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Mit axialem Erhitzervorrichtungslayout ausgestatteter Kraftstoffverteiler zur Motor-Kaltstartoperation mit Ethanol

Rampe de carburant avec dispositif de chauffage axial pour les opérations de démarrage à froid du moteur avec de l'éthanol

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Description

[0001] The present invention relates to a fuel rail equipped with a particular axial heater device layout to increase the heat flux homogeneity in a primary return-less fuel rail for an Ethanol Cold Start (ECS) system.

Prior art

[0002] It is a well-known fact that when using fuels different from classic gasoline in an Internal Combustion (IC) engine several functions of the engine may be affected. In a modern IC-engine (figure 1), comprising a combustion chamber (1) with a spark ignition device (2), an exhaust (3) and inlet (4) manifold with a gas flow regulating (5) throttle body and an electronically controlled (6) mixture preparation system with Port Fuel Injectors (PFI) (7), a classic gasoline fuel with a typical chemical structure of C₈H₁₈ enables a cold start performance, which allows the engine to start and warm-up at temperatures down to approximately 30°C below zero without use of auxiliary add-on devices. Figure 1 shows a layout of a speed/density (Manifold Absolute Pressure (MAP) and engine speed sensor input), but this layout is not mandatory. The layout can use any kind of strategy as long as it supplies the necessary data to enable the Engine Control Unit (ECU) to compute the relevant data for injector and ignition control.

[0003] In the case of a different low vaporizing fuel for example ethanol (C₂H₅OH) or a mixture between gasoline or ethanol (example: gasohol or E85) the cold start performance is strongly affected by the vaporization and surface tension parameters of the ethanol component, which are notably different from those of a pure gasoline. Fuelling the engine by pure ethanol creates the most difficult situation. In that case the cold start and warm up becomes very delicate below ambient temperatures of about 10° to 12° C. The main reason for which not only the cold start but also the warm-up phase is of major interest is that for pollutants control (mainly the HC-content in the exhaust gas) in the time period during which the oxygen-sensor is not functioning (open-loop control strategy) a very precise injector control enables a decrease in unburned HC emission.

[0004] In recent years the presence of the ethanol cold start problem has led to several suggestions of add-on devices, which introduce either a separate high-vaporizing fuel (gasoline) or one or more heating devices, which are not positioned according to the present invention in the normal fuel rail on the upstream side of the fuel injectors. Both approaches have major inconveniences.

[0005] Although functioning well for the cold start itself, the first approach is costly as a separate tank and fuel line for the high-vaporizing fuel must be installed on the vehicle and as the volume of this secondary system is limited (normally under-bonnet location) its capacity to be used during the warm-up period is very limited. The second type of approach can be used for the cold start,

but an approach of this type, which does not follow the particular layout defined by the invention becomes totally unreliable for the warm-up period as the random introduction of a powerful heat source in the fuel-rail on the injector upstream side eventually leads to heat-conditioned cavitations in the liquid fuel.

[0006] Basically a fuel injector is designed to introduce a metered amount of liquid (non compressible) fuel in the intake system. Unfortunately heat-conditioned cavitations introduce gas bubbles into the liquid fuel and thereby change the state of the fluid from non-compressible to compressible. The basic fluid dynamics of compressible fluids is totally different from those of non-compressible fluids and therefore the metering function of the fuel injector designed for liquid fuel is not anymore controllable when a compressible fluid is passing through the metering area inside the injector.

[0007] The applicant has patented a solution, which enables, by a simple mechanical means without complicated electronic feed-back temperature control, to provide an asymptotic temperature stabilization of the fuel inside the fuel rail during the cold start phase, as described in Brazilian Patent Application nr. PI 0705422-0 or EP 2071159 B1.

[0008] This patent document describes a fuel rail of an Ethanol Cold Star (ECS) system according to the preamble part of claim 1 and in which is inserted a tubular passively regulated dissipater for heat diffusion which has a tube connecting the two heating elements to each other which are inserted in the axial end portions of the fuel rail main cavity, said tube having rows of holes along the tube enabling flow from the outside of the tube to its inner volume.

[0009] To prevent fuel for an IC engine from being frozen and not only enhance the startability of the engine but also reduce HC component contained in exhaust gas even if the engine is used in cold districts, the Japanese Patent document JP-A-08 338 339 discloses a common fuel rail storing fuel fed in the fuel rail through an extremity thereof and in which a single electrically controlled fuel heater is inserted, said fuel heater extending longitudinally in the fuel rail main cavity from the extremity of the latter which is opposite to the fuel entrance and being cantilever mounted on the fuel rail from said opposite extremity.

[0010] But such a common rail with a fuel heater is proposed for equipping a diesel engine having fuel injectors fed with high pressure diesel fuel, the characteristics, properties and behavior of which are very different from that of low vaporizing fuels such as ethanol or ethanol gasoline mixtures.

[0011] DE 103 41 708 A1 also discloses a tubular common rail for feeding several injectors with fuel and in the main cavity of which a single electrical heating element axially extends. But similarly, this fuel rail is fed with high density, high viscosity, and low vaporizing fuels at high pressure, such as diesel fuels, which need to be heated at a convenient temperature for having a convenient vis-

cosity for feeding the injectors.

Summary of the invention

[0012] The invention is defined in claim 1, with the purpose of improvement of the cold start and warm up phases by usage of low vaporizing fuels such as ethanol.

[0013] The distribution of the active heating surface along the rail cavity symmetry axis is favored by this particular axial layout, which increases significantly the homogeneity of the net heat flux in the lateral direction of the cavity and thereby decreases the hot fuel temperature difference between the fuel injectors connected to the rail.

[0014] The present invention presents several different installation layouts of the axial heaters within the perimeter of the fuel rail. Advantageous embodiments are the subject matters of dependent claims 2-5.

Brief description of the drawings

[0015] The objective of the present invention will be better understood by confronting the joined figures, which are presented as mere examples, which should in no way limit the scope of the invention.

- Figure 1 shows a conventional internal combustion engine with its associated injection system.
- Figure 2 shows a fuel rail with attached fuel injectors and axial heaters located at each extremity of the rail.
- Figures 3a and 3b show the internal part of the fuel rail of figure 2 with the axial heaters located as well as the detailed layout of each heating element.
- Figures 4a, 4b, 4c, 4d and 4e show axial cuts of several different installation layouts in different fuel rail designs according to the invention.
- Figure 5 shows a graphical representation of the stabilization versus time of the fuel temperature at each fuel injector (example 4 cylinder engine) by application of the present invention.

Preferred Embodiments

[0016] In conformity with the joined figures, and in particular with reference to figure 2 and figure 3a, the invention adds to the internal volume of a fuel rail one or more electronically controlled heating elements.

[0017] Figure 2 illustrates the principle of the invention. The common fuel rail (10) supplies pressurized fuel to a number of fuel injectors (11a to 11d) and as an example two heating elements (12a and 12b) are located on each side of the fuel rail. Each heating element is a fast acting device with a typical temperature rise-time of ~ 70°C/s (measured in still air at 1 mm from the heater surface). The total number of heating elements will typically absorb approximately 800 W at 10 V supply. The maximum heater temperature should typically be attained after approximately 6 s. The above-indicated numerical values are

not limitative.

[0018] Figure 3a shows an example of the internal layout of the system. The active heating parts of the elements (12a and 12b) are located in a position, which is axial or co-axial with respect to the main axis (14) of the fuel rail. The example shows a layout with only one fuel entrance pipe (13), which connects the fuel rail to the fuel delivery pump.

[0019] Figure 3b shows details of the heating elements. An element is composed of a unit, which is axially located in the rail. This unit is divided in two parts, the active heating part (100) of the length L_a (typically between 35 and 70 mm) and an inactive support (101) of a length X (typically between 0 and 35 mm). The axial unit is connected to a connector body (102) and an electrical connector (103). To comply with a large number of mounting requirements the connector body (102) and the connector (103) can be positioned at an angle α (between 0 and 90 °) with respect to the axial parts (100 and 101).

[0020] Figures 4a, 4b, 4c, 4d and 4e show further variants of the installation layout for an axial heating element according to the present invention.

[0021] Figure 4a shows a variant with two fuel inlet pipes (201 and 202), which supply the cold fuel at symmetrical positions in the vicinity of the axial heating elements (12a, 12b). The precise position of the inlet pipes as well as the lengths X and L_a are tuned to provide the maximum equilibrium of heat flux towards the fuel injectors (11a-11d).

[0022] Figure 4b shows a variant by which the effect of heat flux homogeneity is obtained with only one cold fuel inlet pipe (203), which is connected to a transfer bore (204), located inside the fuel rail (10) with outlets in the vicinity of the heating elements (12a, 12b).

[0023] Figure 4c shows a layout, which adds a separate compartment (300), which enables the introduction of a third parallel heating element (301) to provide a supplementary heat flux directed towards the center located fuel injectors (11 b, 11 c). The electrical power output of the three heating elements (12a, 12b, 301) is typically adapted to a total consumption of approximately 800 W at 10 V, but this value is not limitative. Fuel is supplied into the separate compartment (300) through the transfer bores (302) and the heated fuel is supplied to the center fuel injectors (11 b, 11 c) through the outlet bores (303).

[0024] Figure 4d shows a layout in which the rail cavity, by any appropriate mechanical means (400), is divided into two separate left (401) and right (402) hand cavities. Each left or right hand cavity, equipped with an individual inlet pipe (403) and (404), supplies hot fuel to respectively

the left (11 a, 11 b) and right (11 c, 11 d) hand injectors. Heat flux distribution oscillations due to the intermittent injector duty cycle order are hereby significantly reduced.

[0025] Figure 4e shows a layout in which is combined only one cold fuel inlet pipe (503), communicating with an internal transfer bore (504), and a rail cavity separated by any appropriate mechanical means (500) in two left (501) and right (502) hand cavities. Each cavity supplies hot fuel to respectively the left (11 a, 11 b) and right (11 c, 11 d) hand injectors.

[0026] For convenience the figures 3 to 4e show the different constituent elements such as fuel inlet pipes (13, 201 and 202, 203) and the location of the separate heating compartment (300) in the same plane as the cut of the main fuel rail. However, this is not mandatory as long as the active heating elements all maintain an axial location parallel to or on the fuel rail main axis (14).

[0027] To optimally comply with under-bonnet packaging requirements both the inlet pipes and the separate third heating element compartment can be axially turned clock- or anticlockwise around the fuel rail main axis (14).

Example

[0028] Figure 5 shows a recording of the average temperature evolution of the liquid in the tubes connecting the fuel-rail to the fuel injectors at a cold start event at an ambient temperature of - 5 ° C

[0029] The recording demonstrates that when all dimensional and orientation parameters are correctly adapted according to the invention the common temperature profile at the fuel injector inlets remains well below the flash-boiling threshold. The tests made with the present invention demonstrate clearly that the suggested layout is a very efficient and low cost means to obtain a well controlled heating of the fuel on the upstream side of the fuel injectors without imposing major geometrical changes of existing fuel supply lines or the introduction of a secondary expensive fuel reservoir.

Claims

1. A fuel rail, for being mounted on an IC-engine with the purpose of improvement of the cold start and warm up phases by usage of low vaporizing fuels such as ethanol, in which at least two heating elements (12a, 12b, 301) are inserted in said fuel rail (10), each heating element having two parts, an inactive support part (101) and an active heating part (100), having lengths (X, La), which are tuned to obtain a heat flux along said fuel rail (10) towards fuel injectors (11 a-11 d) connected to said fuel rail (10), with two heating elements being axial heating elements (12a, 12b) axially inserted at each extremity respectively of a fuel rail main cavity, in such a way that said heating part (100) of each of said heating elements is oriented along or parallel to the main

symmetry axis (14) of the main cavity of said fuel rail (10) **characterized in that** one or more cold fuel inlet pipe(s) (201, 202, 203, 403, 404, 503) is/are positioned and connected to said fuel rail main cavity in such a way that cold fuel arrives symmetrically with respect to said heating elements (12a, 12b, 301)

2. The fuel rail as in claim 1, in which each heating element (12a, 12b, 301) includes an electrical body and a connector which are oriented in-line with the heating part (100) oriented along or parallel to the fuel rail main symmetry axis (14) or tilted at an arbitrary angle between 1 ° and 90 ° with respect to the axially oriented heating part (100).
3. The fuel rail as in claim 1 or 2, in which a center-positioned axial heating element (301) is inserted in a separated cavity being parallel to said fuel rail main axis (14) to supply center-connected fuel injectors (11 b, 11 c) with heated fuel.
4. The fuel rail as in claim 3, in which said separated cavity communicates with right and left hand cavities dividing said main cavity through two transfer bores (302) and with said center-connected fuel injectors (11 b, 11c) through a number of outlet bores (303) equal to the number of center-connected injectors, and for which the diameter ratio between transfer and outlet bores (302, 303) is equal or less than 0.5.
5. The fuel rail as in claim 1 or 2, in which said fuel rail main cavity having the heating elements (12a, 12b) axially inserted at each extremity of said main cavity is separated in two non-communicating cavities (401, 402; 501, 502) dividing said main cavity in right and left hand parts each supplying an equal number of fuel injectors (11 a, 11 b; 11 c, 11 d) with heated fuel.

Patentansprüche

1. Kraftstoffzuführung zur Montage an einem Verbrennungsmotor zum Zweck der Verbesserung des Kaltstarts und der Aufwärmphasen durch Verwendung eines Kraftstoffes mit niederem Dampfdruck wie Ethanol, wobei mindestens zwei Heizelemente (12a, 12 b, 301) in die genannte Kraftstoffzuführung (10) eingebracht sind, wobei jedes Heizelement zwei Teile hat, einen nicht aktiven Stützteil (101) und einen aktiven Heizteil (100), die Längen (X, La) haben, die so eingestellt sind, um einen Wärmefluss entlang der besagten Kraftstoffzuführung (10) hin zu Einspritzventilen (11a-11d) zu erzielen, die mit der besagten Kraftstoffzuführung (10) verbunden sind, wobei zwei Heizelemente axiale Heizelemente (12a, 12b) sind, die jeweils in je ein Ende eines Kraftstoffzuführungsraumes derart eingebracht

- sind, dass das besagte Heizteil (100) von jedem der Heizelemente entlang oder parallel zu der Hauptsymmetriearchse (14) des Haupthohlraumes der besagten Kraftstoffzuführung (10) orientiert ist, **durch gekennzeichnet, dass** ein oder mehrere Rohr(e) (201, 202, 203, 403, 404, 503) derart am Kraftstoffzuführungshaupthohlraum positioniert und verbunden ist/sind, dass kalter Kraftstoff symmetrisch bezüglich der besagten Heizelemente (12a, 12b, 301) ankommt.
2. Kraftstoffzuführung nach Anspruch 1, wobei jedes Heizelement (12a, 12b, 301) einen elektrischen Körper und einen Anschluss enthalten, die in Reihe mit dem Heizteil (100) ausgerichtet sind, wobei das Heizteil entlang oder parallel zur Kraftstoffzuführungshauptsymmetriearchse (14) ausgerichtet oder in einem beliebigen Winkel zwischen 1 ° und 90° bezüglich dem axial ausgerichteten Heizteil (100) geneigt ist.
3. Kraftstoffzuführung nach Anspruch 1 oder 2, wobei ein zentral positioniertes axiales Heizelement (301) in einen separaten Hohlraum eingebracht ist, der parallel zur Kraftstoffzuführungshauptachse (14) ist, um zentral verbundene Einspritzventile (11 b, 11 c) mit erwärmtem Kraftstoff zu versorgen.
4. Kraftstoffzuführung nach Anspruch 3, wobei besagter separater Hohlraum mit linksseitigen und rechtsseitigen Hohlräumen in Verbindung steht, die den Haupthohlraum durch zwei Transferbohrungen (302) teilt, und mit besagten zentral verbundenen Einspritzventilen (11 b, 11 c) durch eine Anzahl von Abführbohrungen (303), die gleich der Anzahl von zentral verbundenen Einspritzventilen ist, wobei das Durchmesserverhältnis von Transfer- zu Abführbohrungen (302, 303) kleiner oder gleich 0,5 ist.
5. Kraftstoffzuführung nach Anspruch 1 oder 2, wobei in den besagten Kraftstoffzuführungshaupthohlraum die Heizelemente (12a, 12b) axial an jedem Ende des besagten Haupthohlraums eingebracht sind, und wobei der Kraftstoffzuführungshaupthohlraum in zwei nicht in Verbindung stehende Hohlräume (401, 402; 501, 502) unterteilt ist, die den besagten Haupthohlraum in rechtsseitige und linksseitige Teile teilt, wobei jeder Teil eine gleiche Anzahl von Einspritzventilen (11a, 11 b; 11 c, 11 d) mit erwärmtem Kraftstoff bereitstellt.
- nol, dans lequel au moins deux éléments chauffants (12a, 12b, 301) sont insérés dans ladite rampe de carburant (10), chaque élément chauffant ayant deux parties, une partie de support inactive (101) et une partie de chauffage active (100), ayant des longueurs (X, La), qui sont calibrées pour obtenir un flux de chaleur le long de ladite rampe de carburant (10) en direction d'injecteurs de carburant (11a-11d) raccordés à ladite rampe de carburant (10), avec deux éléments chauffants qui sont des éléments chauffants axiaux (12a, 12b) insérés axialement à chaque extrémité respectivement d'une cavité principale de la rampe de carburant, de telle manière que ladite partie de chauffage (100) de chacun desdits éléments chauffants soit orientée le long de ou parallèlement à l'axe de symétrie principal (14) de la cavité principale de ladite rampe de carburant (10) **caractérisée en ce qu'un ou plusieurs tuyaux d'entrée de carburant froid (201, 202, 203, 403, 404, 503) est/sont positionné(s) et raccordé(s) à ladite cavité principale de ladite rampe de carburant de telle manière que le carburant froid arrive symétriquement par rapport auxdits éléments chauffants (12a, 12b, 301).**
2. Rampe de carburant selon la revendication 1, dans laquelle chaque élément chauffant (12a, 12b, 301) inclut un corps électrique et un connecteur qui sont orientés en ligne avec la partie de chauffage (100) orientée le long de ou parallèlement à l'axe de symétrie principal (14) de la rampe de carburant ou inclinés d'un angle arbitraire compris entre 1 ° et 90° par rapport à la partie de chauffage (100) orientée axialement.
3. Rampe de carburant selon la revendication 1 ou 2, dans laquelle un élément chauffant (301) axial positionné au centre est inséré dans une cavité séparée qui est parallèle audit axe principal (14) de ladite rampe de carburant pour alimenter des injecteurs de carburant (11b, 11c) raccordés au centre en carburant chauffé.
4. Rampe de carburant selon la revendication 3, dans laquelle ladite cavité séparée communique avec des cavités droite et gauche divisant ladite cavité principale par deux alésages de transfert (302) et avec lesdits injecteurs de carburant (11b, 11c) raccordés au centre par un certain nombre d'alésages de sortie (303) dont le nombre est égal au nombre d'injecteurs raccordés au centre, et dont le rapport des diamètres entre les alésages de transfert et de sortie (302, 303) est inférieur ou égal à 0,5.
5. Rampe de carburant selon la revendication 1 ou 2, dans laquelle ladite cavité principale de la rampe de carburant ayant les éléments chauffants (12a, 12b) insérés axialement à chaque extrémité de ladite ca-

Revendications

- Rampe de carburant, à monter sur un moteur à combustion interne dans le but d'améliorer les phases de démarrage à froid et réchauffage du moteur en utilisant des carburants peu volatils comme de l'étha-
- Rampe de carburant selon la revendication 1 ou 2, dans laquelle ladite cavité principale de la rampe de carburant ayant les éléments chauffants (12a, 12b) insérés axialement à chaque extrémité de ladite ca-

vité principale est séparée en deux cavités non communicantes (401, 402 ; 501, 502) divisant ladite cavité principale en parties droite et gauche alimentant chacune un nombre égal d'injecteurs de carburant (11a, 11b ; 11c, 11d) en carburant chauffé.

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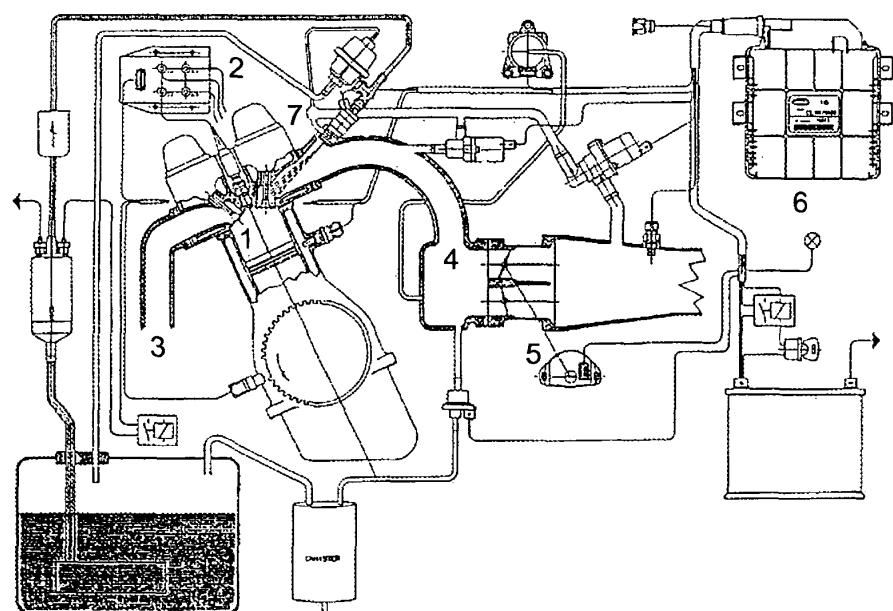


FIG. 1

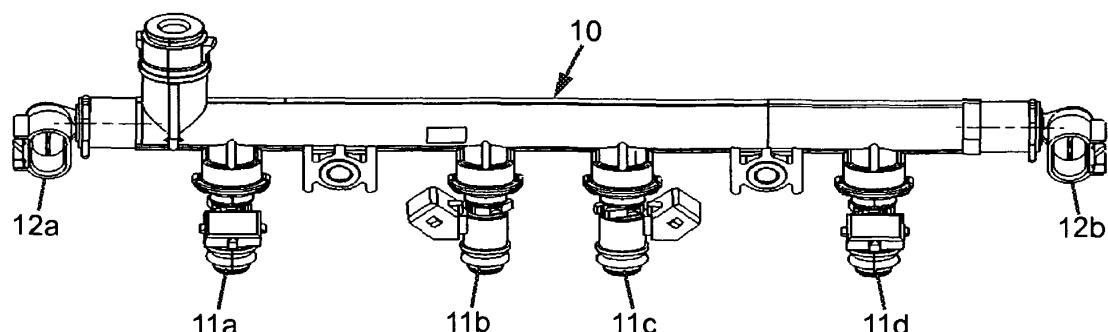


FIG. 2

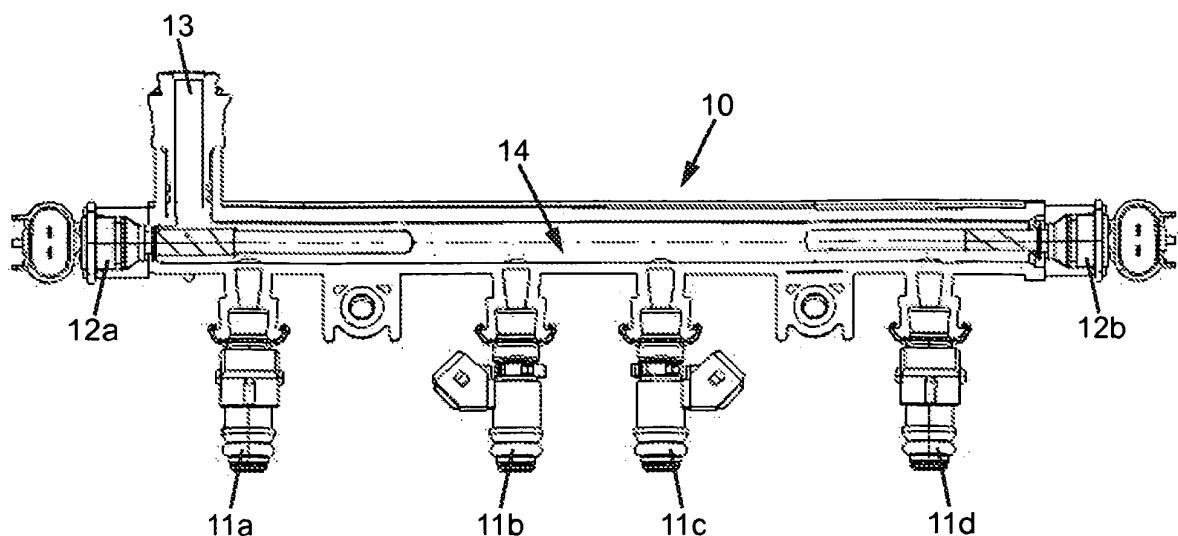


FIG. 3a

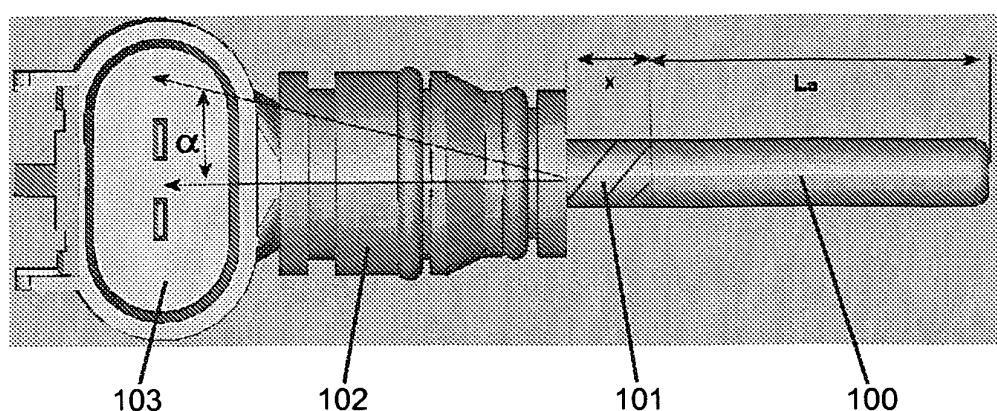


FIG. 3b

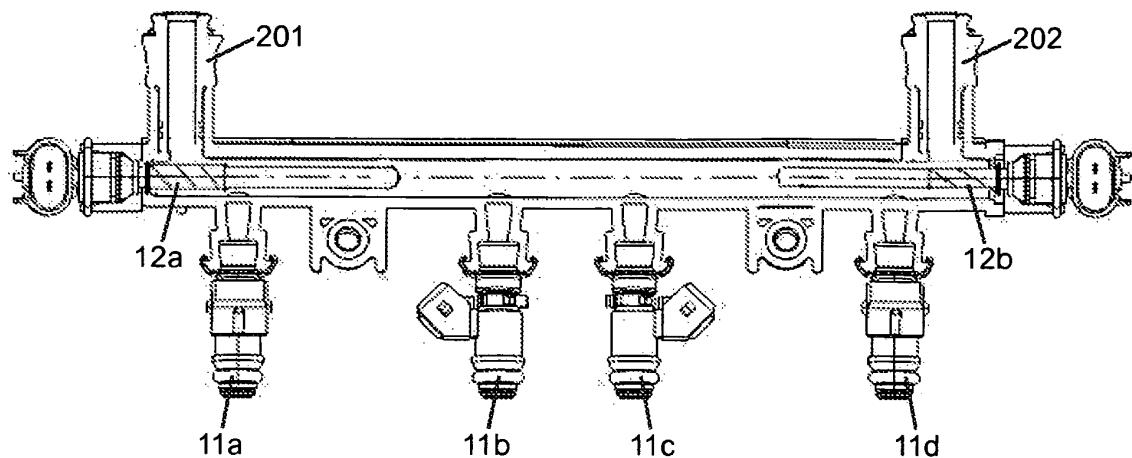


FIG. 4a

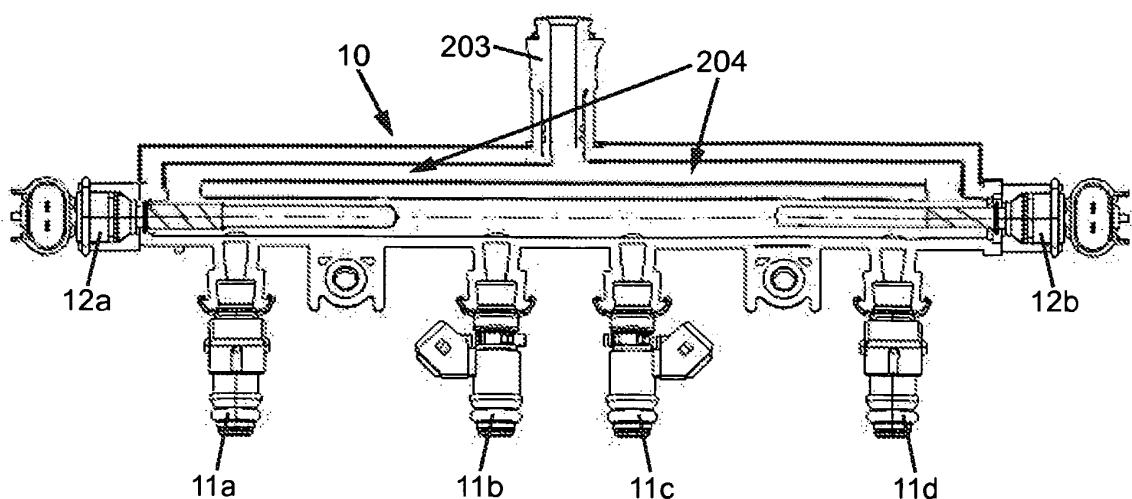


FIG. 4b

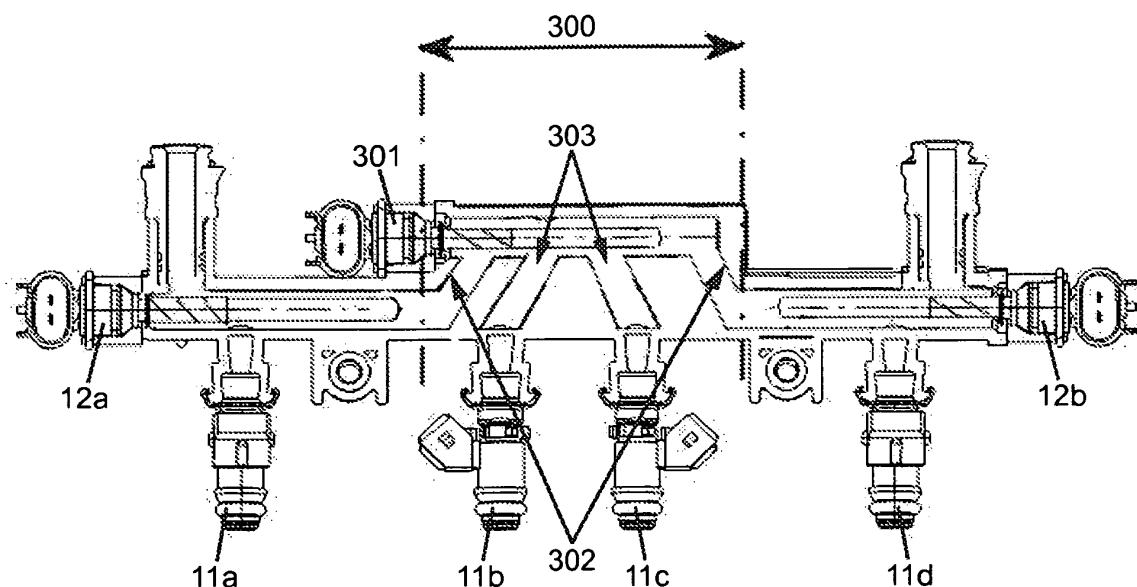


FIG. 4c

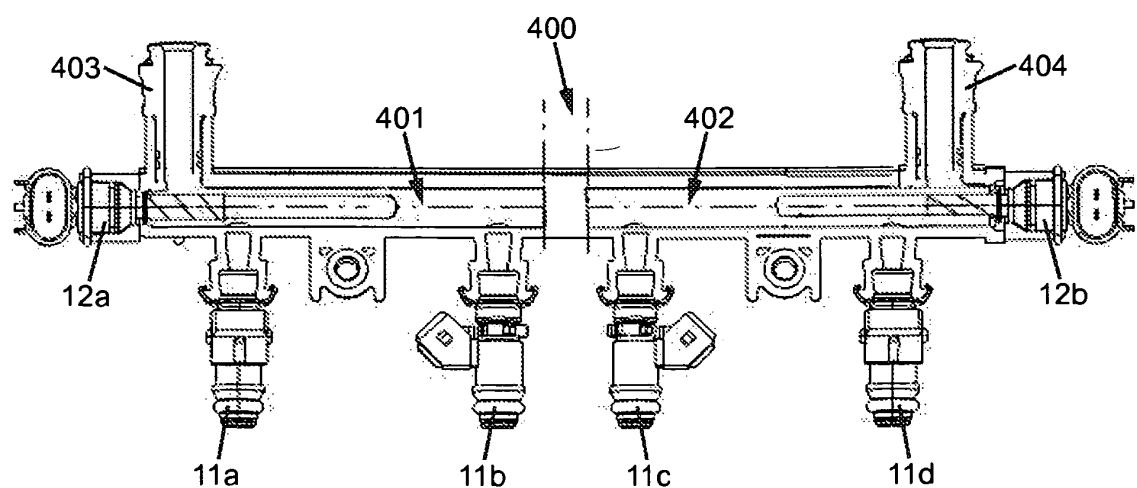


FIG. 4d

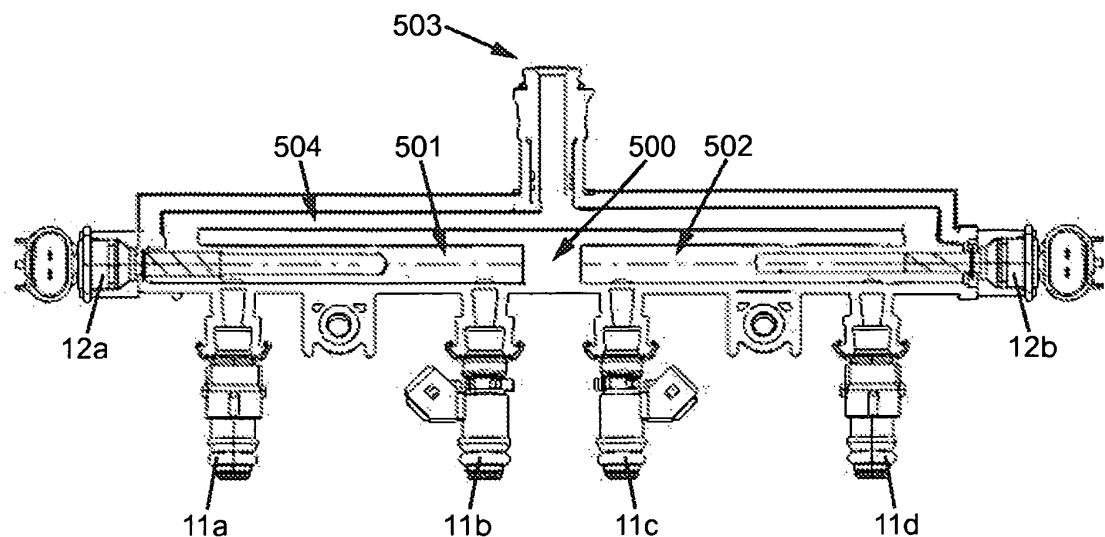


FIG. 4e

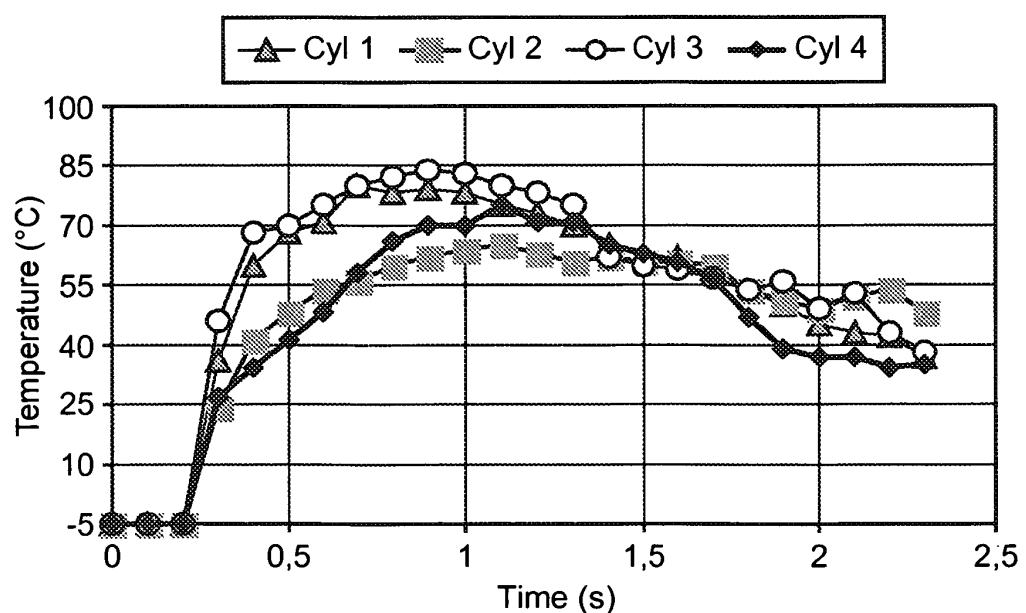


FIG. 5

REFERENCES CITED IN THE DESCRIPTION

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