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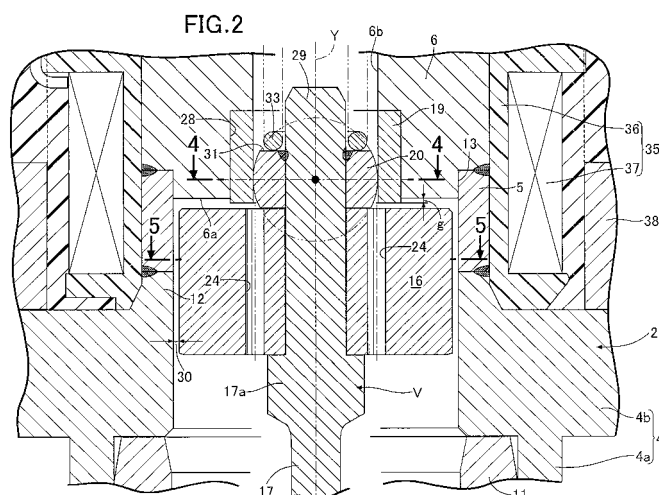
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(54) **ELECTROMAGNETIC FUEL-INJECTION VALVE**

(57) In the disclosed electromagnetic fuel-injection valve: a non-magnetic or weakly magnetic guide bush (19) is affixed at the inner periphery of an immobile core (6); the front end of the guide bush (19) protrudes from the suction surface (6a) of the immobile core (6); during excitation of a coil (37), by means of a mobile core (16) being caused to contact the front end of the guide bush (19), the opening boundary of a valve body (15) is de-

fined, and an air gap (g) is formed between the immobile core (6) and the mobile core (16); and a sliding member (20) that is slidably borne at the inner peripheral surface of the guide bush (19) is provided to a valve assembly (V). As a result, a structure-simple electromagnetic fuel injection valve is provided wherein the opening/closing postures of the valve body can be effectively stabilized, and moreover at the time of demagnetization of the coil, valve closing responsiveness can be favorably obtained.



## Description

### TECHNICAL FIELD

**[0001]** The present invention relates to improvement of an electromagnetic fuel-injection valve that includes a valve housing that has a conical valve seat at one end, a fixed core that is connectedly provided at the other end of the valve housing and has a hollow portion serving as a fuel flow path, a valve assembly that includes a movable core disposed so as to oppose an attracting face of the fixed core, a valve body cooperating with the valve seat, and a stem integrally linking the fixed core and the valve body, a valve spring that urges the valve body in a valve-closing direction, and a coil that is disposed on an outer periphery of the fixed core and makes the valve body open by making the fixed core attract the movable core by energization, the fixed core being provided with a guide part slidably supporting a rear end portion of the valve assembly.

### BACKGROUND ART

**[0002]** Such an electromagnetic fuel-injection valve is already known, as disclosed in Patent Document 1.

### RELATED ART DOCUMENTS

#### PATENT DOCUMENTS

**[0003]** Patent Document 1: Japanese Patent Application Laid-open No. 2008-31853

### SUMMARY OF THE INVENTION

### PROBLEMS TO BE SOLVED BY THE INVENTION

**[0004]** In such an electromagnetic fuel-injection valve, there is the advantage that the support span for the valve assembly can be set longer than the distance between the valve seat and the fixed core, thus preventing effectively the valve assembly from tilting and stabilizing effectively the opening/closing attitude of the valve body.

**[0005]** It is an object of the present invention to provide an electromagnetic fuel-injection valve with a simple structure that, while ensuring the above-mentioned advantage, can quicken elimination of residual magnetism in the fixed core and the movable core at the time of de-energization of the coil, thus improving the valve-closing responsiveness.

### MEANS FOR SOLVING THE PROBLEMS

**[0006]** In order to attain the above object, according to a first aspect of the present invention, there is provided an electromagnetic fuel-injection valve comprising a valve housing that has a conical valve seat at one end, a fixed core that is connectedly provided at the other end

of the valve housing and has a hollow portion serving as a fuel flow path, a valve assembly that comprises a movable core disposed so as to oppose an attracting face of the fixed core, a valve body cooperating with the valve seat, and a stem integrally linking the fixed core and the valve body, a valve spring that urges the valve body in a valve-closing direction, and a coil that is disposed on an outer periphery of the fixed core and makes the valve body open by making the fixed core attract the movable core by energization, the fixed core being provided with a guide part slidably supporting a rear end portion of the valve assembly, characterized in that a non-magnetic or weakly magnetic guide bush is fixedly provided on an inner periphery of the fixed core as the guide part, a front end of the guide bush projects further than the attracting face of the fixed core, when the coil is energized the movable core is abutted against the front end of the guide bush so as to define a valve-opening limit of the valve body and to form an air gap between the fixed core and the movable core, and the valve assembly is provided with a sliding member slidably supported on an inner peripheral face of the guide bush. It should be noted here that the guide bush corresponds a second guide bush 19 of embodiments which will be described later.

**[0007]** Further, according to a second aspect of the present invention, in addition to the first aspect, the hardness of the guide bush is set higher than that of the fixed core.

**[0008]** Furthermore, according to a third aspect of the present invention, in addition to the first aspect, the hardness of the guide bush and the hardness of the sliding member are set substantially equal.

**[0009]** Moreover, according to a fourth aspect of the present invention, in addition to the first or third aspect, an outer peripheral face of the sliding member is formed as a spherical surface having the center on a central axis of the valve assembly, and the sliding member is always in line contact with the inner peripheral face of the guide bush.

**[0010]** Further, according to a fifth aspect of the present invention, in addition to the first aspect, an outer peripheral face of the valve body is formed as a spherical surface having the center on a central axis of the valve assembly, a guide part slidably supporting the valve body is formed in the valve housing, and the outer peripheral face of the valve body is always in line contact with an inner peripheral face of the guide part. It should be noted here that the guide part corresponds to a first guide bush 18 of the embodiments which will be described later.

**[0011]** Furthermore, according to a sixth aspect of the present invention, in addition to any one of the first, third and fourth aspects, a flat face defining a fuel flow path between the flat face and the guide bush is formed on an outer peripheral face of the sliding member.

**[0012]** Moreover, according to a seventh aspect of the present invention, in addition to any one of the first and third to sixth aspects, a rear end face of the sliding member is formed as a spring seat supporting a front end of

the valve spring.

**[0013]** Further, according to an eighth aspect of the present invention, in addition to the seventh aspect, the sliding member is fitted and secured to a support shaft projectingly provided on a rear end face of the movable core, and the support shaft projects from the spring seat of the sliding member so as to be fitted into an inner periphery of the valve spring.

#### EFFECTS OF THE INVENTION

**[0014]** In accordance with the first aspect of the present invention, since the guide bush fixedly provided on the inner periphery of the fixed core is formed from a non-magnetic or weakly magnetic material, the front end thereof projects further than the attracting face of the fixed core, and at the time of energization of the coil the movable core is abutted against the front end so as to define the valve-opening limit of the valve body and to form an air gap between the fixed core and the movable core, the guide bush has both the function of stabilizing the opening/closing attitude of the valve assembly by supporting the sliding member while ensuring a long support span for the valve assembly and the function of enhancing the valve-closing responsiveness by avoiding direct contact of the movable core and the fixed core at the time of energization of the coil, and it is thus possible to achieve a balance between stabilization of the fuel injection flow rate characteristics and simplification of the structure of the electromagnetic fuel-injection valve.

**[0015]** In accordance with the second aspect of the present invention, due to the guide bush having a high hardness of the fixed core, the abrasion resistance of the guide bush improves, and it is possible to stabilize over a long period of time both the opening/closing attitude of the valve assembly and the coefficient of sliding friction, thus contributing to stabilization of the fuel injection flow rate characteristics of the electromagnetic fuel-injection valve.

**[0016]** In accordance with the third aspect of the present invention, since the hardness of the guide bush and the hardness of the sliding member are set so as to be substantially equal, it is possible to enhance the abrasion resistance of the two, thus further stabilizing the opening/closing attitude of the valve assembly over a long period of time.

**[0017]** In accordance with the fourth aspect of the present invention, the outer peripheral face of the sliding member is formed as a spherical surface having its center on the central axis of the valve assembly, this sliding member always being in line contact with the inner peripheral face of the guide bush, and it is thereby possible to smoothly operate the valve assembly without increasing the sliding resistance even if there is tilting of the valve assembly due to the manufacturing tolerances of each portion.

**[0018]** In accordance with the fifth aspect of the present invention, the outer peripheral face of the valve body is

formed as a spherical surface having its center on the central axis of the valve assembly, the guide part slidably supporting this valve body being formed in the valve housing and the outer peripheral face of the valve body always being in line contact with the inner peripheral face of the guide part, and it is thereby possible to smoothly operate the valve assembly without increasing the sliding resistance even if there is tilting of the valve assembly due to the manufacturing tolerances of each portion and to reliably carry out valve-closing by always appropriately seating the valve body on the valve seat.

**[0019]** In accordance with the sixth aspect of the present invention, the fuel flow path can be simply formed around the sliding member by flat machining of the outer peripheral face of the sliding member, and sliding surfaces of the sliding member and the guide bush can be lubricated effectively by means of fuel passing through the fuel flow path, thereby contributing to an improvement of their abrasion resistance.

**[0020]** In accordance with the seventh aspect of the present invention, the sliding member, which has a higher hardness than that of the fixed core, serves as a spring seat supporting the front end of the valve spring, and it is thereby possible to obtain a spring seat with abrasion resistance.

**[0021]** In accordance with the eighth aspect of the present invention, the support shaft projectingly provided on the rear end face of the movable core fulfills a role of fixing the sliding member to the movable core and, in addition, fulfills a role as an expansion/contraction guide in order to prevent the valve spring from buckling by fitting into the inner periphery of the front end portion of the valve spring, thereby contributing to stabilization of the expansion/contraction operation of the valve spring, and consequently to stabilization of the opening/closing operation of the valve assembly.

#### BRIEF DESCRIPTION OF DRAWINGS

**[0022]**

[FIG. 1] FIG. 1 is a longitudinal section side view of an electromagnetic fuel-injection valve for an engine related to a first embodiment of the present invention. (first embodiment)

[FIG. 2] FIG. 2 is an enlarged view of part 2 in FIG. 1. (first embodiment)

[FIG. 3] FIG. 3 is a sectional view along line 3-3 in FIG. 1. (first embodiment)

[FIG. 4] FIG. 4 is a sectional view along line 4-4 in FIG. 2. (first embodiment)

[FIG. 5] FIG. 5 is a sectional view along line 5-5 in FIG. 2. (first embodiment)

[FIG. 6] FIG. 6 is a view, corresponding to FIG. 2, of a second embodiment of the present invention. (second embodiment)

## EXPLANATION OF REFERENCE NUMERALS AND SYMBOLS

### [0023]

|    |                                |
|----|--------------------------------|
| I  | Fuel injection valve           |
| V  | Valve assembly                 |
| Y  | Central axis of valve assembly |
| 2  | Valve housing                  |
| 6  | Fixed core                     |
| 6a | Attracting face of fixed core  |
| 6b | Hollow portion of fixed core   |
| 8  | Valve seat                     |
| 15 | Valve body                     |
| 16 | Movable core                   |
| 17 | Stem                           |
| 18 | Guide part (first guide bush)  |
| 19 | Guide bush (second guide bush) |
| 20 | Sliding member                 |
| 23 | Fuel flow path                 |
| 26 | Fuel flow path                 |
| 29 | Support shaft                  |
| 31 | Spring seat                    |
| 33 | Valve spring                   |

## MODES FOR CARRYING OUT THE INVENTION

**[0024]** Modes for carrying out the present invention are explained below by reference to the attached drawings.

### EMBODIMENT 1

**[0025]** A first embodiment of the present invention shown in FIG. 1 to FIG. 5 is now explained. In FIG. 1 and FIG. 2, a cylinder head 1 of an engine is provided with a fitting hole 1b opening in a combustion chamber 1a, and an electromagnetic fuel injection valve I is fitted into the fitting hole 1b. This fuel injection valve I can inject fuel toward the combustion chamber 1a.

**[0026]** A valve housing 2 of this fuel injection valve I is formed from a valve seat member 3, a magnetic cylindrical body 4 coaxially connected to a rear end portion of this valve seat member 3, and a non-magnetic cylindrical body 5 coaxially connected to the rear end of this magnetic cylindrical body 4. A fixed core 6 is coaxially connected to the rear end of the non-magnetic cylindrical body 5, and a fuel inlet tube 7 is coaxially provided so as to be connected to the rear end of the fixed core 6. The fixed core 6 has a hollow portion 6b communicating with the interior of the fuel inlet tube 7. A fuel filter 14 is fitted into an inlet of the fuel inlet tube 7.

**[0027]** The valve seat member 3 is formed from a small diameter tubular portion 3a having a front end wall and a flange portion 3b formed at the rear end of this small diameter tubular portion 3a. Formed in the front end wall of the small diameter tubular portion 3a are a conical valve seat 8, a valve hole 9 communicating with the front end of this valve seat 8, and a fuel discharge hole 10

communicating with this valve hole 9 and opening on the front end face of the small diameter tubular portion 3a.

**[0028]** The magnetic cylindrical body 4 is formed from a thin tube portion 4a and a thick tube portion 4b provided so as to be connected to the rear end of this thin tube portion 4a, the thick tube portion 4b having a smaller internal diameter than that of the thin tube portion 4a and a larger external diameter than that of the thin tube portion 4a. Fitted in sequence into an inner peripheral face of the thin tube portion 4a are a shim 11 and the flange portion 3b of the valve seat member 3, the flange portion 3b being liquid-tightly welded to the thin tube portion 4a.

**[0029]** The thick tube portion 4b has an annular projection 12 protruding from a rear end face on the inner peripheral side thereof, and the non-magnetic cylindrical body 5 is abutted against and liquid-tightly welded to the tip of this annular projection 12. The thick tube portion 4b and the non-magnetic cylindrical body 5 are formed so that inner peripheral faces thereof are continuous with each other.

**[0030]** The fixed core 6 has an annular recess 13 on the outer periphery of its front end portion, and a rear end portion of the non-magnetic cylindrical body 5 is fitted into and liquid-tightly welded to this annular recess 13.

The fixed core 6 and the non-magnetic cylindrical body 5 are formed so that outer peripheral faces thereof are continuous.

**[0031]** A valve assembly V is housed within the valve housing 2 from the valve seat member 3 to the non-magnetic cylindrical body 5. This valve assembly V is formed from a valve body 15 that opens and closes the valve hole 9 in cooperation with the valve seat 8, a movable core 16 disposed on the inside of the magnetic cylindrical body 4 and the non-magnetic cylindrical body 5 so as to oppose an attracting face 6a at the front end of the fixed core 6, and a stem 17 integrally linking the valve body 15 and the movable core 16.

**[0032]** The stem 17 is formed so as to have a smaller diameter than that of the valve body 15 and has a length that extends through a central part of the movable core 16 and projects from a rear end face of the movable core 16. Furthermore, the stem 17 has a linking flange 17a abutting against the front end of the movable core 16, the linking flange 17a meeting a front end face of the movable core 16. Moreover, the stem 17 is integrally joined to the valve body 15 by welding.

**[0033]** In FIG. 2 and FIG. 3, a cylindrical first guide bush 18 slidably supporting this valve body 15 is press fitted into an inner peripheral face of a front end portion of the small diameter tubular portion 3a. The outer peripheral face of the valve body 15 is formed as a spherical surface having its center on a central axis Y of the valve assembly V so that it is always in line contact with the inner peripheral face of the first guide bush 18. A tubular fuel flow path 21 is defined between the first guide bush 18 and the stem 17, and a plurality of flat faces 25 defining a fuel flow path 22 between the valve body 15 and the first guide bush 18 are formed on the outer peripheral

face of the valve body 15. Therefore, the first guide bush 18 allows fuel to pass through while guiding the opening/closing movement of the valve body 15.

**[0034]** A fitting recess 28 is formed in the inner peripheral face of the fixed core 6 so as to open on the attracting face 6a, and a cylindrical second guide bush 19 is fixedly provided in this fitting recess 28 by press fitting. This second guide bush 19 is formed so that its inner peripheral face is continuous with the inner peripheral face of the fixed core 6. On the other hand, a portion, projecting to the rear of the movable core 16, of the stem 17 is formed as a support shaft 29 projecting into the second guide bush 19, and a sliding member 20 slidably supported on the inner peripheral face of the second guide bush 19 is fitted on this support shaft 29 and secured by welding, swaging, etc. The movable core 16 is therefore held by the linking flange 17a and the sliding member 20.

**[0035]** An outer peripheral face of the sliding member 20 is formed as a spherical surface having its center on the central axis Y of the valve assembly V so as to be in line contact with the inner peripheral face of the second guide bush 19.

**[0036]** Furthermore, the front end face of the second guide bush 19 projects from the attracting face 6a of the fixed core 6 by a predetermined length, and by abutting the rear end face of the movable core 16 against the front end face of this second guide bush 19 the valve-opening limit of the valve body 15 is restricted. Furthermore, when the movable core 16 abuts against the second guide bush 19, an air gap g is formed between opposing faces of the movable core 16 and the fixed core 6, the air gap g corresponding to the length of the second guide bush 19 that projects forward from the fixed core 6. The second guide bush 19 and the sliding member 20 are formed from a non-magnetic or weakly magnetic material having higher hardness than that of the fixed core 6, for example, martensitic stainless steel. Therefore, the hardness of the second guide bush 19 and the hardness of the sliding member 20 are substantially equal.

**[0037]** Due to the two point support of the valve assembly V by the first and second guide bushes 18 and 19, a tubular gap 30 is ensured between the outer peripheral face of the movable core 16 and the inner peripheral faces of the magnetic cylindrical body 4 and non-magnetic cylindrical body 5, the gap 30 preventing contact therebetween.

**[0038]** As shown in FIG. 4, formed on the outer peripheral face of the sliding member 20 are a plurality of flat faces 26 defining a fuel flow path 23 between the sliding member 20 and the second guide bush 19. Furthermore, the movable core 16 is provided with a plurality of through holes 24 extending vertically therethrough.

**[0039]** Referring again to FIG. 1 and FIG. 2, a rear end face of the sliding member 20 serves as an annular spring seat 31, and a valve spring 33 urging the movable core 16 toward the side on which the valve body 15 closes is provided in a compressed state between the spring seat 31 and a pipe-shaped retainer 32 fitted into the hollow

portion 6b of the fixed core 6 and fixed by swaging from the side. Therefore, the spring seat 31 supports the front end of the valve spring 33. In this process, the set load of the valve spring 33 is adjusted by the depth to which the retainer 32 is fitted into the fixed core 6 and, after adjustment thereof, by partially swaging inward an outer peripheral wall of the fixed core 6 the retainer 32 is fixed to the fixed core 6. As described above, since the hardness of the sliding member 20 is higher than that of the fixed core 6, the spring seat 31 at the rear end thereof can be one having high abrasion resistance.

**[0040]** The support shaft 29 projects from the spring seat 31 of the sliding member 20 and is fitted into the inner periphery of a front end portion of the valve spring 33 so that the projecting portion thereof serves as an expansion/contraction guide for the valve spring 33.

**[0041]** A coil assembly 35 is fitted around outer peripheral faces from the annular projection 12 of the magnetic cylindrical body 4 to the fixed core 6. This coil assembly 35 is formed from a bobbin 36 fitted around the above-mentioned outer peripheral faces and a coil 37 wound therearound, the front end of a coil housing 38 surrounding the coil assembly 35 is joined to a rear end face of the magnetic cylindrical body 4 by abutment welding, and an annular yoke 39 connected to the rear end of the coil housing 38 is joined to the outer peripheral face of the fixed core 6 by welding, etc.

**[0042]** A covering layer 40 made of a synthetic resin is molded on outer peripheral faces from a rear end portion of the magnetic cylindrical body 4 to an intermediate part of the fuel inlet tube 7. A connector housing part 41 is formed as a cutout on the rear outer periphery of the covering layer 40, a connector 42 connected to the coil 37 is disposed in this connector housing part 41, and a cover 43 made of a synthetic resin closing a side opening of this connector housing part 41 is secured to the covering layer 40. Connected to the connector 42 is an external lead 44 for the supply of power.

**[0043]** The operation of this first embodiment is now explained.

**[0044]** In a state in which the coil 37 is de-energized, the valve assembly V is pushed forward by means of the urging force of the valve spring 33, the valve body 15 is seated on the valve seat 8, and the valve hole 9 is closed.

**[0045]** When the coil 37 is energized by passing an electric current, the magnetic flux generated thereby runs in sequence through the fixed core 6, the coil housing 38, the magnetic cylindrical body 4, and the movable core 16, the resulting magnetic force makes the movable core 16 of the valve assembly V be attracted by the fixed core 6 against the set load of the valve spring 33 to detach the valve body 15 from the valve seat 8, and the valve hole 9 is thereby opened. Therefore, fuel that has been fed under pressure to the fuel inlet tube 7 from a fuel pump, which is not illustrated, is directly injected into the engine combustion chamber from the fuel discharge hole 10 via, in sequence, the interior of the pipe-shaped retainer 32, the hollow portion 6b of the fixed core 6, the

fuel flow path 23 around the sliding member 20, the through holes 24 of the movable core 16, the interior of the valve housing 2, the fuel flow path 21 inside the first guide bush 18, the fuel flow path 22 around the valve body 15, the valve seat 8, and the valve hole 9.

[0046] Since, with regard to the valve assembly V, the valve body 15 and the sliding member 20 provided in the front end portion and the rear end portion respectively are slidably supported by the first guide bush 18 of the valve seat member 3 and the second guide bush 19 of the fixed core 6 respectively, it becomes possible to set the support span for the valve assembly V longer than the distance between the valve seat 8 and the fixed core 6, thereby stabilizing the opening/closing attitude of the valve assembly V and preventing deviation in the fuel injection flow rate characteristics. Moreover, since the second guide bush 19 is formed from a non-magnetic or weakly magnetic material having higher hardness than that of the fixed core 6, the abrasion resistance is high, and it is possible to stabilize the coefficient of sliding friction of the valve assembly V over a long period of time, thereby further stabilizing the fuel injection flow rate characteristics of the fuel injection valve 1.

[0047] Furthermore, since the hardness of the second guide bush 19 and the hardness of the sliding member 20 are set so as to be substantially equal, it is possible to enhance the abrasion resistance of the two, that is, 19 and 20, thus further stabilizing the opening/closing attitude of the valve assembly V over a long period of time.

[0048] Moreover, since the outer peripheral faces of the valve body 15 and the sliding member 20 are formed as spherical surfaces that have their centers on the central axis Y of the valve assembly V and are in line contact with the inner peripheral faces of the first and second guide bushes 18 and 19 respectively, it is possible to smoothly operate the valve assembly V without increasing the sliding resistance even if there is tilting of the valve assembly V due to the manufacturing tolerances of each portion and to reliably carry out valve-closing by appropriately seating the valve body 15 on the valve seat 8.

[0049] Furthermore, since, at the time of energization of the coil 37, the movable core 16 of the valve assembly V abuts against the front end face of the second guide bush 19, which projects further than the attracting face of the fixed core 6, to thus define the valve-opening limit of the valve body 15, and the movable core 16 opposes the attracting face 6a of the fixed core 6 across the air gap g to thus avoid direct contact with the fixed core 6, together with the effect of the second guide bush 19 being non-magnetic or weakly magnetic, when the coil 37 is de-energized, residual magnetism between the two cores 6 and 16 quickly disappears, and the valve-closing responsiveness of the valve body 15 can be enhanced.

[0050] As described above, the second guide bush 19 has both the function of stabilizing the opening/closing attitude of the valve assembly V by supporting the sliding member 20 and the function of enhancing the valve-closing responsiveness by avoiding direct contact between

the movable core 16 and the fixed core 6 at the time of energization the coil 37, and it is possible to achieve a balance between stabilization of the fuel injection characteristics and simplification of the structure.

[0051] Moreover, since the valve body 15 has formed on the outer peripheral face thereof the plurality of flat faces 25 defining the fuel flow path 22 between the valve body 15 and the first guide bush 18, and the sliding member 20 has formed on the outer peripheral face thereof the plurality of flat faces 26 defining the fuel flow path 23 between the sliding member 20 and the second guide bush 19, the fuel flow paths 22 and 23 can be formed simply around the valve body 15 and the sliding member 20 by flat machining of the outer peripheral face of each of the valve body 15 and the sliding member 20, and the sliding surfaces of the valve body 15 and the first guide bush 18 and the sliding member 20 and the second guide bush 19 can be lubricated effectively by fuel that is passing through these fuel flow paths 22 and 23, thus contributing to improvement of the abrasion resistance thereof.

[0052] Furthermore, since the support shaft 29 extends so as to project from the spring seat 31 of the sliding member 20 and is fitted into the inner periphery of the front end portion of the valve spring 33 so as to be an expansion/contraction guide for the valve spring 33, it fulfills a role of fixing the sliding member 20 to the movable core 16 and, in addition, fulfills a role as an expansion/contraction guide for preventing the valve spring 33 from buckling, thereby contributing to stabilization of the expansion/contraction operation of the valve spring 33, and consequently stabilization of the opening/closing operation of the valve assembly V.

## EMBODIMENT 2

[0053] A second embodiment of the present invention is now explained by reference to FIG. 6.

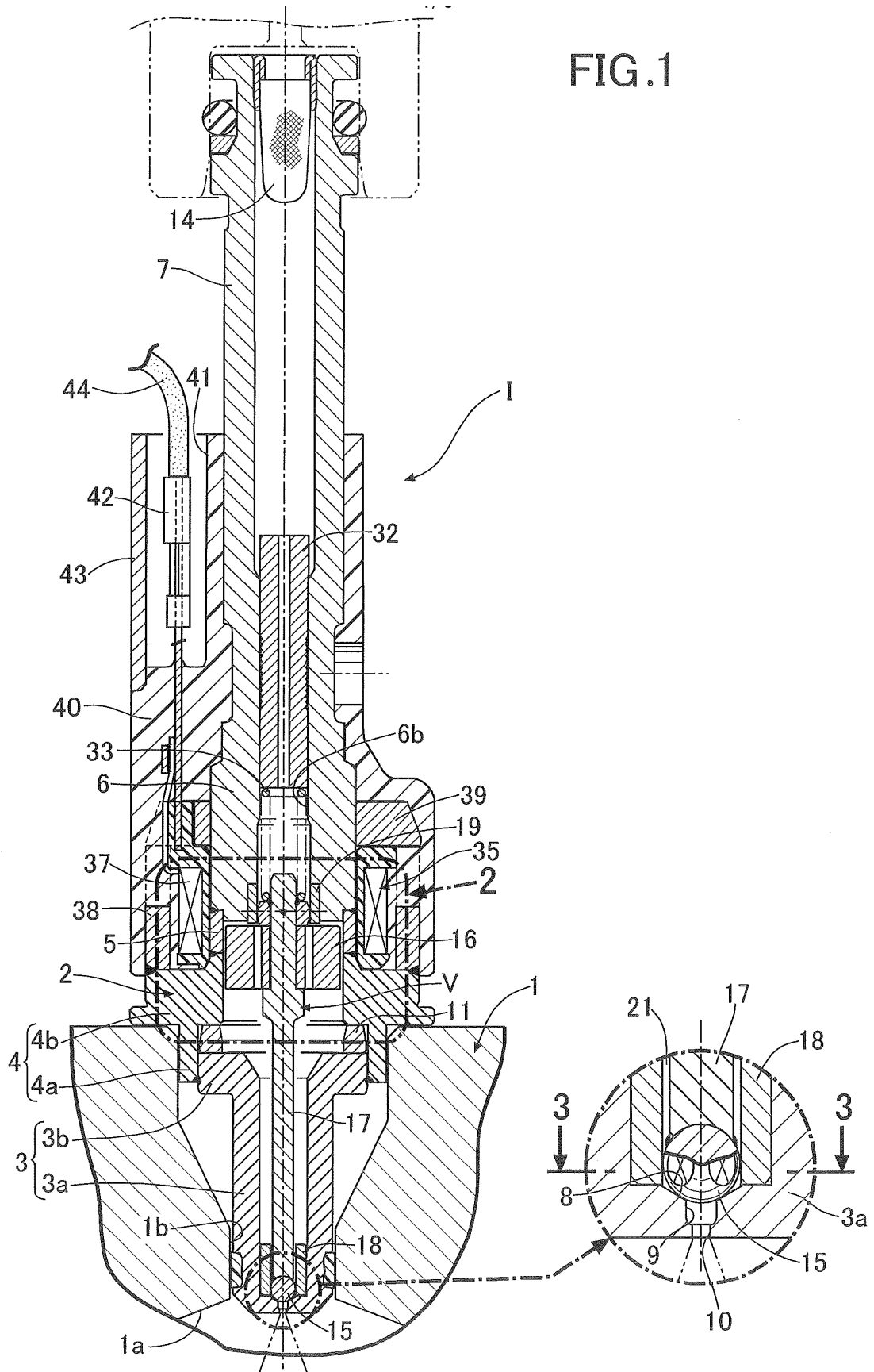
[0054] In this second embodiment, with regard to a valve assembly V, a stem 17 is formed integrally with a front end face of a movable core 16, a support shaft 29 is formed integrally with a rear end face thereof using the same material as for the movable core 16, and a sliding member 20 is fitted and secured to the support shaft 29; the arrangement thereof is otherwise the same as that of the preceding embodiment, and portions in FIG. 6 corresponding to those of the preceding embodiment are therefore denoted by the same reference numerals and symbols, duplication of the explanation being omitted.

[0055] The present invention is not limited to the above-mentioned embodiments and may be modified in a variety of ways as long as the modifications do not depart from the spirit and scope thereof. For example, the fuel injection valve V may be formed as a type in which fuel is injected into an engine intake system. Furthermore, instead of the first guide bush 18 slidably supporting the valve body 15, a guide hole may be formed in the valve seat member 3.

## Claims

1. An electromagnetic fuel-injection valve comprising a valve housing (2) that has a conical valve seat (8) at one end, a fixed core (6) that is connectedly provided at the other end of the valve housing (2) and has a hollow portion (6b) serving as a fuel flow path, a valve assembly (V) that comprises a movable core (16) disposed so as to oppose an attracting face (6a) of the fixed core (6), a valve body (15) cooperating with the valve seat (8), and a stem (17) integrally linking the fixed core (6) and the valve body (15), a valve spring (33) that urges the valve body (15) in a valve-closing direction, and a coil (37) that is disposed on an outer periphery of the fixed core (6) and makes the valve body (15) open by making the fixed core (6) attract the movable core (16) by energization, the fixed core (6) being provided with a guide part slidably supporting a rear end portion of the valve assembly (V),  
**characterized in that** a non-magnetic or weakly magnetic guide bush (19) is fixedly provided on an inner periphery of the fixed core (6) as the guide part, a front end of the guide bush (19) projects further than the attracting face (6a) of the fixed core (6), when the coil (37) is energized the movable core (16) is abutted against the front end of the guide bush (19) so as to define a valve-opening limit of the valve body (15) and to form an air gap (g) between the fixed core (6) and the movable core (16), and the valve assembly (V) is provided with a sliding member (20) slidably supported on an inner peripheral face of the guide bush (19).
2. The electromagnetic fuel-injection valve according to Claim 1, wherein the hardness of the guide bush (19) is set higher than that of the fixed core (6).
3. The electromagnetic fuel-injection valve according to Claim 1, wherein the hardness of the guide bush (19) and the hardness of the sliding member (20) are set substantially equal.
4. The electromagnetic fuel-injection valve according to Claim 1 or 3, wherein an outer peripheral face of the sliding member (20) is formed as a spherical surface having the center on a central axis (Y) of the valve assembly (V), and the sliding member (20) is always in line contact with the inner peripheral face of the guide bush (19).
5. The electromagnetic fuel-injection valve according to Claim 1, wherein an outer peripheral face of the valve body (15) is formed as a spherical surface having the center on a central axis (Y) of the valve assembly (V), a guide part (18) slidably supporting the valve body (15) is formed in the valve housing (2), and the outer peripheral face of the valve body (15) is always in line contact with an inner peripheral face of the guide part (18).
6. The electromagnetic fuel-injection valve according to any one of Claims 1, 3 and 4, wherein a flat face (26) defining a fuel flow path (23) between the flat face (26) and the guide bush (19) is formed on an outer peripheral face of the sliding member (20).
7. The electromagnetic fuel-injection valve according to any one of Claims 1 and 3 to 6, wherein a rear end face of the sliding member (20) is formed as a spring seat (31) supporting a front end of the valve spring (33).
8. The electromagnetic fuel-injection valve according to Claim 7, wherein the sliding member (20) is fitted and secured to a support shaft (29) projectingly provided on a rear end face of the movable core (16), and the support shaft (29) projects from the spring seat (31) of the sliding member (20) so as to be fitted into an inner periphery of the valve spring (33).

FIG.1



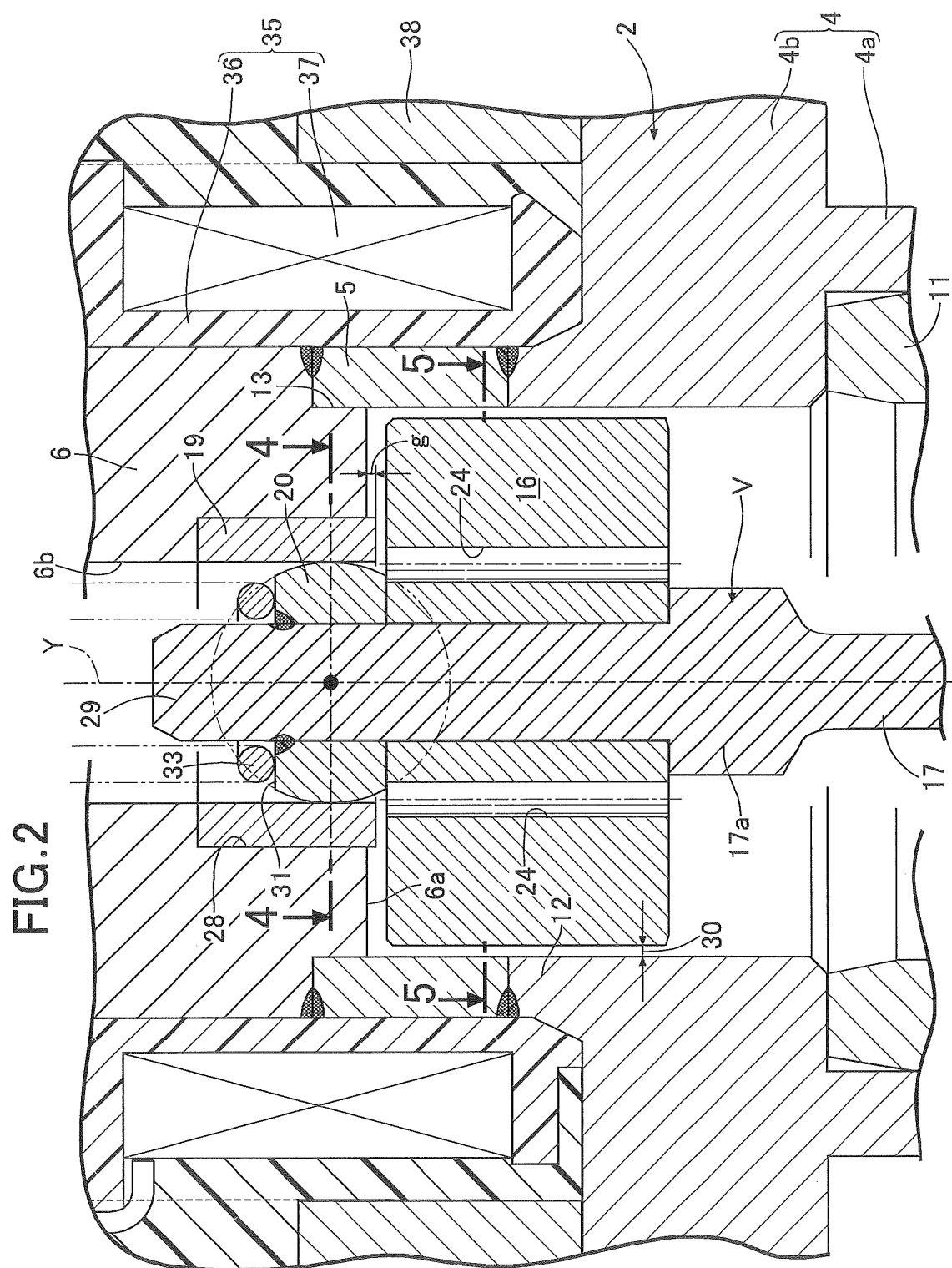


FIG. 3

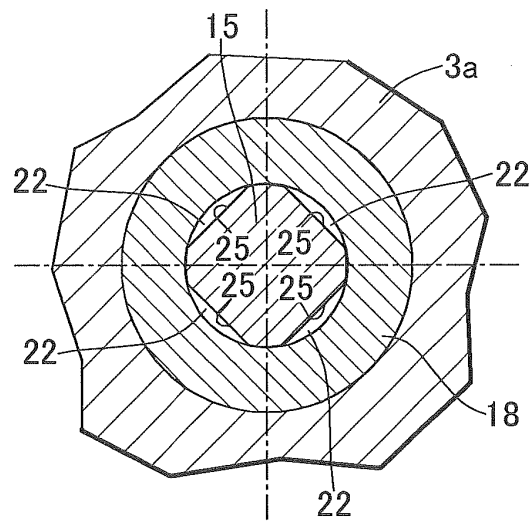


FIG. 4

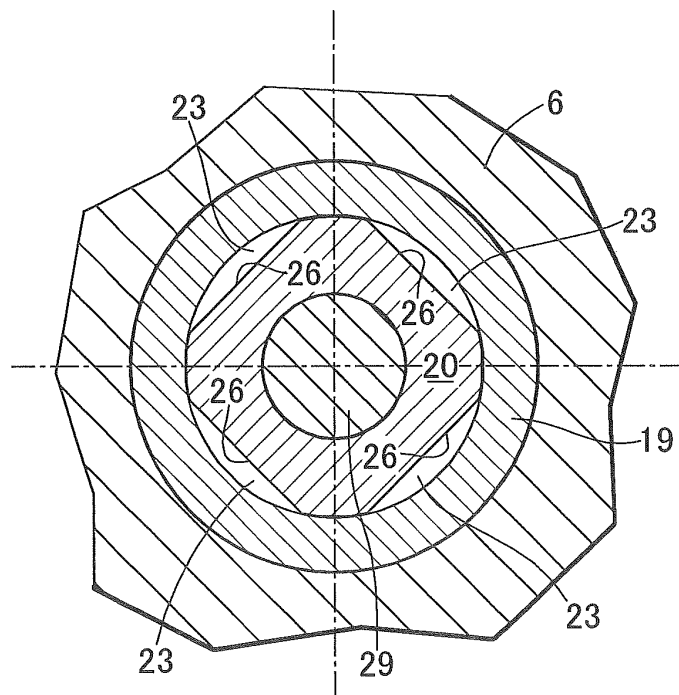
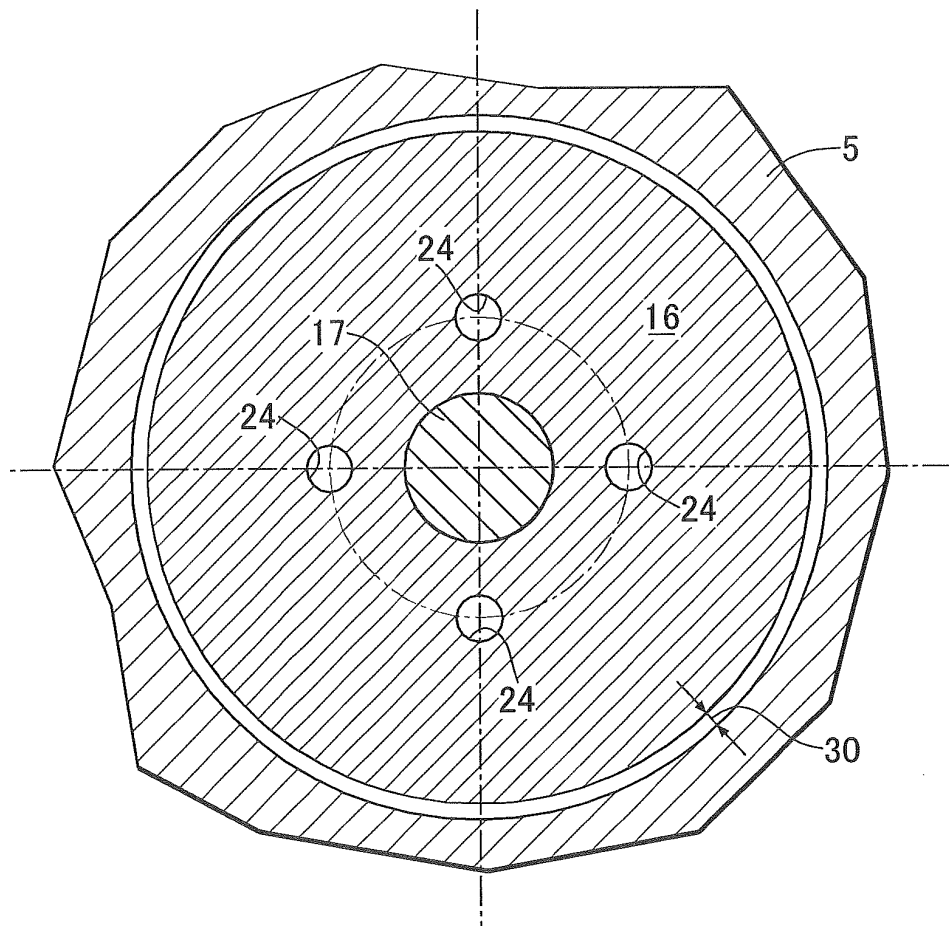
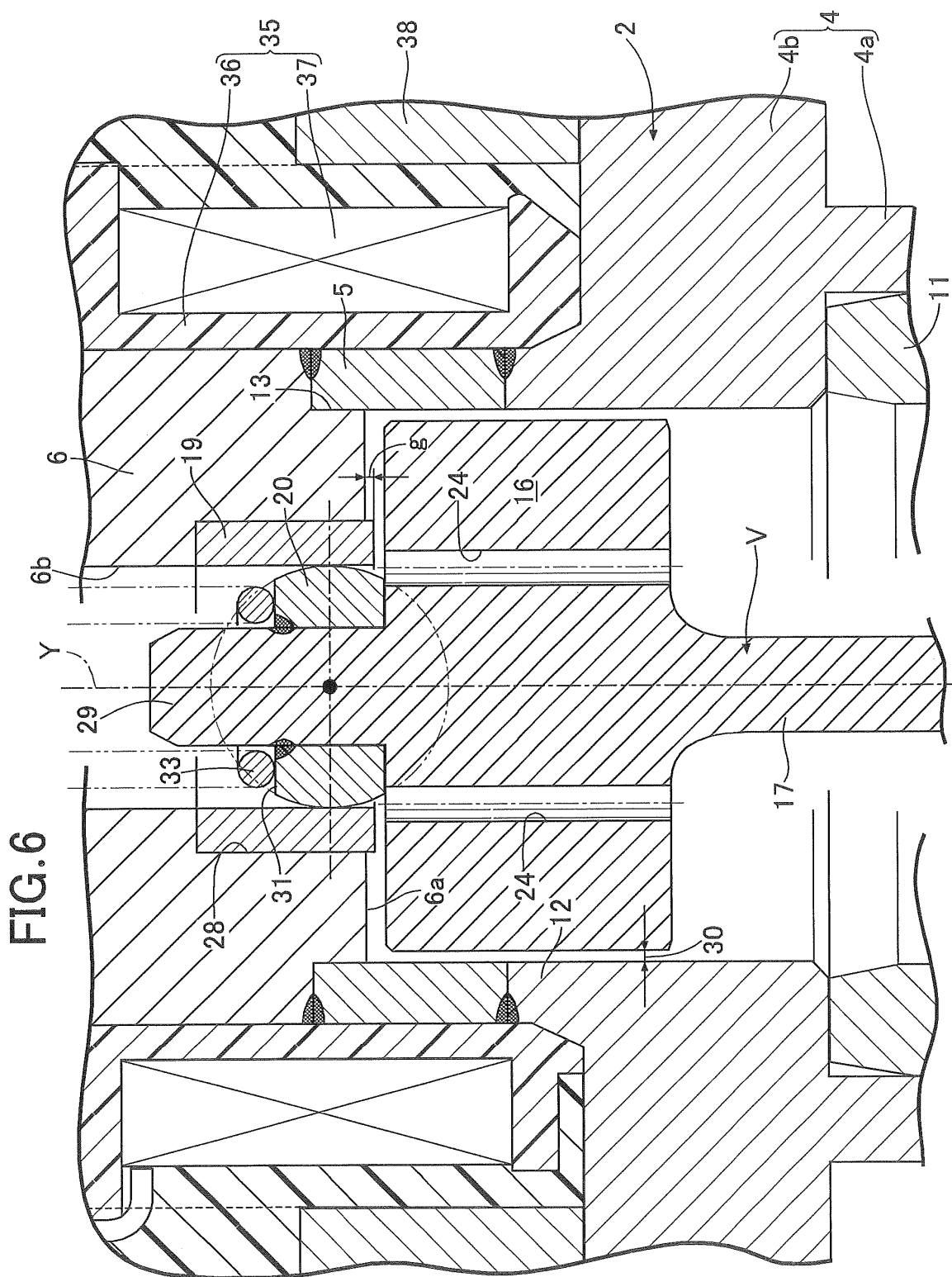


FIG.5





## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/060244

## A. CLASSIFICATION OF SUBJECT MATTER

F02M51/06 (2006.01) i

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

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F02M51/06

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

|                           |           |                            |           |
|---------------------------|-----------|----------------------------|-----------|
| Jitsuyo Shinan Koho       | 1922-1996 | Jitsuyo Shinan Toroku Koho | 1996-2011 |
| Kokai Jitsuyo Shinan Koho | 1971-2011 | Toroku Jitsuyo Shinan Koho | 1994-2011 |

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

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                              | Relevant to claim No. |
|-----------|-----------------------------------------------------------------------------------------------------------------|-----------------------|
| A         | JP 2009-221879 A (Kehin Corp.),<br>01 October 2009 (01.10.2009),<br>entire text; all drawings<br>(Family: none) | 1-8                   |
| A         | JP 2008-144663 A (Denso Corp.),<br>26 June 2008 (26.06.2008),<br>entire text; all drawings<br>(Family: none)    | 1-8                   |
| A         | JP 2005-69410 A (Kehin Corp.),<br>17 March 2005 (17.03.2005),<br>entire text; all drawings<br>(Family: none)    | 1-8                   |

☒ Further documents are listed in the continuation of Box C.☐ See patent family annex.

\* Special categories of cited documents:

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Date of the actual completion of the international search  
18 May, 2011 (18.05.11)Date of mailing of the international search report  
31 May, 2011 (31.05.11)Name and mailing address of the ISA/  
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/060244

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                   | Relevant to claim No. |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| A         | WO 2003/042526 A1 (Hitachi, Ltd.),<br>22 May 2003 (22.05.2003),<br>entire text; all drawings<br>& US 2005/0067512 A1 & EP 1452717 A1 | 1-8                   |

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**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

- JP 2008031853 A [0003]