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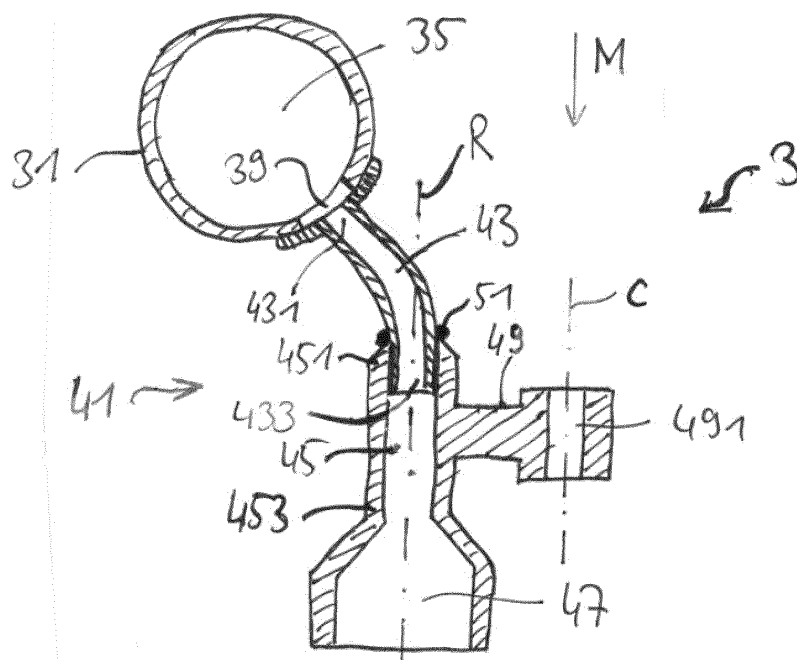
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(54) **Fuel rail assembly for an internal combustion engine and method for producing the same**

(57) A fuel rail assembly (3) for an internal combustion engine (1) is disclosed. It comprises an elongated fuel rail (31), a plurality of injector cups (47) for hydraulically coupling the fuel rail assembly (3) to respective fuel injectors (7) and a pipe (41) assigned to each injector cup (47) for hydraulically coupling the respective injector cup (47) to the fuel rail (31). Each pipe (41) comprises an upper tube (43) and a lower tube (45). A fixation bracket (49) is assigned to each pipe (41) which is configured for positionally fixing the fuel rail assembly (3) with respect to the combustion engine (1) and is rigidly connect-

ed to the respective lower tube (45). A rigid connection (51) is established between a downstream end section (433) of the upper tube (43) and an upstream end section (451) of the lower tube (45). The downstream end section (433) of the upper tube (43) and the upstream end section (451) of the lower tube (45) are in engagement with one another in such fashion that, absent the rigid connection (51), the upper tube (43) and the lower tube (45) are rotatable with respect to one another around a predetermined rotational axis (R). Further, a method for producing the fuel rail assembly (3) is disclosed.

Fig. 2



Description

[0001] The present disclosure relates to a fuel rail assembly for an internal combustion engine and to a method for producing the fuel rail assembly.

[0002] Fuel rails, in particular for gasoline direct injection engines are usually designed according to the engine packaging of the specific internal combustion engine. Usually, the design of the fuel rail is specific to a particular engine and unusable for other engines.

[0003] It is an object of the present disclosure to specify a fuel rail which is easily configurable during production for use with engines of different shapes and/or which is particularly cost-effective.

[0004] A fuel rail assembly for an internal combustion engine is specified according to one aspect of the present disclosure. The fuel rail assembly is in particular a fuel rail assembly for an internal combustion engine.

[0005] The fuel rail assembly comprises an elongated fuel rail. The fuel rail comprises a tubular fuel reservoir. The fuel reservoir is in particular made of a metal or an alloy. In one embodiment, the fuel rail also comprises at least one of the following elements: an inlet fitting, a sensor port, an end plug. For example, the inlet fitting and the end plug are positioned at opposite ends of the fuel rail, in particular in the direction along which the fuel rail is elongated. In other words, the inlet fitting and the end plug may limit the tubular fuel reservoir at opposite ends. Other positions for the inlet fitting are also conceivable. The sensor port is preferably configured for receiving a pressure sensor to measure the fuel pressure inside the fuel rail. Preferably, fuel is supplied under high pressure into the fuel rail, in particular by a fuel pump, and stored in the fuel rail for being dispensed into the internal combustion engine by a plurality of fuel injectors. The fuel injectors are in particular operable to inject the fuel directly into a combustion chambers of the combustion engine.

[0006] The fuel rail assembly has a plurality of injector cups for hydraulically coupling the fuel rail assembly to the fuel injectors. One, and only one, fuel injector is in particular assigned to one injector cup and vice versa.

[0007] A pipe is assigned to each injector cup for hydraulically coupling the respective injector cup to the fuel rail. In this way, fuel is guided from the fuel rail and through the pipe to the injector cup to be subsequently delivered to the fuel injector.

[0008] Each pipe comprises an upper tube and a lower tube. The upper tube and the lower tube expediently are two separate parts. The upper tube and the lower tube are in particular metal tubes. Preferably, the upper tube and the lower tube are rigid, i.e. in particular they are configured for retaining their shape during operating of the fuel rail assembly and/or during assembly of the pipe.

[0009] An upstream end section of the upper tube is attached to the fuel rail. In particular, the fuel rail has a plurality of outlet ports, each outlet port being assigned to one of the pipes, wherein the upstream end section of

the upper tube has an interface with the respective outlet port.

[0010] A downstream end section of the lower tube is attached to the respective injector cup or merges with the respective injector cup to which the pipe is assigned. For example, the lower tube is in one piece with the injector cup. In this case, the lower tube is in particular an elongated upstream portion of the injector cup.

[0011] In the present context, the expressions "upstream" and "downstream" in particular refer to the direction of fuel flow from the fuel rail to the fuel injector. In other words, the upstream end section of the upper tube is positioned adjacent to the fuel rail and a downstream end section of the upper tube is positioned remote from the fuel rail. Analogously, the downstream end of the lower tube faces towards the injector cup and an upstream end of the lower tube faces away from the injector cup.

[0012] The fuel rail assembly further comprises a plurality of fixation brackets. Each fixation bracket is assigned to one of the pipes and rigidly connected to the respective lower tube.

[0013] The fixation brackets are configured for positionally fixing the fuel rail assembly with respect to the combustion engine. In other words, when the fuel rail assembly is installed, it is held in place with respect to the combustion engine by means of the fixation brackets. In particular, the fuel rail assembly is held in position with respect to the combustion engine solely by fixing via the fixation brackets. In particular, the fixation brackets are coupled to the combustion engine by screws and there are no further screw connections between the fuel rail assembly and the combustion engine.

[0014] That the fuel rail assembly is held in position with respect to the combustion engine solely by fixing via the fixation brackets is not meant to exclude the presence of other, inevitable, mechanical coupling between the fuel rail and the combustion engine, for example through the hydraulic connections, for example via the inlet fitting and via the fuel injectors. Preferably however, between the fuel rail assembly and the combustion engine no mechanical connection - apart from the fixation brackets - is made which is primarily provided for mechanically fixing the fuel rail to the combustion engine.

[0015] Between a downstream end section of the upper tube and an upstream end section of the lower tube, a rigid connection is established. The rigid connection is in particular a welded connection such as a weld seam or a brazed connection.

[0016] The downstream end section of the upper tube and the upstream end section of the lower tube are in mechanical engagement with one and other in such fashion that, absent the rigid connection, the upper tube and the lower tube are rotatable with respect to one another around a predetermined rotational axis. Tilting of the lower tube relative to the upper tube with respect to the rotation axis is, however, in particular prevented or at least limited by the mechanical engagement.

[0017] According to one aspect of the present disclo-

sure, a method for producing the fuel rail assembly according to at least one of the previous embodiments is specified.

[0018] According to one step of the method, the upper tubes - in particular the fuel rail with the upper tubes attached to the fuel rail - are provided. According to a further method step, the lower tubes and bringing the lower tubes are brought in engagement with the upper tubes.

[0019] According to an additional method step, an angular position with respect to the respective rotational axis is determined for each fixation bracket in dependence on the shape of the internal combustion engine for which the fuel rail assembly is produced. According to yet another method step, each of the lower tubes is rotated around the respective rotational axis relative to the respective upper tube until the respective fixation bracket is in the determined angular position and, subsequently, the respective rigid connection is established for retaining the fixation bracket in the determined angular position.

[0020] In one embodiment of the method, the fixation brackets are all moved to the determined angular positions before the rigid connections are established. In another embodiment of the method, the pipes are subsequently processed, i.e. in particular, after rotating one lower tube around the respective rotation axis for bringing the fixation bracket in the determined angular position, the rigid connection for that pipe is established before the method continues with rotating the lower tube of a further pipe and establishing the rigid connection for that pipe.

[0021] By means of the fuel rail assembly and the method according to the present disclosure, the positions of the individual fixing brackets are easily adaptable to different engine shapes during fabrication of the fuel rail assembly. In this way, it is possible to produce fuel rails for different engines from the same components and/or with the same tools. In this way, production of the fuel rail assembly may be particularly cost-effective.

[0022] In one embodiment, each fixation bracket has an opening which perforates the fixation bracket in a mounting direction. For example, the opening is configured for receiving a fixation element like a screw or a bolt. Preferably, a central axis of the opening is parallel to the rotational axis of the respective pipe and in particular laterally offset with respect to the rotational axis. In this way, the position of the fixation element relative to the fuel injector cup - and, thus, to the fuel injector when the fuel rail assembly is installed with the combustion engine - is easily adaptable during production of the fuel rail assembly.

[0023] According to one embodiment of the fuel rail assembly, the downstream end section of the upper tube and the upstream end section of the lower tube are in engagement with one another in such fashion that, absent the rigid connection, the lower tube is axially displaceable relative to the upper tube with respect to the rotational axis.

[0024] According to an embodiment of the method, an

axial position for each fixation bracket with respect to the respective rotational axis is determined in dependence on the shape of the internal combustion engine for which the fuel rail is produced and, for each of the lower tubes, the lower tube is axially displaced relative to the upper tube with respect to the respective rotational axis until the respective fixation bracket is in the determined axial position. In this case, the axial displacement is expediently effected before the respective rigid connection is established. By means of the lower tubes being axially displaceable during production of the fuel rail assembly, the adaptability of the fuel rail assembly to various engine shapes is further improved.

[0025] In an advantageous embodiment, the fixation brackets are spaced apart from the fuel rail and are spaced apart from one another. In this way, the positions of the fixation brackets can be determined independently from one another during production of the fuel rail assembly.

[0026] In one embodiment, the lower tubes each have a straight shape with a longitudinal axis which is coaxial to the rotational axis. In this way, the lower tubes can be easily rotated during manufacturing the fuel rail assembly. The upper tubes also may have a straight shape, the longitudinal axes of the upper tubes being in particular coaxial with the longitudinal axes of the respective lower tubes. In another embodiment, the upper tubes have a bent shape. In this case, it is preferable that the downstream end section of each upper tube has a straight shape. In this way, a good mechanical coupling between the downstream end section of the upper tube and the upstream end section of the lower tube is achievable.

[0027] Preferably, the downstream end section of each upper tube overlaps axially with the upstream end section of the respective lower tube. For example, the downstream end section of the upper tube is shifted into the lower tube. In this way, mechanical engagement which allows rotation of the lower tube relative to the upper tube and axial displacement of the lower tube relative to the upper tube is easily achievable.

[0028] Further advantages, advantageous embodiments and developments of the fuel rail assembly and of the method will become apparent from the exemplary embodiments which are described below in association with schematic figures.

[0029] In the figures:

Figure 1 shows a schematic exploded view of a portion of an internal combustion engine with a fuel rail assembly according to a first embodiment,

Figure 2 shows a schematic sectional view of the fuel rail assembly according to the first embodiment,

Figure 3 shows a perspective view of a fuel rail assembly according to a second exemplary

embodiment, and

Figure 4 shows a perspective view of a portion of a fuel rail assembly according to a third embodiment.

[0030] In the exemplary embodiments and figures, similar, identical or similarly acting elements are provided with the same reference symbols.

[0031] Figure 1 shows an exploded perspective view of an internal combustion engine 1 with a fuel rail assembly 3 according to a first embodiment and with fuel injectors 7. The fuel injectors 7 are installed in receptacle bores 51 of a cylinder head 5 of the internal combustion engine 1.

[0032] The fuel rail assembly 3 comprises an elongated fuel rail 31. For example, the fuel rail 31 is metallic; in particular it is made from steel. Fuel is supplied to the fuel rail through an inlet fitting 33 on one side of the fuel rail 31. The opposite end of the fuel rail 31 is sealed by an end plug 35 (not visible in figure 1). Further, the fuel rail 31 has a sensor port 37 for connecting a pressure sensor. The fuel rail 31 also has a plurality of outlet ports 39; in the present embodiment it has four outlet ports 39.

[0033] The fuel rail assembly 3 comprises a plurality of pipes 41. One pipe 41 is hydraulically connected to each outlet port 39. Each pipe comprises an upper tube 43 and a lower tube 45. Each of the upper tubes 43 and the lower tubes 45 is preferably a rigid metal tube and in particular made from steel.

[0034] The lower tube 45 merges with an injector cup 47. The lower tube 45 and the injector cup 47 are a one-piece element. A fixation bracket 49 is rigidly connected to the lower tube 45. In the present embodiment, the fixation bracket 49 and the lower tube 45 are in one piece. One of the injectors 7 is received in the injector cup 47.

[0035] For the sake of simplicity, only one outlet port 39, pipe 41, injector cup 47, fixation bracket 49 and injector 7 are provided with reference numbers in the figure 1. However, the other outlet ports 39, pipes 41, injector cups 47, fixation brackets 49 and injectors 7 are of the same construction.

[0036] The individual outlet ports 39 follow one another along an elongation direction of the fuel rail 31 and are spaced apart from one another. The pipes 41 also follow one another along the elongation direction and are spaced apart from one another. Also the injector cups 47 follow one another along the elongation direction and are spaced apart from one another. In addition, the fixation brackets 49 are spaced apart from the fuel rail 31 and from one another and also follow one another along the elongation direction of the fuel rail 31. The elongation direction is in particular that direction in which the fuel rail 31 has its largest dimension. If the fuel rail 31 is in the general shape of a cylinder shell, the elongation direction is directed along the cylinder axis of the cylinder shell.

[0037] The fuel rail assembly 3 is rigidly fixed to the

cylinder head 5 by means of fixation elements 9 via the fixation brackets 49. One of the fixation elements 9 is shown in figure 1. The fixation elements 9 assigned to the other fixation elements 49 are omitted for reasons of simplicity. The fixation element 9 may be a screw, as shown in figure 1, or a bolt, for example.

[0038] The fixation element 49 has an opening 491 which perforates the fixation bracket 49 in a mounting direction M. The fixation element 9 extends through the opening 491 in the mounting direction M and is screwed into the cylinder head 5, for example. In this way, the fuel rail assembly 3 is held in position with respect to the combustion engine 1 solely by fixing via the fixation brackets 49.

[0039] Figure 2 shows a schematic section view of the fuel rail assembly 3 through one of the pipes 41.

[0040] The upper tube 43 of the pipe 41 has an upstream end section 431 which is attached to the fuel rail in such fashion that the upper tube 43 is hydraulically connected to the fuel rail 31 via the outlet port 39. For example, the upstream end section 431 has a flange which extends laterally around the outlet port 39 and is rigidly connected to the fuel rail 31, e.g. by brazing or welding.

[0041] A downstream end portion 453 of the lower tube 45 merges with the injector cup 47. For example, the one-piece element which comprises the lower tube 45 and the injector cup 47 has a central opening with a cross section which widens in the region where the downstream end portion 453 of the lower tube 45 merges with the injector cup 47. In one embodiment, cross section of the central opening is the same at every position along the whole lower tube 45.

[0042] A downstream end section 433 of the upper tube 43 is shifted into an upstream end section 451 of the lower tube 45. While the upper tube 43 has a generally bent shape, its downstream end section 433 has the straight shape. Also, the lower tube has a straight shape. The lower tube 45 and the downstream end section 433 of the upper tube 43 share a common longitudinal axis R which is also a longitudinal axis of the injector cup 47 and of the fuel injector 7 when the latter is received in the injector cup 47.

[0043] The opening 491 of the fixation bracket 49 has a central axis C which is parallel to the mounting direction M. The central axis C is parallel to the longitudinal axis R of the lower tube 45 and laterally spaced apart from the longitudinal axis R. In the present embodiment, the fixation bracket 49 has a ring shaped segment comprising on the opening 491 and a beam which extends from the ring-shaped segment to the lower tube 45 in a radial direction with respect to the axes R and C.

[0044] By means of the downstream end 433 of the upper tube 43 being shifted into the upstream end section 451 of the lower tube 45, the upper tube 43 and the lower tube 45 are rotatable with respect to one another around the common longitudinal axis R during manufacturing of the fuel rail assembly 3. Therefore, the longitudinal axis

can also be denoted as a predetermined rotational axis R.

[0045] By means of the rotatable engagement of the upper tube 43 and the lower tube 45, an angular position of the fixation bracket 49 with respect to the rotational axis R - and thus in particular the angular position of the opening 491 with its central axis C - can be determined in dependence on the shape of the internal combustion engine 1 for which the fuel rail assembly 3 is produced. The angular position may be in particular determined with respect to the shape of the cylinder head 5 and preferably with respect to the positions of the receptacle bores in the cylinder head 5 which receive the fixation elements 9 in this or any other embodiment.

[0046] The lower tube 45 can be rotated around the rotational axis R until the fixation bracket 49 is in the determined angular position. Subsequently, a rigid connection 51 is established between the upper tube 43 and the lower tube 45. The rigid connection 51 is a brazed connection in the present case. Alternatively, the rigid connection 51 can be a weld seam. By means of the rigid connection 51, the upper tube 43 and the lower tube 45 are positionally and rotationally fixed to one another, in particular blocking relative rotational displacement which is possible absent the rigid connection 51 as described above. The rigid connection 51 may also be operable to establish a fluid tight seal in the interface region between the upper tube 43 and the lower tube 45.

[0047] By means of being shifted into the upstream end section 451 of the lower tube 45, the downstream end section 433 of the upper tube 43 and the upstream end section 451 of the lower tube 45 overlap axially with respect to the rotational axis R. Due to the axial overlap, the lower tube 45 is axially displaceable relative to the upper tube 43 with respect to the rotational axis R while remaining in engagement with the upper tube 43.

[0048] In this way, the axial position of the fixation bracket 49 can be determined in dependence on the shape of the internal combustion engine 1 - and in particular on the shape of the cylinder head 5. During production of the fuel rail assembly 3, before the rigid connection 51 is established, the lower tube 45 can be axially displaced relative to the upper tube 43 with respect to the rotational axis R until the fixation bracket 49 is in the determined axial position and then fixed in this position by means of establishing the rigid connection 51.

[0049] Figure 3 shows a perspective view of the second exemplary embodiment of a fuel rail assembly 3 together with fuel injectors 7 being received in the fuel injector cups 47 of the fuel rail assembly 3. For better representability, some parts of the fuel rail assembly 3 are drawn in semitransparent fashion in figure 3.

[0050] The fuel rail assembly 3 of the second embodiment corresponds in general to the fuel rail assembly 3 of the previous embodiments. However, in the present embodiment, the upper tube 43 has a straight shape so that it shares the longitudinal and rotational axis R with the lower tube 45 and with the fuel injector 7 when the latter is received in the injector cup 47.

[0051] In one embodiment, the fuel rail assembly 3 is configured for rotationally indexing the fuel injectors 7. In other words, the fuel rail assembly 3 and the fuel injectors 7 are shaped in such fashion that the fuel injectors 7 can only be connected to the injector cups 47 in predetermined rotational positions of the fuel injectors 7 with respect to the respective injector cups 47.

[0052] Figure 4 shows an example of such a design.

[0053] In this exemplary embodiment, the fuel rail assembly 3 comprises a spring clip 53. The spring clip 53 has a base portion 531 which is positionally fixed with respect to the fuel injector 7. For example, it is arranged in a slit of a plastic housing of the fuel injector 7 so that it is in form fit engagement with the plastic housing to lock movement of the spring clip 53 relative to the fuel injector 7 along the longitudinal axis R of the fuel injector 7. Preferably, the spring clip 53 and the plastic housing of the fuel injector 7 are also shaped in such fashion as to block rotational movement of the spring clip 53 with respect to the plastic housing. One or more spring arms 535 project from the base portion 531 in axial direction towards the injector cup 47 and abut, for example, a downstream end surface of the injector cup 47.

[0054] The spring arms 535 are bent so that they are elastically deformable when the relative axial positions of the fuel injector 7 and the injector cup 47 change. In this way, the spring clip 53 is preferably operable to transfer an axially repellant spring force between the fuel injector 7 and the injector cup 47.

[0055] The spring clip 53 comprises a spike 533 which may also be denoted as a pin. The spike 533 extends from the base portion 531 in axial direction towards the injector cup 47 and axially overlaps with the injector cup 47. Preferably, the elongation direction of the spike 533 is parallel to the longitudinal axis R.

[0056] The injector cup 47 has an axially elongated notch 471 in which - when the fuel injector 7 is received in the injector cup 47 - the spike 533 is received in such fashion that rotational displacement of the spring clip 53 with respect to the injector cup 47 is blocked while the spring clip is axially displaceable with respect to the injector cup 47. For example, the notch 471 is an axially extending channel having basically the same transverse dimension as the spike 533. Thus, by means of the mechanical connection between the fuel injector 7 and the spring clip 53 as described above and by means of the mechanical connection of the spring clip 53 with the injector cup 47 via the spike 533 and the notch 471, rotational movement of the fuel injector 7 with respect to the injector cup 47 is blocked.

[0057] In another exemplary embodiment, as shown in figures 1 and 3, each injector cup 47 may have an aperture in which a tab of the spring clip 53 is received to block rotational movement of the spring clip 53 with respect to the injector cup 47. The tab may be configured such that it is operable to establish a snap fit connection with the injector cup 47 to prevent withdrawing of the fuel injector 7 out of the injector cup 47.

[0058] Further embodiments for limiting axial and/or rotational movement of the fuel injector 7 with respect to the injector cup 47 are also conceivable. In addition, fuel injection devices with a fuel injector 7, a spring clip 53 and an injector cup 47 having one or more of the above mentioned features, in particular for limiting rotational and/or axial displacement of the fuel injector 7 with respect to the injector cup 47 may also be useful independently of the further design of the fuel rail assembly 3.

[0059] The invention is not limited to specific embodiments by the description on basis of these exemplary embodiments. Rather, it comprises any combination of elements of different embodiments. Moreover, the invention comprises any combination of claims and any combination of features disclosed by the claims.

Claims

1. Fuel rail assembly (3) for an internal combustion engine (1) comprising

- an elongated fuel rail (31),
- a plurality of injector cups (47) for hydraulically coupling the fuel rail assembly (3) to respective fuel injectors (7) which are operable to inject fuel into the combustion engine (1) and
- a pipe (41) assigned to each injector cup (47) for hydraulically coupling the respective injector cup (47) to the fuel rail (31),

wherein

- each pipe (41) comprises an upper tube (43) and a lower tube (45), an upstream end section (431) of the upper tube (43) is attached to the fuel rail (31) and a downstream end section (453) of the lower tube (45) is attached to the respective injector cup (47) or merges with the injector cup (47),
- a fixation bracket (49) is assigned to each pipe (41) which is configured for positionally fixing the fuel rail assembly (3) with respect to the combustion engine (1) and which is rigidly connected to the respective lower tube (45),
- a rigid connection (51) is established between a downstream end section (433) of the upper tube (43) and an upstream end section (451) of the lower tube (45), and
- the downstream end section (433) of the upper tube (43) and the upstream end section (451) of the lower tube (45) are in engagement with one another in such fashion that, absent the rigid connection (51), the upper tube (43) and the lower tube (45) are rotatable with respect to one another around a predetermined rotational axis (R).

2. The fuel rail assembly (3) according to the preceding claim, wherein the downstream end section (433) of the upper tube (43) and the upstream end section (451) of the lower tube (45) are in engagement with one another in such fashion that, absent the rigid connection (51), the lower tube (45) is axially displaceable relative to the upper tube (43) with respect to the rotational axis (R).

3. The fuel rail assembly (3) according to one of the preceding claims, wherein the fixation brackets (49) are spaced apart from the fuel rail (31) and from one another.

4. The fuel rail assembly (3) according one of the preceding claims, wherein the fuel rail assembly (3) is configured to be held in position with respect to the combustion engine (1) solely by fixing via the fixation brackets (49).

5. The fuel rail assembly (3) according to one of the preceding claims, wherein the lower tube (45) has a straight shape with a longitudinal axis which is coaxial to the rotational axis (R).

6. The fuel rail assembly (3) according to one of the preceding claims, wherein the fixation bracket (49) has an opening (491) which perforates the fixation bracket (49) in a mounting direction (M), a central axis (C) of the opening (491) being parallel to the rotational axis (R).

7. The fuel rail assembly (3) according to one of the preceding claims, wherein the upper tube (43) has a bent shape.

8. The fuel rail assembly (3) according to one of the preceding claims, wherein the downstream end section (433) of the upper tube (43) is shifted into the lower tube (45).

9. The fuel rail assembly (3) according to one of the preceding claims, wherein the rigid connection (51) is a welded connection or a brazed connection.

10. The fuel rail assembly (3) according to one of the preceding claims, wherein the fuel rail (31) comprises at least one of the following elements: an inlet fitting (33), an end plug (35), a sensor port (37).

11. Method for producing a fuel rail assembly (3) according to one of the preceding claims comprising the following steps:

- providing the fuel rail (31) with the upper tubes (43) attached to the fuel rail (31),
- providing the lower tubes (45) and bringing the downstream end sections (433) of the upper

tubes (43) in engagement with the upstream end section (451) of the lower tubes (45) in such fashion that each of the upper tubes (43) and the respective lower tube (45) are rotatable with respect to one another around a respective pre-determined rotational axis (R),
 - determining an angular position with respect to the respective rotational axis (R) for each fixation bracket (49) in dependence on the shape of the internal combustion engine (1), and
 - for each of the lower tubes (45), rotating the lower tube (45) around the respective rotational axis (R) relative to the respective upper tube (43) until the respective fixation bracket (49) is in the determined angular position and subsequently establishing the respective rigid connection (51) for retaining the fixation bracket (49) in the determined angular position.

12. Method according to claim 11, wherein the downstream end sections (433) of the upper tubes (43) and the upstream end sections (451) of the lower tubes (45) are brought in engagement with one another in such fashion that, absent the rigid connection (51), the lower tubes (45) are axially displaceable relative to the respective upper tubes (43) with respect to the rotational axis (R), the method further comprising the following steps:

- determining an axial position for each fixation bracket (49) with respect to the respective rotational axis (R) in dependence on the shape of the internal combustion engine (1), and
 - for each of the lower tubes (45), axially displacing the lower tube (45) relative to the upper tube (43) with respect to the respective rotational axis (R) until the respective fixation bracket (49) is in the determined axial position before establishing the respective rigid connection (51).

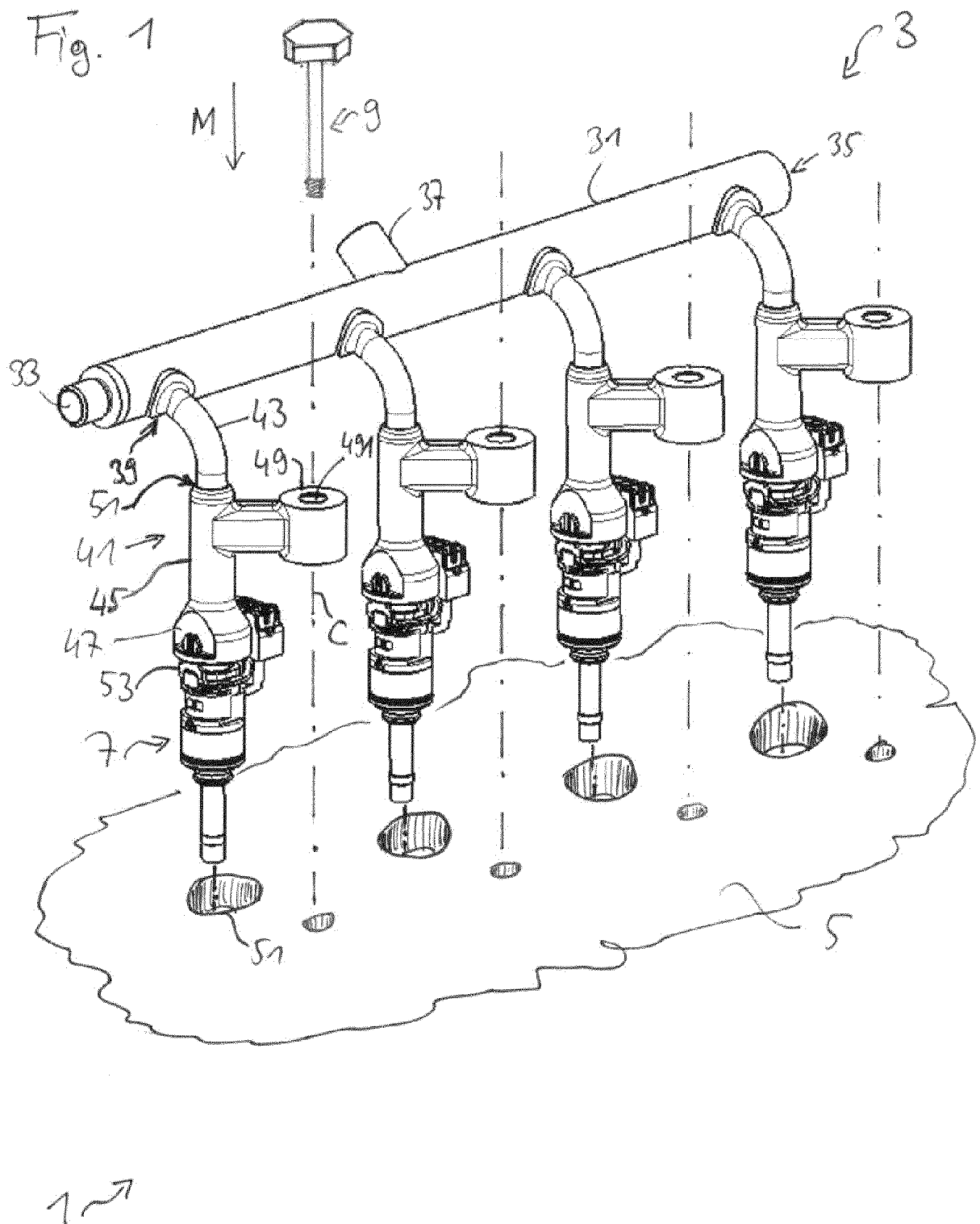


Fig. 2

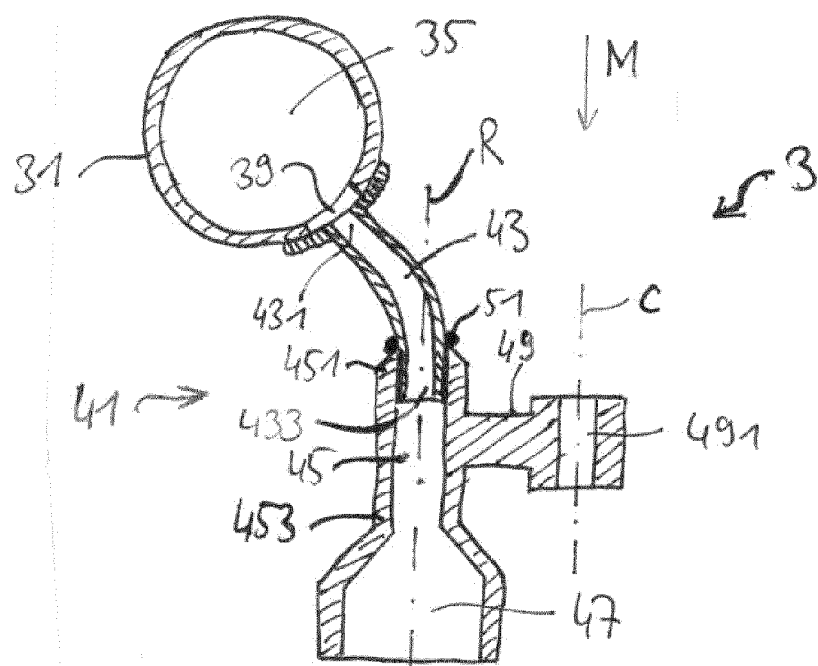


Fig. 3

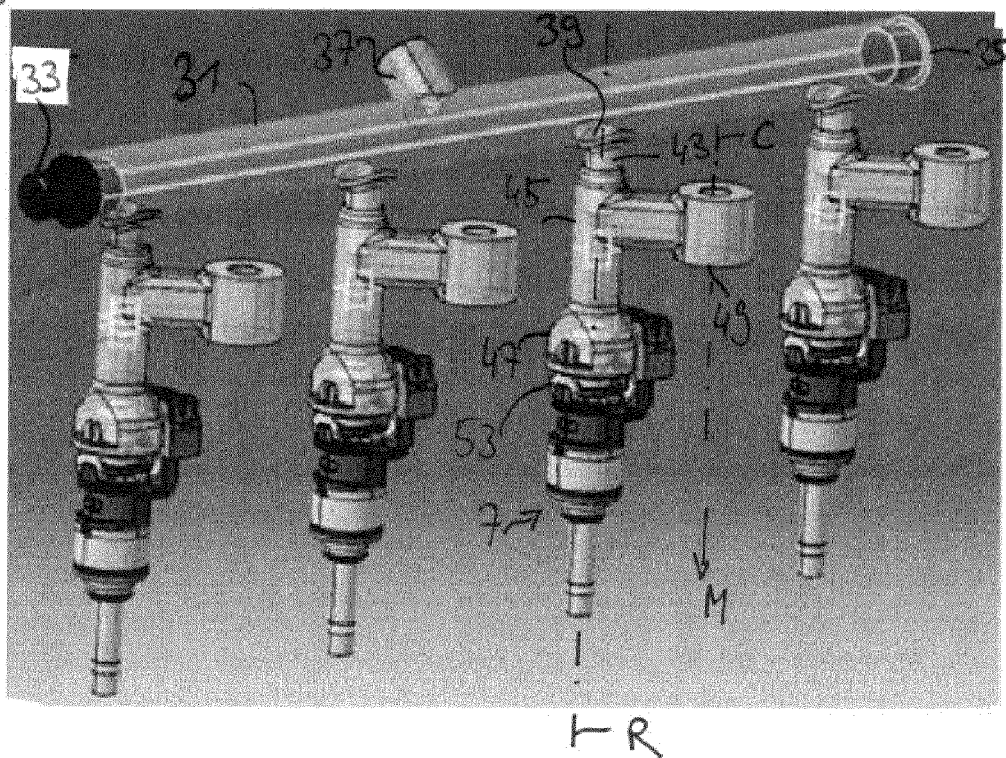
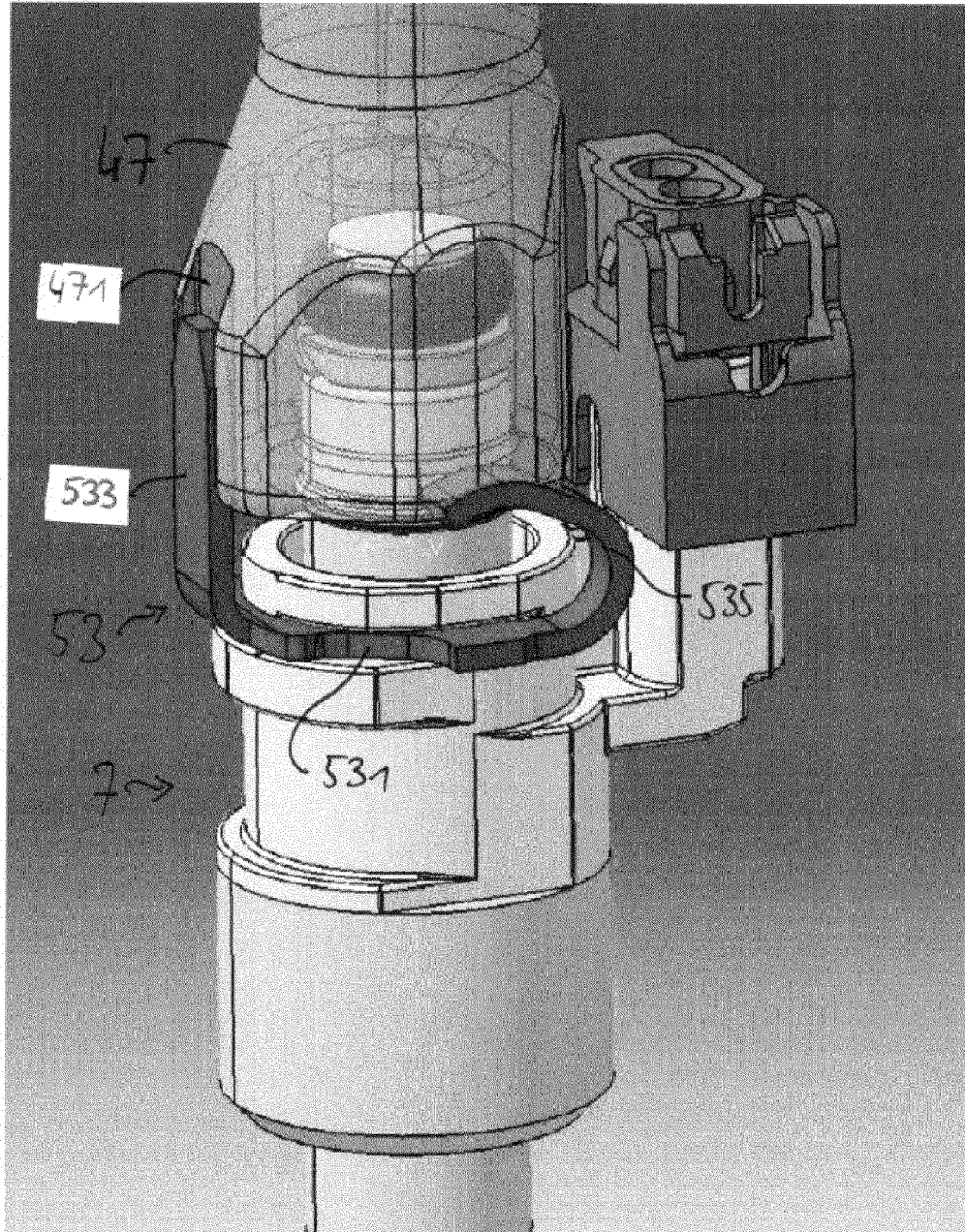


Fig. 4





EUROPEAN SEARCH REPORT

Application Number
EP 14 15 6573

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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 21 May 2014	Examiner Landriscina, V
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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 14 15 6573

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