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Remarks:
Amended claims in accordance with Rule 137(2) EPC.

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

(57) The manufacturing method regards a servo valve (5) of a fuel injector, wherein a bushing (41) is designed to slide on a fixed stem for opening/closing the servo valve (5) and carries an armature (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 armature (17) has been mounted on the guide portion (61), a ring (73) is fitted on the terminal portion (71) so that it is brought in contact upon the armature; the ring (73) is then welded to the terminal portion (71) with weld material along a circumference so that a sight welding is carried out without any need for angular positioning between the bushing (41) and the welding device.

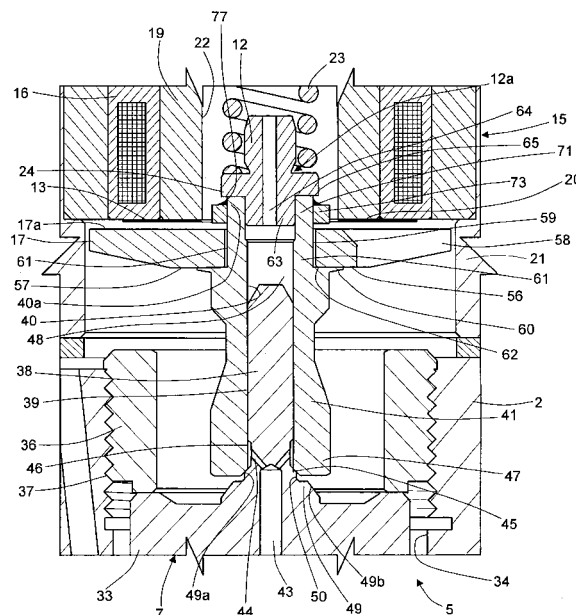


Fig.1

Description

[0001] The present invention relates to a method for manufacturing a fuel injector servo valve, wherein 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 applying the afore-said method.

[0002] Servo valves of the type just described have a discharge duct that exits on a lateral surface of the stem in such a way that, in the closing position, the bushing is subjected 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 armature, 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 armature from the bushing and to displace the armature 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 armature, which must be fixed with respect to the bushing and must be set on the latter with extreme precision. In addition, during production there is the problem of mounting the armature in a slidable way on the bushing and of fixing thereon one of the stop elements by means of welding, for example laser welding, which presents various difficulties. In particular, the external profile of the armature and the profile of its housing on the bushing must not present any 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 that will solve the problems referred to above and present a 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 by way of example with the aid of the annexed drawings, wherein:

- Figure 1 is a 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;
- Figure 3 regards a step of the manufacturing method according to the present invention;
- Figure 4 is similar to Figure 2 and shows a variant

of the servo valve made 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, in which a rod for control of fuel injection is able to slide (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 armature 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 armature 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 external annular portion defining a flange 24 made of a single piece with the pin 12. Between a plane top surface 17a of the armature 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 armature 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 ring nut 36, screwed on an internal thread 37 of the cavity 34. The armature 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 constant angular distances 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 in the direction of the armature 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 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 armature 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 external portion 58, with section tapered outwards. The central portion 56 defines an axial hole 59, by means of which the armature 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 and has a smaller external diameter than the open/close element 47 and than the flange 60.

[0016] The bushing 41 has, in a fixed position, a first element for axial stop of the armature 17. Said first element is a shoulder 62 that is located at the bottom of the guide portion 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 than the internal surface 40 of the bushing 41 in order to reduce the portion to be ground so as to ensure fluid tightness with the surface 39 of the stem 38.

[0018] Notwithstanding the seal between the surface 39 of the stem 38 and the internal surface 40 of the bushing 41 there occurs 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 armature 17 and is located in a position such as to allow the armature 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 armature 17 and the bushing 41.

The bushing 41 comprises a terminal portion 71, which is an axial extension or prolongation of the guide portion 61, defines the seat 40a, and has an external diameter and an internal diameter substantially equal to those of the guide portion 61. The terminal portion 71 is preferably made of a single piece with the guide portion 61, which is in turn made of a single piece with the remaining part of the bushing 41 in the embodiment shown in Figure 1 and 2.

[0020] With reference to Figure 2, the terminal portion 71 carries a ring 73 in a fixed position and has a portion of lateral surface 79, which projects axially with respect to the ring 73 and is welded to the ring 73, as will be explained more fully in what follows.

[0021] The internal lateral surface 78 of the ring 73 is fitted on the terminal portion 71 in a slidable way, i.e., without resting on axial shoulders, and is kept in a fixed position exclusively by weld material applied along a circumference and defined in particular by a weld bead 77. As an alternative to the weld bead 77, weld spots could be envisaged.

[0022] The flange 24 has a plane surface 65, which is kept in axial contact against the terminal portion 71 by the thrust of the spring 23 and does not come into contact against the weld bead 77 and/or against the ring 73.

[0023] The ring 73 is delimited axially by two opposite surfaces, which are designated by the reference numbers 75 and 76 and are plane. The surface 76 faces axially the surface 17a and constitutes the second of the two elements provided for axial stop of the travel of the armature 17, with respect to the bushing 41. In other words, the axial distance between the surface 76 and the shoulder 62 is greater than the axial thickness of the portion 56 of the armature 17: the difference between said axial distance and said axial thickness constitutes the maximum play or relative displacement in the axial direction between the armature 17 and the bushing 41.

[0024] 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 armature 17 rests against the shoulder 62, and the lamina 13 rests by gravity on the surface 17a of the armature 17. Since the weight of the lamina 13 is negligible with respect to that of the armature 17 and of the bushing 41, for reasons of simplicity it is assumed that the lamina 13 is located adjacent to the surface 20, as shown in Figure 1, in so far as this hypothesis does not jeopardize the operation described.

[0025] The travel, or lift, of the open/close element 47 is defined by the axial distance between the surface 76 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 armature 17, which at the start performs a loadless travel, or pre-travel, without affecting the displacement of the bushing 41, until its surface 17a comes into contact with the surface 76 of the ring 73. At this point, the action of the electromagnet 16 on the armature 17 overcomes the force of the spring 23, via interposition of the ring 73 and of the flange 24, and the armature 17 draws the bushing 41 axially towards the core 19 to enable the open/close element 47 to perform its opening travel: consequently, also with the pressure of the fuel in the chamber 46, the open/close element 47 rises, and the servo valve 5 opens.

[0026] It is thus evident that the armature 17 performs a travel greater than that of the bushing 41; i.e., in opening, it performs a pre-travel along the collar 61 equal to the play G between the surface 17a of the armature 17 and the surface 76 of the ring 73.

[0027] 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 surface 76 remains in contact with the surface 17a of the armature 17, which moves away from the polar surface 20, moving substantially together with the bushing 41.

[0028] At the end of its closing travel, the open/close element 47 strikes, 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, the small area of contact, and 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 armature 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 armature 17 and the shoulder 62 of the flange 60.

[0029] 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 armature 17 and the bushing 41, the subsequent rebounds of the bushing 41 are markedly reduced or even eliminated as compared to the case where the armature 17 is fixed with respect to the bushing 41.

[0030] By appropriately sizing the weights of the armature 17 and of the bushing 41, the travel of the armature 17, and the travel of the open/close element 47, the impact of the armature 17 against the bushing 41 occurs 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 armature 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.

[0031] 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 external 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 enter axially into the bushing 41 as far as the compartment 48; or else via an external welding between the surfaces 79 and 65. This welding does not require any phasing; i.e., it does not require any particular angular positioning between the bushing 41 and the welding device.

[0032] During manufacture of the servo valve 5, as has been mentioned above, the ring 73 is fixed to the terminal portion 71 by means of a welding device 72, preferably of the laser type, shown schematically in Figure 3.

[0033] Said welding operation is performed by forming weld material along a circumference between the surfaces 79 and 75. Consequently, a sight welding is carried out, without any need for phasing between the device 72 and the bushing 41, i.e., without locating the device 72 in a particular predefined angular position with respect to the bushing 41.

[0034] Figure 4 shows a variant 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 variant, the terminal portion 71 does not project axially with respect to the ring 73, but is located underneath the surface 75 so that the welding of the ring 73 is performed via the weld bead 77 between the internal lateral surface 78 of the ring 73 and an axial edge 70 of the terminal portion 71. In this case, the pin 63 engages the axial hole of the ring 73, and the flange 24 is in contact against the surface 75. The body 12a can be placed simply resting on the ring 73, or else be welded on the ring 73 along a circumference between the surface 75 and

the lateral surface of the flange 24 in a way not illustrated.

[0035] Once again according to the variant of Figure 4, the terminal portion 71 and the guide portion 61 form 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 external 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 co-axial and opposed to the terminal portion 71 and engages the seat 40a or else the surface 40 in a position corresponding to the flange 60. In fact, the shoulder 62 reaches the seat 40a or else the surface 40, forming a circular edge. Advantageously, welding of the sleeve 81 is made by forming weld material 77a precisely along said circular edge, i.e., along a circumference between the shoulder 62 and the external lateral surface of the sleeve 81. In this case, a chamfered portion or recess 83 is provided on the armature 17 in a position corresponding to the edge between the surface 57 and the internal surface of the hole 59 in order to prevent interference between the armature 17 and the weld material 77a. The weld is made after the sleeve 81 has been positioned axially with respect to the remaining part of the bushing 41, for example by resting the sleeve 81 on a push rod (not illustrated), set in the central hole of the open/close element 47. Alternatively, weld material 77b (represented with a dashed line) is formed between an end edge 80a of the terminal portion 63a and the internal surface 40 of the compartment 48, using a welding device appropriately shaped for entering axially into the bushing 41 as far as the compartment 48. Consequently, also the connection of the sleeve 81 does not require any phasing, i.e., any particular angular positioning between the bushing 41 and the welding device, since the welding operation is performed along a circumference forming the weld beads 77a or 77b. As an alternative to the beads 77a, 77b, a process of spot welding could be adopted.

[0036] In a variant (not illustrated), the body 12a is absent, the spring 23 acts directly on the surface 75 of the ring 73, and the lateral surface 79 of the terminal portion 71 projects axially with respect to the ring 73 for a relatively large height so as to define a centring for mounting the end of the spring 23.

[0037] The method for manufacturing the servo valve 5 is performed in the following way.

[0038] First, a bushing is provided in such a way that it has the guide portion 61, for coupling the armature 17, and the terminal portion 71 that extends as axial prolongation of the guide portion 61.

[0039] During machining of the bushing 41 or else by an additional 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.

[0040] On the other side, the armature 17 and the ring 73 are fitted one after another on the guide portion 61 and, respectively, on the terminal portion 71 downwards, i.e., towards the shoulder 62, maintaining the axis of the

bushing 41 vertical. During these operations, the ring 73 is rested on the surface 17a of the armature 17.

[0041] As schematically shown in Figure 3, by means of one or more push rods (not illustrated), the armature 17, with the ring 73 set onto it, is raised with respect to the shoulder 62 by an amount G equal to the desired play to be obtained for the travel of the armature 17 between the shoulder 62 and the surface 76 so as to position the ring 73 in an axial reference position.

[0042] Whilst it is kept in said axial reference position by the push rods, the ring 73 is welded to the terminal portion 71 via the device 72, forming weld material, i.e., the weld bead 77, along a circumference.

[0043] For the solution of Figure 2, where the body 12a is envisaged, the pin 63 is inserted in the seat 40a of the bushing 41.

[0044] After manufacture, 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 around the lateral surface 79 if the body 12a is not envisaged) until the spring 23 itself rests on the flange 24 (or else on the surface 75 of the ring 73).

[0045] From what has been seen above, there emerge clearly the advantages of the manufacturing method according to the invention as compared to the known art.

[0046] The weld bead 77 does not modify the external profile of the bushing 41 and of the body 12a, nor does it alter the surfaces 39, 40 of the stem 38 or of the bushing 41, nor again does it vary the distance between the shoulder 62 and the surface 76.

[0047] In particular, welding is carried out without any need for phasing between the bushing 41 and the welding device, and the weld material is at sight in order to facilitate not only execution of the weld, but also quality control. In addition, the weld material defined by the beads 77, 77a, 77b does not create interference during the movement of the armature 17 in the space provided between the shoulder 62 and the surface 76.

[0048] In addition, the play that defines the axial travel of the armature 17 is regulated in a fine way directly during the production cycle by the lift of the push rods with respect to the bushing 41, when the ring 73 is located in its axial reference position under the thrust of the armature 17. Consequently, to obtain the desired play, it is not necessary to choose an armature 17 with a very precise axial thickness and/or calibrated spacers to be added beneath or above the armature 17.

[0049] It may be understood that various modifications and improvements may be made to the manufacturing method described above, without thereby departing from the scope of protection defined by the annexed claims.

[0050] For example, the armature 17 can be defined by a disk of 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 additional stop element fixed on the remaining part of the bushing 41. Also the stop element defined by the surface

76 could be an additional element fixed to the ring 73.

[0051] As already mentioned above, the welds described may be made by spot welding rather than by continuous-bead welding.

A spring could be set between the surface 57 of the armature 17 and the flange 33 so as to keep the surface 17a of the armature 17 in 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 preloading much lower than those of the spring 23 so as not to affect the dynamics of impact of the armature 17 against the bushing 41 during the phases of rebound described above.

[0052] The open/close element 47 could be a separate piece fixed to the remaining part of the bushing 41, and/or the sleeve 81 could have dimensions different from those shown.

[0053] It may be understood that the sizing of the weld bead or the weld spots will have to be made by taking into account the operation of the servo valve in conditions of fatigue 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) exiting from a lateral surface (39) of said stem (38), a spring (23) being provided for keeping said bushing (41) in 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 armature (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 said armature (17), and
- b) a terminal portion (71) adjacent to 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 armature (17);

- fitting said armature (17) on said guide portion (61) towards said first element (62);

- providing a second element (76) on the opposite side of said guide portion (61) for axial stop of said armature (17); said second element (76) being carried in a fixed position by a ring (73), which is fitted on said terminal portion (71) and

is rested on said armature (17);

- placing said ring (73) in an axial reference position, by raising said armature (17), with said ring (73) resting on top, with respect to said first element (62) by an amount equal to a desired axial play to be obtained for said armature (17) between said first and second elements (62, 76);

- welding said ring (73) in said axial reference position with 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 first element (62) is defined by a first shoulder made of a single piece with said bushing (41).
3. The method according to any one of the preceding claims, **characterized in that** said second element is defined by a second shoulder (76) made of a single piece with said ring (73).
4. The method according to any one of the preceding claims, **characterized in that** said guide portion and terminal portion (61, 71) have external diameters that are substantially equal.
5. The method according to any one of the preceding claims, **characterized in that** said guide portion and terminal portion (61, 71) are made of a single piece.
6. The method according to Claim 5, **characterized in that** said guide portion and terminal portion (61, 71) form part of a perforated piece (81), which is fixed to the remaining part of said bushing (41).
7. The method according to Claim 6, **characterized in that** said perforated piece (81) is fixed to the remaining part of said bushing (41) by means of welding along a circumference.
8. The method according to Claim 7, **characterized in that** said perforated piece (81) comprises a further terminal portion (63a), which is coaxial and opposed to said terminal portion (71) and engages the internal surface (40) of an axial hole of said bushing (41).
9. The method according to Claim 8, **characterized in that** said perforated piece (81) is welded by forming weld material (77a) along a circumference between said first element (62) and the external lateral surface of said perforated piece (81); a recess (83) being provided on said armature (17) in a position corresponding to the edge between an axial surface (57) and an internal surface (59) of the armature (17) for housing said weld material (77a).
10. The method according to Claim 8, **characterized in that** said perforated piece (81) is welded by forming

weld material (77b) along a circumference between an end edge (80a) of said further terminal portion (63a) and said internal surface (40).

11. The method according to any one of the preceding claims, **characterized in that** said terminal portion (71) comprises a lateral surface (79), which projects axially with respect to said ring (73) when said ring (73) is located in its reference position; welding of said ring (73) being performed along a circumference between the lateral surface (79) of said terminal portion (71) and a top surface (75) of said ring (73). 5
12. The method according to Claim 11, **characterized in that** the lateral surface (79) of said terminal portion (71) defines a centring for mounting one end of said spring (23), and **in that** said top surface (75) defines an axial rest for said spring (23). 10
13. The method according to any one of Claims 1 to 11, **characterized by** further comprising the following steps: 15
 - providing an intermediate body (12a) comprising: 20
 - 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); and 25
 - inserting said connection pin (63) in an axial seat (40a). 30
14. The method according to Claim 13, **characterized in that** said axial seat (40a) is defined by said terminal portion (71). 35
15. The method according to Claim 14, **characterized in that** said intermediate body (12a) is welded with weld material along a circumference between an end edge (80) of said connection pin (63) and said axial seat (40a). 40
16. The method according to Claim 14 or Claim 13, **characterized in that** said intermediate body (12a) is fixed by forcing said connection pin (63) with interference fit into said axial seat (40a). 45
17. A fuel injector servo valve, manufactured by applying the method according to any one of the preceding claims. 50

Amended claims in accordance with Rule 137(2) EPC.

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), a spring (23) being provided for keeping said bushing (41) in 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 armature (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 said armature (17), and
- b) a terminal portion (71) adjacent to 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 armature (17);
- fitting said armature (17) on said guide portion (61) axially towards said first element (62);
- providing a second element (76) on the opposite side of said guide portion (61) for axial stop of said armature (17);

characterised in that said discharge duct (43, 44) exits from a lateral surface (39) of said stem (38) and said second element (76) is carried in a fixed position by a ring (73); the method further comprising the steps of:

- fitting said ring (73) on said terminal portion (71) axially towards said armature (17);
- resting said ring (73) on said armature (17) when it is fitted on said terminal portion (71);
- placing said ring (73) in an axial reference position so as to obtain a desired axial play for said armature (17) between said first and second elements (62, 76); the placement of said ring (73) in the axial reference position being carried out by raising said armature (17) with respect to said first element (62) by an amount equal to said desired axial play, with said ring (73) resting on said armature (17);
- welding said ring (73) to said terminal portion (71) with weld material, whilst the ring (73) is kept in said axial reference position; the weld material being applied along a circumference.

2. The method according to claim 1, **characterised in that** said ring (73) is kept in said axial reference position by the thrust of said armature (17) during welding.

3. The method according to claim 2, **characterised in that** said armature (17) is raised by means of push rods.

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

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

6. The method according to any one of the preceding claims, **characterized in that** said guide portion and terminal portion (61, 71) have external diameters that are substantially equal.

7. The method according to any one of the preceding claims, **characterized in that** said guide portion and terminal portion (61, 71) are part of a single piece (81), which is perforated and is fixed to the remaining part of said bushing (41) by means of welding along a circumference.

8. The method according to Claim 7, **characterized in that** said perforated piece (81) comprises a further terminal portion (63a), which is coaxial and opposed to said terminal portion (71) and engages the internal surface (40) of an axial hole of said bushing (41).

9. The method according to Claim 8, **characterized in that** said perforated piece (81) is welded by forming weld material (77a) along a circumference between said first element (62) and the external lateral surface of said perforated piece (81); a recess (83) being provided on said armature (17) in a position corresponding to the edge between an axial surface (57) and an internal surface (59) of the armature (17) for housing said weld material (77a).

10. The method according to Claim 8, **characterized in that** said perforated piece (81) is welded by forming weld material (77b) along a circumference between an end edge (80a) of said further terminal portion (63a) and said internal surface (40).

11. The method according to any one of the preceding claims, **characterized in that** said terminal portion (71) comprises a lateral surface (79), which projects axially with respect to said ring (73) when said ring (73) is located in its reference position;

welding of said ring (73) being performed along a circumference between the lateral surface (79) of said terminal portion (71) and a top surface (75) of said ring (73).

12. The method according to Claim 11, **characterized in that** the lateral surface (79) of said terminal portion (71) defines a centring for mounting one end of said spring (23), and **in that** said top surface (75) defines an axial rest for said spring (23).

13. The method according to any one of Claims 1 to 11, **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); and

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

14. The method according to Claim 13, **characterized in that** said axial seat (40a) is defined by said terminal portion (71).

15. The method according to Claim 14, **characterized in that** said intermediate body (12a) is welded with weld material along a circumference between an end edge (80) of said connection pin (63) and said axial seat (40a).

16. The method according to Claim 14 or Claim 13, **characterized in that** said intermediate body (12a) is fixed by forcing said connection pin (63) with interference fit into said axial seat (40a).

17. A fuel injector servo valve, manufactured by applying the method according to any one of the preceding claims.

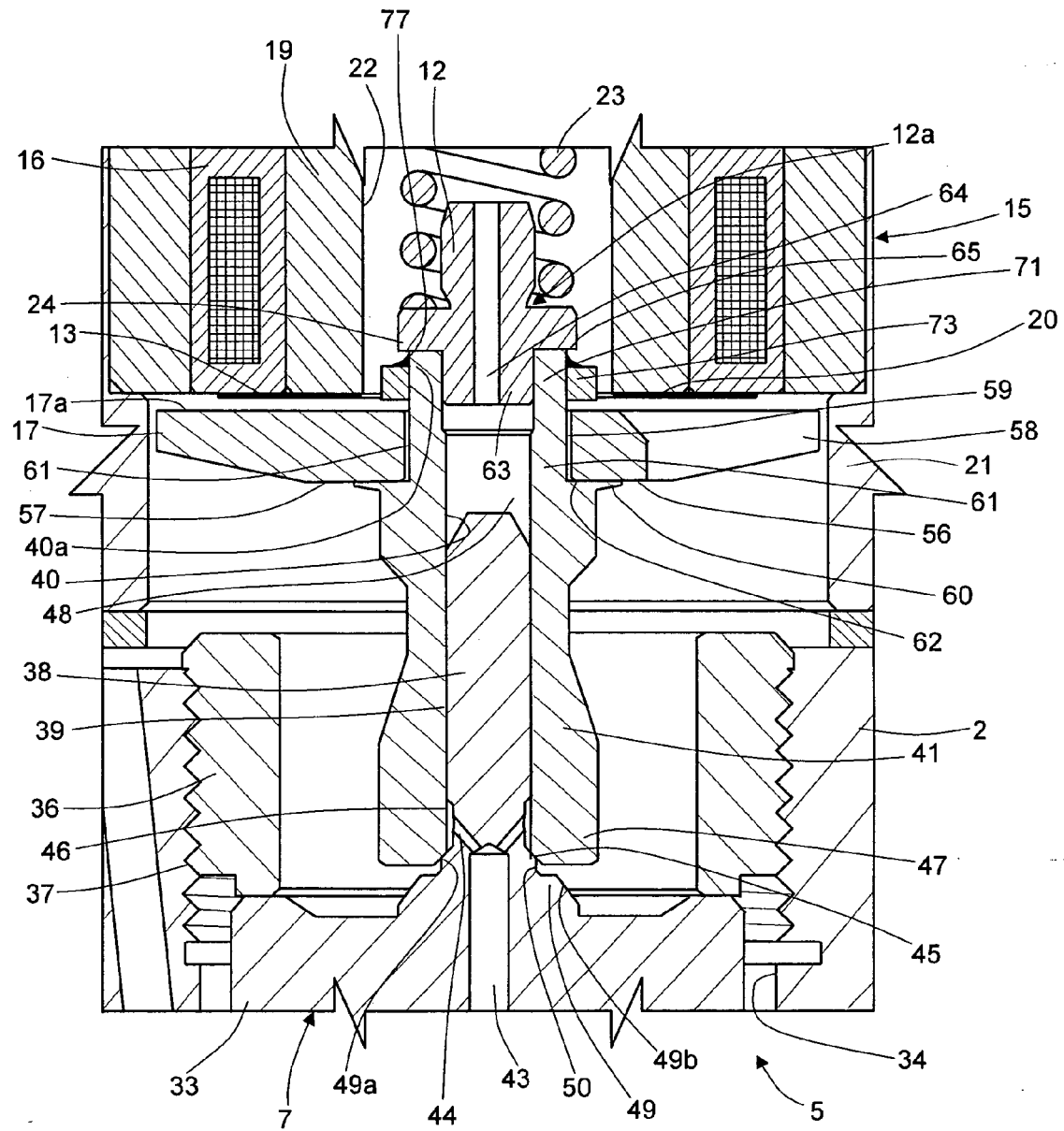


Fig.1

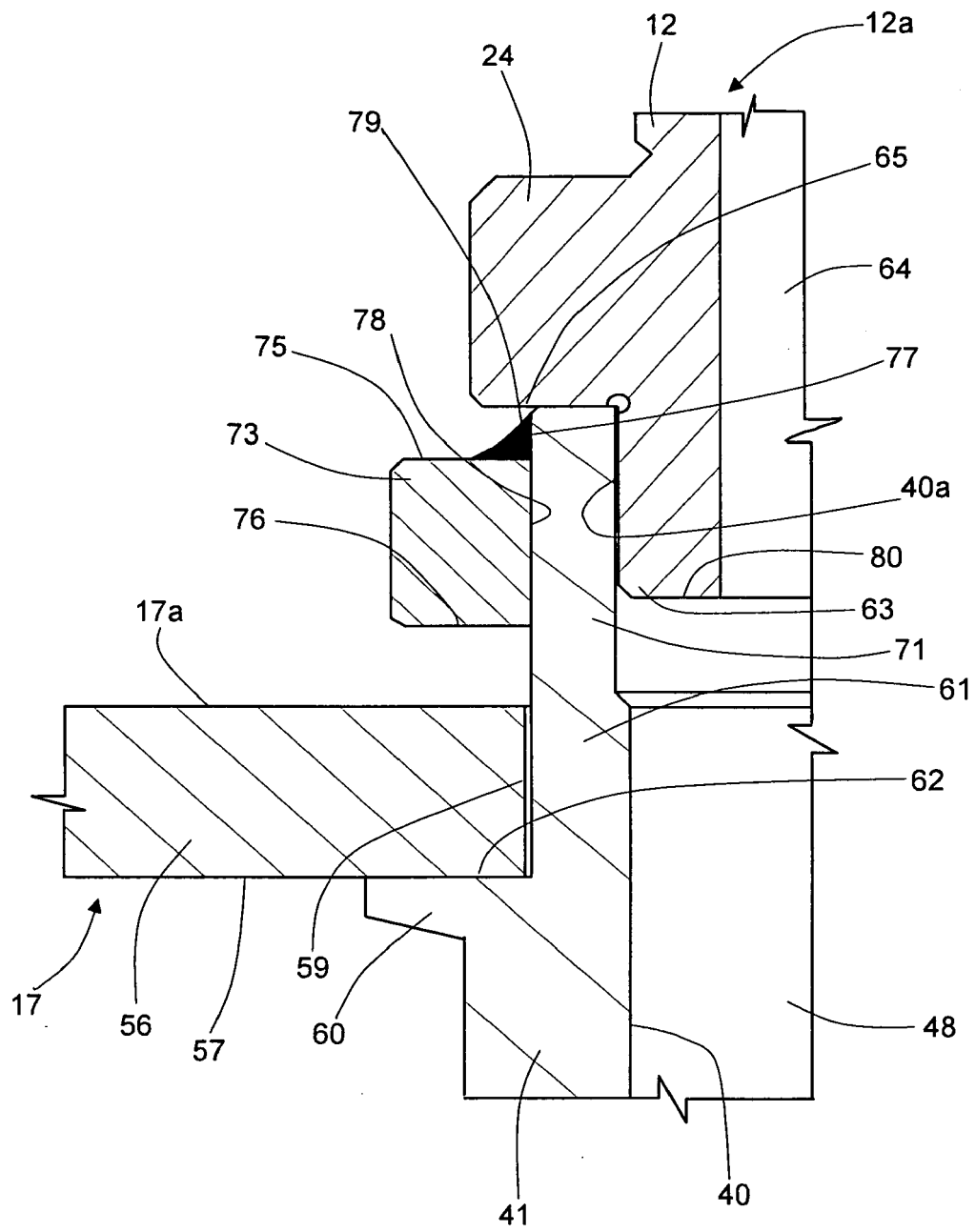


Fig.2

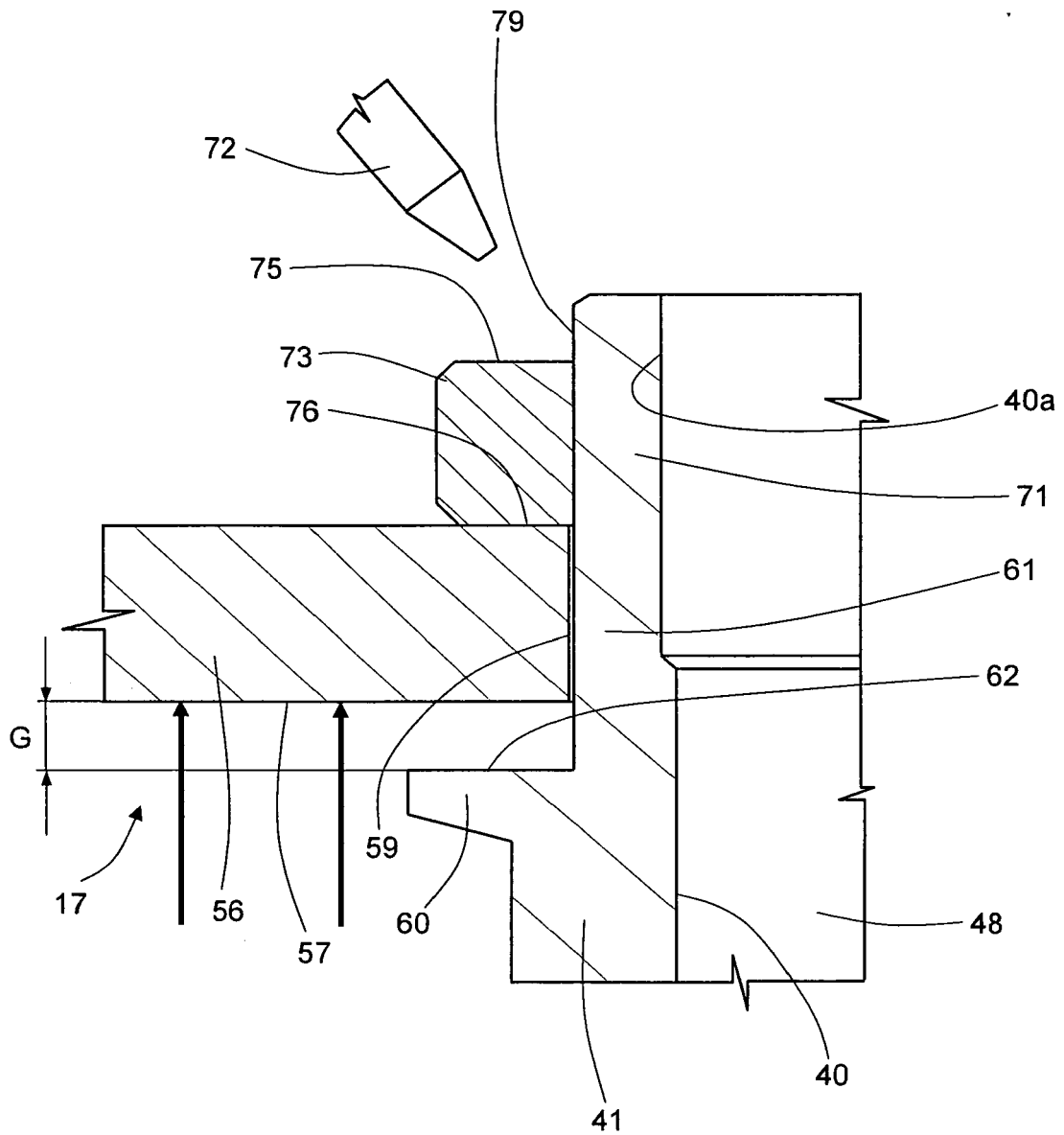


Fig.3

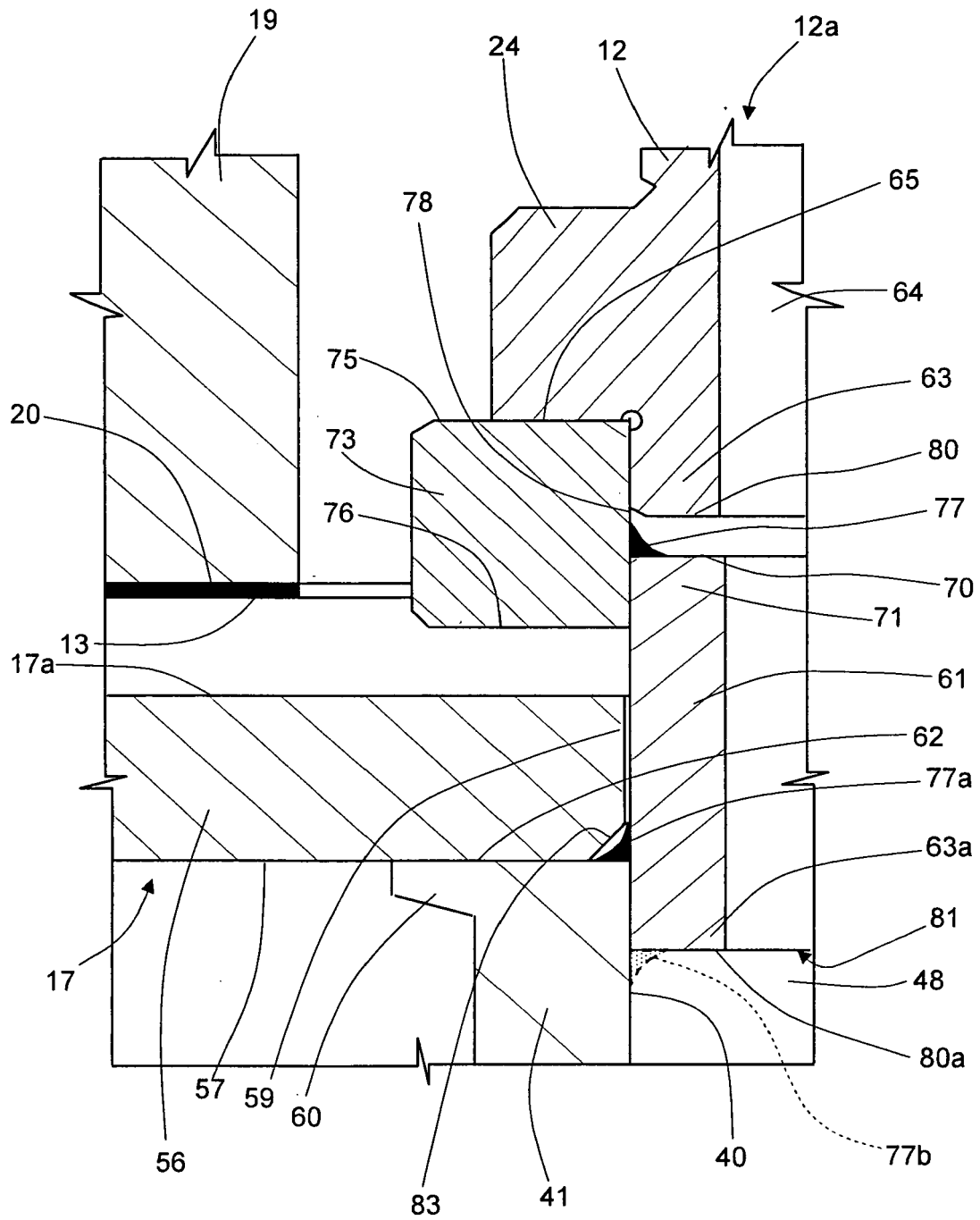


Fig.4



EUROPEAN SEARCH REPORT

Application Number
EP 09 42 5061

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