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(54) **Integrated air-fuel manifold for an internal combustion engine, and relative production method**

(57) An integrated air-fuel manifold for an internal combustion engine (1) having a number of cylinders (3) formed in a cylinder head (2). The integrated air-fuel manifold has an intake manifold (4) which is made of a first material, supplies air to the cylinders (3), and has connecting means for mechanical connection to the cylinder head (2) of the engine (1); and a fuel manifold (11) which is made of a second material, different from the first material, distributes pressurized fuel to injectors (12) fitted to the cylinders (3), and is incorporated in the intake manifold (4).

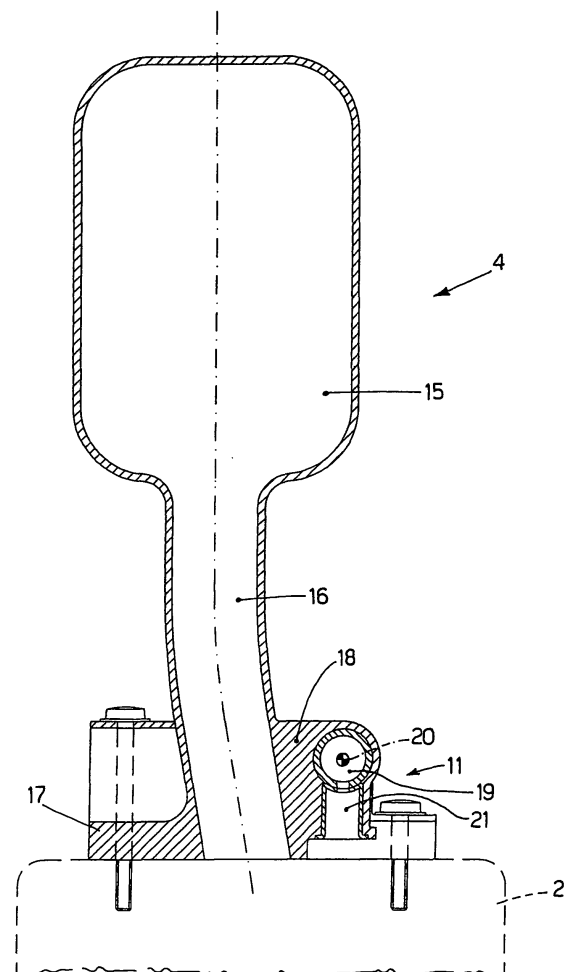


Fig.3

Description

TECHNICAL FIELD

[0001] The present invention relates to an integrated air-fuel manifold for an internal combustion engine, and relative production method.

[0002] The present invention may be used to particular advantage in a direct-petrol-injection, internal combustion engine, to which the following description refers purely by way of example.

BACKGROUND ART

[0003] The past few years have seen a continual increase in sales of direct-petrol-injection, internal combustion engines. In an engine of this sort, pressurized petrol is fed to a fuel manifold connected to a number of injectors (one for each engine cylinder), which are activated cyclically to inject part of the pressurized petrol in the fuel manifold directly into the respective cylinders.

[0004] In an indirect-petrol-injection engine, the petrol in the fuel manifold is at fairly low pressure (normally 2 to 4 atmospheres). Consequently, fuel manifolds of indirect-petrol-injection engines are currently made of plastic material (typically, molded engineering polymers), on the grounds that it is easy to process and cheap. In an indirect-petrol-injection engine, the intake (or air) manifold is also made of plastic material and fixed by screws to the fuel manifold.

[0005] Conversely, the petrol pressure in the fuel manifold of a direct-petrol-injection engine is fairly high (currently between 100 and 200 atmospheres). A plastic fuel manifold has poor mechanical characteristics, and is therefore unable to safely withstand the relatively high petrol pressures typical of direct petrol injection.

[0006] To ensure the necessary mechanical strength, known direct-petrol-injection engines employ all-steel fuel manifolds, which are expensive to produce, on account of the amount of machining and welding involved. Moreover, this solution calls for fitting the steel fuel manifold with a connecting flange for connection to the intake (or air) manifold, and which must be machined separately, thus further increasing machining cost.

[0007] A shell-cast aluminium fuel manifold has been proposed, but is also expensive to produce, on account of shell casting being a relatively slow process, requiring numerous machining operations once the piece is removed from the mold, and imposing minimum piece thicknesses of 4-5 mm. To reduce the machining cost of cast aluminium fuel manifolds, die-casting using thixotropic aluminium has been proposed. Tests, however, show aluminium fuel manifolds fail to provide for consistent, satisfactory mechanical strength, particularly with petrol pressures in the fuel manifold of over 150 atmospheres. Moreover, an aluminium fuel manifold fails to ensure satisfactory resistance to corrosion by various currently marketed fuels (in particular containing large per-

centages of ethyl or methyl alcohol), so that the petrol-exposed parts of the fuel manifold must be anodized or nickel plated. Both are complex, high-cost processes which tests have shown do not always succeed in ensuring the necessary corrosion resistance, particularly on account of the relatively high temperature of the petrol in the fuel manifold (even exceeding 100°C) during normal operation of the engine.

[0008] As described in Patent Application IT2004BO00114, a two-material fuel manifold has also been proposed, comprising a steel feed conduit for feeding the pressurized fuel to the injectors; and a connecting body, which incorporates the feed conduit, provides for mechanically connecting the fuel manifold inside the engine, is made of molded plastic or cast aluminium, and is produced by forming the plastic material or aluminium in a mold containing the feed conduit.

[0009] As stated, the fuel manifold is normally fixed to the intake (or air) manifold at the interface with the cylinder head. Because of the high operating pressure and the strict requirements imposed by the location of the fuel manifold, complex, dedicated systems are required, designed to support and fasten the fuel manifold firmly and reliably. These problems apply, to a greater or lesser extent, to any type of engine featuring a fuel manifold fixed to an air manifold. Conventional manufacturing solutions comprise steel fuel manifolds, to which metal brackets are soldered, and which are fitted by screws to air manifolds normally made of injection-molded engineering polymers. The metal brackets, however, being specially designed for individual applications, have a manufacturing cost which is partly determined by the impossibility of exploiting standard engine layouts.

DISCLOSURE OF INVENTION

[0010] It is an object of the present invention to provide an integrated air-fuel manifold for an internal combustion engine, and relative production method; which manifold and method are designed to eliminate the aforementioned drawbacks and, in particular, are cheap and easy to implement.

[0011] According to the present invention, there are provided an integrated air-fuel manifold for an internal combustion engine, and relative production method, as recited in the accompanying Claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] A number of non-limiting embodiments of the present invention will be described by way of example with reference to the accompanying drawings, in which:

Figure 1 shows a schematic view of a direct-petrol-injection, internal combustion engine featuring an integrated air-fuel manifold in accordance with the present invention;

Figure 2 shows a schematic front view of part of the

Figure 1 integrated air-fuel manifold fitted to a cylinder head of the Figure 1 engine;

Figure 3 shows a lateral section along line III-III of the Figure 2 integrated air-fuel manifold;

Figure 4 shows a schematic lateral section of part of an alternative embodiment of an integrated air-fuel manifold fitted to a cylinder head of the Figure 1 engine.

PREFERRED EMBODIMENT OF THE INVENTION

[0013] Number 1 in Figure 1 indicates as a whole an internal combustion engine comprising a cylinder head 2, in which are formed four cylinders 3 (only one shown in Figure 1), each of which is connected to an intake (or air) manifold 4 by at least one intake valve 5, and to an exhaust manifold 6 by at least one exhaust valve 7. Intake manifold 4 is supplied with fresh air (i.e. from outside) via a throttle valve 8 adjustable between a closed position and a fully-open position. An exhaust pipe 9 extends from exhaust manifold 6, and has one or more catalysts (not shown) for emitting into the atmosphere the gases produced by combustion in cylinders 3.

[0014] A low-pressure pump (not shown) feeds petrol from a tank (not shown) to a high-pressure pump 10, which in turn feeds the petrol to a fuel manifold 11. A number of injectors 12 (one for each cylinder 3) are connected to fuel manifold 11, and each is activated cyclically to inject part of the pressurized petrol in fuel manifold 11 into respective cylinder 3. The petrol in fuel manifold 11 is maintained instant by instant at a desired pressure by a pressure regulator 13 connected to fuel manifold 11, and which drains any surplus petrol into a recirculating channel, by which the surplus petrol is fed back to a point upstream from the low-pressure pump (not shown). Fuel manifold 11 is also fitted with a sensor 14 to measure the pressure of the petrol in fuel manifold 11.

[0015] As shown more clearly in Figures 2 and 3, intake manifold 4 comprises an elongated main body 15 connected to throttle valve 8, and from which originate four intake pipes 16 (only two shown in Figure 2), each connecting main body 15 to a cylinder 3. More specifically, each intake pipe 16 terminates with a connecting flange 17, which is common to all of intake pipes 16 and provides for fitting intake manifold 4 to cylinder head 2 of engine 1. Intake manifold 4 also comprises a housing body 18 positioned contacting both connecting flange 17 and intake pipes 16, and incorporating fuel manifold 11. In other words, fuel manifold 11 is incorporated inside intake manifold 4 or, more specifically, inside housing body 18 of intake manifold 4, so that intake manifold 4 and fuel manifold 11 form an integrated air-fuel manifold.

[0016] Fuel manifold 11 comprises a cylindrical tubular main channel 19 having a central axis 20 of symmetry, and which distributes pressurized petrol to injectors 12. From main channel 19 extend four cylindrical tubular secondary channels (or bowls) 21, each of which is perpendicular to main channel 19 and houses a top portion of

an injector 12 in fluidtight manner. As shown in Figure 1, main channel 19 has two open opposite ends 22 and 23; end 22 is connected to high-pressure pump 10 to feed pressurized petrol to fuel manifold 11; and end 23 is closed by a screw cap (not shown), and provides for easier, more precise manufacture of main channel 19 when forming fuel manifold 11. Close to end 23, main channel 19 has an opening (not shown) for receiving pressure regulator 13, and another opening (not shown) for receiving pressure sensor 14.

[0017] Figure 4 shows an alternative embodiment of the integrated air-fuel manifold, which substantially differs as regards the shape of connecting flange 17 and housing body 18.

[0018] Intake manifold 4 (comprising main body 15, intake pipes 16, connecting flange 17, and housing body 18) is made of molded plastic material, whereas fuel manifold 11 is made of steel. In other words, intake manifold 4, which is complex in shape and not subjected to severe mechanical or chemical stress, is made of a first material which is cheap, easy to work, and of low strength; whereas fuel manifold 11, which is simple in shape and subjected to severe mechanical and chemical stress, is made of a second material which is more expensive, more complex to work, and of high strength. An important point to note is that mechanical connection of fuel manifold 11 to cylinder head 2 of engine 1 is achieved by mechanically connecting intake manifold 4 to cylinder head 2 of engine 1; and mechanical connection of fuel manifold 11 to intake manifold 4 is achieved by incorporating fuel manifold 11 inside intake manifold 4. As a result, fuel manifold 11 is extremely simple and linear in shape, by requiring no connecting elements (bored flanges or similar).

[0019] Since intake manifold 4 does not come into contact with the petrol, and therefore need withstand neither petrol pressure nor petrol-induced corrosion, the first material of intake manifold 4 is one which is cheap and easy to work. Preferably, the first material of intake manifold 4 is a thermoplastic or thermosetting plastic material, such as an engineering polymer, ABS, nylon, or epoxy resin. Alternatively, if greater mechanical strength is required, the first material of intake manifold 4 may be a metal, such as aluminium or thixotropic aluminium. An important requirement of the first material is that it have a lower melting point than the second material, so that the first material can be formed inside a mold containing fuel manifold 11, made of the second material, without damaging or deforming fuel manifold 11.

[0020] Since fuel manifold 11, in use, comes into contact with pressurized petrol, the second material of fuel manifold 11 is one of both good mechanical strength and good corrosion resistance, preferably stainless steel (e.g. a series 300 stainless steel, such as stainless steel 316). Alternatively, if greater corrosion resistance than that of stainless steel is required, the second material of fuel manifold 11 may be a nickel alloy.

[0021] It is important to note that petrol pressure re-

sistance is entrusted solely to fuel manifold 11. That is to say, though the mechanical strength of fuel manifold 11 is enhanced slightly by housing body 18 surrounding it, fuel manifold 11 is nevertheless designed to withstand fuel pressure unaided.

[0022] The integrated air-fuel manifold therefore comprises an intake manifold 4, which is made of a first (plastic) material, provides for mechanical connection to cylinder head 2 of engine 1, and feeds air to cylinders 3; and a fuel manifold 11, which is made of a second material (stainless steel), is incorporated in housing body 18 of intake manifold 4, and distributes pressurized petrol to injectors 12.

[0023] The integrated air-fuel manifold comprising intake manifold 4 and fuel manifold 11, as described above, is produced by producing steel fuel manifold 11 separately from intake manifold 4; placing fuel manifold 11 inside a known mold (not shown) negatively reproducing the shape of intake manifold 4; and feeding plastic material into the mold to form intake manifold 4 around fuel manifold 11. The plastic material is preferably injected into the mold containing fuel manifold 11. Fuel manifold 11 may be produced by either welding secondary channels 21 to main channel 19, or hydroforming a one-piece metal pipe.

[0024] Operating as described above, fuel manifold 11 is substantially embedded inside housing body 18 of intake manifold 4. That is, housing body 18 of intake manifold 4 encases substantially the whole of fuel manifold 11, but obviously leaves exposed, and accessible from outside, at least end 22 of main channel 19, which must be connected to high-pressure pump 10; the open ends of secondary channels 21, for receiving injectors 12; and the openings (not shown) for pressure regulator 13 and pressure sensor 14.

[0025] The integrated air-fuel manifold therefore comprises an inner part (fuel manifold 11) and an outer part (intake manifold 4), which perform different functions, are made of different materials, and are produced using two different manufacturing techniques. The inner part (fuel manifold 11), made of the second material, performs the structural functions of withstanding petrol pressure and petrol-induced corrosion; while the outer part (intake manifold 4), made of the first material, provides for mechanical connection of the integrated air-fuel manifold inside engine 1, and for air supply to cylinders 3. Dividing the functions between two separate parts enables the best geometry, material, and production process to be adopted for each.

[0026] The integrated air-fuel manifold comprising intake manifold 4 and fuel manifold 11, as described above, is extremely cheap and easy to produce, reduces assembly time of engine 1, and at the same time provides for excellent resistance to fuel pressure and fuel-induced corrosion.

[0027] More specifically, the integrated air-fuel manifold described above is cheap and easy to produce, by making intake manifold 4, which is complex in shape,

from a first low-cost material that is easy to work, and by making fuel manifold 11, which is simple in shape, from a second material that is more difficult to work.

[0028] The fuel manifold described above may obviously also be used to advantage in an internal combustion engine fuelled with other than petrol, such as LPG, methane, alcohol, or diesel fuel.

10 Claims

1. An integrated air-fuel manifold for an internal combustion engine (1) comprising a number of cylinders (3) formed in a cylinder head (2); the integrated air-fuel manifold comprising:

an intake manifold (4) which is made of a first material, supplies air to the cylinders (3), and has connecting means for mechanical connection to the cylinder head (2) of the engine (1); and a fuel manifold (11) which is made of a second material, different from the first material, and distributes pressurized fuel to injectors (12) fitted to the cylinders (3);

the integrated air-fuel manifold being **characterized in that** the fuel manifold (11) is incorporated in the intake manifold (4).

2. An integrated air-fuel manifold as claimed in Claim 1, wherein the first material is a plastic material, and the second material is a metal material.

3. An integrated air-fuel manifold as claimed in Claim 2, wherein the second material is stainless steel.

4. An integrated air-fuel manifold as claimed in Claim 2 or 3, wherein the first material is a thermoplastic plastic material.

5. An integrated air-fuel manifold as claimed in Claim 2 or 3, wherein the first material is a thermosetting plastic material.

6. An integrated air-fuel manifold as claimed in one of Claims 1 to 5, wherein the intake manifold (4) comprises an elongated main body (15), from which extend a number of intake pipes (16), each connecting the main body (15) to a cylinder (3).

7. An integrated air-fuel manifold as claimed in Claim 6, wherein each intake pipe (16) terminates with a connecting flange (17), which is common to all the intake pipes (16) and permits mechanical connection of the intake manifold (4) to the cylinder head (2) of the engine (1).

8. An integrated air-fuel manifold as claimed in Claim 7, wherein the intake manifold (4) comprises a hous-

ing body (18) positioned contacting both the connecting flange (17) and the intake pipes (16), and which incorporates the fuel manifold (11).

9. An integrated air-fuel manifold as claimed in one of Claims 1 to 8, wherein the fuel manifold (11) comprises a cylindrical tubular main channel (19), from which extend a number of secondary channels (21), each perpendicular to the main channel (19) and housing an injector (12) in fluidtight manner. 5
10. An integrated air-fuel manifold as claimed in Claim 9, wherein the main channel (19) has an open first end (22) connectable to a fuel pump (10) for feeding pressurized fuel into the main channel (19). 10 15
11. An integrated air-fuel manifold as claimed in Claim 10, wherein the main channel (19) has an open second end (23) opposite the open first end (22) and closed by a screw cap. 20
12. An integrated air-fuel manifold as claimed in Claim 11, wherein, close to the second end (23), the main channel (19) has a first opening for receiving a pressure regulator (13), and a second opening for receiving a pressure sensor (14). 25
13. A method of producing an integrated air-fuel manifold for an internal combustion engine (1) comprising a number of cylinders (3) formed in a cylinder head (2); the integrated air-fuel manifold comprising: 30
an intake manifold (4) which is made of a first material, supplies air to the cylinders (3), and has connecting means (17) for mechanical connection to the cylinder head (2) of the engine (1); and 35
a fuel manifold (11) which is made of a second material, different from the first material, and distributes pressurized fuel to injectors (12) fitted to the cylinders (3); 40
the method being **characterized by** comprising the steps of:
making the fuel manifold (11) from the second material separately from the intake manifold (4); 45
placing the fuel manifold (11) inside a mold negatively reproducing the shape of the intake manifold (4); and 50
forming the intake manifold (4) about the fuel manifold (11) by feeding at least the first material into the mold so that the fuel manifold (11) is incorporated in the intake manifold (4). 55
14. A method as claimed in Claim 13, wherein the first material is a plastic material, and the second material

is a metal material.

15. A method as claimed in Claim 14, wherein the second material is stainless steel.
16. A method as claimed in Claim 13, 14 or 15, wherein the first material is fed into the mold containing the fuel manifold (11) by means of an injection process.
17. A method as claimed in Claim 13, 14 or 15, wherein the first material is fed into the mold containing the fuel manifold (11) by means of a die-casting process.

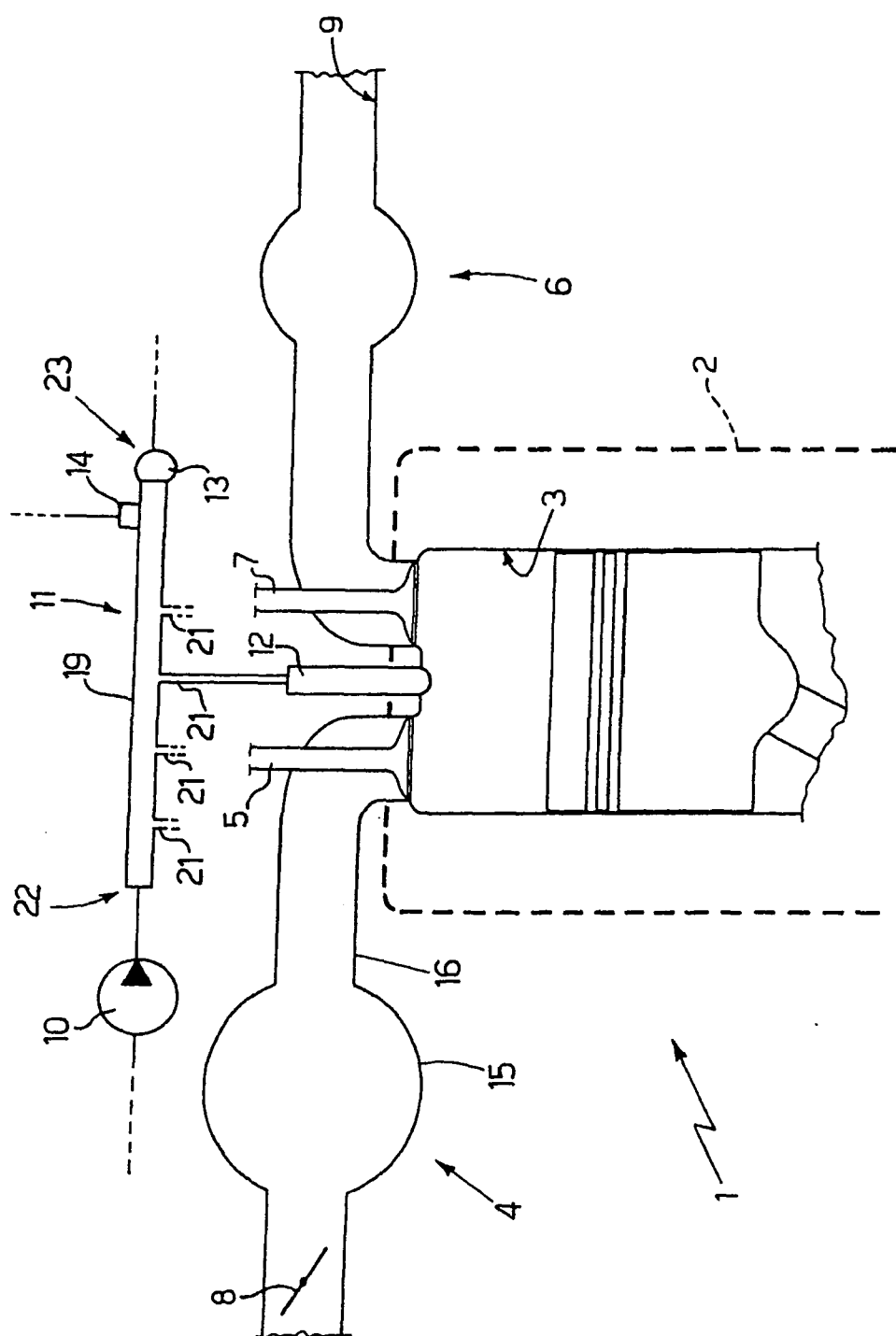


Fig. 1

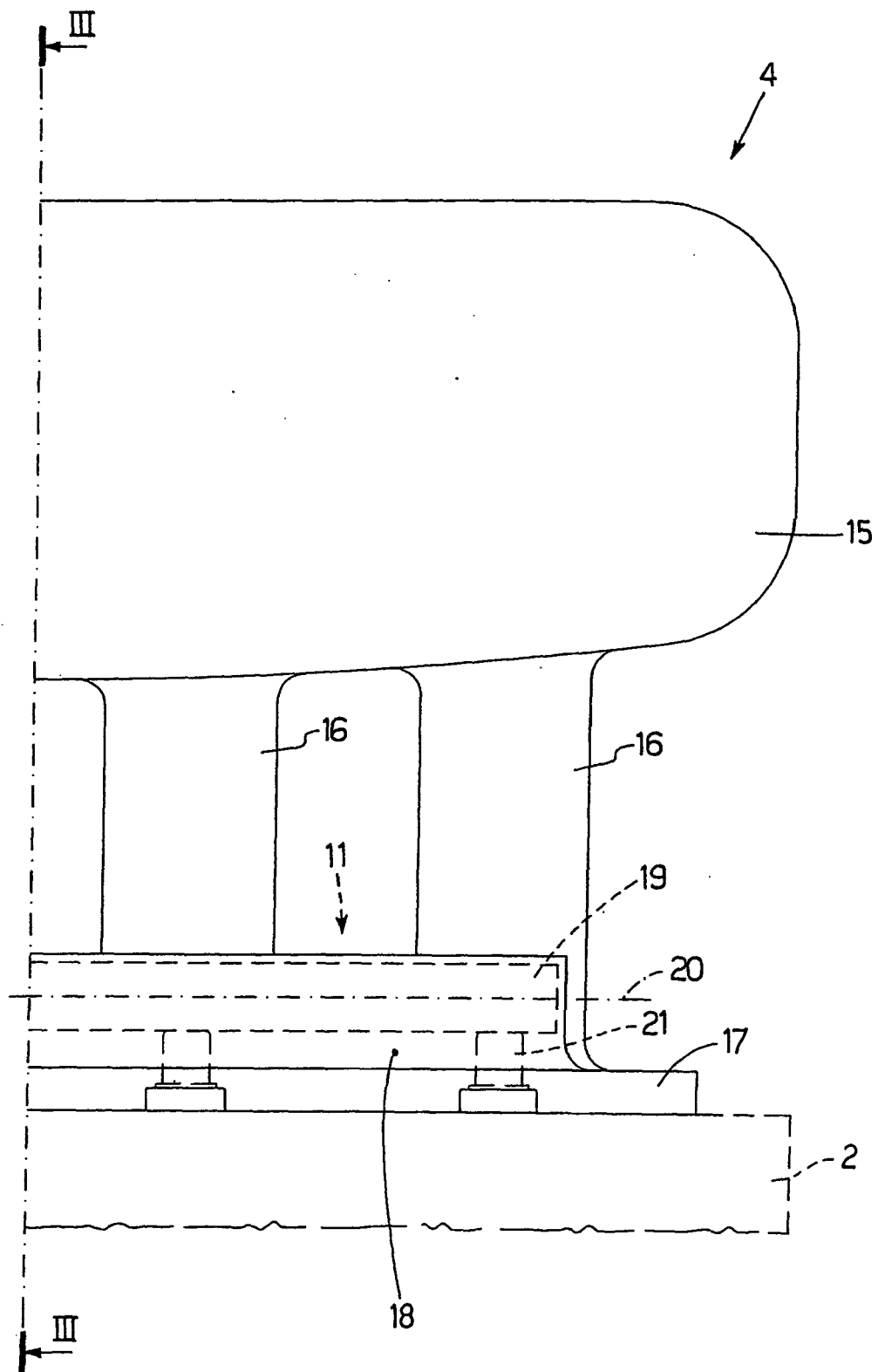


Fig.2

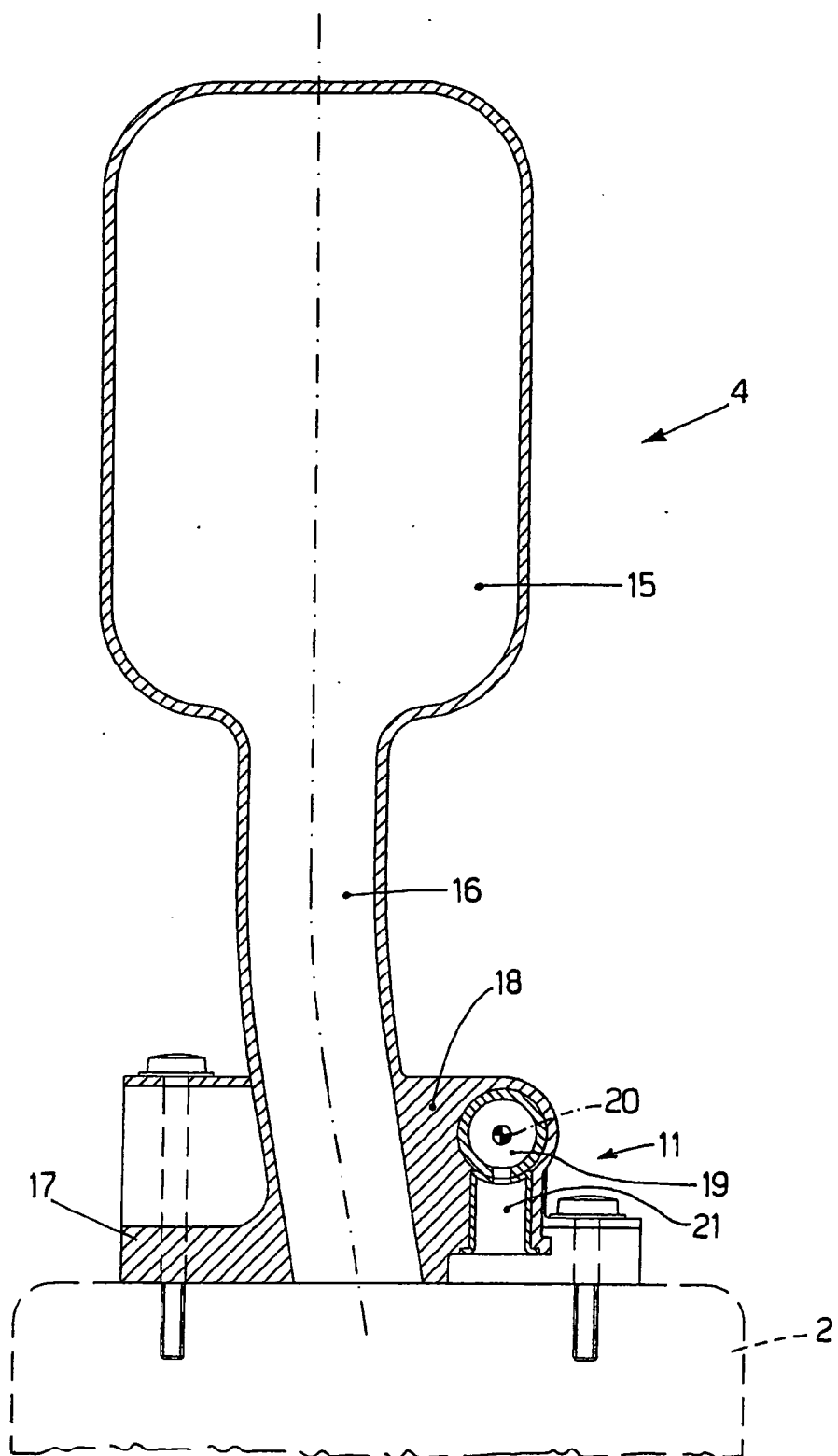


Fig.3

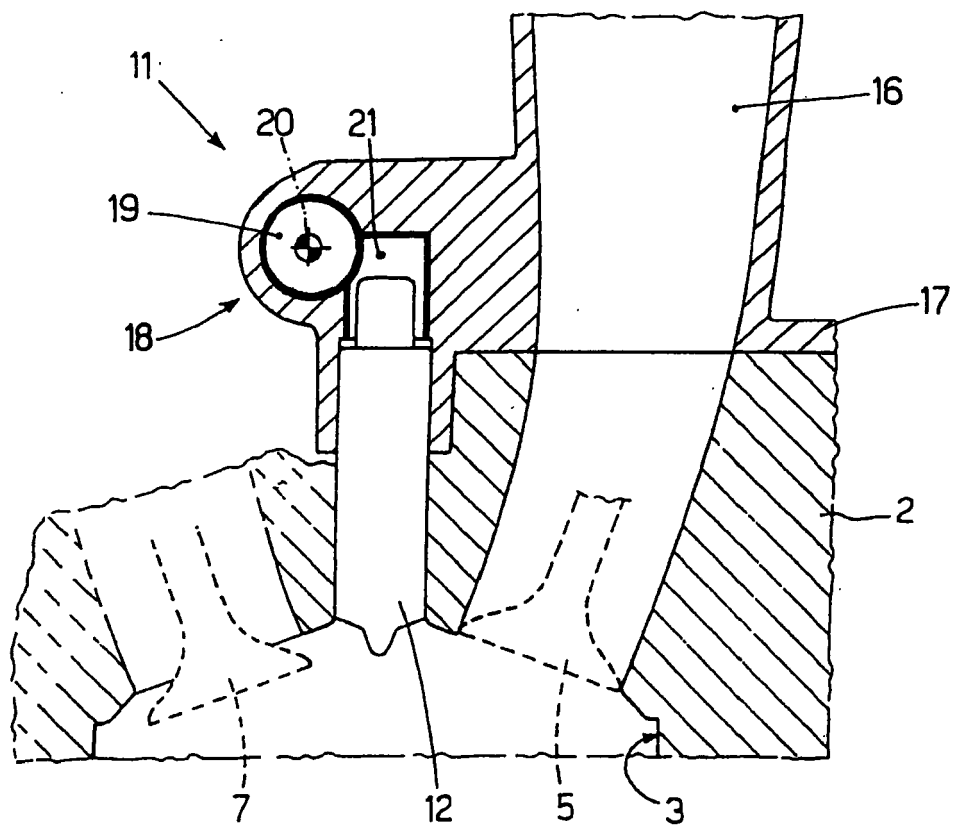


Fig.4



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 05 42 5618

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Place of search Munich		Date of completion of the search 28 December 2005	Examiner Marsano, F
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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