(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 170 500 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
09.01.2002 Bulletin 2002/02

(51) Int Cl.7: F02M 51/06

(21) Application number: 00202331.5

(22) Date of filing: 03.07.2000

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(71) Applicant: Med S.p.A.
42100 Reggio Emilia (IT)

(72) Inventor: Reggiani, Medardo
42100 Reggio Emilia (IT)

(74) Representative: Corradini, Corrado et al
Studio Ing. C. CORRADINI & C. S.r.l. 4, Via Dante Alighieri
42100 Reggio Emilia (IT)

(54) Fuel injection valve for internal combustion engines

(57) The valve comprises a fuel passage port (20) in the form of a seat for a valving element, and an axially movable valving element (30) having a surface (31) arranged to act on said port (20) to close its passage; the valving element (30) being subjected to alternating axial movements by which it is urged into contact with the passage port (20) to close it, and alternately to open it; the valve comprises at least one guide element (50, 51) having an outer peripheral edge (50', 51') secured to a fixed part of the valve and an inner edge (50", 51") secured to the valving element (30), and positioned with its axis substantially coinciding with the axis of the valving element, to prevent the valving element (30) undergoing rotations about its axis and radial movements, said guide element (50, 51) being deformable by flexure in a generic axial plane in such a manner as not to create substantial resistance to the axial movement of the valving element (30).

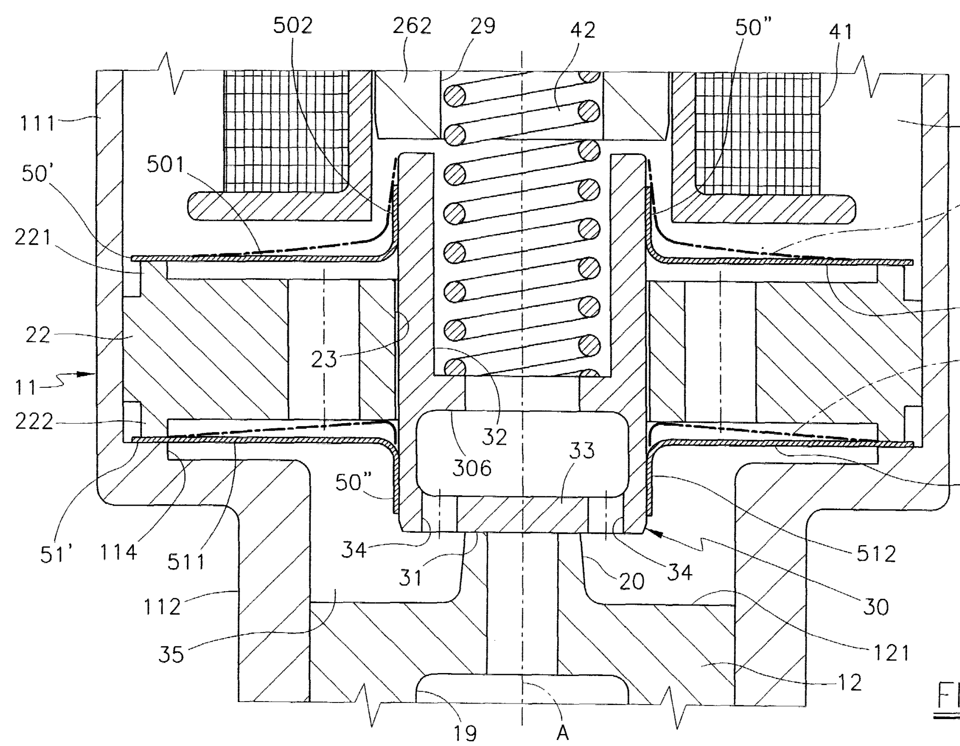

FIG.2

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Description

[0001] This invention relates to a fuel injection valve for internal combustion engines, in particular an electromagnetically operated valve.

[0002] For metering fuel (either liquid or gaseous) fed into the intake duct or combustion chamber, electromagnetically operated valves are known comprising a fuel passage port in the form of a seat for a valving element, and an axially movable valving element having a surface arranged to act on said port to close it, said valving element being operated with alternating axial movements which bring it into contact with the passage port in order to close it, and move it away therefrom in order to open it. The fuel is fed though the open port to the intake duct or to the combustion chamber. The port is open by an electromagnet which attracts the valving element away from the port, whereas it is closed by a spring which urges the valving element downwards against the port.

[0003] The valving element is usually driven with a relatively high frequency of between 5 and 200 Hertz.

[0004] A drawback of these devices is the fact that the impact of the valving element against the fuel passage port (at the end of the travel produced by the spring) results in excessive wear of the mutually contacting surfaces, such as to compromise the seal within a relatively short time.

[0005] A further drawback is the fact that the valving element is inserted with only little clearance into an axial hole in which it slides axially. The valving element is guided by the cylindrical surface of this hole, and rubs against it to create resistance to the axial movement of the valving element, and to enlarge the hole by wear to the extent that the valving element no longer maintains its correct axial position and tends to incline, with the result that its lower surface does not correctly close the passage port.

[0006] These and further drawbacks are overcome by the invention as characterised in the claims.

[0007] The invention is based on the fact of comprising one (or more than one) guide element having an outer edge secured to a fixed part of the valve and an inner edge secured to the valving element, and positioned with its axis substantially coinciding with the axis of the valving element, to prevent the valving element undergoing angular rotations about its axis and movements perpendicular to said axis, the guide element being deformable by flexure in a generic axial plane in such a manner as not to create substantial resistance to the axial movement of the valving element.

[0008] In particular, said guide element is in the form of a thin flexible membrane of circular shape in plan development.

[0009] In a preferred embodiment, the guide element comprises a substantially flat outer portion of circular ring shape lying in a plane perpendicular to the axis of the valving element and having its outer edge secured to a fixed part of the valve, and an inner portion having one edge joined to the inner edge of the inner portion, its other edge being secured to the lateral surface of the valving element.

[0010] The invention is described in detail hereinafter with the aid of the accompanying figures, which illustrate one embodiment thereof by way of non-limiting example.

[0011] Figure 1 is a section through the valve of the invention taken on a generic axial plane.

[0012] Figure 2 is an enlarged detail of Figure 1.

[0013] Figure 3 is a section on the plane III-III of Figure 1.

[0014] Figure 4 is a section, similar to that of Figure 3, taken through a second embodiment of the guide elements 50, 51.

[0015] Figure 5 is a section, similar to that of Figure 3, taken through a third embodiment of the guide elements 50, 51.

[0016] Figure 6 is a section on the plane VI-VI of Figure 5.

[0017] In the embodiment shown in the figures, the valve comprises a hollow cylindrical lower outer casing 11 of ferromagnetic material, and axially symmetrical about its axis A. Its upper portion 111 contains a valving element 30.

[0018] The lower portion 112 of the casing 11 contains, forced into it as an exact fit, a tubular piece 12 having its lower portion projecting downwardly outwards and sealedly inserted (by way of a gasket 16) into a hole 14 provided in the air intake duct 17 to the internal combustion engine.

[0019] The tubular piece 12 has an inner bore 19 opening lowerly into the hole 14 and defining at its upper end a fluid passage port 20.

[0020] The port 20 projects axially upwards from the upper surface 121 of the tubular piece 12, to define a seat arranged to sealedly engage the lower surface 31 of the valving element 30. The upper surface of the port 20 is flat and horizontal, as is the lower surface 31.

[0021] Into the lower part of the upper portion 111 there is inserted a cylindrical piece 22 of ferromagnetic material, its outer lateral surface making rigid contact as an exact fit with the inner surface of the outer casing 11. The piece 22 has a through hole 23 of constant cross-section, coaxial with A.

[0022] The valving element 30 is inserted as an exact fit or with slight clearance into the hole 23, and can hence slide axially along the axis A (which coincides with its own axis).

[0023] A hollow cylindrical upper outer casing 25 is applied, axially symmetrical to the axis A, above the lower outer casing 11.

[0024] An upper tubular piece of ferromagnetic material is inserted, coaxial with A, into the outer casing 25 to extend upwards. The lower end of the tubular piece 26 lies a short distance from the normal position of the valving element 30.

[0025] The tubular piece 26 is provided with a through inner bore 29 coaxial with A, its lower end opening above the valving element 30. This latter has an upperly open cavity 32 facing the lower end of the bore 29 and closed lowerly by a horizontal base wall 33, the lower surface 31 of which is arranged to close the port 20.

[0026] The lower portion of the valving element 30 dips into the interior of a chamber 35 defined laterally by the outer casing 11, upperly by the cylindrical piece 22 and lowerly by the upper surface 121 of the tubular piece 12. In the peripheral part of the surface 31, to the side of the central region which closes the port 20, there are provided through holes 34 connecting the cavity 32 to the chamber 35.

[0027] The upper end of the tubular piece 26 is sealedly connected to a conduit 36 which feeds fuel to the valve of the invention.

[0028] Some distance above the piece 22, the tubular piece 26 comprises a cylindrical radial projection 37, the outer lateral surface of which rigidly engages, as an exact fit, the upper end of the inner surface of the outer casing 11. Within the outer casing 11 there is hence defined a second chamber 38, bounded laterally by the casing itself, upperly by the projection 37 and lowerly by the piece 22.

[0029] The central region of the chamber 38 accommodates the lower portion 262 of the tubular piece 26 and the upper part of the valving element 30. A solenoid 41, connected to a source of electric current, is positioned in the chamber 38 about the lower portion 262. The portion 262, the radial projection 37, the upper portion 111 of the casing 11 and the piece 22 define a fixed electromagnet core able to attract the valving element 30 upwards, against the lower end of the tubular piece 26.

[0030] The valving element 30 is subjected to the action of an elastic spring 42, the upper part of which is inserted into the bore 29, and its lower part into the inner cavity 32. In detail, the lower end of the spring 42 abuts against an annular projection 306 projecting radially within the cavity 32. The upper end of the spring 42 is axially locked by a bush 43 forced into the bore 29. The spring 42 is precompressed between the projection 306 and the bush 43 to an extent such as to thrust the valving element 30 downwards against the port 20, and close it.

[0031] When in operation, the fuel reaches the inner bore 29 through the conduit 36. After passing through a possible filter 45, the fuel flow passes downwards through the inner bore 29 to reach the cavity 32 of the valving element 30, from which it passes into the chamber 35 via the holes 34. When the valving element 30 is raised, the fuel passes from the chamber 35, through the port 20 to the bore 19 and from here to the intake duct 17; otherwise, it remains at rest in the chamber 35.

[0032] The solenoid 41 is activated cyclically to attract and release the valving element 30 alternately. This latter is hence subjected to alternating axial movements which urge it into contact with the passage port 20 (action of the spring 42) to close it, and then pull it away from the port 20 (action of the electromagnet) to open it.

[0033] The engine feed is hence controlled by the operation of the solenoid 41.

[0034] According to the invention there is provided at least one guide element 50 axially symmetrical in shape and positioned with its axis of symmetry substantially coincident with the axis A of the valving element. Specifically, the guide element 50 is in the form of a thin elastic membrane which in plan development is in the shape of a circle of diameter virtually equal to the inner diameter of the outer casing 11.

[0035] The guide element 50 is fixed by its outer circular edge 50' to the piece 22 and is positioned a small distance above the upper surface of the piece 22. The guide element 50 has its outer peripheral edge 50' secured to a fixed part of the valve, for example bonded to the top of an upwardly extending annular projection 221 provided on the upper face of the piece 22, as shown in the figures. The inner edge of the guide element 50 is secured to the valving element.

[0036] The guide element 50 is deformable by flexural stress in an axial plane so as not to create substantial resistance to axial movement of the valving element 30. In contrast it is virtually indeformable by stress in the plane perpendicular to the axis A and is hence able to prevent angular rotation of the valving element 30 about the axis A. In practice it also prevents radial movement of the valving element.

[0037] Preferably, as in fact present in the embodiment shown in the figures, there is also provided a second guide element 51, identical to the first 50, applied to and axially spaced from the valving element 30 and acting in the same direction thereas.

[0038] The second guide element 51 is fixed by its outer circular edge 51' to the piece 22 and is positioned a short distance below the lower surface of the piece 22. Specifically, the guide element 51 is positioned below the piece 22 and has its outer peripheral edge 51' fixed to the bottom end of a downwardly facing annular projection 222 provided on the lower face of the piece 22, and lying against an upwardly facing step 114 provided on the inner surface of the casing 11.

[0039] According to the preferred embodiment shown in the figures, each said guide element 50, 51 comprises a substantially flat, circular ring-shaped outer portion 501, 511 respectively, lying in a plane perpendicular to the axis A and having its outer edge defining said edge 50' and 51' respectively, and a substantially cylindrical inner portion 502, 512 respectively, smoothly connected to the outer portion. The inner portion 502 of the first element 50 faces upwards and its free upper edge 50" is secured, for example by an interference fit, to the highest part of the lateral surface of the valving element 30. In contrast, the portion 512 of the second element 51 faces downwards and its free lower edge 51" is secured, for example by an interference fit, to the lowest part of the lateral surface of the valving element 30.

[0040] In an alternative embodiment, not shown in the figures, the two guide elements are substantially flat and their inner edge (50" and 51"), also flat and perpendicular to the axis of the valving element, is fixed radially to the valving element 30, for example by bonding.

[0041] In a preferred embodiment, each guide element 50, 51 is of thin metal having a thickness of between 0.04 and 0.2 mm. This thickness must be such, in relation to its other geometrical characteristics and to the force exerted by the electromagnet and spring 42, as not to create a substantial resistance to this force when the elements 50, 51 flex in the axial plane.

[0042] To increase the flexibility of the elements 50 and 51, they can be provided with radial slits 55 involving in a radial direction the entire outer portion 501 and 511 (see Figure 3).

[0043] In the embodiment shown in Figure 4, the outer portions 501 and 511 of the elements 50, 51 have apertures 61 giving rise to a continuous outer annular edge 62, and to radial strips 63 joining said outer edge 62 to the cylindrical inner portion 502, 512. The number of these radial strips 63 is preferably odd.

[0044] The embodiment shown in Figures 5 and 6 differs from the preceding in that the outer portions 501 and 511 of the elements 50, 51 have an outer edge 71 bent at a right angle to extend about the outer cylindrical surface of the respective annular projection 221, 222, to which it is fixed. Said outer portions 501 and 511 also have relief impressions (embossings) distributed uniformly about the axis A to decrease the resistance of the elements 50, 51 to the axial movement of the valving element 30.

[0045] When in operation, the elements 50 and 51 maintain their outer edge 50', 51' secured to the piece 22 and their other edge 50", 51" secured to the valving element 30. As the valving element 30 undergoes axial movements, the elements 50, 51 deform by flexure, the horizontal outer portions 501 and 511 flexing in particular (as shown in Figure 2). Because of the relatively small thickness of the elements 50 and 51, this flexure does not create substantial resistance to the movement of the valving element 30. Instead, the valving element 30 is prevented from undergoing even small rotations about the axis A, given that the resistance offered by the elements 50, 50' to torsional deformation about the axis of symmetry is high. Again, because of their axially symmetrical shape, the elements 50, 51 deform in an axially symmetrical manner, to enable the valving element to undergo movement along this axis of symmetry, ie the axis A. Finally, because of the fact that two guide elements 50, 51 are provided deforming symmetrically about the axis A, the valving element is prevented from undergoing any rotation in an axial plane.

[0046] In brief, by means of the two guide elements 50 and 51, the valving element is constrained in such a manner as to undergo only translational movements (without rotation) along the axis A.

[0047] It has been found experimentally that by virtue of the constraints created by the elements 50 and 51, wear between the mutually contacting surfaces of the port 20 and valving element 30, produced by the impacts, is considerably reduced.

[0048] One explanation is that, as any rotation and radial movement of the valving element 30 is prevented, points on the lower surface 31 always make contact with the same corresponding points on the port 20. This results in a sort of mutual upsetting and adaptation between the contacting surfaces, with consequent increase in mutual contact and hence a relative increase in sealing, together with considerable reduction in wear compared with the traditional method (in which the valving element rotates freely about the axis A).

[0049] Moreover the presence of at least two guide elements 50, 51 means, as stated, that the valving element 30 is prevented from undergoing radial rotation (ie in an axial plane), hence preventing any lateral contact between the outer lateral surface of the valving element and the surface of the hole 23, with resultant total lack of wear between these surfaces together with precise contacting engagement between the valving element 30 and the port 20, and consequent optimal sealing action.

[0050] In addition, as the elements 50, 51 behave elastically, they can be formed in such a manner as to be normally loaded to urge the valving element 30 downwards. Consequently when the electromagnetic attraction on the valving element 30 ceases, this latter is urged downwards against the port 20 to close it, by the action of the elements 50, 51. This dispenses with the need to provide the spring 42 and the bush 43.

[0051] Numerous modifications of a practical and applicational nature can be made to the invention, but without leaving the scope of the inventive idea as claimed hereinafter.

Claims

1. A fuel injection valve for internal combustion engines, comprising a fuel passage port (20) in the form of a seat for a valving element, and an axially movable valving element (30) having a surface (31) arranged to act on said port (20) to close its passage, said valving element (30) being subjected to alternating axial movements by which it is urged into contact with the passage port (20) in order to close it, and is attracted away therefrom in order to open it,

   characterised by comprising at least one guide element (50, 51) having an outer peripheral edge (50', 51') secured to a fixed part of the valve and an inner edge (50", 51") secured to the valving element (30), and positioned with its axis substantially coinciding with the axis of the valving element, to prevent the valving element (30) undergoing rotations about its axis and radial movements, said guide element (50, 51) being deformable by flexure in a generic axial plane in such a manner as not to create substantial resistance to the axial movement of the valving element (30).

2. A valve as claimed in claim 1, **characterised in that** said guide element (50, 51) is in the form of a thin elastic membrane of circular shape in plan development.

3. A valve as claimed in claim 1, **characterised in that** said guide element is of as shape substantially symmetrical about its axis.

4. A valve as claimed in claim 1, **characterised by** comprising at least two said guide elements (50, 51) applied to the valving element (30) at an axial distance apart, they acting in the same direction to prevent the valving element (30) undergoing rotations in axial planes and radial movements.

5. A valve as claimed in claim 1, **characterised in that** said guide element (50, 51) comprises a substantially flat outer portion (501, 511) of circular ring shape lying in a plane perpendicular to the axis of the valving element and having its outer edge (50', 51') secured to a fixed part of the valve, and a substantially cylindrical inner portion (502, 512) having its free edge (50", 51") secured to the lateral surface of the valving element (30).

6. A valve as claimed in claim 1, **characterised in that** said guide element (50, 51) is substantially completely flat, its inner edge (50" and 51"), also flat and perpendicular to the axis of the valving element, being fixed radially to the valving element (30).

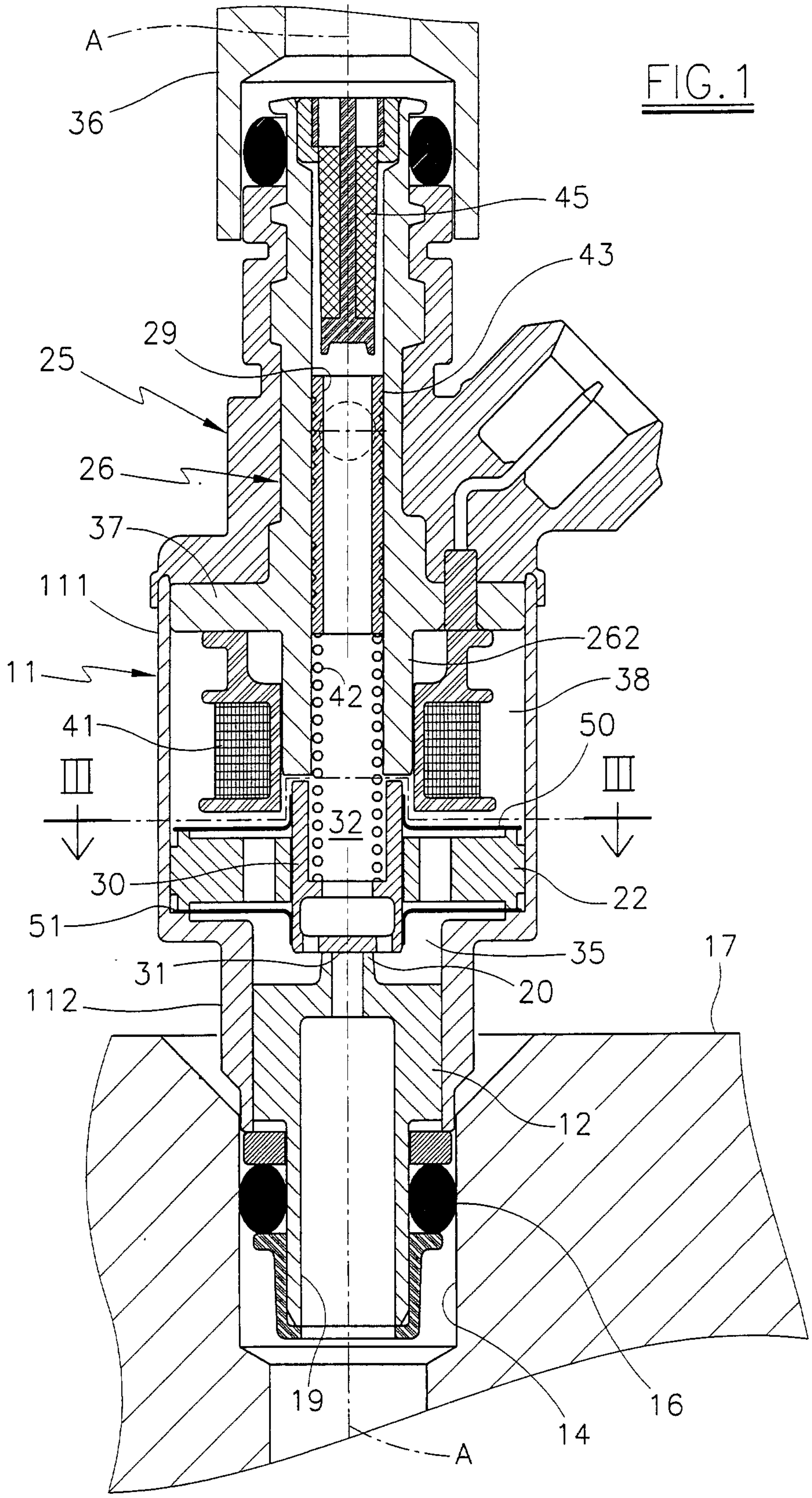
7. A valve as claimed in claim 1, **characterised in that** said guide element (50, 51) is of thin metal having a thickness of 0.04 - 0.2 mm.

8. A valve as claimed in claim 1, in which the valving element (30) is slidingly inserted as an exact fit into an axial hole (23) provided in a fixed guide piece (22), **characterised in that** the guide element (50) is fixed by its outer circular edge (50') to the piece (22) and is positioned a small distance above the upper surface of the piece (22).

9. A valve as claimed in claim 1, in which the valving element (30) is slidingly inserted with slight clearance into an axial hole (23) provided in a fixed guide piece (22),
characterised by comprising a second guide element (51) fixed by its outer circular edge (51') to the piece (22) and positioned a small distance below the lower surface of the piece (22).

10. A valve as claimed in claim 1, **characterised in that** the guide elements (50, 51) behave elastically, they being formed in such a manner as to be normally loaded to urge the valving element (30) downwards, the action of the elements (50, 51) being such that when the electromagnetic attraction on the valving element (30) ceases, this latter is urged downwards against the port (20) to close it.

FIG. 1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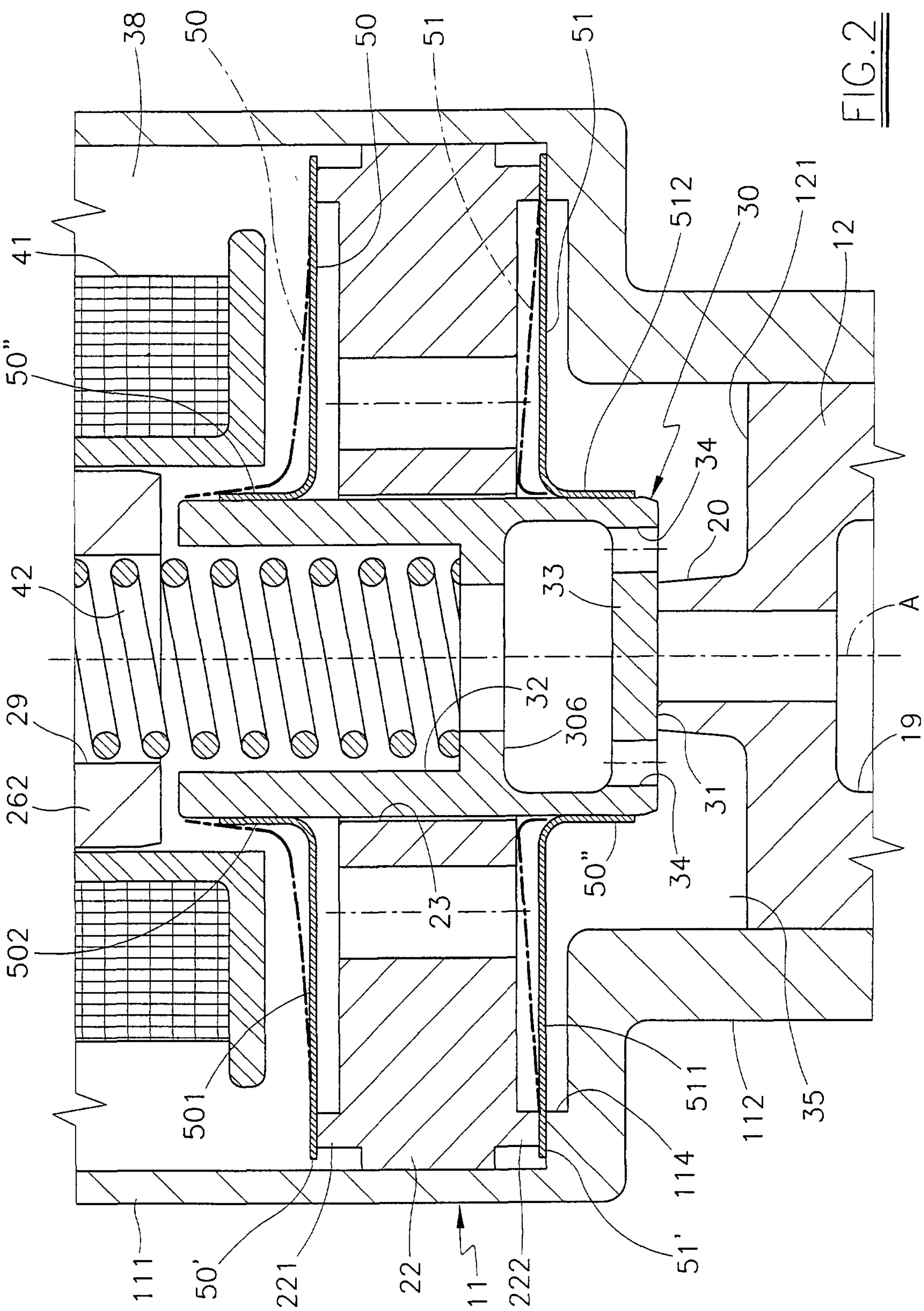
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FIG. 2

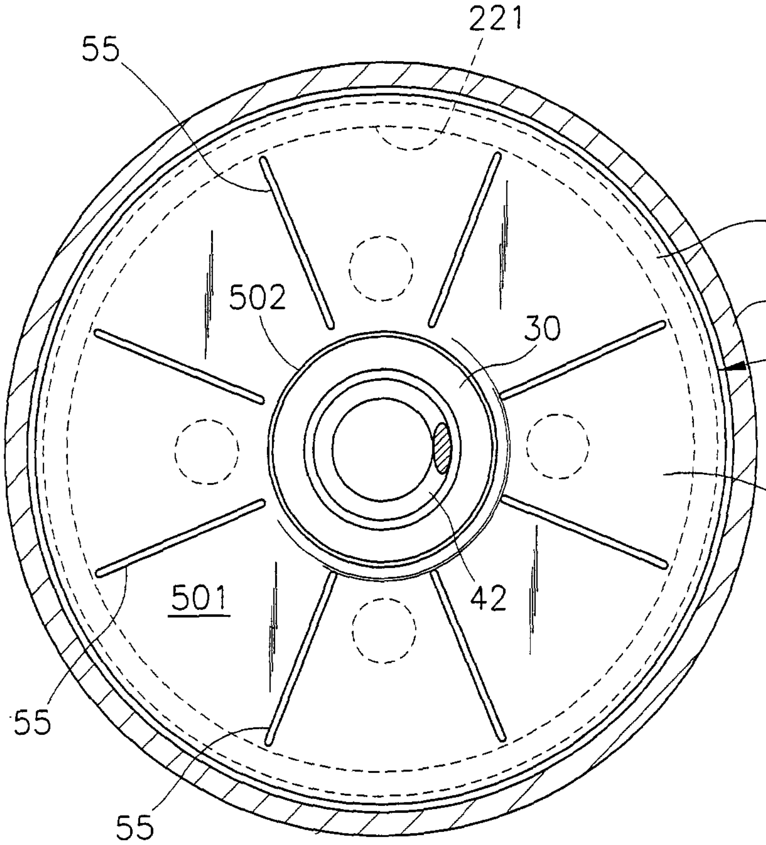
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FIG.3

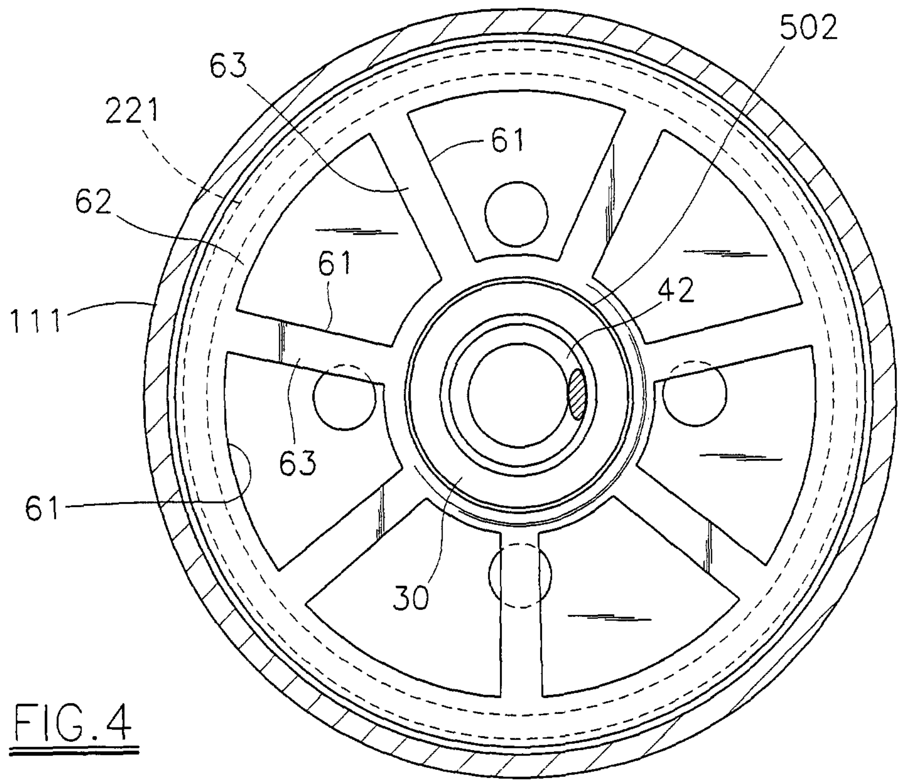
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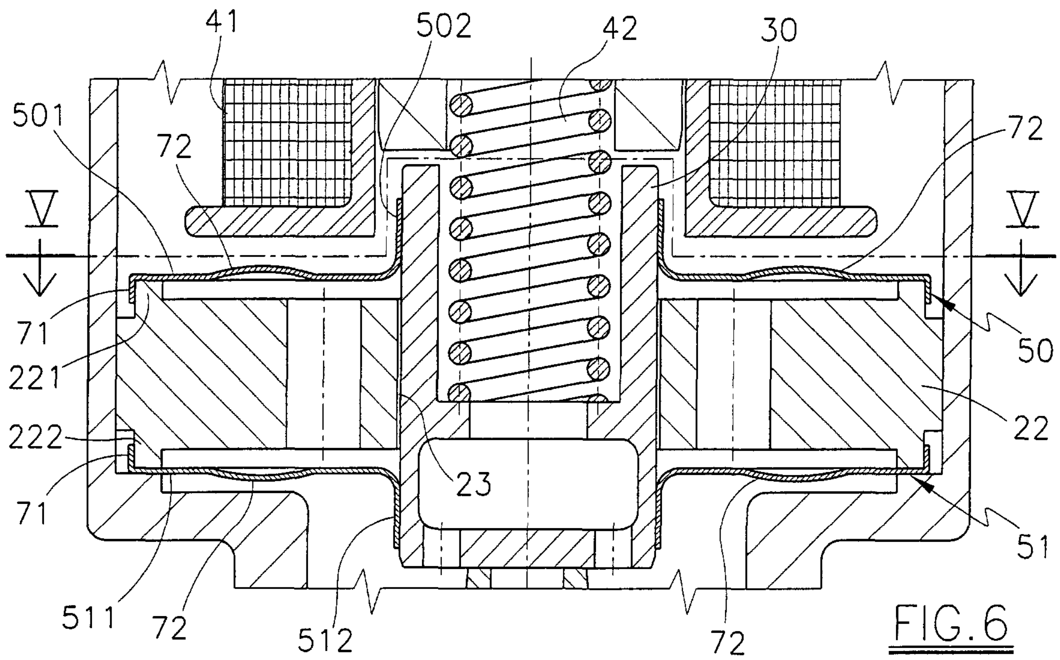
FIG.4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512
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FIG.6

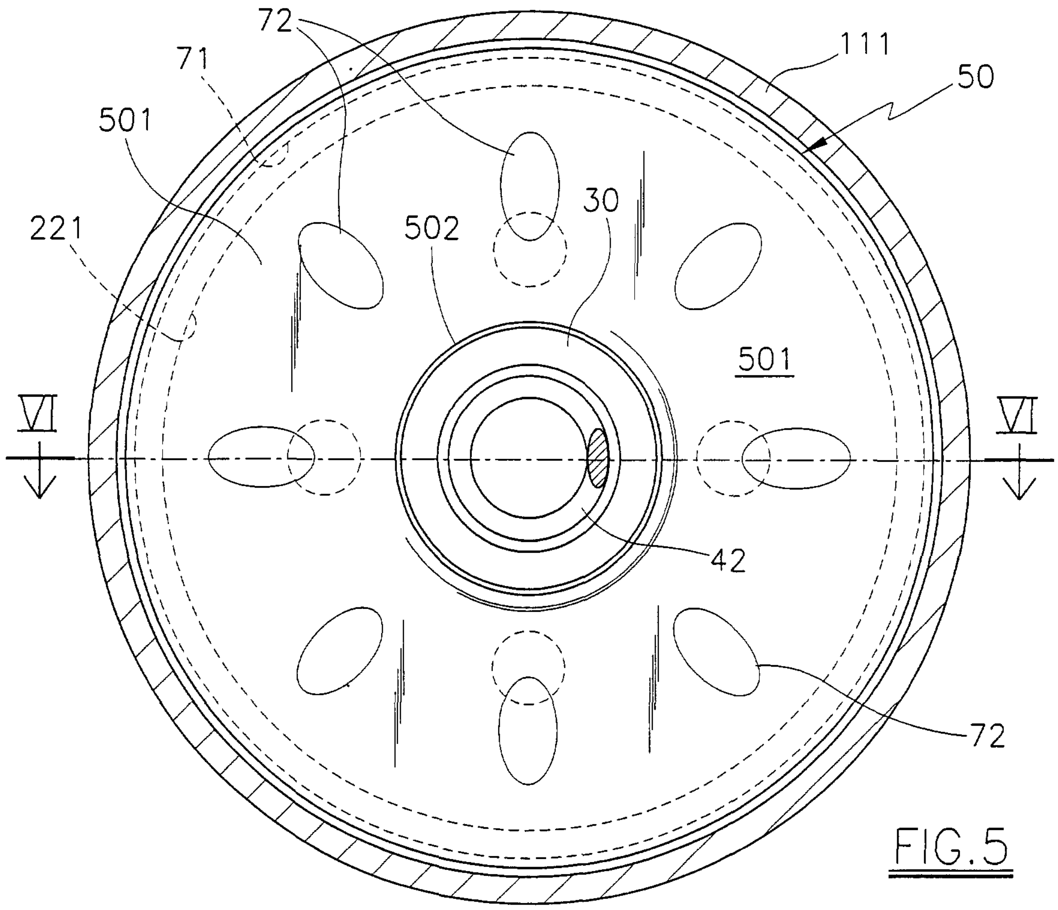
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FIG.5

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 20 2331

DOCUMENTS CONSIDERED TO BE RELEVANT

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	20 November 2000	Friden, C

CATEGORY OF CITED DOCUMENTS

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