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

(11) EP 2 221 470 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
25.08.2010 Bulletin 2010/34

(51) Int Cl.:
F02M 61/16 *(2006.01)* ***F02M 63/00*** *(2006.01)*

(21) Application number: **09425059.4**

(22) Date of filing: **16.02.2009**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK TR
Designated Extension States:
AL BA RS

(71) Applicant: **C.R.F. Società Consortile per Azioni**
10043 Orbassano (Torino) (IT)

(72) Inventors:
- **Ricco, Mario**
  70010 Casamassima (IT)
- **Stucchi, Sergio**
  70010 Valenzano (IT)
- **Ricco, Raffaele**
  70010 Valenzano (IT)
- **De Michele, Onofrio**
  70010 Valenzano (IT)
- **Gravina, Antonio**
  70010 Valenzano (IT)
- **Lepore, Domenico**
  70010 Valenzano (IT)

(74) Representative: **Bergadano, Mirko et al**
Studio Torta S.r.l.
Via Viotti, 9
10121 Torino (IT)

(54) **Method for manufacturing a fuel injector servo valve**

(57) The manufacturing method regards a fuel injector servo valve (5), wherein a bushing (41) is designed to slide on a fixed stem for opening/closing the servo valve (5) and carries an anchor (17), which is free to slide axially on the bushing (41); according to the method, the bushing (41) is provided in such a way that it has a guide portion (61) and an adjacent terminal portion (71); after the anchor (17) has been mounted on the guide portion (61), a ring (73) is fitted on the terminal portion (71) so that it is brought to bear upon an axial shoulder (72) provided between the guide portion (61) and the terminal portion (71); the ring (73) is then welded to the terminal portion (71) via weld material along a circumference, so that a weld is carried out in view without any need for angular positioning between the bushing (41) and the welding device.

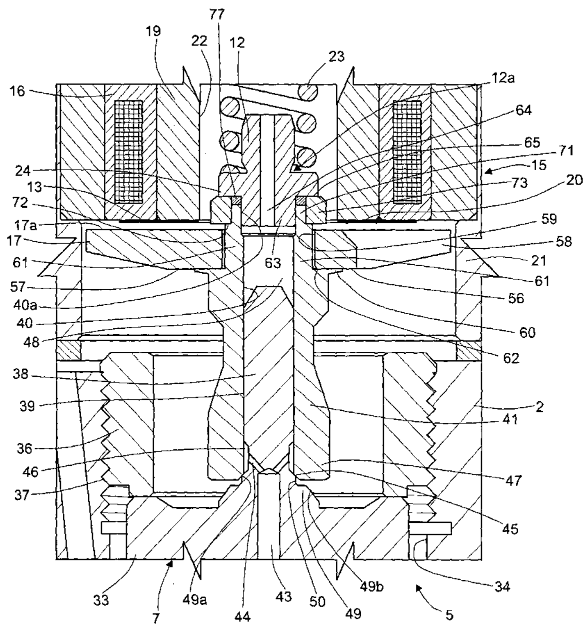

Fig.1

EP 2 221 470 A1

Description

[0001] The present invention relates to a method for manufacturing a fuel injector servo valve, in which the servo valve comprises a bushing designed to move for a certain axial travel along a fixed stem between an opening position and a closing position. The invention moreover relates to a servo valve produced using the aforesaid method.

[0002] Servo valves of the type just described have a discharge duct, which exits on a lateral surface of the stem, in such a way that, in the closing position, the bushing will be subject to a substantially zero axial thrust exerted by the pressure of the fuel. Consequently, the servo valve is of a balanced type and requires relatively small forces for opening and closing it. The bushing is brought into the closing position by a corresponding spring, and is controlled so as to be brought into the opening position, against the action of the spring, by a disk-shaped anchor, actuated by an electric actuator.

[0003] In order to reduce or eliminate the rebounds of the bushing when it is brought into the closing position, the need is felt to separate the anchor from the bushing and to displace the anchor axially for a travel greater than that of the bushing so as to strike against the latter when it rebounds.

[0004] During production of this type of servo valve, there is the problem of providing two stop, or impact, elements for the travel of the anchor. Such elements must be fixed with respect to the bushing and must be arranged on the latter with extreme precision. In addition, during production, there is the problem of mounting the anchor in a slidable way on the bushing and of fixing on the latter one of the stop elements by means of welding, for example laser welding, which presents various difficulties. In particular, the outer profile of the anchor and the profile of its housing on the bushing must not present interference with the weld material.

[0005] The aim of the invention is to provide a method for manufacturing a servo valve of the type described above, which will solve the problems indicated above and will present high reliability and a limited cost.

[0006] According to the invention, the above purpose is achieved by a method for manufacturing a fuel injector servo valve, as defined in Claim 1.

[0007] For a better understanding of the invention described herein is a preferred embodiment, provided purely by way of example with the aid of the annexed drawings, wherein:

- Figure 1 is partial median section of a servo valve produced according to the method of the present invention;
- Figure 2 illustrates, at an enlarged scale, a detail of Figure 1; and
- Figures 3 and 4 are similar to Figure 2 and show respective variants of the servo valve obtained according to the method of the present invention.

[0008] With reference to Figure 1, designated as a whole by 2 is a hollow body or casing of a fuel injector for an internal-combustion engine, in particular a diesel engine. The casing 2 extends along a longitudinal axis, and terminates with a nozzle, or nebulizer (not visible in the figure), for injection of the fuel at a high pressure.

[0009] The casing 2 has an axial cavity 34, which houses a dosage servo valve 5, comprising a valve body 7 having an axial hole, slidable in which is a rod for control of the injection (said rod and said axial hole are not visible in Figure 1). Said rod is controlled by the pressure of the fuel in a control chamber, which is contained in the valve body 7 and is not visible in Figure 1 either. An electric actuator 15 is housed in a portion of the cavity 34 and comprises an electromagnet 16 designed to control an anchor 17 having the shape of a notched disk. In particular, the electromagnet 16 comprises a magnetic core 19, which has a polar surface 20 perpendicular to the axis of the casing 2, and is held in position by a support or jacket 21.

[0010] The electric actuator 15 has an axial cavity 22 in communication with the discharge of the servo valve 5 for recirculation of the fuel towards the usual tank. Housed in the cavity 22 is a helical compression spring 23, pre-loaded so as to exert an action of thrust on the anchor 17, in a direction opposite to the attraction exerted by the electromagnet 16. The spring 23 acts on an intermediate body, designated as a whole by 12a, which comprises a pin 12 defining a centring element for one end of the spring 23. The body 12a further comprises an outer annular portion defining a flange 24 made of a single piece with the pin 12. Set between a plane top surface 17a of the anchor 17 and the polar surface 20 of the core 19, is a thin lamina 13 made of non-magnetic material in order to guarantee a certain gap between the anchor 17 and the core 19.

[0011] The valve body 7 comprises a flange 33 housed in the cavity 34 and kept fixed, in a fluid-tight way, against a shoulder not visible in the figure, by a threaded ringnut 36, screwed on an internal thread 37 of the cavity 34. The anchor 17 is associated to a bushing 41 guided axially by a stem 38, which is made of a single piece with the flange 33 of the valve body 7 and extends in cantilever fashion from the flange 33 itself towards the cavity 22. The stem 38 has a cylindrical lateral surface 39, which guides axial sliding of the bushing 41. In particular, the bushing 41 has a cylindrical internal surface 40, coupled to the lateral surface 39 of the stem 38 substantially in a fluid-tight way, for example with a diametral play of less than 4 μm, or else by means of interposition of annular seal elements (not illustrated).

[0012] The fuel comes out of the control chamber of the body 7 through an outlet duct 43, made axially inside the flange 33 and the stem 38. The duct 43 is in communication with at least one substantially radial stretch of duct 44. Advantageously, two or more radial stretches 44 can be provided, set at a constant angular distance apart, which give out into an annular chamber 46, formed by a groove of the lateral surface 39 of the stem 38. In Figure 1, two stretches 44 are provided, inclined towards the anchor 17.

[0013] The annular chamber 46 is obtained in an axial position adjacent to the flange 33 and is opened/closed by a terminal portion of the bushing 41: said terminal portion defines an open/close element 47 for said annular chamber 46 and hence also for the radial stretches of duct 44. Preferably, the open/close element 47 is made of a single piece with the remaining part of the bushing 41 and co-operates with a corresponding stop element for closing the servo valve 5. In particular, the open/close element 47 has an internal surface 45 shaped like a truncated cone that is flared towards the end edge and is designed to stop against a connector 49 shaped like a truncated cone set between the flange 33 and the stem 38.

[0014] Advantageously, the connector 49 comprises two surface portions shaped like a truncated cone 49a and 49b, separated by an annular groove 50, which has a cross section shaped substantially like a right angle; i.e., it comprises an internal cylindrical stretch and an external stretch orthogonal to the axis of the casing 2. The surface shaped like a truncated cone 45 of the open/close element 47 engages in a fluid-tight way the portion of surface shaped like a truncated cone 49a, against which it stops in the closing position. On account of the wear between these surfaces 45 and 49a, after a certain time, the closing position of the open/close element 47 requires a greater travel of the bushing 41 towards the connector 49, but the diameter of the sealing surface at the most remains defined by the diameter of the cylindrical stretch of the annular groove 50.

[0015] The anchor 17 is at least in part made of a magnetic material, and is formed by a distinct piece, i.e., a piece separate from the bushing 41. It comprises a central portion 56 having a plane bottom surface 57, and a notched outer portion 58, with cross section tapered towards the outside. The central portion 56 defines an axial hole 59, by means of which the anchor 17 engages with a certain radial play along a guide portion 61 forming part of the bushing 41: the portion 61 projects axially with respect to a flange 60 of the bushing 41, is referred to hereinafter also as "intermediate collar", and has an outer diameter smaller than that of the open/close element 47 and than that of the flange 60.

[0016] The bushing 41 carries, in a fixed position, a first element for axial stop of the anchor 17: said first element is a shoulder 62 that is set at the bottom of the intermediate collar 61 and, in the particular examples illustrated, is made of a single piece with the bushing 17, being defined by the flange 60.

[0017] The body 12a comprises an axial pin 63 for connection with the bushing 41: the pin 63 is made of a single piece with the flange 24, projects axially from the flange 24 in a direction opposite to the pin 12, and is inserted in an axial seat 40a of the bushing 41. The seat 40a has a diameter slightly greater with respect to the internal surface 40 of the bushing 41 in order to reduce the portion to be ground so as to provide fluid tightness with the surface 39 of the stem 38.

[0018] Notwithstanding the tightness between the surface 39 of the stem 38 and the internal surface 40 of the bushing 41, there is in general a certain leakage of fuel towards a compartment 48, between the end of the stem 39 and the pin 63. In order to enable discharge of the fuel from the compartment 48 towards the cavity 22, the body 12a is provided with an axial hole 64.

[0019] As has been mentioned above, the shoulder 62 constitutes the first of two elements provided for axial stop of the anchor 17 and is set in a position such as to allow the anchor 17 to perform a pre-set travel greater than the travel of the open/close element 47, i.e., a relative axial displacement between the anchor 17 and the bushing 41.

[0020] According to the invention, the bushing 41 is provided with a ring-shaped terminal portion 71, which is referred to also hereinafter as "end collar", is adjacent to the intermediate collar 61 and has an outer diameter smaller than that of the intermediate collar 61 so as to form an axial step or shoulder 72. In the particular embodiment illustrated in Figure 2, the end collar 71 is made of a single piece with the remaining part of the bushing 41, defines the seat 40a, and terminates axially with an end edge 70. The end collar 71 carries a ring 73 defining a spacer between the flange 24 and the shoulder 72. Once again according to the particular embodiment illustrated in Figure 2, the ring 73 has an axial height greater than that of the end collar 71, i.e., greater than the axial distance between the end edge 70 and the shoulder 72: consequently, the ring 73 has an internal lateral surface 78, which is fitted on the end collar 71 and comprises a portion 79, which projects axially with respect to the end edge 70.

[0021] The ring 73 has a base surface 74, which is in contact with the shoulder 72 and is plane. The ring 73 moreover has a plane surface 75, opposite and parallel to the surface 74. The flange 24 has a plane surface 65 that is set in contact with the surface 75 of the ring 73, in particular by the thrust of the spring 23. The ring 73 has an outer diameter greater than that of the intermediate collar 61, so that an annular portion 76 of the surface 74 projects radially outwards with respect to the intermediate collar 61 and faces axially the surface 17a.

[0022] The annular portion 76 constitutes the second of the two elements provided for axial stop of the travel of the anchor 17, with respect to the bushing 41. In other words, the axial distance between the annular portion 76 and the shoulder 62 is greater than the axial thickness of the portion 56 of the anchor 17: the difference between said axial distance and said axial thickness constitutes the maximum play or relative displacement in the axial direction between the anchor 17 and the bushing 41.

[0023] When the electromagnet 16 is not energized, the open/close element 47 is kept resting with its surface shaped like a truncated cone 45 against the portion shaped like a truncated cone 49a of the connector 49 by the thrust of the spring 23, which acts through the flange 24 and the ring 73, so that the servo valve 5 is closed. In the annular chamber 46 there is set up a fuel pressure, the value of which is substantially equal to the supply pressure of the injector. In this condition, normally the anchor 17 is resting against the shoulder 62 and the lamina 13 is resting by gravity on the surface 17a of the anchor 17: since the weight of the lamina 13 is negligible with respect to that of the anchor 17 and of the bushing 41, for reasons of simplicity it is assumed that the lamina 13 is adjacent to the surface 20 as represented in Figure 1, in so far as this hypothesis does not jeopardize the operation described.

[0024] The travel, or lift, of the open/close element 47 is defined by the axial distance between the annular portion 76 of the surface 74 of the ring 73 and the lamina 13. When the electromagnet 16 is energized for opening the servo valve 5, the core 19 attracts the anchor 17, which at the start performs a loadless travel, or pre-travel, without affecting the displacement of the bushing 41, until it brings its surface 17a into contact with the annular portion 76 of the surface 74 of the ring 73. At this point, the action of the electromagnet 16 on the anchor 17 overcomes the force of the spring 23, via the interposition of the ring 73 and of the flange 24, and the anchor 17 draws the bushing 41 axially towards the core 19, to enable the open/close element 47 to perform its opening travel: consequently, also by the pressure of the fuel in the chamber 46, the open/close element 47 lifts up and the servo valve 5 opens.

[0025] It is thus evident that the anchor 17 performs a travel greater than that of the bushing 41; i.e., in opening it performs along the collar 61 a pre-travel equal to the play between the surface 17a of the anchor 17 and the annular portion 76 of the surface 74 of the ring 73.

[0026] When energization of the electromagnet 16 ceases, the spring 23, via the body 12a and the ring 73, causes the bushing 41 to perform the travel towards the closing position. During at least one first stretch of this closing travel, the annular portion 76 of the surface 74 remains in contact with the surface 17a of the anchor 17, which moves away from the polar surface 20, moving substantially together with the bushing 41.

[0027] At the end of its closing travel, the open/close element 47 impacts with its conical surface 45 against the portion of surface shaped like a truncated cone 49a of the connector 49 of the valve body 7. On account of the type of stresses involved, of the small area of contact, and of the hardness of the open/close element 47 and of the valve body 7, after impact, the open/close element 47 rebounds overcoming the action of the spring 23. Instead, the anchor 17 continues its travel towards the valve body 7, i.e., towards the shoulder 62, recovering precisely the play that had formed between the plane surface 57 of the portion 56 of the anchor 17 and the shoulder 62 of the flange 60.

[0028] After a certain time from impact of the open/close element 47, there is an impact of the plane surface 57 of the portion 56 against the shoulder 62 of the bushing 41, which is rebounding. As a result of this impact between the anchor 17 and the bushing 41, the subsequent rebounds of the bushing 41 are markedly reduced or even eliminated as compared to the case in which the anchor 17 is fixed with respect to the bushing 41.

[0029] By appropriately sizing the weights of the anchor 17 and of the bushing 41, the travel of the anchor 17, and the travel of the open/close element 47, the impact of the anchor 17 against the bushing 41 is obtained during the first rebound, immediately following upon de-energization of the electromagnet 16, so that both said first rebound and the possible subsequent rebounds are attenuated. The impact between the anchor 17 and the shoulder 62 of the bushing 61 can in particular occur upon return of the open/close element 47 into the closing position, i.e., at the end of the first rebound. In this case, the rebounds of the open/close element 47 subsequent to the first are blocked.

[0030] During production of the servo valve 5, the ring 73 is fixed to the end collar 71 by means of a welding device, preferably of the laser type, not shown in the attached figures, after the surface 74 of the ring 73 has been brought into contact against the shoulder 72, which defines an axial reference position for the ring 73 during welding. Said welding is carried out by forming weld material along a circumference between the end edge 70 and the portion 79. Preferably, the weld material defines a continuous bead 77 along the aforesaid circumference, which has an internal diameter greater than the diameter of the seat 40a.

[0031] Consequently, welding is carried out so that it is in view, without any need for phasing between the welding device and the bushing 41, i.e., without having to set the welding device in a pre-defined angular position with respect to the bushing 41.

[0032] As an alternative to a welding operation that produces a continuous bead, spot welding could be sufficient.

[0033] In the solution of Figure 2, the body 12a is removably connected to the bushing 41, by simply inserting the pin 63 into the seat 40a, in so far as the outer diameter of the pin 63 approximates by defect the diameter of the seat 40a. Alternatively, the pin 63 can be sized in such a way as to be connected to the bushing 41 in a fixed position, for example, by means of forced interference fit into the seat 40a, or else by welding between a terminal edge 80 of the pin 63 and the seat 40a using a welding device appropriately shaped so as to slide axially into the bushing 41 as far as the compartment 48. Alternatively, the body 12a can be fixed to the ring 73 by means of a continuous bead, or else by spot welding, with a weld between the surface 75 of the ring 73 and the lateral surface of the flange 24. These two types of welding do not require any phasing either.

[0034] Figures 3 and 4 show respective variants of the servo valve 5, the components of which are designated, where possible, by the same reference numbers as the ones used in Figure 2. In said variants, the body 12a is absent, the spring 23 acts directly on the surface 75 of the ring 73, and the ring 73 has an axial height lower than that of the terminal portion 71, so that the terminal portion 71 comprises one end 70a, which projects axially with respect to the surface 75 and defines a centring for mounting the spring 23. In addition, the bead 77 is provided along a circumference between the surface 75 and the cylindrical lateral surface of the end 70a, still remaining in view; as an alternative to the continuous bead, it may be understood that once again a spot-welding operation is possible, provided that the resistance to the action of thrust of the anchor 17 is guaranteed even so.

[0035] In the solution of Figure 4, the terminal portion 71 is made of a single piece with the intermediate collar 61, as in the solution of Figure 2, so that the compartment 48 communicates directly with the cavity 22.

[0036] In the solution of Figure 3, instead, the terminal portion 71 forms part of an axially perforated pin, i.e., a sleeve 81, fixed to the remaining part of the bushing 41, preferably via welding. In particular, the outer diameter of the sleeve 81 approximates by defect the diameter of the seat 40a so as to obtain a fit without interference. In this way, the sleeve 81 comprises a terminal portion 63a, which is coaxial and opposed to the terminal portion 71 and engages the seat 40a, in a position corresponding to the intermediate collar 61.

[0037] Advantageously, welding of the sleeve 81 is carried out by forming weld material 77a along a circumference between the shoulder 72 and the external lateral surface of the sleeve 81, after the sleeve 81 has been positioned axially with respect to the remaining part of the bushing 41, for example, by being rested on a projecting element (not illustrated) set in the central hole of the open/close element 47. In this case, a chamfered portion or recess 83 is provided on the ring 73 in a position corresponding to the edge between the surfaces 74 and 78 so as to prevent any interference between the ring 73 and the weld material 77a. Alternatively, weld material 77b (represented with a dashed line) is formed between an end edge 80a of the terminal portion 63a and the lateral surface of the seat 40a, using a welding device appropriately shaped so as to slide axially into the bushing 41 as far as the compartment 48. Also these welds of the sleeve 81 to the intermediate collar 61 do not require any phasing, i.e., any particular angular positioning between the bushing 41 and the welding device, given that welding is carried out along a circumference, preferably with a continuous bead.

[0038] The method for manufacturing the servo valve 5 is performed in the following way.

[0039] First, a bushing is provided in such a way that it has the guide portion 61, for coupling of the anchor 17, and the terminal portion 71, the latter set in a position adjacent to the guide portion 61 and with an outer diameter smaller than that of the guide portion 61 so as to define the shoulder 72.

[0040] During machining of the bushing 41 or else by application of a piece, the stop element defined by the shoulder 62 is provided in a fixed position on the bushing 41 on one side of the guide portion 61.

[0041] On the other side, the ring 73 is fitted on the terminal portion 71 until it is brought to bear upon the shoulder 72 so as to provide an axial reference position for the stop element defined by the annular portion 76. In particular, the ring 73 is mounted after the anchor 17 has been fitted on the guide portion 61 and the anchor 17 has been left to rest on the shoulder 62.

[0042] Finally, the ring 73 is welded with weld material via an appropriate welding device, forming weld material, i.e., the bead 77, along a circumference between the ring 73 and the terminal portion 71.

[0043] The anchor 17, the axial position of the shoulder 62, and the axial position of the annular portion 76 have been previously chosen so as to allow for a pre-defined freedom of axial movement of the anchor 17 equal to the axial play established in the design stage. In particular, for a fine calibration of the extent of the axial play, the anchor 17 is chosen from among a plurality of anchors that are divided into classes on the basis of their axial thickness.

[0044] In the case of the embodiment of Figure 2, also the body 12a is provided, with the flange 24 for supporting the spring 23, and with the pins 12 and 63. The pin 63 of the body 12a is inserted in the seat 40a of the bushing 41.

[0045] After installation, the servo valve 5 is mounted by fixing the valve body 7 in the cavity 34 and fitting the bushing 41 on the stem 38. Finally, the spring 23 is fitted on the pin 12 or else on the end 70a, until the spring 23 itself comes to rest on the flange 24 or else, respectively, on the surface 75 of the ring 73.

[0046] From what has been seen above the advantages of the manufacturing method according to the invention as compared to the known art are evident.

[0047] The bead 77 does not modify the outer profile of the bushing 41 and of the body 12a, nor does it alter the surfaces 39, 40 of the stem 38 and of the bushing 41, nor does it vary the distance between the shoulder 62 and the annular portion 76 of the surface 74.

[0048] In particular, welding is carried out without any need for phasing between the bushing 41 and the welding device, and the weld material remains in view in order to facilitate not only carrying out thereof, but also quality control. In addition, the weld material defined by the beads 77, 77a, 77b does not create any interference during the movement of the anchor 17 in the space provided between the shoulder 62 and the annular portion 76.

[0049] In addition, the shoulder 72 defines a precise reference position for the ring 73 and enables transfer of the loads from the spring 23 to the bushing 41 without affecting the welding areas. Also the transfer of the loads between the spring 23 and the anchor 17 occurs through the ring 73 without affecting the welding areas.

[0050] It may be understood that various modifications and improvements may be made to the method of fabrication described above without thereby departing from the scope defined by the annexed claims.

[0051] For example, the anchor 17 can be defined by a disk with constant thickness. In addition, the flange 60 can be eliminated, so that the shoulder 62 is obtained in the thickness of the bushing 41. As has been mentioned above, the shoulder 62 can also be replaced by an applied stop element fixed on the remaining part of the bushing 41. In this case, the anchor 17 could be fitted on the guide portion 61 before application and fixing of said stop element; possibly, if the radial dimensions of the remaining part of the bushing 41 so allow, the anchor 17 could be fitted on the side of the open/close element 47 (instead of on the side of the terminal portion 71), until they reach the guide portion 61, even after the ring 73 has been welded.

[0052] Also the stop element defined by the annular portion 76 of the surface 74 could be an applied element fixed to the ring 73 and/or could be set at an axial distance apart from the shoulder 72.

[0053] The ring 73 can also be welded to the bushing 41 by means of weld material along a circumference between the annular portion 76 of the surface 74 and the lateral surface of the collar 61. In this case, the anchor 17 is provided with an appropriate chamfered portion or recess in a position corresponding to the edge that corresponds to the weld material, for housing said material and preventing interference with the axial travel of the anchor 17.

[0054] The pin 63 could engage the portion 79 of the internal lateral surface 78, instead of engaging the terminal portion 71.

[0055] The open/close element 47 could be a separate piece fixed to the remaining part of the bushing 41.

[0056] The perforated pin 81 could have dimensions different from the ones shown: for example, it could have an internal diameter substantially equal to that of the surface 40 and/or could be set so that it rests axially on the guide portion 61.

[0057] A spring could be set between the surface 57 of the anchor 17 and the flange 33 so as to bring the surface 17a of the anchor 17 into contact with the surface 76 of the ring 73 when the electric actuator is not energized. Said possible spring must have a stiffness and a pre-load much lower than those of the spring 23 so as not to affect the dynamics of impact of the anchor 17 against the bushing 41 during the phases of rebound described above.

[0058] It may be understood that the sizing of the bead, or of the weld spots, will have to be chosen taking into account operation of the servo valve in fatigue conditions, for a sufficient number of cycles.

Claims

1. A method for manufacturing a fuel injector servo valve (5), the servo valve comprising an open/close element (47) fixed with respect to a bushing (41), which is designed to move for a certain axial travel along a fixed stem (38) for opening/closing a discharge duct (43, 44) departing from a lateral surface (39) of said stem (38), a spring (23) being provided for bringing said bushing (41) into the closing position, wherein said bushing (41) is subject to a substantially zero axial pressure by the fuel; said bushing (41) being movable under the control of an axially perforated anchor (17), actuated by an electric actuator (15) against the action of said spring (23); the method comprising the following steps:

   - providing said bushing (41) in such a way that it has:

     a) a guide portion (61) for coupling of said anchor (17), and
     b) a terminal portion (71) adjacent to said guide portion (61) and having an outer diameter smaller than that of said guide portion (61) so as to define an axial shoulder (72) between said guide portion (61) and said terminal portion (71);

   - fitting said anchor (17) on said guide portion (61);
   - providing a first element (62) in a fixed position on said bushing (41) on one side of said guide portion (61) for axial stop of said anchor (17);
   - providing a second element (76) on the other side of said guide portion (61) for axial stop of said anchor (17); said second element (76) being brought into a fixed position by a ring (73), which is fitted on said terminal portion (71) until it is brought to bear upon said axial shoulder (72) in an axial reference position;
   - choosing the thickness of said anchor (17) and the axial positions of said first and second elements (62,76) so as to allow for a pre-defined freedom of axial movement to said anchor (17) on said guide portion (61); and
   - welding said ring (73) in said axial reference position via weld material along a circumference between said ring (73) and said terminal portion (71).

2. The method according to Claim 1, **characterized in that** said anchor (17) is fitted on said guide portion (61) before fitting said ring (73) on said terminal portion (71).

3. The method according to Claim 2, **characterized in that** said first element (62) is provided on said bushing (41) before fitting of said anchor (17).

4. The method according to any one of the preceding claims, **characterized in that** said anchor (17) is

chosen from among a plurality of anchors that have been divided into classes on the basis of the value of their axial thickness.

5. The method according to any one of the preceding claims, **characterized in that** said first element (62) is defined by a shoulder made of a single piece with said bushing (41).

6. The method according to any one of the preceding claims, **characterized in that** said second element is defined by an outer annular portion (76) made of a single piece with said ring (73).

7. The method according to Claim 6, **characterized in that** said outer annular portion (76) is welded to an external lateral surface of said guide portion (61), and **in that** a recess is provided on said anchor (17) in a position corresponding to the weld material.

8. The method according to any one of the preceding claims, **characterized in that** said terminal portion (71) is made of a single piece with the remaining part of said bushing (41).

9. The method according to any one of Claims 1 to 7, **characterized in that** said terminal portion (71) is provided by applying and fixing a perforated piece (81) on the remaining part of said bushing (41).

10. The method according to Claim 9, **characterized in that** said perforated piece (81) is fixed via welding along a circumference.

11. The method according to Claim 10, **characterized in that** said axial shoulder (72) is welded to an external lateral surface of said perforated piece (81); and **in that** a recess is provided (83) between a base surface (74) and an internal lateral surface (78) of said ring (73) for housing the weld material.

12. The method according to Claim 10, **characterized in that** said perforated piece comprises a further terminal portion (63a), which is coaxial and opposed to said terminal portion (71), is inserted in an axial compartment (48) of said bushing (41), and is welded to the internal surface of said axial compartment (48).

13. The method according to any one of the preceding claims, **characterized in that** said terminal portion (71) has an axial height greater than that of said ring (73) so as to comprise one end (70a), which projects axially with respect to said ring (73).

14. The method according to Claim 13, **characterized in that** said end (70a) defines a centring for mounting said spring (23), and **in that** said ring (73) defines an axial rest for said spring (23).

15. The method according to any one of Claims 1 to 13, **characterized by** further comprising the following steps:

- providing an intermediate body (12a) comprising:

  a) a flange (24) defining a rest for said spring (23),
  b) a connection pin (63), and
  c) a centring pin (12) for said spring (23), said centring pin (12) being coaxial and opposed to said connection pin (63);

- inserting said connection pin (63) in an axial seat (40a).

16. The method according to Claim 15, **characterized in that** said ring (73) has an axial height greater than that of said terminal portion (71) and has an internal lateral surface comprising an annular portion (79), which projects axially with respect to said terminal portion (71); said flange (24) being rested axially upon said ring (73).

17. The method according to Claim 16, **characterized in that** welding of said ring (73) is carried out along a circumference between an axial end edge (70) of said terminal portion (71) and said annular portion (79).

18. The method according to any one of Claims 15 to 17, **characterized in that** said intermediate body (12a) is welded to said terminal portion (71) or to said ring (73) via weld material along a circumference.

19. The method according to any one of Claims 15 to 17, **characterized in that** said intermediate body (12a) is fixed by forced interference fit of said connection pin (63) into said axial seat (40a).

20. A fuel injector servo valve, obtained with the method according to any one of the preceding claims.

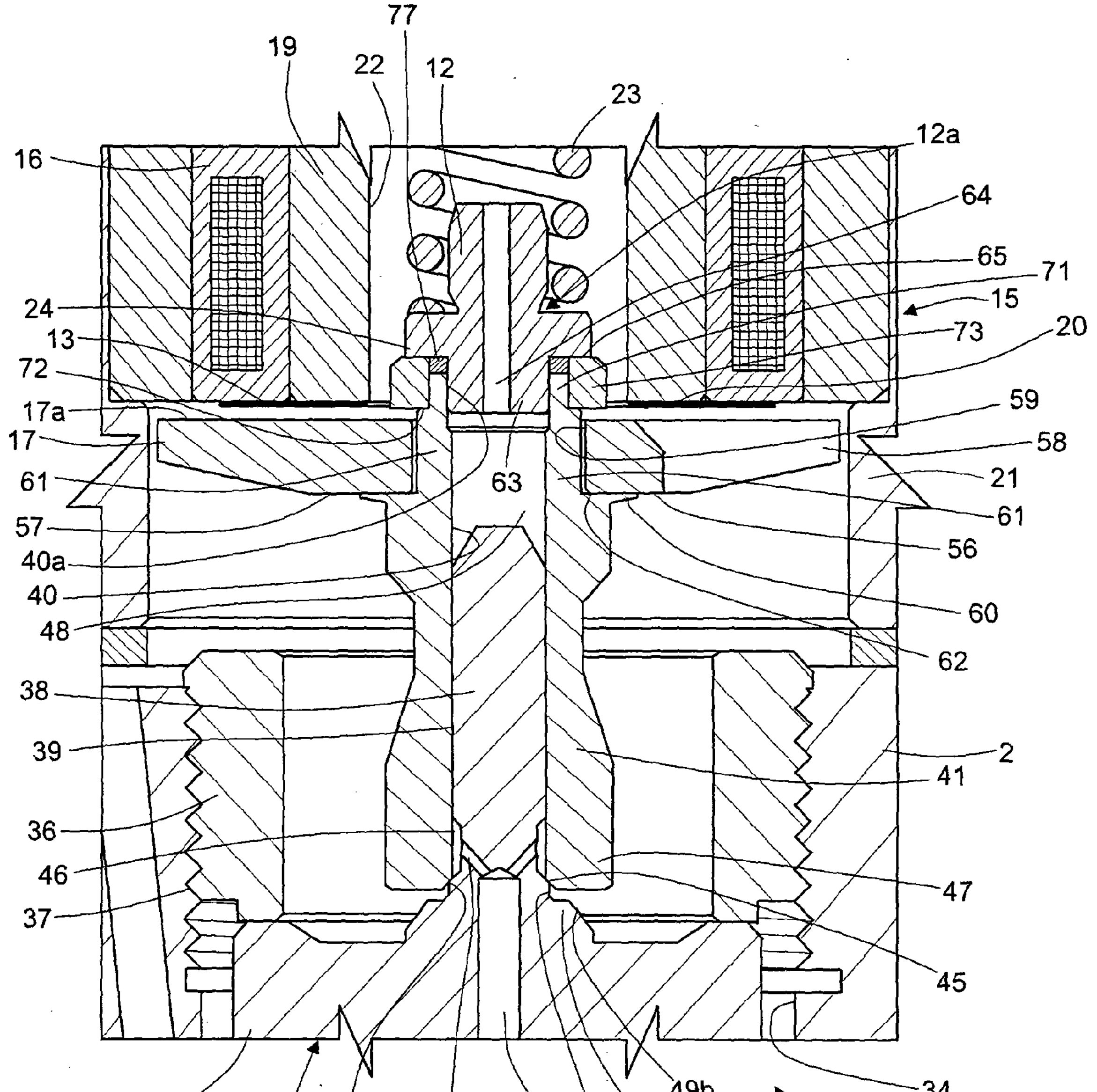
77
19
22
12
23
12a
16
64
65
71
24
15
13
73
20
72
17a
59
17
58
61
63
21
61
57
56
40a
40
60
48
62
38
2
39
41
36
46
47
37
45
33
7
49a
44
43
50
49
49b
34
5

Fig.1

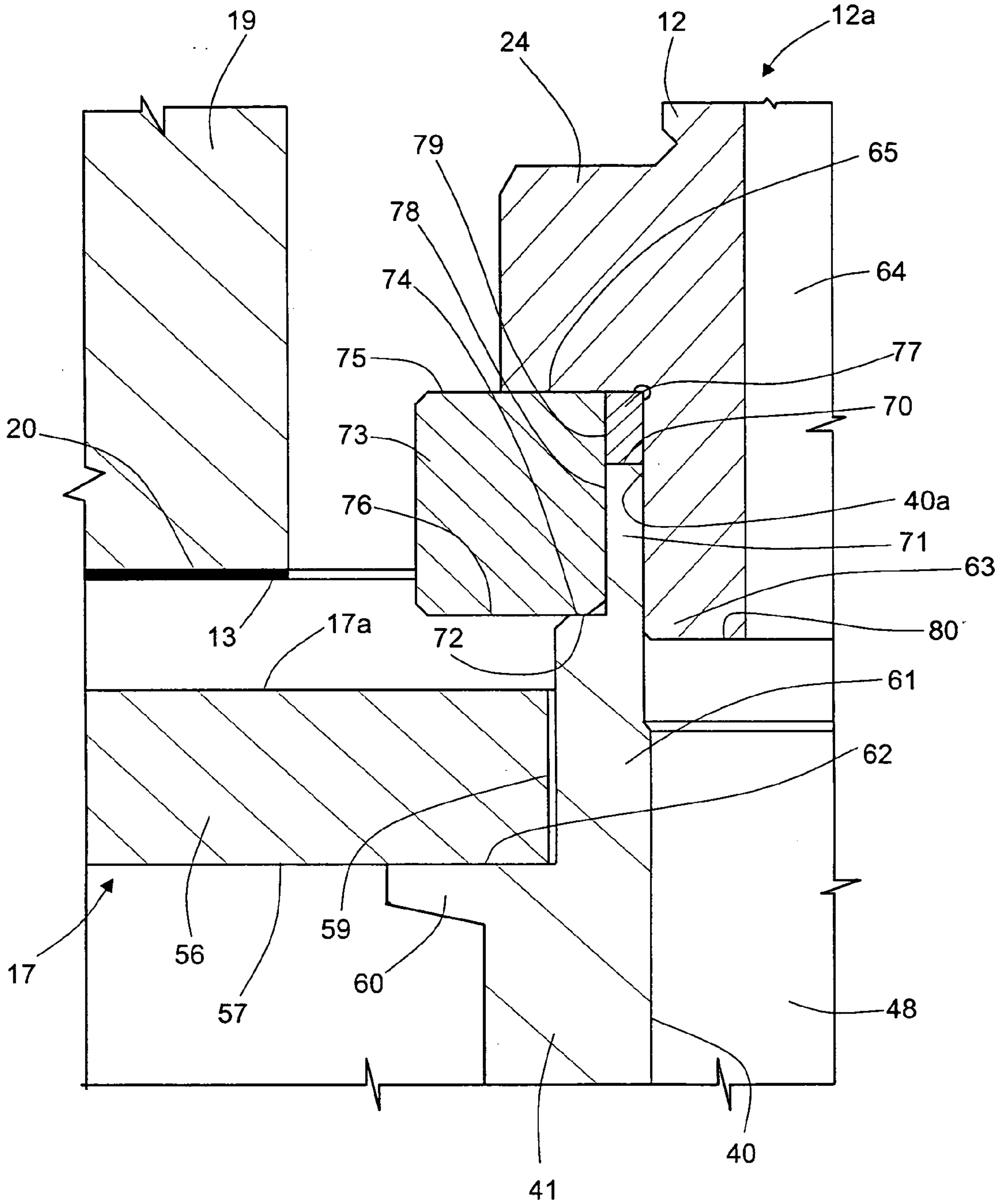
19
24
12
12a
79
65
78
64
74
75
77
70
73
20
40a
76
71
63
80
13
17a
72
61
62
59
17
56
60
57
48
41
40

Fig.2

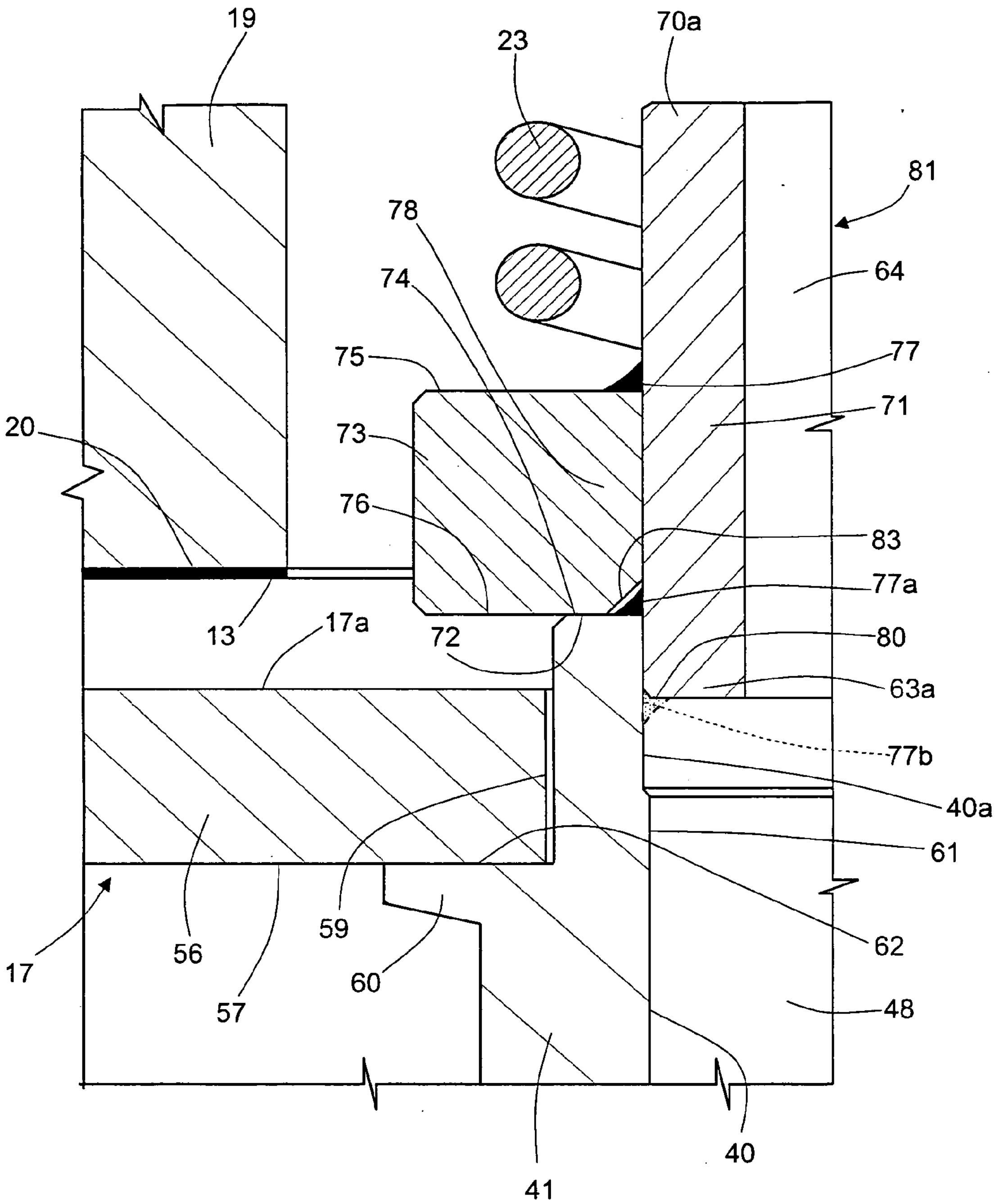
19
23
70a
81
78
64
74
75
77
20
71
73
76
83
77a
13
17a
72
80
63a
77b
40a
61
59
62
17
56
57
60
48
40
41

Fig.3

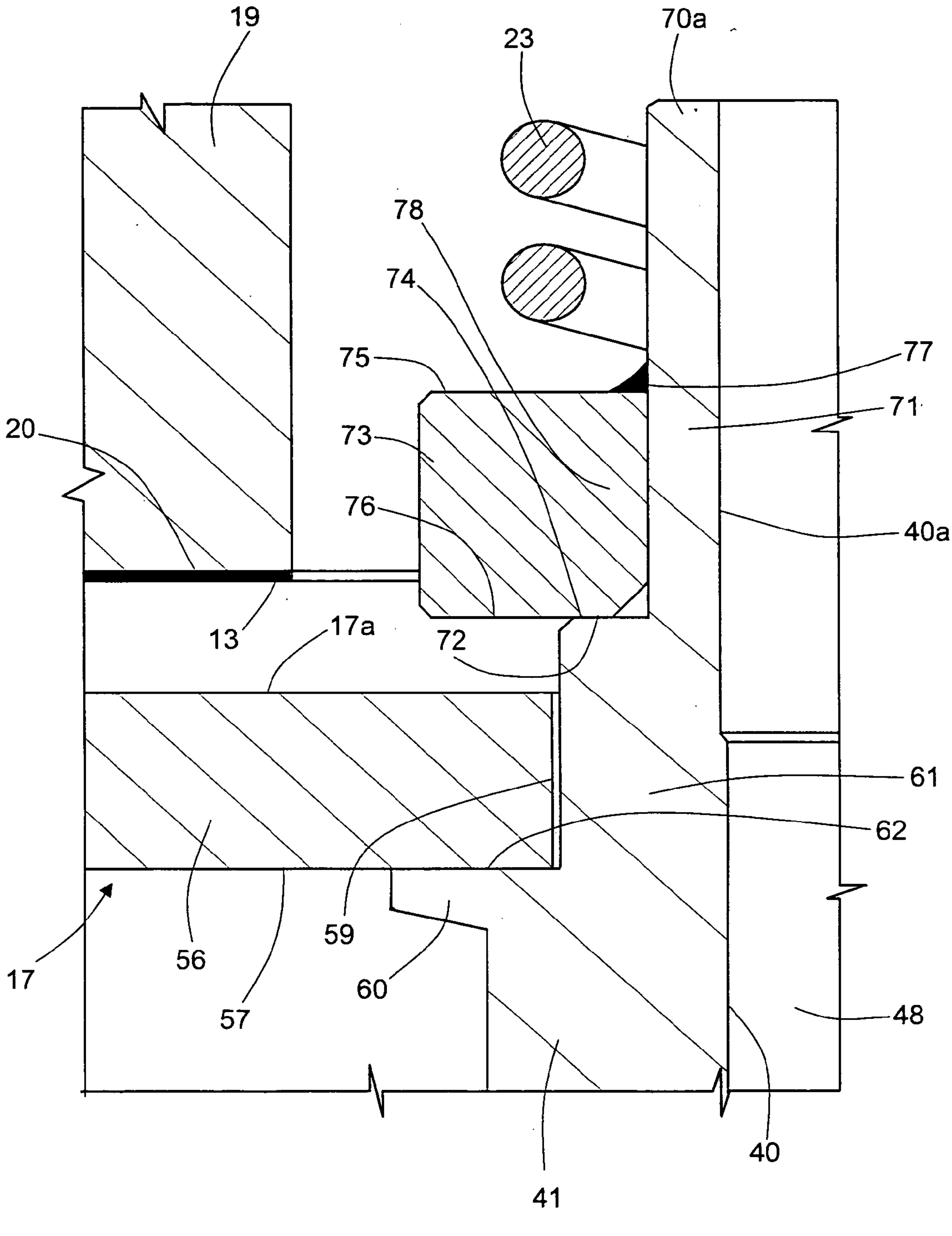
19
23
70a
78
74
75
77
71
73
20
76
40a
13
17a
72
61
62
59
17
56
57
60
48
40
41

Fig.4

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 09 42 5059

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	DE 10 2006 021741 A1 (BOSCH GMBH ROBERT [DE]) 15 November 2007 (2007-11-15) * paragraph [0016] - paragraph [0026]; figure 1 * -----	1-20	INV. F02M61/16 F02M63/00
A	US 2009/032621 A1 (RICCO MARIO [IT] ET AL) 5 February 2009 (2009-02-05) * paragraph [0014] - paragraph [0029]; figures 1,2 * -----	1-20	
A	US 5 299 776 A (BRINN JR BENJAMIN F [US] ET AL) 5 April 1994 (1994-04-05) * column 1, line 64 - column 3, line 13; figure 1 * -----	1-20	
A	US 2003/141475 A1 (RUTHARDT SIEGFRIED [DE] ET AL) 31 July 2003 (2003-07-31) * paragraph [0024]; figure 4 * -----	1-20	
A	WO 02/053905 A (BOSCH GMBH ROBERT [DE]; GRYTZ UWE [DE]) 11 July 2002 (2002-07-11) * page 9, line 20 - page 11, line 13; figures 2,3 * -----	1-20	TECHNICAL FIELDS SEARCHED (IPC) F02M

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	8 July 2009	Jucker, Chava

2

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

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 09 42 5059

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

08-07-2009

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102006021741 A1	15-11-2007	EP 2021618 A1	11-02-2009
		WO 2007128613 A1	15-11-2007
US 2009032621 A1	05-02-2009	CN 101358570 A	04-02-2009
		EP 2025921 A1	18-02-2009
		JP 2009030590 A	12-02-2009
		KR 20090013000 A	04-02-2009
US 5299776 A	05-04-1994	CN 1119885 A	03-04-1996
		DE 69406780 D1	18-12-1997
		DE 69406780 T2	09-04-1998
		EP 0690958 A1	10-01-1996
		JP 8508325 T	03-09-1996
		WO 9423196 A1	13-10-1994
US 2003141475 A1	31-07-2003	DE 10063193 A1	27-06-2002
		WO 0250424 A2	27-06-2002
		EP 1346144 A2	24-09-2003
		JP 2004516407 T	03-06-2004
WO 02053905 A	11-07-2002	DE 10100422 A1	11-07-2002
		EP 1266135 A1	18-12-2002
		JP 4083014 B2	30-04-2008
		JP 2004516425 T	03-06-2004
		US 2003178593 A1	25-09-2003

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82