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<p>(21) International Application Number: PCT/IB97/00781</p> <p>(22) International Filing Date: 16 June 1997 (16.06.97)</p> <p>(30) Priority Data: 9612971.3 20 June 1996 (20.06.96) GB</p> <p>(71)(72) Applicant and Inventor: OMARSSON, Kristján, Björn [IS/IS]; Grund, Villingsholtshreppi, IS-801 Selfoss (IS).</p> <p>(74) Agent: BROOKS, Nigel; Hill Hampton, East Meon, Petersfield, Hampshire GU32 1QN (GB).</p>	<p>(81) Designated States: AL, AM, AT, AU, AZ, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).</p> <p>Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p>	
<p>(54) Title: FUEL-AIR MIXTURE APPARATUS</p>		
<p>(57) Abstract</p> <p>Fuel-air mixture apparatus (1) has a body (2) adapted for connection via a flange (3) to an air cleaner housing (3') and to an engine inlet manifold (4'). In the body (2) is arranged a primary air passage (5) having an inlet (6), an adjustable throttle (7), a throat (8) and an outlet (9). The throttle will be connected in use to a speed control device for the engine via a linkage (10). Also provided in the body (2) is a secondary air passage (13) having an inlet (14) from the air cleaner housing and an outlet (15) to the primary air passage (5) at the throat (8). Towards its downstream end, the secondary air passage opens into a chamber (16), with the opening (17) being arranged tangentially to the chamber to induce swirling air flow in the chamber. The outlet (11) is provided axially of the chamber. At the other end of the chamber, in a bore (18) in the body a nozzle device (21) is provided. It has a circumferential void (24) to the body. This void has a fuel supply bore (25) in the body (2) and connected to a continuous fuel pump opening into it. A fuel inlet (26) leads from the void to an internal bore in the sleeve (22). Slidably mounted in the sleeve is a guide (27), sealed to the sleeve via a gland (28). The outside end of the guide carries a compression spring (29) and the end of the guide is closed by a plug (30) providing an abutment for the spring, whereby the guide is urged outwards. The guide has a bore (31) in which a needle (32) is slidably mounted. The arrangement is such that when the plug (30) is pushed fully inwards of the body, as on closure of the throttle, the needle closes the aperture (38) and the fuel supply to the engine, but the force with which the needle is urged into the aperture is regulated by the internal spring (33). In use, the plug (30) is acted on by an abutment member (40), which is movable in step with the throttle (7) via a branch of the linkage (10). The linkage is designed to ensure that the stoichiometrically required amount of fuel is provided for the throttle opening.</p>		

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FUEL-AIR MIXTURE APPARATUSBackground of the Invention

The present invention relates to a fuel-air mixture apparatus, particularly for an
5 internal combustion engine.

Fuel-air mixture apparatuses of the type where fuel is mixed with air prior to
induction into the cylinder(s) of an engine generally rely on a pressure reduction at a
throttle in the device to draw fuel into the device, in which case the device is known as
10 a carburettor, or rely on fuel injection into the air as it passes through the device.

Generally, the prior devices rely on a single stage of mixture of fuel and air and
are limited as regards the droplet size and total vaporisation of the fuel in the air which
they induce. Inadequate vaporisation and too large a droplet size result in unburned
15 and/or incompletely burnt fuel being present in the exhaust from the engine.

The Invention

The object of the present invention is to provide a fuel-air mixture apparatus
which causes low quantities of unburned and incompletely burnt fuel to be present in
20 the exhaust.

The fuel-air mixture apparatus of my invention comprises:
a primary air passage having an inlet, an adjustable throttle and an outlet,
a secondary air passage having an inlet and an outlet to the primary air passage
25 between its adjustable throttle and its outlet and
a nozzle for introducing fuel into the secondary air passage, whereby in use the
fuel mixes with the air flowing through this passage prior to mixing with the air
flowing in the primary air passage.

30 Whilst it can be envisaged that the nozzle should be a fixed orifice nozzle, it
preferably has a variable orifice. In the preferred embodiments, the nozzle has a
tapered needle in its mouth to provide variability by axial movement of the needle. In
one embodiment, the needle has a small bead, preferably a small ball or invert cone, at

its tip for inducing divergence of the fuel as it flows from the end of the needle and/or for discouraging fuel flow to the point of the needle and linear drop formation from the point.

5 Normally, the inlet of the primary air passage will be connected to an air cleaner and the outlet will be connected to an inlet manifold of an internal combustion engine.

The inlet of the secondary air passage can be from the primary air passage
10 between its inlet and its throttle. Alternatively the inlets to the two air passages can be independent of each other, but normally downstream of the same air cleaner.

The outlet of the secondary air passage may be provided at a fixed throat in the primary air passage, to induce increased air flow speed in the primary passage and
15 reduced pressure at the outlet of the secondary air passage for enhanced air flow in the secondary air passage. In one embodiment, a plurality of outlets from the secondary air passage are provided at the fixed throat. The secondary air passage has a branch surrounding the primary air passage, the said outlets being from the branch and spaced around the primary air passage.

20

In one embodiment, the secondary air passage is provided with a constriction for inducing increased air flow speed therethrough and the nozzle is arranged at the constriction whereby the fuel is mixed with the air at its region of increased flow speed. The constriction can be formed as an annular space between the nozzle or the needle
25 and a ring. Preferably the ring has up- and down-stream bevels meeting at an edge for inducing turbulence.

In another embodiment, the secondary air passage is provided with a chamber, with the nozzle being arranged to inject fuel into the chamber for initial fuel-air mixing
30 in the chamber. The passage may have a constriction at the upstream and/or downstream ends of the chamber. When at the downstream end, the constriction can be at the outlet from the secondary air passage to the primary air passage.

The constriction(s) is/are preferably configured to induce turbulence in the air flow in the secondary air passage, to enhance the mixing of the fuel with the air, suitably by forming the constriction with a pair of bevels meeting at an edge.

5

Alternatively, or in addition to the constriction(s), the portion of the secondary air passage upstream of the chamber may approach the chamber at least substantially tangentially thereto, so as to induce swirling of the air flow in the chamber. In this embodiment, the nozzle is preferably arranged to introduce the fuel at the centre of the swirl, whence it can radiate for mixing with the air.

10

In one embodiment, the nozzle is so arranged that the fuel leaving its orifice impinges on an ultrasonic transducer for comminution of the fuel into small droplets.

15

In one embodiment, a linkage is provided for linking the needle to the adjustable throttle in the primary air passage for adjustment of the orifice of the nozzle, whereby the fuel flow from the nozzle is matched to the air flow in the two passages.

20

In another embodiment, a control device is provided for servo control of the nozzle orifice is in accordance with measurement(s) of throttle position and/or engine parameters including the composition of the exhaust from the engine, whereby the fuel flow from the nozzle is matched to the air flow in the two passages.

25

Whilst it can be envisaged that fuel flow from the nozzle may be induced by depressed pressure in the device at the nozzle's orifice, normally a pump will be provided for pumping fuel will be pumped to the nozzle. Preferably, the pump will be adapted to deliver fuel to the nozzle at substantially constant pressure.

30

It is envisaged that the fuel may be gaseous or liquid.

The Drawings

To help understanding of the invention, three specific embodiments thereof will now be described by way of example and with reference to the accompanying drawings, in which:

Figure 1 is a lateral cross-sectional view of a body of a fuel-air mixture
5 apparatus according to the invention,

Figure 2 is a scrap cross-sectional view on the line II-II in Figure 1 of a mixture chamber in a secondary air passage,

Figure 3 is similar cross-sectional view as Figure 1, but on a larger scale, of a nozzle device of the fuel-air mixture apparatus,

10 Figure 4 is a plan cross-sectional view of a second fuel-air mixture apparatus according to the invention,

Figure 5 is a view similar to Figure 4 of a variant of the second fuel-air mixture apparatus,

15 Figure 6 is a cross-sectional side view showing throttles in the primary air passage and

Figure 7 is a view similar to Figure 1 of a third fuel-air mixture apparatus according to the invention.

First Embodiment

20 The fuel-air mixture apparatus 1 has a body 2 adapted for connection via a flange 3 to an air cleaner housing 3' (only partially shown) and via a spigot 4 to an engine inlet manifold 4' (again only partially shown). In the body 2 is arranged a primary air passage 5 having an inlet 6, an adjustable throttle 7, a throat 8 and an outlet
25 9. The throttle will be connected in use to a speed control device for the engine (not shown), typically an accelerator pedal of a car or a governor, via a linkage 10. The throat is provided in a tubular insert 11, with the internal diameter of the throat chosen to match the size of the engine to which the device 1 is fitted. Where the throat is smaller than that shown in Figure 1, the tubular insert may have an upper extension as far as the throttle 7, which is provided with a smaller butterfly 12 to suit.

30

Also provided in the body 2 is a secondary air passage 13 having an inlet 14 from the air cleaner housing and an outlet 15 to the primary air passage 5. This is at the throat 8 and will be described in more detail below. Towards its downstream end,

the secondary air passage opens into a chamber 16, with the opening 17 being arranged tangentially to the chamber to induce swirling air flow in the chamber. The outlet 11 is provided axially of the chamber.

5 At the other end of the chamber, in a bore 18 in the body a nozzle device 21 is provided. It comprises a main sleeve 22 having two O-ring grooves 23 for O-rings 23' sealing a circumferential void 24 to the body. This void has a fuel supply bore 25 in the body 2 and connected to a continuous fuel pump (not shown) opening into it. A fuel inlet 26 leads from the void to an internal bore in the sleeve 22. Slidably mounted
10 in the sleeve is a guide 27, sealed to the sleeve via a gland 28. The outside end of the guide carries a compression spring 29 and the end of the guide is closed by a plug 30 providing an abutment for the spring, whereby the guide is urged outwards.

 The guide has a bore 31 in which a needle 32 is slidably mounted. A spring 33
15 acts between the plug 30 and a washer 34 acting on an O-ring 34' abutting a head 35 of the needle. The latter has a point 36, carrying a small ball 37, which extends through a gauged aperture 38 in the end of the sleeve 22. This arrangement is such that when the plug 30 is pushed fully inwards of the body, as on closure of the throttle, the needle closes the aperture 38 and the fuel supply to the engine, but the force with which the
20 needle is urged into the aperture is regulated by the internal spring 33.

 In use, the plug 30 is acted on by an abutment member 40, which is movable in step with the throttle 7 via a branch of the linkage 10. The arrangement is such that as the throttle 7 is progressively opened, the abutment member is progressively
25 withdrawn to withdraw the needle point 36 from the aperture 38. This allows more fuel to flow through the bore 25, inlet 26 and aperture 38. The linkage is designed to ensure that the stoichiometrically required amount of fuel is provided for the throttle opening.

30 The major portion of the air drawn into the engine flows through the primary air passage 5. A small amount of air flows in the secondary air passage 13. As mentioned above, this air flow enters the chamber 16 and causes swirling air flow there. Fuel leaving the nozzle device 21 on the axis of the chamber spreads radially in

this air flow, mixing with it. The fuel is induced to leave the needle point 36 at the ball 37 in small droplets, which enhances vaporisation of the fuel. It and the air leaves the chamber at a constriction 40 in the insert 11, formed as a pair of up- and down-stream facing bevels 41,42 defining an edge 43, which induces further turbulence in the secondary air flow as it meets the primary air flow. This flow is also turbulent downstream of the throttle 7. The result is thorough mixing of the fuel and the air prior to induction into the engine. It should be noted that the fuel flows continuously from the nozzle device and mixes continuously with first the secondary air flow and then the primary air flow.

Second Embodiment

Turning now to Figure 4, a second embodiment is shown in which the nozzle device 121 is arranged tangentially to the primary air passage 105 and is of simpler construction, whereby its plug 130 is driven by a threaded shaft output (not shown) from a stepper motor 151 or a linearly controllable, electromagnetic actuator under control from an engine management computer 153, whose programming will be within the domain of the man skilled in the art and will not therefore be described. The computer 153 also controls a second stepper motor 152 connected to the throttle for controlling its position. In addition to the computer control of the needle 132, this embodiment includes an ultrasonic transducer 154 against the face 155 of which the fuel from the needle is introduced. This has the effect of disintegrating the fuel droplets for their vaporisation in the swirling secondary air flow. In other respects, this embodiment is similar to the embodiment of Figure 1.

Variant of the Second Embodiment

Figures 5 & 6 show a variant of the second embodiment, in which the secondary air passage has two branches 161,162 leading to two chambers 163,164. The first chamber 163, to which the first branch 161 leads, is similar to that 16 in the first embodiment, in that it accommodates the needle 165. The latter extends through a constriction 166, similar to that 40 of the first embodiment, and has a small invert cone 167 at its end. The cone is arranged to provide a sharp edge from which fuel droplets shed into the air-stream through the constriction. The second chamber 164 is fed with air from the second branch 162. The two secondary air-streams meet in the

region of a sonde 168 of an ultrasonic transducer 169. The fuel droplets from the needle impinge on the sonde and are comminuted. The secondary air flow with the fuel leaves the second chamber and enters an annular passage 170 behind a fixed throttle insert 171. The insert has two series of drillings 172, 173 equi-angularly spaced around it. Upper ones 172 of these are at smallest diameter section of the throttle and convey the bulk of the secondary air flow into the primary air flow through the throttle. The lower drillings 173 are drains from a groove 174 at the back of the insert, the groove being downwardly directed to drain any fuel liquid, which may accumulate therein, into the primary air passage 105. To arrange for the flow through the individual ones of the upper drillings 172 to be as even as possible, bearing in mind the longer flow path from the second chamber 164, the drillings further from this chamber are larger.

Third Embodiment

Turning on to Figure 7, the third embodiment there shown differs from the first and second embodiments in not having a chamber in its secondary air passage 213. Rather its nozzle device 221 incorporates a nose 261 mounted with the device in the bore 218 in the body 202. The nose has a lateral inlet 262 for the secondary air flow which impinges on a tip 263 of the needle sleeve 222 and is accelerated as it flows through a tapered outlet 264 of the nose. This outlet has a further taper 265 back-to-back with the taper 264, forming a constriction 266, causing the secondary air to be turbulent on leaving the nose. The constriction is arranged to be the outlet of the secondary air passage. The fuel introduction orifice, between the nozzle 221 and the needle 232 is close to the constriction, with the needle actually extending into the constriction. The arrangement induces fine fuel droplet formation and vaporisation of the fuel in the secondary air as it mixes with the primary air flow.

It should be noted that the engine management computer can enrich the fuel-air mixture for cold starting, but the degree of enrichment is less than that required with a conventional carburettor.

The invention is not intended to be restricted to the details of the above described invention. For instance, the engine management computer can incorporate

additional features, allowing adaptation of the apparatus to the type of fuel, grade of fuel and style of driving of the vehicle in which the apparatus is installed. Further, the invention find application other than in internal combustion engines. It may for instance be used in boilers.

CLAIMS:

1. A fuel-air mixture apparatus comprising:
a primary air passage having an inlet, an adjustable throttle and an outlet,
a secondary air passage having an inlet and an outlet to the primary air passage
5 between its adjustable throttle and its outlet and
a nozzle for introducing fuel into the secondary air passage, whereby in use the
fuel mixes with the air flowing through this passage prior to mixing with the air
flowing in the primary air passage.
2. A fuel-air mixture apparatus as claimed in claim 1, wherein the nozzle is a fixed
10 orifice nozzle.
3. A fuel-air mixture apparatus as claimed in claim 1, wherein, the nozzle is a
variable orifice.
4. A fuel-air mixture apparatus as claimed in claim 3, wherein the nozzle has a
tapered needle in its mouth to provide variability by axial movement of the needle.
- 15 5. A fuel-air mixture apparatus as claimed in claim 4, wherein the needle has a
small bead, preferably a small ball or invert cone, at its tip for discouraging fuel flow to
the point of the needle and linear drop formation from the point and/or for inducing
divergence of the fuel as it flows from the end of the needle.
6. A fuel-air mixture apparatus as claimed in any preceding claim, wherein the
20 inlet of the primary air passage is adapted to be connected to an air cleaner and the
outlet of the primary air passage is adapted to be connected to an inlet manifold of an
internal combustion engine.
7. A fuel-air mixture apparatus as claimed in any preceding claim, wherein the
inlet of the secondary air passage is from the primary air passage between its inlet and
25 its throttle.
8. A fuel-air mixture apparatus as claimed in any one of claims 1 to 6, wherein the
inlets to the two air passages can be independent of each other, but preferably
downstream of the same air cleaner.
9. A fuel-air mixture apparatus as claimed in any preceding claim, wherein the
30 outlet of the secondary air passage is provided at a fixed throat in the primary air
passage, the fixed throttle inducing increased air flow speed in the primary passage and
reduced pressure at the outlet of the secondary air passage for enhanced air flow in the
secondary air passage.

10. A fuel-air mixture apparatus as claimed in claim 9, wherein there are provided a plurality of outlets from the secondary air passage at the fixed throat.
11. A fuel-air mixture apparatus as claimed in claim 10, wherein the secondary air passage has a branch surrounding the primary air passage, the said outlets being from
5 the branch and spaced around the primary air passage.
12. A fuel-air mixture apparatus as claimed in any preceding claim, wherein the secondary air passage is provided with a constriction for inducing increased air flow speed therethrough and the nozzle is arranged at the constriction whereby the fuel is mixed with the air at its region of increased flow speed.
- 10 13. A fuel-air mixture apparatus as claimed in claim 12, wherein constriction is formed as an annular space between a ring and the nozzle or the needle - when provided.
14. A fuel-air mixture apparatus as claimed in claim 13, wherein the ring has up- and down-stream bevels meeting at an edge for inducing turbulence.
- 15 15. A fuel-air mixture apparatus as claimed in any preceding claim, wherein the secondary air passage is provided with a chamber, with the nozzle being arranged to inject fuel into the chamber for initial fuel-air mixing in the chamber.
16. A fuel-air mixture apparatus as claimed in claim 15, wherein the passage has a constriction at the upstream and/or downstream end(s) of the chamber.
- 20 17. A fuel-air mixture apparatus as claimed in claim 16, wherein the constriction is at the outlet from the secondary air passage to the primary air passage.
18. A fuel-air mixture apparatus as claimed in claim 16 or claim 17, wherein the constriction(s) is/are configured to induce turbulence in the air flow in the secondary air passage, to enhance the mixing of the fuel with the air, preferably by forming the
25 constriction with a pair of bevels meeting at an edge.
19. A fuel-air mixture apparatus as claimed in any one of claims 15 to 18, wherein a portion of the secondary air passage upstream of the chamber approaches the chamber at least substantially tangentially thereto, so as to induce swirling of the air flow in the chamber.
- 30 20. A fuel-air mixture apparatus as claimed in claim 19, wherein the nozzle is arranged to introduce the fuel at the centre of the swirl, whence it can radiate for mixing with the air.

21. A fuel-air mixture apparatus as claimed in claim 20, wherein the nozzle is so arranged that the fuel leaving its orifice impinges on an ultrasonic transducer for comminution of the fuel into small droplets.

22. A fuel-air mixture apparatus as claimed in claim 4 or claim 5 or any one of
5 claims 6 to 21 as appendant to claim 4 or claim 5, wherein a linkage is provided for linking the needle to the adjustable throttle in the primary air passage for adjustment of the orifice of the nozzle, whereby the fuel flow from the nozzle is matched to the air flow in the two passages.

23. A fuel-air mixture apparatus as claimed in claim 4 or claim 5 or any one of
10 claims 6 to 21 as appendant to claim 4 or claim 5, wherein a control device is provided for servo control of the nozzle orifice is in accordance with measurement(s) of throttle position and/or engine parameters including the composition of the exhaust from the engine, whereby the fuel flow from the nozzle is matched to the air flow in the two passages.

15 24. A fuel-air mixture apparatus as claimed in any preceding claim, wherein the apparatus is adapted and arranged for fuel flow from the nozzle to be induced by depressed pressure at the nozzle.

25. A fuel-air mixture apparatus as claimed in any one of claims 1 to 23, in combination with a pump provided for pumping fuel to the nozzle.

20 26. A fuel-air mixture apparatus as claimed in any claim 25, wherein the pump is adapted to deliver fuel to the nozzle at substantially constant pressure.

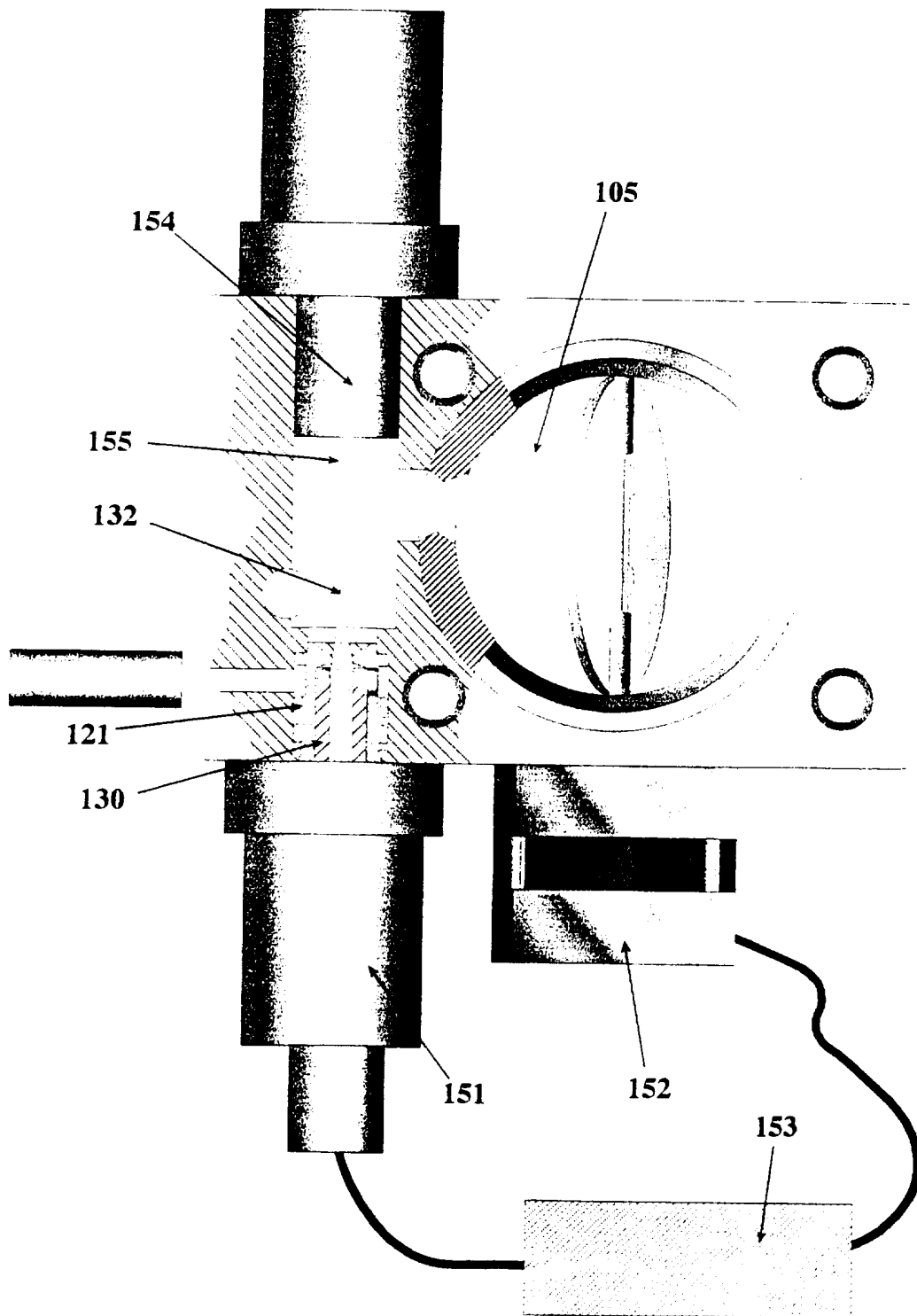
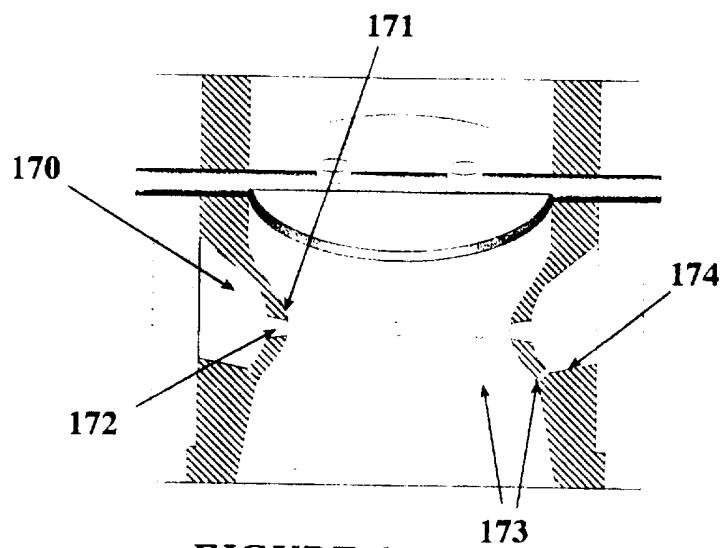
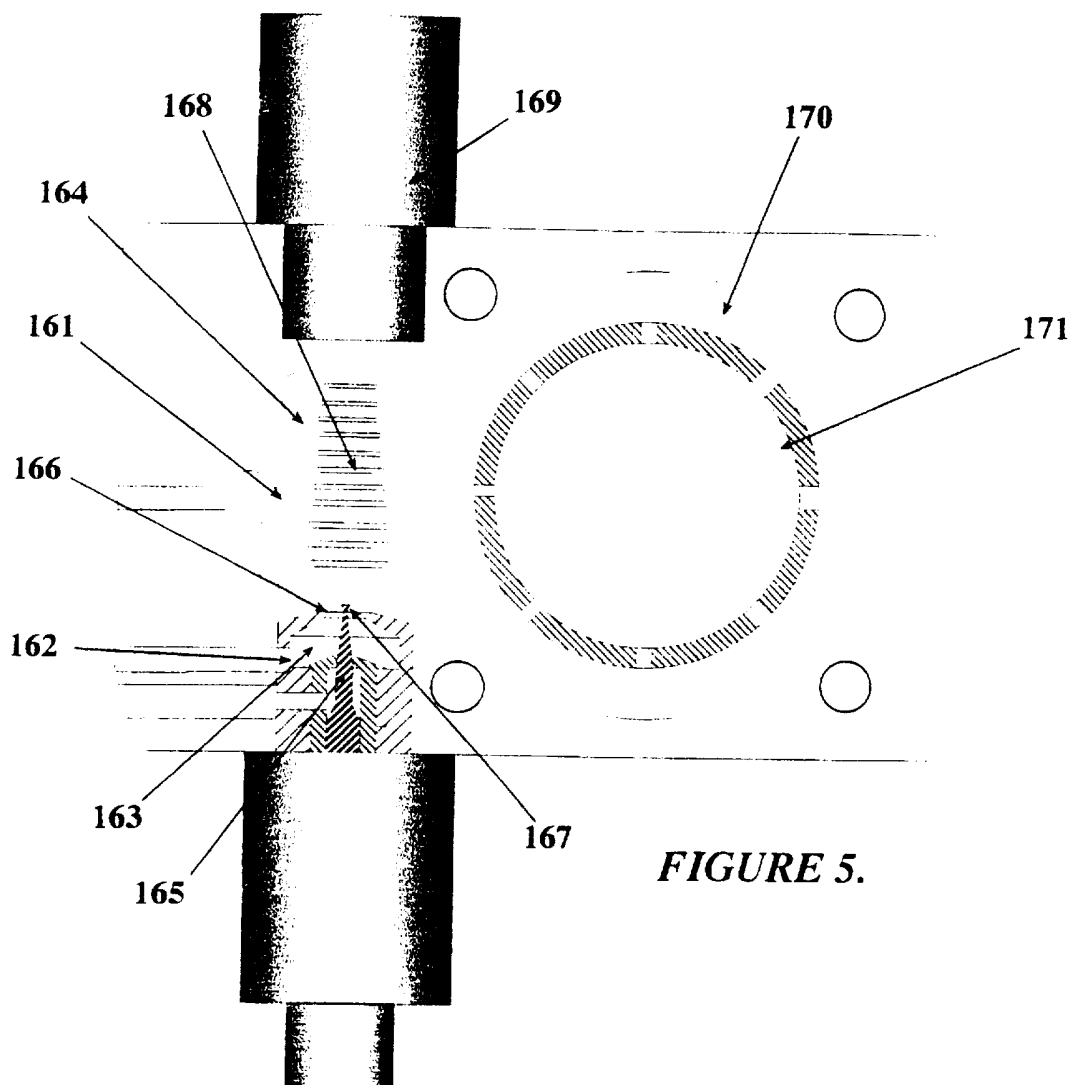


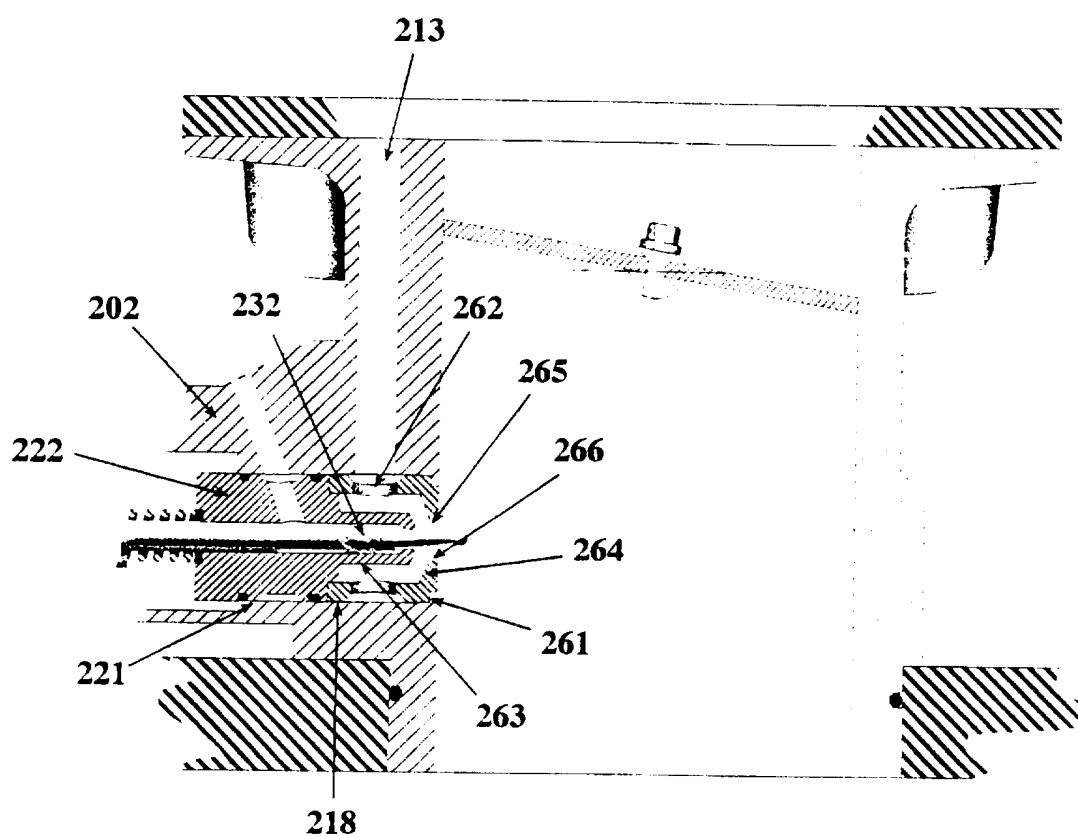
FIGURE 4.

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**FIGURE 7.**

INTERNATIONAL SEARCH REPORT

International Application No

PCT/IB 97/00781

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 F02M7/22 F02M69/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 F02M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	PATENT ABSTRACTS OF JAPAN vol. 5, no. 139 (M-086), 3 September 1981 & JP 56 072244 A (AUTOMOB ANTIPOLLUT & SAF RES CENTER), 16 June 1981, see abstract ---	1,3-5,7, 8,12,13, 15,16, 23,24
X	DE 28 19 474 A (TOYOTA) 9 November 1978 see page 12, line 28 - page 15, line 34; figures 1-3 --- -/--	1,3-7, 15-20, 25,26

☒ Further documents are listed in the continuation of box C.

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Date of the actual completion of the international search

2 October 1997

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14. 10. 97

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INTERNATIONAL SEARCH REPORT

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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