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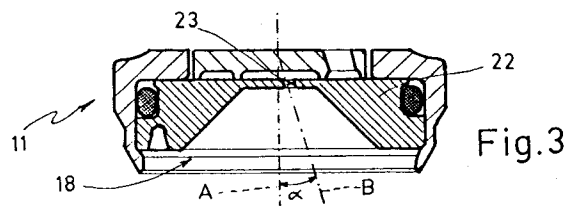
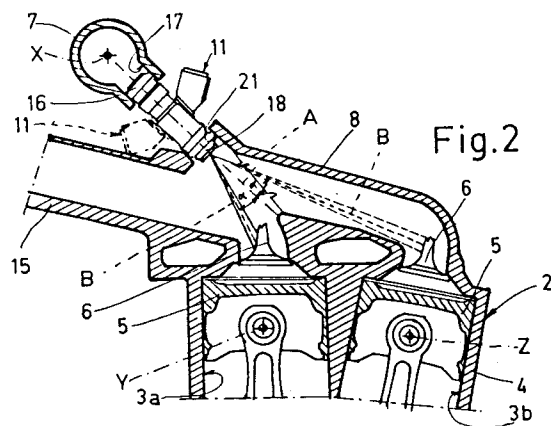
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**I-10121 Torino (IT)**(54) **Fuel injection system for a multi-cylinder endothermic engine.**

(57) The system comprises first cylinders (3a) provided along a first axis (Y), second cylinders (3b) provided along a second axis (Z), intake valves (6), one for each cylinder, a fuel manifold (7), supply pipes (8) which lead to the head of the respective cylinder, and injectors (11), one for each cylinder, in order to inject fuel along a respective supply pipe. The injectors comprise a nozzle (18) in which there is provided an injection hole (23) which is defined

along an axis (B) which converges on the longitudinal axis (A) of the injector according to an angle ( $\alpha$ ). The axis of the injection hole of the injectors which supply the first cylinders converges on the intake valve of the first cylinders, whereas the axis of the injection hole of the injectors which supply the second cylinders converges on the intake valve of the second cylinders.

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The present invention relates to a fuel injection system for a multi-cylinder endothermic engine.

As is known, the cylinders of multi-cylinder endothermic engines may be subdivided into two rows. The fuel injection system for these engines includes a fuel manifold, a plurality of supply pipes (one per cylinder) which originate from the fuel manifold and extend as far as the respective cylinder, a plurality of injectors suitable for injecting fuel along the respective supply pipe towards the corresponding cylinder, and an air intake manifold which has ducts which lead into the supply pipes. Since the cylinders are subdivided into two rows, the said supply pipes have a different length, a first length for the cylinders which are closer to the fuel manifold, and a second length for the cylinders which are further from the fuel manifold. The fuel manifold has a plurality of seats for the injectors, these seats being distributed along a predetermined axis. Owing to the difference in length of the supply pipes, and since the injectors are mounted along the same axis, the present system requires the fuel jet to be in line with the longitudinal axis of the injectors, and the latter to be oriented such that the fuel jet is directed in a median direction between the straight line which connects the injector and the cylinder which is closer to the fuel manifold, and the straight line which connects the injector and the cylinder which is further from the fuel manifold. For this reason, the fuel jet strikes the inner walls of the supply pipe.

The above-described system has some disadvantages caused by the fact that the fuel jet has a direction of impact on the inner walls of the supply pipe such that particles of fuel are deposited on these walls. In transient conditions in particular, these deposits give rise to problems in controlling the stoichiometry of the air-fuel mixture, and concerning the quantity of fuel conveyed to the cylinder. In addition, atomisation of the fuel is less effective. In particular, accumulation of particles of fuel on the walls distorts the stoichiometry of the mixture (which is controlled by an electronic unit), since these particles of fuel can be mixed with air in a cycle after that in which they have been injected. Furthermore, if the particles of fuel deposited on the walls of the supply pipe during the stage of intake by the cylinder, remain on these walls, the cylinder takes in a quantity of fuel which is less than that actually injected by the injector. If these particles which are still in a liquid state are then taken in in a successive cycle, this gives rise to incorrect atomisation of the mixture taken in by the cylinder. Finally, if these particles evaporate, in the successive cycle the cylinder takes in a quantity of fuel which is greater than that actually injected by the injector. This impossibility of control of the stoichiometry and of the quantity of fuel

actually taken in by the cylinder, and the existence of incorrect atomisation, obviously affect the performance of the engine, particularly in transient conditions.

5 The object of the present invention is to provide a fuel injection system for a multi-cylinder endothermic engine, which is free from the above-described disadvantages.

10 According to the present invention, a fuel injection system for a multi-cylinder endothermic engine is provided which comprises:

a plurality of first cylinders provided along a first axis;

15 a plurality of second cylinders provided along a second axis which is parallel to the first axis;

a plurality of intake valves, each of which is mounted in the head of a respective cylinder;

a fuel manifold with a longitudinal axis which is parallel to the first and second axis;

20 a plurality of fuel supply pipes which lead to the head of a respective cylinder;

a plurality of fuel injectors, one for each cylinder, the longitudinal axis of which converges towards a median area defined between the first and second axis, and which can collect fuel from the fuel manifold and inject this fuel into a respective fuel supply pipe; and

25 an air intake manifold which can convey air into the fuel supply pipes;

30 characterized in that the injectors comprise a nozzle in which there is provided an injection hole which is defined along an axis which converges on the longitudinal axis of the injector, according to a respective and predetermined angle, and characterized in that the axis of the injection hole of the injectors which supply the first cylinders converges on the intake valve of the first cylinders, whereas the axis of the injection hole of the injectors which supply the second cylinders converges on the intake valve of the second cylinders.

35 For improved understanding of the present invention, a preferred embodiment is now described, purely by way of non-limiting example, with reference to the attached drawings, in which:

45 Figure 1 is a schematic plan view of an injection system according to the present invention;

Figure 2 is an enlarged cross-section along line II-II in Figure 1; and

50 Figure 3 is a partial enlarged cross-section of a detail of the system in Figure 2.

55 As Figure 1 illustrates, 1 indicates as a whole a fuel injection system for an endothermic engine 2 of the type which has a plurality of cylinders distributed in two rows. The engine 2 comprises a base 4 in which there are defined two parallel axes Y and Z; along the axis Y there is provided a first plurality of cylinders 3a, and along the axis Z there is provided a second plurality of cylinders 3b. Each

cylinder 3a and 3b (Figure 2) accommodates a respective piston 5, and has in its head a respective intake valve 6.

With reference to Figures 1 and 2, the system 1 comprises:

a fuel manifold 7 with longitudinal axis X which is parallel to the axes Y and Z;

a plurality of fuel supply pipes 8 (one for each cylinder 3a and 3b) which lead to the head of the respective cylinder 3a and 3b;

a plurality of fuel injectors 11, one for each cylinder 3a and 3b;

an air intake manifold 12, along which there acts a regulation valve 13 which is preferably of the throttle type;

an expansion box 14 into which the manifold 12 leads; and

a plurality of air supply pipes 15 which originate from the expansion box 14, and which are of the same number as the fuel supply pipes 8.

With reference to Figure 2, the injectors 11 have a head 16, in which there is recessed the fuel inlet mouth, which is accommodated in a respective seat 17 recessed in the fuel manifold 7, and a nozzle 18 (Figure 3) which is accommodated in a seat 21 recessed along the respective fuel supply pipe 8. The fuel manifold 7 is mounted to the side of the base 4, and in particular in the vicinity of the axis Y, such that the pipes 8 which supply the cylinders 3a have a length which is shorter than that of the pipes 8 which supply the cylinders 3b. The injectors 11 have a respective longitudinal axis A which converges towards an area of the base 4 in a median position between the axes Y and Z. The axes A of all the injectors 11 are defined on a single plane, i.e. all the injectors 11 have the same angle relative to the longitudinal axis X of the fuel manifold 7. The air supply pipes 15 lead to a respective fuel supply pipe 8, inside which the air and fuel are mixed in order to obtain the air-fuel mixture which the cylinder 3a, 3b will take in by means of the valve 6 during the intake stage.

With reference to Figure 3, the nozzle 18 of the injector 11 has a plate 22 in which there is provided an injection hole 23 defined along an axis B which converges on the axis A according to an angle  $\alpha$ ; the fuel jet is thus not in line with the axis A but is at an angle  $\alpha$  relative to the latter.

With reference to Figure 2, the injectors 11 which supply the cylinders 3a are oriented differently, and in particular are rotated around the axis A by  $180^\circ$  relative to the injectors 11 which supply the cylinders 3b. The orientation of the injectors 11 which supply the cylinders 3a, and the angle  $\alpha$  of the fuel jet relative to the axis A, cause the fuel jet to strike fully the valve 6 of the cylinders 3a. Whereas the orientation of the injectors 11 which supply the cylinders 3b and the angle  $\alpha$

of the fuel jet relative to the axis A, cause the fuel jet to strike fully the valve 6 of the cylinders 3b, this latter solution being illustrated in broken lines in Figure 3.

According to the above description, the advantages obtained by implementing the present invention are clear.

In particular, an injection system is provided according to which all the cylinders use the same injectors, in which the injection hole is at an angle relative to the axis of the injector. If the injector is now positioned according to a predetermined orientation of the injection hole axis, the fuel jet can be directed against the intake valve of the closer cylinder or of the further cylinder. This aimed direction of the fuel jet does not give rise to the depositing of particles on the walls of the fuel supply pipe, since these walls are not along the axis of the jet. Consequently, all the quantity of fuel injected is then taken in by the cylinder, and in addition there is no distortion of the stoichiometry prescribed for the air-fuel mixture.

Finally, it is clear that modifications and variants may be applied to the system 1 described and illustrated here, without departing from the protective context of the present invention.

In particular, the system 1 can contain any number of cylinders distributed in two rows, and can include injectors of a type other than that described. The cylinders of one row can have their longitudinal axis parallel or converging with the longitudinal axis of the cylinders of the other row. In addition, the injectors which supply the cylinders 3a could have their injection holes defined along angled axes, with an angle which differs from that of the injection holes of the injectors which supply the cylinders 3b.

According to a different embodiment, all the injectors could have the same orientation, and include a plate 22 which can be pivoted around the axis A in order to determine the injection hole 23 defined on an axis which converges on the respective intake valve 6.

## Claims

1. Fuel injection system for a multi-cylinder endothermic engine (2) comprising;
  - a plurality of first cylinders (3a) provided along a first axis (Y);
  - a plurality of second cylinders (3b) provided along a second axis (Z) which is parallel to the first axis (Y);
  - a plurality of intake valves (6) each of which is mounted in the head of a respective cylinder (3a, 3b);
  - a fuel manifold (7) with a longitudinal axis (X) which is parallel to the first and second

axis (Y and Z);

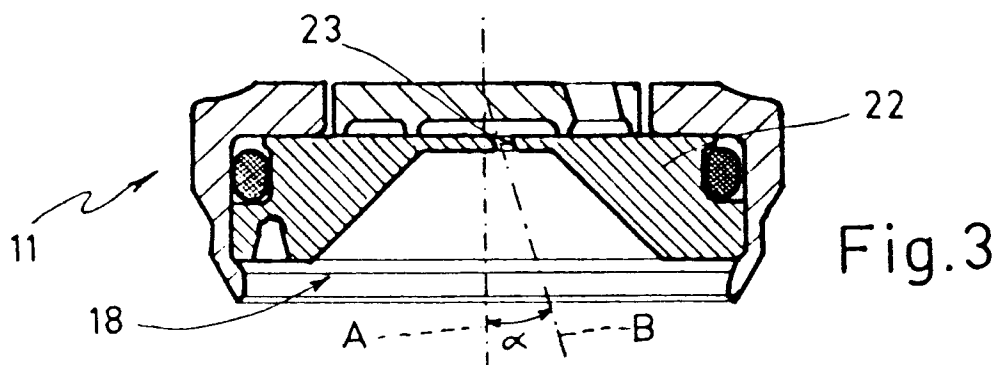
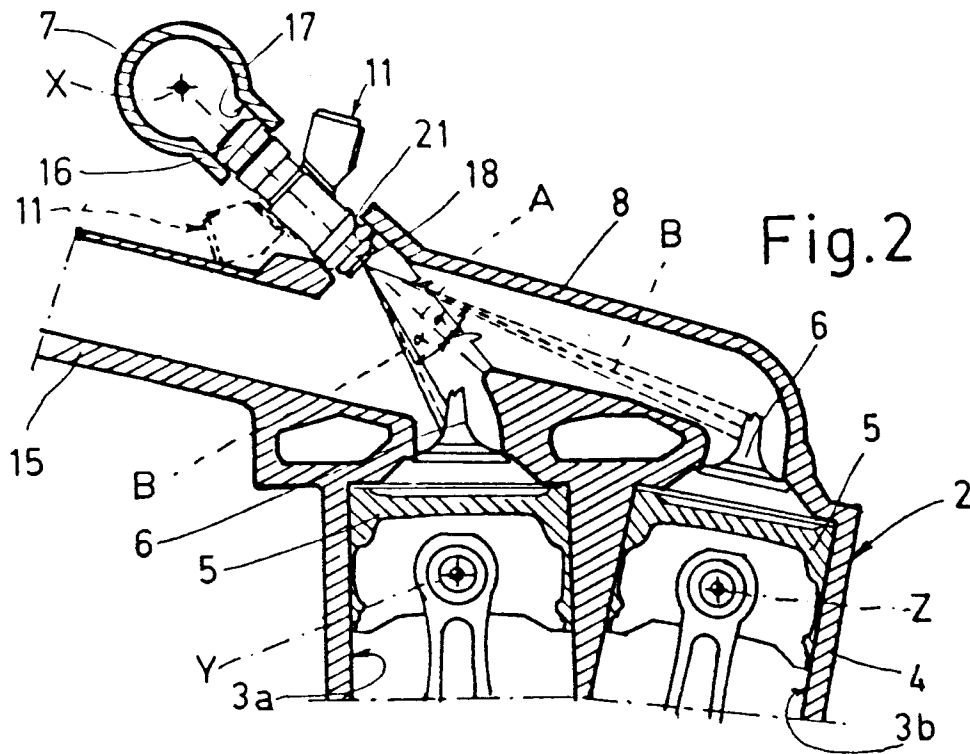
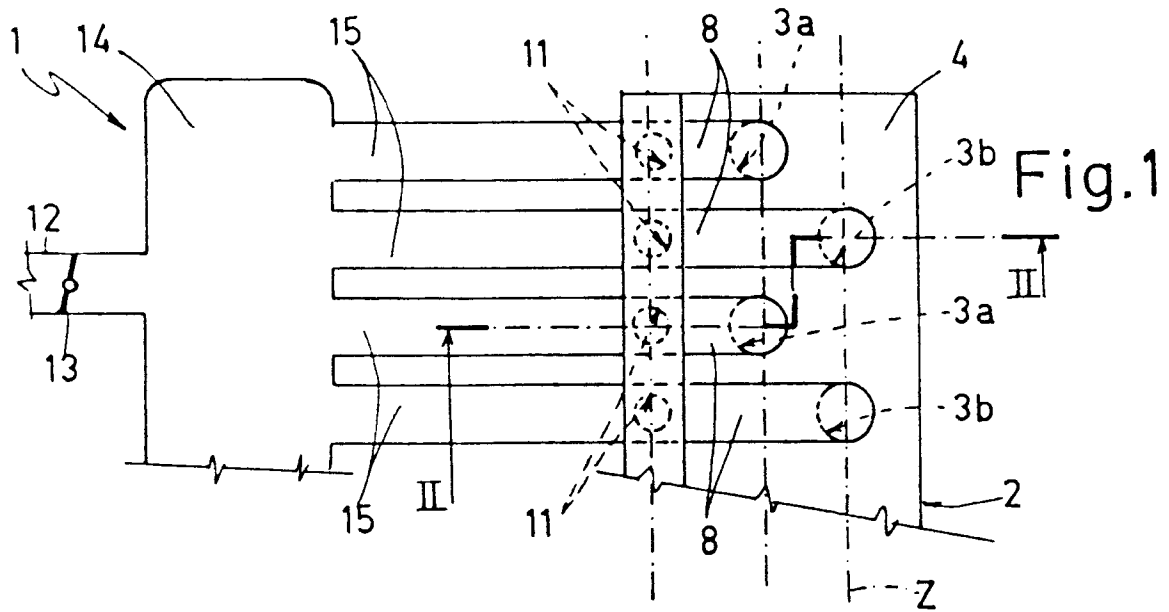
a plurality of fuel supply pipes (8) which lead to the head of a respective cylinder (3a, 3b);

a plurality of fuel injectors (11), one for each cylinder (3a, 3b), the longitudinal axis (A) of which converges towards a median area defined between the first and second axis (Y and Z), and which can collect fuel from the fuel manifold (7) and inject this fuel into a respective fuel supply pipe (8); and

an air intake manifold (12) which can convey air into the fuel supply pipes (8);

characterized in that the injectors (11) comprise a nozzle (18) in which there is provided an injection hole (23) which is defined along an axis (B) which converges on the longitudinal axis (A) of the injector (11) according to a respective and predetermined angle ( $\alpha$ ), and characterized in that the axis (B) of the injection hole (23) of the injectors (11) which supply the first cylinders (3a) converges on the intake valve (6) of the first cylinders (3a), whereas the axis (B) of the injection hole (23) of the injectors (11) which supply the second cylinders (3b) converges on the intake valve (6) of the second cylinders (3b).

2. System according to Claim 1, characterized in that all the injectors (11) have the same angle between their own longitudinal axis (A) and the axis (B) of their own injection hole (23).
3. System according to Claim 2, characterized in that the injectors (11) which supply the first cylinders (3a) are oriented differently, and in particular are rotated around their own longitudinal axis (A) by 180° relative to the injectors (11) which supply the second cylinders (3b).
4. System according to Claim 2, characterized in that all the injectors (11) have the same orientation, and in that the nozzles (18) of the injectors (11) which supply the first cylinders (3a) are oriented differently, and in particular are rotated around the longitudinal axis (A) by 180° relative to the nozzles (18) of the injectors (11) which supply the second cylinders (3b).





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## EUROPEAN SEARCH REPORT

Application Number  
EP 94 11 6844

| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                            |                                                     |                                      |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|--------------------------------------|
| Category                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Citation of document with indication, where appropriate, of relevant passages                                                              | Relevant to claim                                   | CLASSIFICATION OF THE APPLICATION    |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | EP-A-0 102 164 (GENERAL MOTORS CORPORATION)<br>* page 3, line 21 - page 6, line 24;<br>figures 1-10 *                                      | 1                                                   | F02M69/04                            |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | GB-A-2 142 089 (PORSCHE)<br>* page 1, line 68 - page 2, line 29;<br>figures 1-3 *                                                          | 1                                                   |                                      |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | PATENT ABSTRACTS OF JAPAN<br>vol. 13, no. 282 (M-843) 28 June 1989<br>& JP-A-01 077 751 (MAZDA MOTOR CORP.) 23 March 1989<br>* abstract *  | 1                                                   |                                      |
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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                            |                                                     | TECHNICAL FIELDS SEARCHED (Int.CL.6) |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                            |                                                     | F02M<br>F02B<br>F02F                 |
| The present search report has been drawn up for all claims                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                            |                                                     |                                      |
| Place of search<br>THE HAGUE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                            | Date of completion of the search<br>11 January 1995 | Examiner<br>Hakhverdi, M             |
| <b>CATEGORY OF CITED DOCUMENTS</b><br>X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document<br>T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>& : member of the same patent family, corresponding document |                                                                                                                                            |                                                     |                                      |