delivering fuel to an associated engine cylinder or combustion space. In particular, but not exclusively, the invention relates to an injector mounting arrangement for a common rail engine including a plurality of piezoelectrically operable fuel injectors.

Background to the Invention

[0002] In known common rail fuel systems, a high pressure fuel pump is arranged to charge an accumulator volume in the form of a common rail with fuel at high pressure for delivery to a plurality of associated injectors. Each injector includes a valve needle which is movable by means of an actuator, towards and away from a valve seat, to control fuel injection through a plurality of injector outlets.

[0003] It is known to control valve needle movement by means of an electromagnetic actuator including a solenoid winding through which a current is passed to activate an armature. In turn, the armature controls a servo valve for controlling a control pressure applied to the valve needle and, hence, valve needle movement. It is also known, however, that particularly good injector performance can be achieved by using a piezoelectric actuator to drive movement of the valve needle. The piezoelectric actuator includes a stack of piezoelectric elements to which a voltage is applied to extend and contract the stack length. The actuator may be coupled directly to the valve needle so that, as the stack is retracted, the injector valve needle is caused to move with the stack retraction. Alternatively, the stack may be coupled to the valve needle via a motion amplifier (for example, a hydraulic amplifier). In other injectors the piezoelectric actuator controls valve needle movement indirectly through a servo valve.

[0004] One example of a piezoelectrically operable fuel injector is described in our granted European patent EP 0995901. Here, the piezoelectric actuator is coupled directly to the valve needle through a coupler having both hydraulic and mechanical coupling elements to provide variable amplification of movement of the valve needle.

[0005] Piezoelectric actuators provide a particular benefit over solenoid injectors as they are capable of generating high rates of force change which gives fast needle response. Injectors configured with direct acting piezoelectric actuators are particularly beneficial in this regard. However, one problem with using a direct acting piezoelectric actuator is that a greater mechanical force is required from the actuator in order to move the valve needle. Such high forces, and the associated high rates for force switching, are transmitted through the injector to the associated engine and result in an undesirable level of noise generation from the engine structure.

[0006] It is an object of the present invention to provide an engine in which the injectors can offer the benefits of a fast acting, high force actuator but in which the level of noise generation within the engine is substantially reduced.

Summary of Invention

[0007] According to a first aspect of the invention, there is provided an injector mounting arrangement for use in an engine, the injector mounting arrangement including a fuel injector mounted upon an engine cylinder housing, and a clamping arrangement including a clamping member for applying a clamping load to the injector so as to clamp the injector to the cylinder housing, wherein the clamping member defines, together with the cylinder housing, a clamp/cylinder interface region and, together with the injector or a part carried thereby, a clamp/injector interface region. The invention is characterised in that a decoupling material is provided in at least one of the clamp/cylinder interface region and the clamp/injector interface region to decouple, respectively, the clamping member from the cylinder housing and/or the clamping member from the injector so as to damp or substantially prevent transmission of injector generated noise to the cylinder housing.

[0008] For the purpose of this specification, a decoupling material is intended to mean one that not only decouples two parts from one another physically, but which suppresses noise transmission between the parts by virtue of its poor audible noise transmission properties. The decoupling material is selected as one which is a poor transmitter of sound (e.g. the speed of sound through the material is relatively low).

[0009] As the injector body and the clamping are separated from one another by decoupling material, and/or the cylinder housing and the clamping member are separated from one another by the decoupling material, the transmission of noise generated within the injector to the engine cylinder housing is substantially reduced due to the poor transmission of audible noise by the decoupling material. The invention provides a particular advantage in engines utilising piezoelectrically operable fuel injectors which require high actuation forces and high force switching rates (e.g. direct acting piezoelectric injectors). Equally, however, the present invention is applicable to engines utilising indirect-acting piezoelectric injectors or electromagnetically operable fuel injectors.

[0010] It is known to provide the injector with a clamping ring part to define the clamp/injector interface region, so in a preferred embodiment the decoupling material is provided between the clamping ring part and the clamping member.

[0011] In a preferred embodiment, the decoupling material is provided in a location between the clamping member and the injector or the part carried thereby, in the clamp/injector interface region.

[0012] In a further preferred embodiment, the clamp/cylinder interface region and the clamp/injector interface region are provided with the decoupling material so that the clamping member is decoupled from both the cylinder housing and the injector.

[0013] By way of example, the clamping member may take the form of a clamping fork wherein one end of the fork defines the clamp/injector interface region, together with the injector or the part carried thereby, and the other end of the fork defines the clamp/cylinder interface region together with the cylinder housing.

[0014] The clamping arrangement may further include a clamping bolt which is received by the clamping fork and the cylinder housing to apply the clamping load to the injector.

[0015] The clamping bolt and the clamping member together define a clamp/bolt interface region, and a further decoupling material is provided in the clamp/bolt interface region to decouple the clamping member from the clamping bolt. For example, the further decoupling material may be located between a head of the bolt and a surface of the clamping member in the clamp/bolt interface region. Preferably, the further decoupling material is the same type of the material as the decoupling material in the clamp/cylinder interface region and/or the clamp/injector interface region.

[0016] Preferably, a washer is provided in a location between the head of the bolt and the surface of the clamping member, either between the bolt head and the clamping member or between the further decoupling material and the clamping member. It is known to provide a washer between the bolt head and the clamping fork, so it will be appreciated that the inclusion of the decoupling material in the clamp/bolt interface region introduces an additional component to the arrangement

[0017] The injector is preferably mounted within a cap nut which defines, together with a washer carried by the injector, a further interface region, and wherein a still further decoupling material is provided at the further interface region.

[0018] The decoupling material at the or each interface region preferably takes the form of a washer, disc or other prefabricated part and is selected to have poor noise and/or vibration transmission properties.

[0019] In an alternative embodiment to the clamping fork, the clamping arrangement may include an annular clamping member (e.g. a gland nut) through which a portion of the injector is received, wherein the annular member is received within the cylinder housing and defines, together with the injector or a part carried thereby (e.g. a clamping ring), the clamp/injector interface region. The clamp/injector interface region is provided with a decoupling material to decouple the annular clamping member from the injector or the part carried thereby (e.g. the clamping ring part). If the injector carries a clamping ring part, this clamping ring defines, together with the clamping member, the clamp/injector interface region.

[0020] According to a second aspect of the invention, there is provided an injector mounting arrangement for an engine, including a fuel injector mounted to an engine cylinder housing and a clamping arrangement for applying a clamping load to the injector so as to clamp the injector to the cylinder housing. The clamping arrangement includes a clamping member which defines, together with the cylinder housing, a clamp/cylinder interface region and, together with the injector or a part carried thereby, a clamp/injector interface region, and a clamping bolt for applying the clamping load. This aspect of the invention is characterised in that the clamping member and the clamping bolt define a clamp/bolt interface region housing a washer and an additional decoupling material, whereby the decoupling material serves to damp or substantially prevent transmission of injector generated noise to the cylinder housing.

[0021] The additional decoupling material is a separate material from the washer usually provided, although may be a layer of decoupling material affixed to the washer itself for convenient.

[0022] It will be appreciated that preferred and/or optional features of the first aspect of the invention may be provided in the second aspect of the invention also, alone or in appropriate combination.

Brief Description of Drawings

[0023] An embodiment of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is schematic diagram of an injector mounting arrangement in accordance with an embodiment of the invention,

Figure 2 is a schematic diagram to illustrate the possible noise transmission paths between the injector, the engine cylinder head and the clamping arrangement for the mounting arrangement in Figure 1; and

Figure 3 is a schematic diagram of an injector mounting arrangement of an alternative embodiment to that shown in Figure 1.

Detailed Description of Preferred Embodiments

[0024] Referring to Figure 1, an injector mounting arrangement in accordance with a first embodiment of the invention includes an engine housing part in the form of an engine cylinder head 10 which defines a cylinder volume, or engine combustion space 12. The arrangement is provided with a plurality of fuel injectors 14, each of which is mounted within a respective opening or bore 16 provided in a respective cylinder head 10. Only one of the injectors is shown in Figure 1 and only one will be described in detail as all of the injectors are substantially identical. One or more outlets (not shown) of the injector 14 projects into the cylinder volume 12 so as to permit

injection of fuel for combustion.

[0025] The injector 14 typically takes the form of the piezoelectrically operable type including a piezoelectric actuator which is coupled, by means of a motion amplifier, to a fuel injector valve needle. The valve needle is moveable under the control of the actuator towards and away from a valve needle seat so as to control the injection of fuel through the injector outlets into the cylinder volume 12. The injector may be of the direct-acting type, for example as described in our granted European patent EP 0995901, or may be a servo-actuated piezoelectric injector. Alternatively, the injectors may be of the electromagnetically actuated type.

[0026] The injector 14 includes a main injector body 18 which protects through the uppermost end of the cylinder head bore 16. An injection nozzle 20 of the injector 14, which is provided with the injector outlets, projects through the lowermost end of the bore 16 into the cylinder volume 12. The injection nozzle 20 is mounted to the main injector body 18 by means of a cap nut 22, with a washer 23 carried on the injector body 18 between the cap nut 22 and the cylinder head 10. The underside of the cap nut 22 and the upper surface of the washer 23 together define what will be referred to as the cap nut/washer interface region.

[0027] As the engine undergoes a high level of vibration during operation it is necessary to ensure the injector 14 is mounted securely to the main engine structure. For this purpose a clamping arrangement, referred to generally as 24, is provided including a clamping member 26 and a clamping bolt 28. The clamping member 26 takes the form of a clamping fork having a first region at one end which defines a fork heel 26a, a second region at the other end which defines a fork nose 26b and an intermediate section 26c connecting the first and second regions 26a, 26b.

[0028] The fork heel 26a defines, together with an upper surface of the cylinder head 10, a clamp/cylinder interface region between the clamping fork 26 and the cylinder head 10 which is provided with a decoupling member formed from a sample 30 of decoupling material. The decoupling material 30 spaces apart the fork heel 26a and the cylinder head 10 so that they are isolated from one another (i.e. the decoupling material 30 is sandwiched between the fork heel and the cylinder head surface).

[0029] At the other end of the clamping fork 26, the main injector body 18 extends into a first drilling or through bore 32 provided in the fork nose 26b. The main injector body 18 carries a clamping ring 34 which bears on a circlip 35 located within an annular groove provided on the injector body 18. An upper surface of the clamping ring 34 defines, together with the underside of the fork nose 26b, a clamp/injector interface region between the ring 34 and the injector 14. The clamping ring 34 forms a separate part from the injector body 18 in the illustration shown, but equally may form an integral part of the injector body 18 itself. In another variation, the circlip 35 may be removed and instead the injector body 18 may be provided with a step or other projection for the clamping ring 34 to bear against.

[0030] The clamp/injector interface region is provided with a decoupling member in the form of a sample 130 of decoupling material, preferably the same material as the decoupling material 30 in the clamp/cylinder interface region, so that the clamping ring 34 and the fork nose 26b are isolated from one another (i.e. the decoupling material 130 is sandwiched between the fork nose and the clamping ring).

[0031] The intermediate section 26c of the clamping fork 26 is provided with a drilling or through bore 36 for receiving a stem 28b of the clamping bolt 28 so that a bolt head 28a projects through one side of the drilling 36 and the bolt stem 28b projects through the other side of the drilling 36. The end of the stem 28b remote from the bolt head 28a extends into a further drilling 40 provided in the upper surface of the cylinder head 10 so that, as the bolt 28 is tightened into the drilling 40, a clamping load is applied to the injector 14 at the clamp/injector interface region to clamp the parts together. An interface region between the underside of the clamping bolt head 28a and the upper surface of the clamping fork 26 (referred to as the clamp/bolt interface region) is also provided with a sample 230 of decoupling material, which isolates the clamping bolt head 28a from the clamping member 26 so that the two parts do not make contact. A washer (not shown) is also provided in the clamp/bolt interface region in a conventional manner. Preferably, the sample 230 of decoupling material at the clamp/bolt interface is of the same material as the samples 130, 30 at the clamp/injector and clamp/cylinder interface regions.

[0032] In addition to the decoupling material provided at the clamp/injector, clamp/cylinder and clamp/bolt interface regions, a sample 330 of decoupling material may be introduced at the interface region between the cap nut 22 and the washer 23 in the cap nut/washer interface region. The way in which the injector 14 mounts to the engine structure is shown in schematic form in Figure 2.

[0033] The decoupling material provided at each of the interface regions is selected to be a material having poor noise transmission at audible frequencies. Any material for which the speed of sound in the material is relatively low is suitable i.e. any material having a relatively high density and a relatively low stiffness compared with that of the interfacing components. It is also preferable for the decoupling material to have good thermal stability, good fretting resistance, good creep resistance and good compressive strength. By way of example, a reinforced composite material made from metal fibres and a phenolic matrix may be used (for example, brake pad material).

[0034] During engine operation, due to the high mechanical forces generated by the piezoelectric actuator and the high rate of force switching, the injector 14 generates a reasonably high degree of audible noise. In a conventional engine set-up this noise is transmitted

through the interface regions between the clamping member and the injector, and/or between the injector and the cylinder head and/or between the clamping member and the cylinder head, causing injector generated noise to be propagated through the cylinder head to the main engine structure (e.g. as illustrated by Figure 2). In the present invention, however, noise transmission is suppressed due to the provision of the decoupling material at one or more of the key interface regions in the load paths; the clamp/injector interface region, the clamp/cylinder interface region, the clamp/bolt interface region and/or the injector/cylinder interface region. In this way a high proportion of the sound energy generated by the injector is absorbed by the decoupling material. In addition, vibration transmission is reduced due to the injector, clamp and cylinder parts being isolated from one another physically.

[0035] The decoupling material at the various interfaces takes the form of a pre-fabricated piece which is received at the desired location during mounting of the injector 14 to the cylinder head 10. For example, the decoupling material at the clamp/bolt interface and the clamp/injector interface may take the form of an annular member or washer. The sample of decoupling material 30 at the clamp/cylinder interface may be provided with a recess to locate the fork heel 26a or, in an alternative embodiment, the sample 30 may itself form an integral part of the fork 26.

[0036] Figure 3 shows an alternative way of mounting the injector 14 to the engine cylinder head 10, wherein the clamping arrangement includes an annular member in the form of a gland nut 42. The main injector body 18 extends into the cylinder head bore 16 and, by means of a screw thread 46 into the bore 16, provides a clamping load to a clamping ring 34 and its circlip 35 (as in the Figure 1 embodiment). In a modification, the clamping ring 34 forms an integral part of the injector body itself, rather than being a separate component.

[0037] A sample of decoupling material 430 is provided within the clamping load path between the gland nut 42 and the clamping ring 34 (i.e. at the clamp/injector interface through which the clamping load is applied to the injector 14) to ensure noise transmission is suppressed between the injector and the clamping arrangement. At the lower end of the injector a sample 30 of decoupling material is provided between the cap nut 22 and the washer 23, as described for the Figure 1 embodiment. The embodiment of Figure 3 therefore provides the same benefits as the embodiment in Figure 1.

[0038] In a modification, the positions of the clamping ring 34 and the decoupling material 430 may be reversed to achieve the same effect, although this may be less desirable than providing flat surface-to-surface contact on either side of the sample 430.

[0039] It will be appreciated that various modifications of the embodiments described previously are also possible whilst still falling within the scope of the invention as set out in the claims. For example, the decoupling material need not be provided at every interface location, and an adequate reduction in noise transmission may be achieved by providing the material at just one or two locations. Other mounting arrangements for the injector are also envisaged, as would be familiar to persons skilled in this field of technology, and it will be appreciated that the use of the decoupling material in accordance with the invention is equally applicable to these arrangements also.

Claims

1. An injector mounting arrangement for use in an engine, the injector mounting arrangement including:

a fuel injector (14),
an engine cylinder housing (10), and
a clamping arrangement (24) including a clamping member (26; 42) for applying a clamping load to the injector (14) so as to clamp the injector (14) to the cylinder housing (10), wherein the clamping member (26; 42) defines, together with the cylinder housing (10), a clamp/cylinder interface region and, together with the injector (14) or a part (34) carried thereby, a clamp/injector interface region,
characterised in that a decoupling material (30, 130, 430) is provided in at least one of the clamp/cylinder interface region and the clamp/injector interface region to decouple, respectively, the clamping member (26, 42) from the cylinder housing (10) and/or the clamping member (26; 42) from the injector (14) so as to damp or substantially prevent transmission of injector generated noise to the cylinder housing (10).

2. The injector mounting arrangement as claimed in claim 1, wherein the decoupling material (130, 430) is provided between the clamping member (26) and the injector (14) or the part (34) carried thereby, in the clamp/injector interface region.

3. The injector mounting arrangement as claimed in claim 2, wherein both the clamp/cylinder interface region and the clamp/injector interface region are provided with the decoupling material (30; 130) so that the clamping member (26) is decoupled from both the cylinder housing (10) and the injector (14).

4. The injector mounting arrangement as claimed in any one of claims 1 to 3, wherein the clamping arrangement further includes a clamping bolt (28) which is received by the clamping member (26) and the cylinder housing (10) to apply the clamping load to the injector (14).

5. The injector mounting arrangement as claimed in

claim 4, wherein the clamping bolt (28) and the clamping member (26) together define a clamp/bolt interface region, and wherein a further decoupling material (230) is provided at the clamp/bolt interface region to decouple the clamping member (26) from the clamping bolt (28).

6. The injector mounting arrangement as claimed in claim 5, wherein the further decoupling material (230) is located at a position between a head (28a) of the bolt (28) and a surface of the clamping member (26) in the clamp/bolt interface region.

7. The injector mounting arrangement as claimed in claim 6, wherein a washer is also provided in a location between the head (28a) of the bolt (28) and the surface of the clamping member (26), together with the further decoupling material (23).

8. The injector mounting arrangement as claimed in claim 1 or claim 2, wherein the clamping arrangement includes an annular clamping member (42) received within the cylinder head (10) for applying a clamping load to the injector (14), wherein the clamp/injector interface region is provided with a decoupling material (430) to decouple the annular clamping member (42) from the injector (14) or the part carried thereby (34).

9. The injector mounting arrangement as claimed in any one of claims 1 to 8, wherein the injector (14) is mounted within a cap nut (22) which defines, together with a washer (23) carried by the injector (14), a further interface region, and wherein a decoupling material (330) is further provided at the further interface region.

10. The injector mounting arrangement as claimed in any one of claims 1 to 9, wherein the decoupling material (30, 130, 230; 330; 430) at the or each interface region takes the form of a washer, disc or other prefabricated member.

11. The injector mounting arrangement as claimed in any one of claims 1 to 10, wherein the decoupling material (30, 130, 230; 330) at the or each interface region is selected to have poor noise and/or vibration transmission properties.

12. The injector mounting arrangement as claimed in any one of claims 1 to 11, wherein the injector (14) carries a clamping ring part (34) to define, together with the clamping member (26, 42), the clamp/injector interface region.

13. An injector mounting arrangement for an engine, the injector mounting arrangement including:

a fuel injector (14) mounted to an engine cylinder housing (10), and

a clamping arrangement (26, 42) for applying a clamping load to the injector (14) so as to clamp the injector (14) to the cylinder housing (10), the clamping arrangement including a clamping member (26) which defines, together with the cylinder housing (10), a clamp/cylinder interface region and, together with the injector (14) or a part (34) carried thereby, a clamp/injector interface region, and a clamping bolt (28) for applying the clamping load to the injector (14),

characterised in that the clamping member (26) and the clamping bolt (28) define a clamp/bolt interface region housing a washer and a decoupling material (230), the decoupling material (230) being a separate component from the washer, whereby the decoupling material (23) serves to damp or substantially prevent transmission of injector generated noise to the cylinder housing (10).

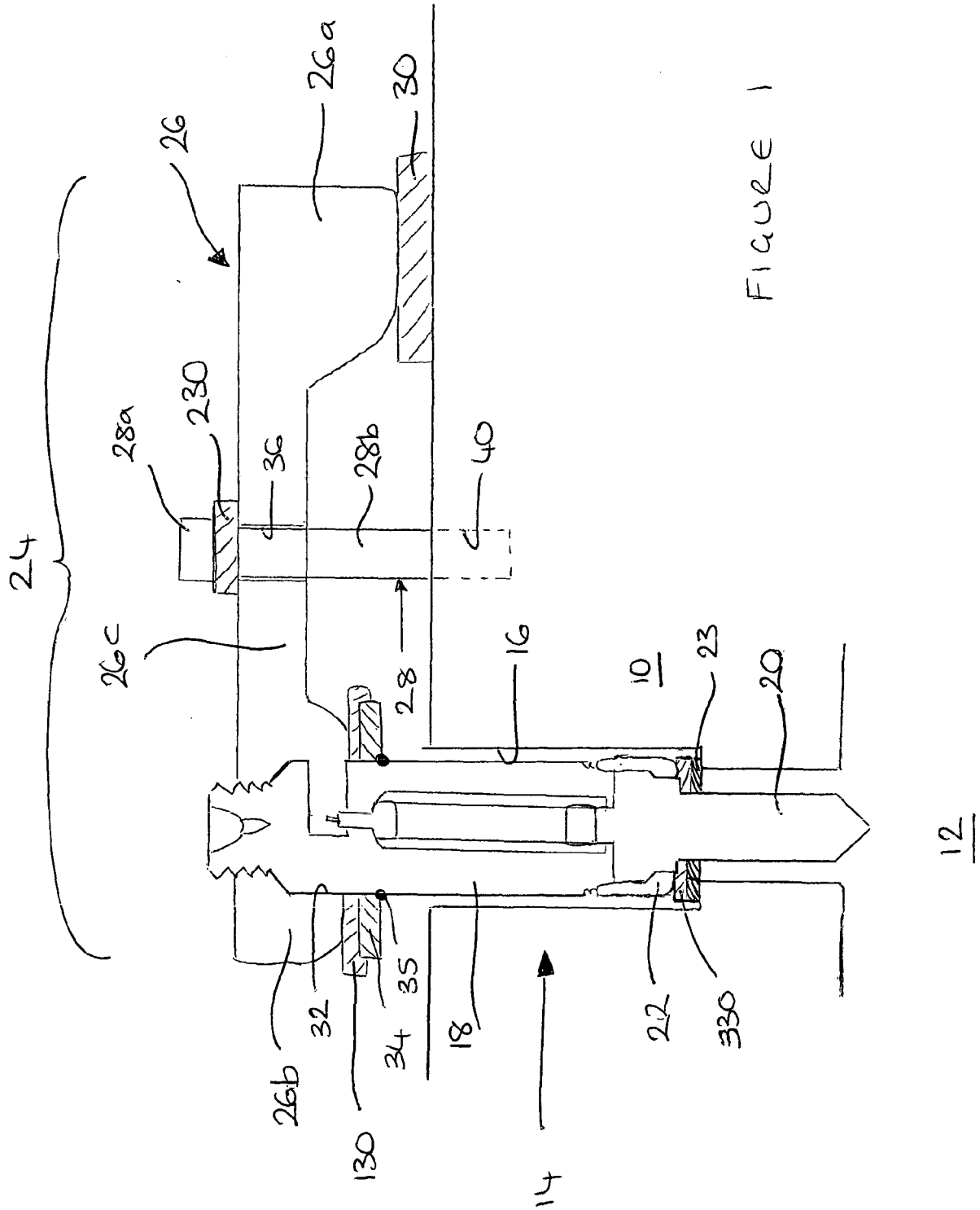
24
26
26a
30
28a
230
36
28b
40
26c
28
16
10
23
20
12
26b
32
34
35
18
130
14
22
330

FIGURE 1

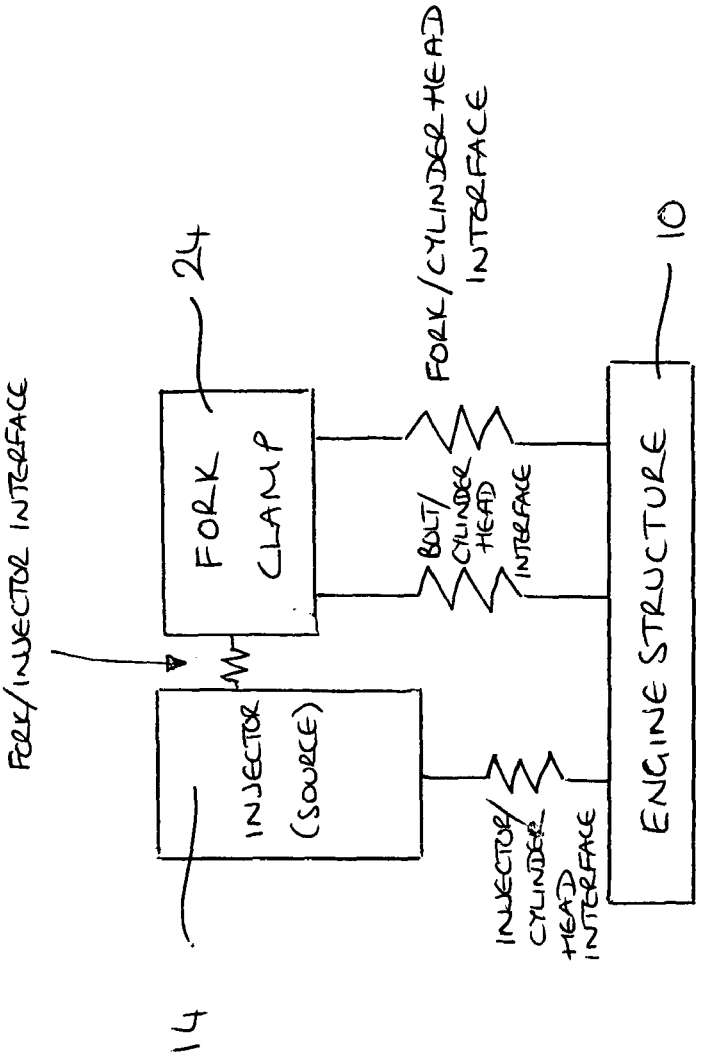
FORK/INJECTOR INTERFACE
24
FORK CLAMP
FORK/CYLINDER HEAD INTERFACE
10
BOLT/ CYLINDER HEAD INTERFACE
INJECTOR (SOURCE)
ENGINE STRUCTURE
INJECTOR/ CYLINDER HEAD INTERFACE
14

FIGURE 2

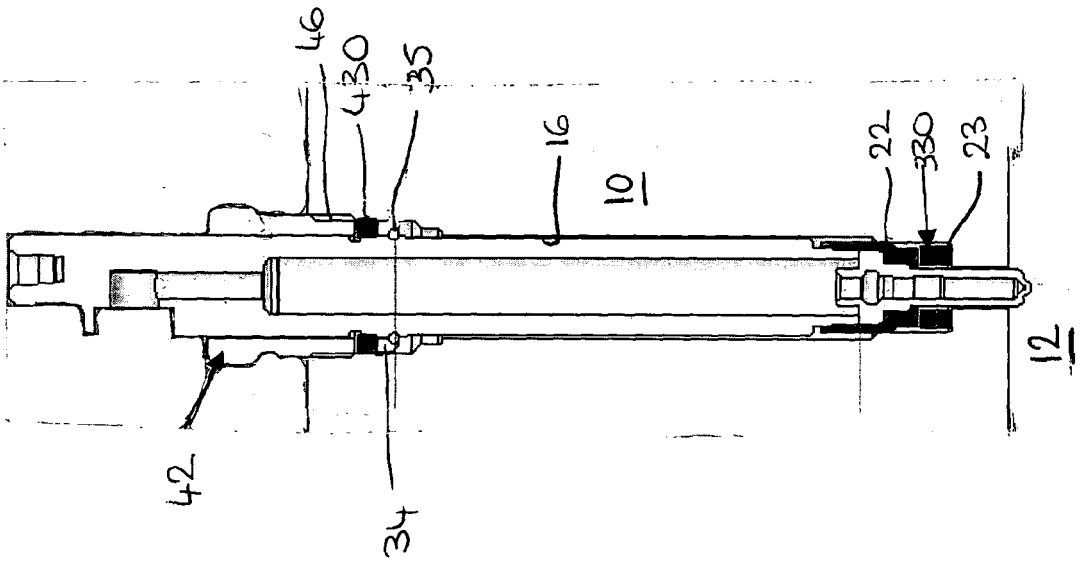

FIGURE 3

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EUROPEAN SEARCH REPORT

Application Number
EP 05 25 5732

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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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TECHNICAL FIELDS SEARCHED (IPC)

F02M
F02F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	9 December 2005	Kolland, U

CATEGORY OF CITED DOCUMENTS

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09-12-2005

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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