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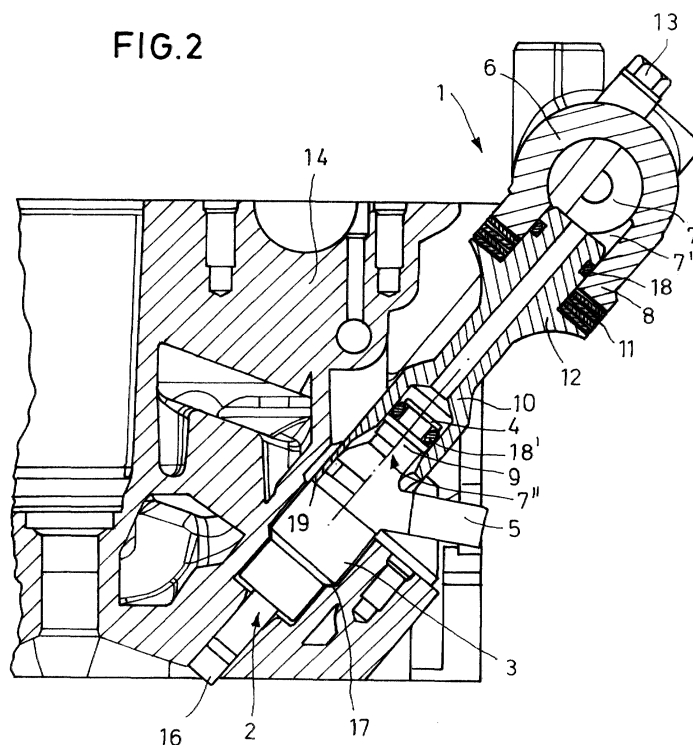
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(54) **Fuel injection system for internal combustion engines**

(57) The fuel injection system (1) for an internal combustion engine consists of a pre-fabricated unit including a common rail (6) and the injectors consisting of electromagnetically operated valves (2). Between the valves and the common rail pipes (10) are arranged which are flexible but sealingly connected at their one end to the common rail and the other end to the valves.

Preferably between the common rail and the pipes plate springs (11) are arranged to keep the injection valves pressed against the seat in the cylinder head. By using the intermediate pipes with sealings (18,18') at both ends and the stack of plate springs (11), the manufacturing tolerances for the bores in the cylinder heads and for the independently fabricated bores in the common rail can be compensated.

FIG.2



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Description

[0001] The invention relates to a fuel injection system with a plurality of electromagnetically operated fuel injection valves. The operation of such injection valves is effected by an electronic control device in dependence of operating parameters of the combustion engine (e.g. air mass flow, required torque, temperature). On the basis of the operating parameters, the amount of fuel which is to be injected is controlled by operation of the electromagnetically operated valves.

[0002] In DE 40 02 393 A 1 such a fuel injection system is disclosed. The fuel injection valves are of the top feed kind which means that the axis of the injector is arranged in a plane which intersects the central axis of a normally cylindrical fuel rail. The electromagnetic valves have a valve housing. The portion of the valve housing which is adjacent to the fuel rail can be described as a fuel supply flange with an internal fuel valve channel and a fuel feed opening on its surface which is normally arranged - when the valve is in its operation position - in a top position with respect to the lower end of the injection valve which is fitted into an opening in the cylinder head which ends in the combustion chamber of the engine. For the connection of the electromagnetically operated valve with the control apparatus an electrical connector is arranged on the outer surface of the valve housing. The fuel rail which guides fuel to all the injection valves has an internal fuel rail channel which is connectable to a fuel feed and a fuel drain. The fuel rail has integrally connected outer branches with internal fuel branch channels which communicate with the internal fuel rail channel of the fuel rail. The branches are sealingly connectable to the fuel injection valves.

[0003] The bores in the cylinder head which receive the injection valves can be economically manufactured only with allowing certain tolerances. This is also true for the fuel rail with the branches which have to be connected to the other end of the injectors.

[0004] Therefore it is desirable particularly for a pre-fabricated unit of fuel rail and injectors to have a construction which is robust enough to compensate the tolerances, but also serves as tight connection even under high pressures (e.g. 100 - 500 bar for gasoline direct injection or 1000 - 2000 bar for diesel direct injection) in the fuel injection system.

[0005] To serve these purposes the pre-fabricated unit of fuel rail and injectors include a fuel rail that is fastened to the cylinder head. The fuel supply flange of the valve is sealingly but flexible connected to a first end of an intermediate pipe, the second end of which is sealingly but flexible connected to the branch arranged on the fuel rail. Between the fuel rail and the valve in the direction of the valve axis a force is exerted by a tensioner device. Thus by fastening the pre-fabricated fuel injection system (consisting of the fuel rail, the intermediate pipe and the electromagnetically operated valves) the valves are held in their proper position in the bores

arranged in the cylinder head. As the intermediate pipe has at its both ends a flexible but sealing connection - preferably with O-rings - the various tolerances are compensated as the intermediate pipe can be tilted relative to the axis of the bores in the cylinder head or vice versa relative to the axis of the flanges in the fuel rail. The pre-fabricated fuel injection system is fixed by appropriate clamps as long as the system is not fastened to the cylinder head by the normally used fastening bolts. After the pre-fabricated fuel injection system is fastened to the cylinder head, the holding clamps preferably are removed. By fastening the fuel rail to the cylinder head a force is exerted from the fuel rail to the elastic tensioner device which rests with one surface against the fuel rail resp. the flange which forms an integral part of the fuel rail. From the tensioner device the force is exerted onto an appropriate surface on the pipe which itself rests against an appropriate flange or edge which is arranged on the injection valve. Further down into the direction of the lower portion of the injection valve where this communicates to the combustion chamber the injection valves rests against an appropriate surface in the cylinder head. By the tensional device any tolerances in the direction of the axis of the injection valve are also compensated.

[0006] A typical tensioner device is a spring or preferably a stack of plate springs. In order to exert a sufficient force into the direction of the axis of the injection valve, the dimensions of the spring and the typical parameters of the spring have to be optimised. To this end in a preferred embodiment - depending on the space that is available it can be advantageous to arrange the tensioner on either end of the pipe or depending on the tolerances also on both ends. Thus the stack of plate springs or the tensioner device could be arranged between the branch and a supporting flange which is mechanically connected to the intermediate pipe.

[0007] On the other hand, the tensioner device or spring can be arranged between a supporting edge on the valve housing and a supporting flange which is connected to the intermediate pipe.

[0008] Preferably, the intermediate pipe with its first end which is in the installed position of the pre-fabricated fuel injection system, the upper end is inserted into the internal fuel branch channel of the branch which is integrally formed to the fuel rail.

[0009] In a further preferred embodiment, the intermediate pipe at its second end (lower end in installed position) has an opening with an inner diameter which is designed to receive the outer surface of the fuel supply flange of the valve.

[0010] The invention is described in more detail in specific embodiments shown in the figures 1 to 4. Fig. 1 shows a plan view of the cylinder head with the fuel injection system in its installed position. The fuel injection system 1 includes the fuel injectors 2 which are shown in their installed position between the air intake channels. The electromagnetically operated fuel injection

tion valves have arranged in their valve housing 3 a front face or top fuel supply 4 which is adjacent to the branch 8 forming an integral part of the fuel rail 6. Electrical connectors 5 serve for the connection between the electromagnetically operated valves and an electronic control unit. Along the axis of the fuel rail 6, the internal fuel rail channel 7 is arranged and can be connected to a fuel feed which would be connected to a fuel pump. The internal fuel rail channel 7 communicates with internal fuel branch channel 7' which downstream towards the injection into the combustion chamber communicate with fuel valve channels 7'' arranged in the valve housing 3. Between the fuel branch 8 and the supporting flange 12 of the valve housing 3 a plate spring or stack of plate springs 11 is arranged. The fuel rail 6 is fixed to the cylinder head 14 by means of fasteners 13.

[0011] In fig. 2 components which have been already described in connection with fig. 1 use the same numerals. In this embodiment the pipe 10 with its upper end is inserted into the opening 7' and sealed against that with an O-ring 18 which is arranged in a groove in the upper end of the pipe 10. For diesel direct injection, the O-ring can be replaced by a deformable metal seal. The sealing at the lower end of the pipe 10 is also achieved by an O-ring 18' which is received in a groove arranged in the valve housing 3. At this lower, the inner diameter of the pipe is adapted to the outer diameter of the O-ring 18' as received in the groove arranged in the fuel supply flange 9 of the valve 2. The bore 16 which is arranged in the cylinder head 14 to receive the valve has a preferably cone shaped stopper surface 17 against which the valve 2 rests. By fastening the fuel rail 6 through the fastener 13 a force is exerted through the branch 8 onto the tensioner 11. As the tensioner 11 rests against a supporting flange 12 of the pipe 10, the force is further exerted onto the pipe 10 and as the pipe 10 rests against a circumferential edge 19 on the housing 3 of the valve, this is hold in its position in the bore 16.

[0012] In the embodiment shown in fig. 3, the force exerted by the fastener 13 is not directly exerted onto the valve 2 by the pipe 10. Instead a cylindrical injector stopper 15 is arranged coaxial with the pipe 10. Here the spring or spring stack rests against an appropriate surface of the injector stopper which in this embodiment includes a supporting ring 12 which is inserted in the groove arranged in the pipe 10 and thereby not only exerts the force onto the injector stopper but also keeps the pipe 10 in the proper position.

[0013] As shown in the embodiment in fig. 4, the lower joint between the intermediate pipe 10 and the valve housing 3 which is formed by the O-ring 18' and the sealing surfaces on the pipe and the valve housing can be achieved by retaining the O-ring in a groove formed on the pipe. This variation in the design can be also used with the embodiment shown in fig. 2 where the force to keep the valve in place is exerted directly by the pipe. The injector stopper 15 preferably rests against a circumferential edge 19 which is designed to form a seat

on the housing of valve. This seat preferably includes a crowned surface 19' at one part of the seat 19 and a conical surface 19'' on the other part of the seat.

Claims

1. Fuel injection system (1) for internal combustion engines
 - with a plurality of electromagnetically operated fuel injection valves (2)
 - which have a valve housing (3) with a top surface fuel feed opening (4) in a fuel supply flange (9) and internal fuel valve channels (7''),
 - with electrical connectors (5) for controlling the operation of the fuel injection valves (2),
 - with a fuel rail (6) with an internal fuel rail channel (7) which is connectable to a fuel feed and a fuel drain and
 - which fuel rail (6) has integrally connected branches (8) with internal fuel branch channels (7') connected to the fuel rail channel (7)
 - and which branches (8) are sealingly connectable to the valves (2)
 - **characterized in that**
 - the fuel rail is fastened to the cylinder head, the fuel supply flange (9) of the valve (2) is flexible sealingly connected to a first end of an intermediate pipe (1) the second end of which is flexible sealingly connected to the branch (8) and between the fuel rail (6) and the valve (2) a force is exerted by a tensioner device (11).
2. Fuel injection system (1) for internal combustion engines according to claim 1, **characterized in that** the tensioner device (11) is a spring which is arranged between the branch (8) and a supporting flange (12) which is mechanically connected to the intermediate pipe (10).
3. Fuel injection system (1) for internal combustion engines according to claim 1, **characterized in that** the tensioner device (11) is a spring which is arranged between a supporting edge of the valve housing (3) and a supporting flange (12) which is mechanically connected to the intermediate pipe (10').
4. Fuel injection system (1) for internal combustion engines according to one of the claims 1 to 3, **characterized in that** the intermediate pipe with its first end is inserted into the internal fuel branch channels (7') of the branch (8).
5. Fuel injection system (1) for internal combustion engines according to one of the claims 1 to 4, **characterized in that** the intermediate pipe at its second

end has an opening with an inner diameter designed to receive the outer surface of the fuel supply flange (9) of the valve (2).

6. Fuel injection system (1) for internal combustion engines according to one of the claims 1 to 4, **characterized in that** the intermediate pipe at its second end has an opening with an outer diameter designed to be received in the inner surface of the fuel supply flange (9) of the valve (2).

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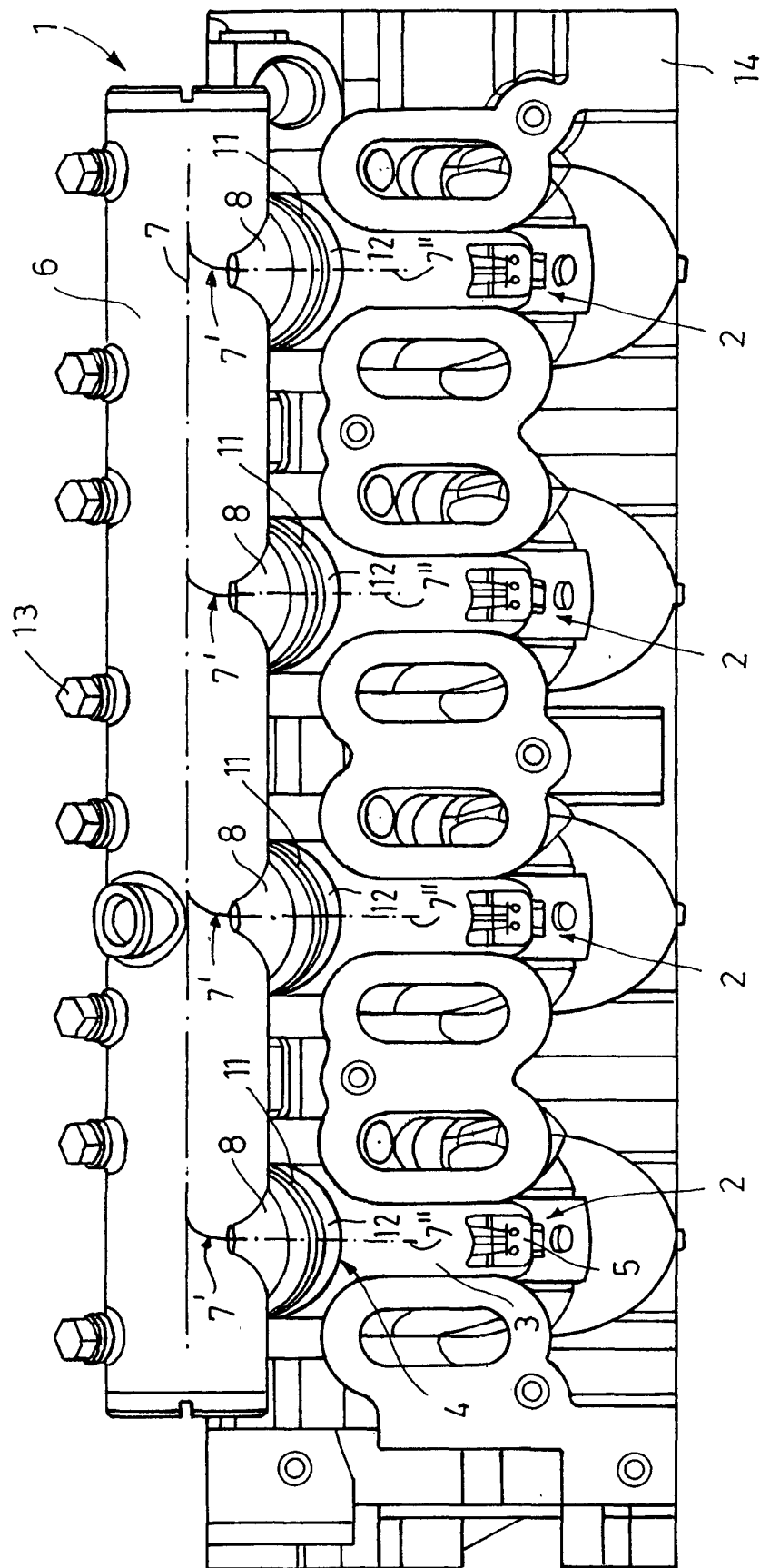


FIG. 1

FIG.2

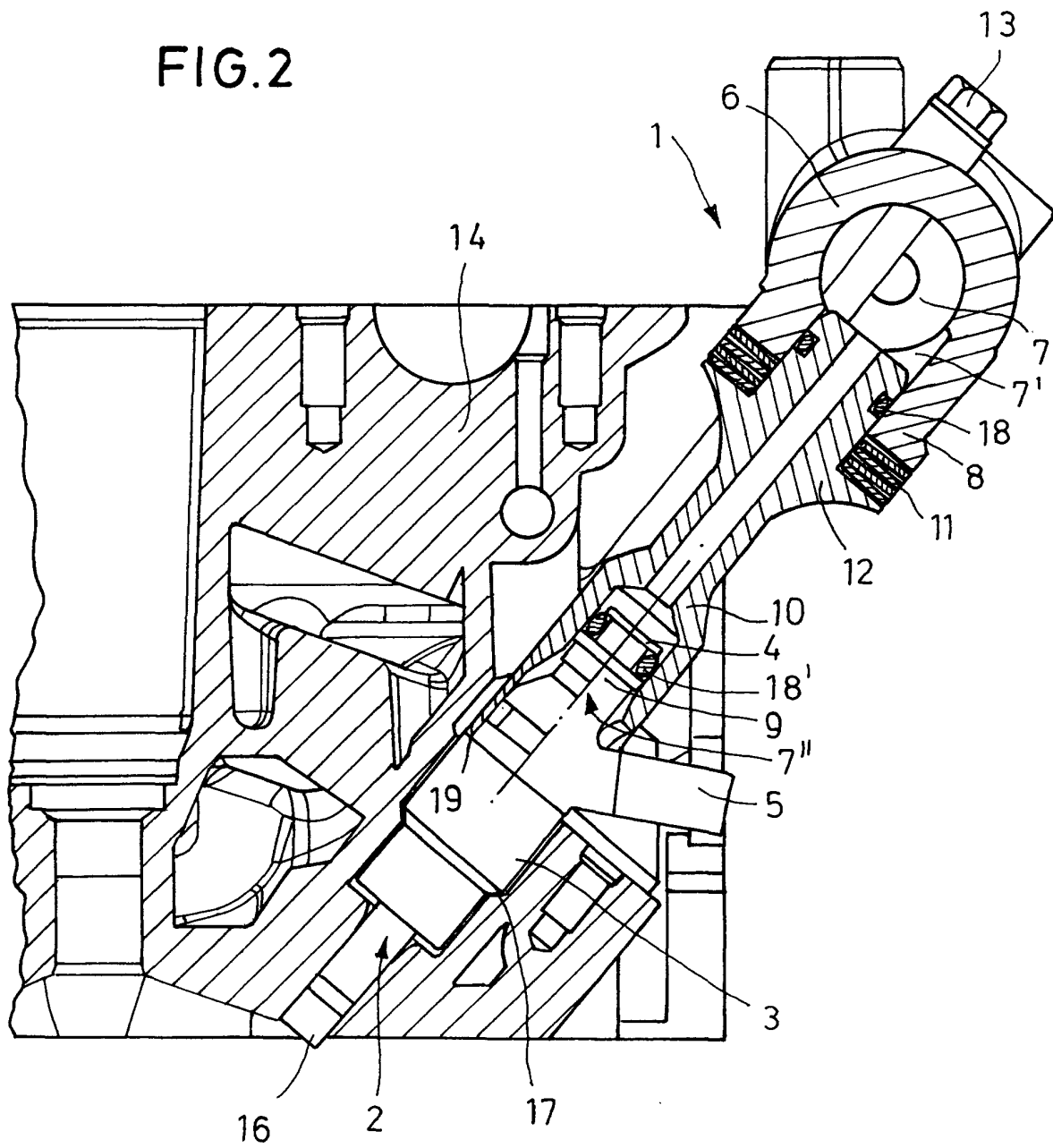
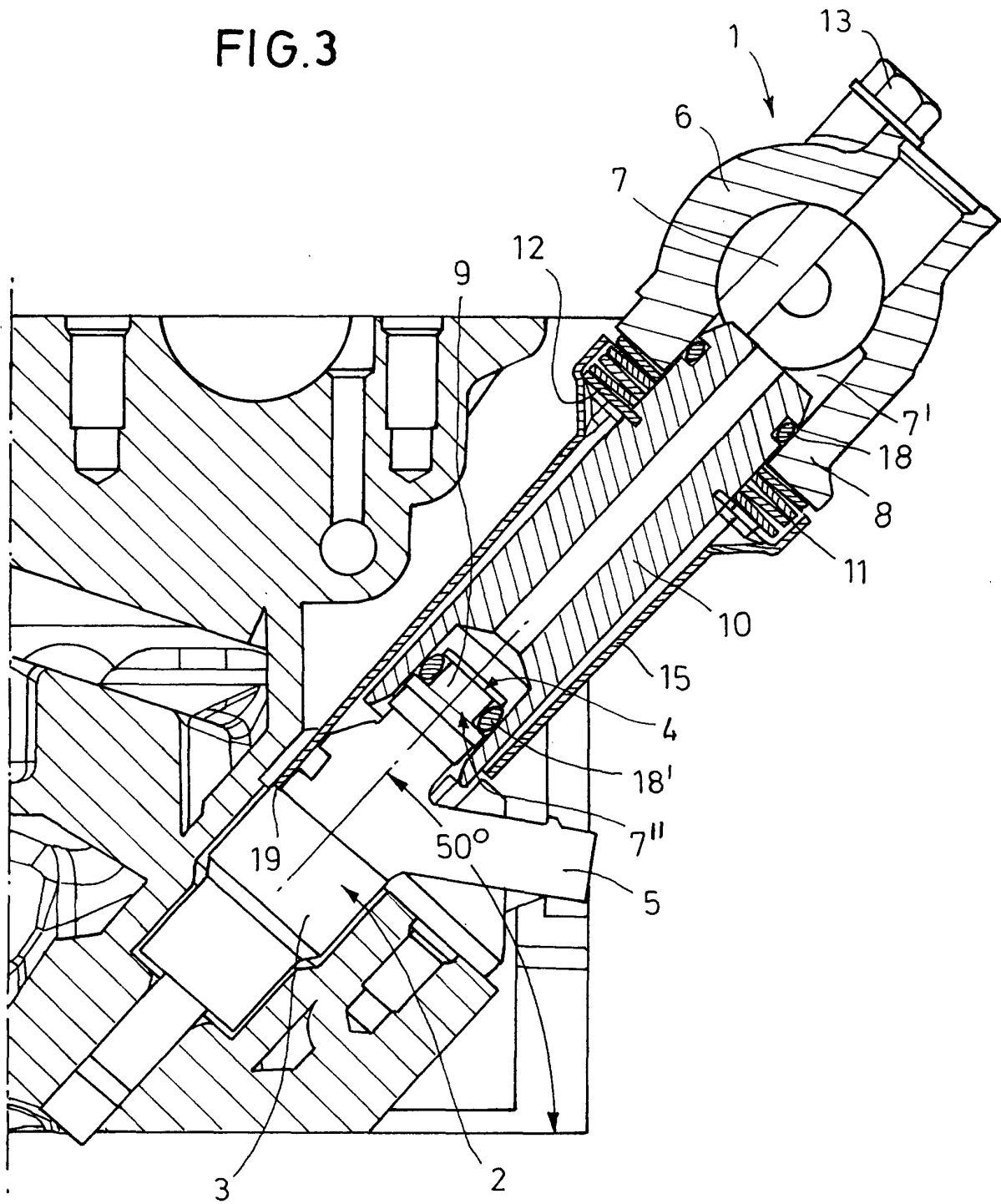


FIG.3



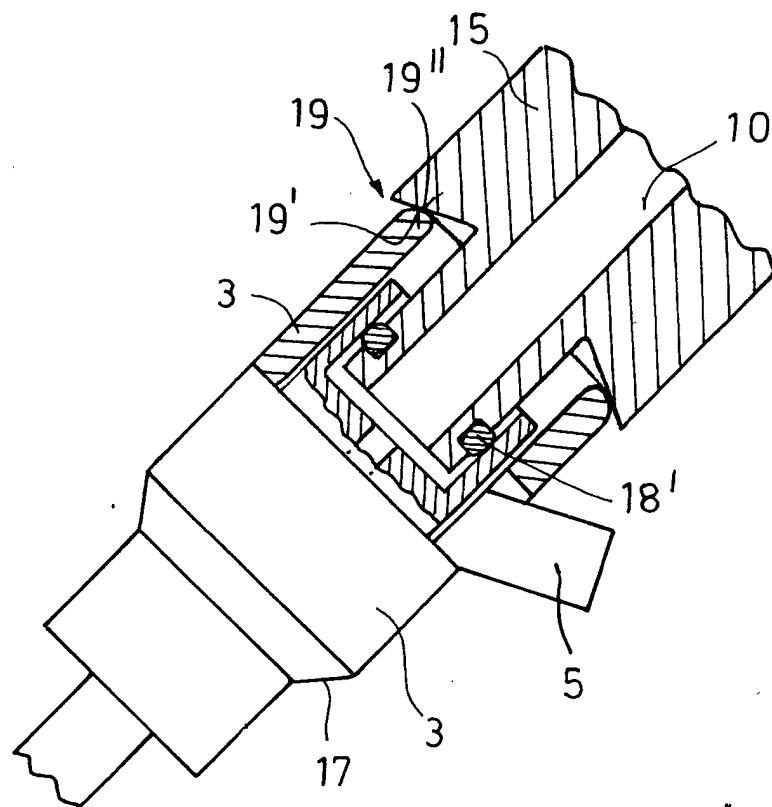


FIG. 4



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EUROPEAN SEARCH REPORT

Application Number
EP 00 10 8835

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
E	DE 198 53 090 A (BOSCH GMBH ROBERT) 25 May 2000 (2000-05-25) * column 3, line 60 - column 6, line 47 * * figures *	1,4,5	F02M55/00 F02M69/46 F02M55/02
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			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			F02M
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 29 September 2000	Examiner Ingegneri, M
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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