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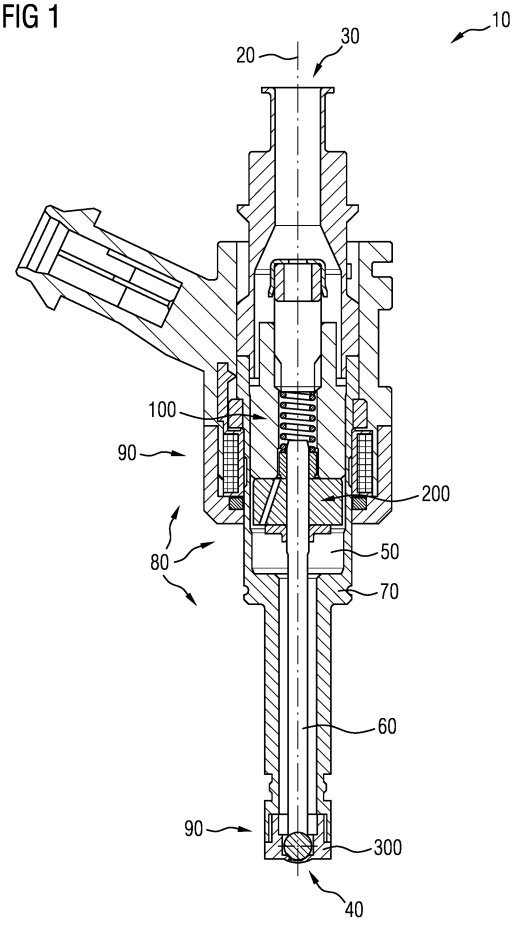
## (54) FLUID INJECTOR FOR INJECTING A CORROSIVE FLUID

(57) The invention relates to a fluid injector (10) for injecting a corrosive fluid, wherein the fluid injector (10) comprises:
- a housing (70) extending along a longitudinal axis (20), wherein the housing (70) defines a cavity (50) within the housing (70) and wherein the housing (70) comprises:
- an inlet portion (30) which is arranged to enable the fluid to flow into the cavity (50) and
- an outlet portion (40) which is arranged to enable the fluid to flow out of the cavity (50),
- the fluid injector (10) further comprises an insert part (80) which is arranged at least partially within the cavity (50) and which comprises a main body (82) and a coating layer (90), wherein the coating layer (90) is in contact with the corrosive fluid during operation of the fluid injector (10), wherein all of the surfaces which define the main body (82) of the insert part (80) are completely coated with the coating layer (90).

FIG 1

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## Description

**[0001]** The present disclosure relates to a fluid injector for injecting a corrosive fluid, for example into a combustion engine of a vehicle.

**[0002]** A fluid injector is configured to permit a flow of fluid in response to an electrical signal. Advanced combustion engine technology requires precise control over opening and closing times of the fluid injector in order to perform high precision injection. In addition, modern fluids which are used, for example, as a fuel for the engine are corrosive for parts of the fluid injector. Such corrosion reduces the lifetime of parts of the fluid injector and therefore the lifetime of the fluid injector itself. In addition, to perform high precision injection of the fluids it is necessary to achieve high quality sealings between some parts of the fluid injector. The corrosion of sealing surfaces could lead to leakages in the fluid injector and could therefore reduce the quality of the injection. Parts which are in contact with the fluid are conventionally made of stainless steel to withstand the corrosive fluid and to ensure the required sealing quality. Parts made of stainless steel are expensive which makes the whole fluid injector expensive.

**[0003]** It is an object of the present disclosure to provide a cost-efficient fluid injector which is able to operate with corrosive fluids.

**[0004]** This object is achieved by a fluid injector with the features of the independent claim. Dependent claims indicate advantageous embodiments and developments.

**[0005]** According to the present disclosure, a fluid injector for injecting a corrosive fluid comprises:

- a housing extending along a longitudinal axis, wherein the housing defines a cavity within the housing and wherein the housing comprises:
  - an inlet portion which is arranged to enable the fluid to flow into the cavity and
  - an outlet portion which is arranged to enable the fluid to flow out of the cavity.

**[0006]** According to the present disclosure the fluid injector further comprises an insert part which is arranged at least partially within the cavity and which comprises a main body and a coating layer, wherein the coating layer is in contact with the corrosive fluid during operation of the fluid injector, wherein all of the surfaces which define the main body of the insert part are completely coated with the coating layer.

**[0007]** According to one embodiment the housing is for example a hollow tube, in particular with a rotational symmetrically shape. It is also conceivable that the housing comprises two or more parts which are mounted to each other by means of a form fit connection, a force-fitting connection or a bonded connection, an example for a bonded connection being a weld connection. According to one embodiment the cavity extends along the longitudinal axis throughout the housing. It is also conceivable that the cavity is defined by some areas of the housing and that within the cavity of the housing are arranged other parts of the fluid injector which narrow the cavity and therefore also define the cavity.

**[0008]** The inlet portion is an area of the housing or a part arranged at the housing which has for example an opening which is arranged to enable the fluid flow in the cavity. The inlet portion is therefore arranged upstream of the outlet portion with respect to the flow direction of the fluid when the fluid injector is in operation.

**[0009]** The outlet portion is an area of the housing or a part which is arranged at the housing which has for example an opening or another device which enables the fluid to flow out of the cavity when the fluid injector is in operation. The outlet portion is therefore arranged downstream of the inlet portion with respect to the flow direction of the fluid when the fluid injector is in operation.

**[0010]** The insert part is a part of the fluid injector which is arranged at least partially within the housing, for example it is attached rigidly to the housing or arranged moveable with respect to the housing.

**[0011]** The insert part comprises the main body, which is according to one embodiment an integrally formed part or according to another embodiment a part assembly which comprises sub parts which are connected to each other. The insert part comprises further the coating layer which coats the main body completely. Therefore, only the coating layer of the insert part is in contact with the fluid during operation of the fluid injector and not the main body of the insert part. This means that the fluid which passes the cavity during operation of the fluid injector passes also at least partially the coating layer of the insert part and is therefore only in contact with the coating layer of the insert part and not with the main body of the insert part.

**[0012]** The corrosive fluid is according to some embodiments gasoline, diesel, water or an aqueous urea solution. Other corrosive fluids are also conceivable.

**[0013]** The main body of the insert part is defined by all of its surfaces. All of the surfaces include the surfaces of bores, threads, holes or cavities. According to the present disclosure the surfaces of the main body of the insert part which define the main body of the insert part are completely coated with the coating layer. This means that the whole main body of the insert part is completely coated with the coating layer. For example, if the main body comprises a cavity or holes or bores even the surfaces of the holes, the bores or the cavities are coated with the coating layer.

**[0014]** According to one embodiment, manufacturing steps for the insert parts comprise, forming the insert part, optionally machine some surfaces of the insert part, optionally drill some holes in the insert part, applying the coating layer to all surfaces of the main body of the insert part, arranging the insert part at least partially within the cavity.

**[0015]** If the insert part is manufactured comprising the above-mentioned steps, the application of the coating layer is the last manufacturing step before the insert part is arranged in the cavity. If this is the case it is easily achievable to apply the coating layer to all surfaces of the main body which define the main body.

**[0016]** According to one embodiment the coating layer of the insert part has higher corrosive resistance properties against the corrosive fluid than the main body of the insert part. If the coating layer does withstand the corrosive fluid, the whole insert part withstands the corrosive fluid.

**[0017]** According to the present disclosure all of the surfaces which define the main body of the insert part are completely coated with the coating layer. No uncoated area of the main body is exposed to the fluid during operation of the fluid injector. Therefore, the main body does not have to be made out of a material which has anti-corrosive properties or is for example made of anti-corrosive material. The main body could therefore be made out of cost efficient material. It is thus possible to produce the insert part cost efficient and it is therefore possible to produce the whole fluid injector cost efficient. The functionality of the fluid injector is not affected of the selection of the material of the main body because the required corrosive resistance properties are provided by the coating layer.

**[0018]** According to one embodiment, the main component of the coating layer is selected from different coating-materials depending on the corrosive fluid which flows through the fluid injector during operation of the fluid injector. The main body of the insert part does not have to be redesigned or does not have to be made from a different material if the fluid injector is used for injecting different corrosive fluids. Only the coating layer of the insert part is selected depending on the corrosive fluid. This helps to reduce the product diversity and reduces costs.

**[0019]** Overall, the fluid injector with the insert part wherein the main body of the insert part is completely coated with the coating layer can be produced very cost efficient even for different applications without losing any functionality.

**[0020]** According to one embodiment, the main component of the coating layer is nickel. If the main component of the coating layer is nickel, the coating layer may have good corrosion resistance properties and wear resistance properties.

**[0021]** According to one embodiment, the main components of the coating layer is an alloy which comprises at least two components selected out of a group which consists of nickel, phosphorus, coper, zinc, tin, silver and gold. The main component of the coating layer is the component which has the highest mass-fraction compared to the other components of the coating layer. If for example, the coating layer consists of three components, wherein the first component has a mass-fraction of 50%, the second component has a mass-fraction of 30% and the third component has a mass-fraction of 20%, the main component of this example is the first component with the mass-fraction of 50%. An alloy is a combination of metals or a metal and another element. An alloy comprises therefore of at least two components.

**[0022]** The main component of the coating layer could be an alloy made out of for example nickel and zinc. With the use of alloys, it is possible to adjust properties of the different elements and to improve, for example, the corrosive resistance properties of the coating layer. With an alloy made out of at least two components selected out of the above mentioned group it is therefore easily achievable to improve the corrosive resistance properties of the insert part.

**[0023]** In one embodiment the main component of the coating layer is a nickel phosphorus alloy. If the main component of the coating layer is the nickel phosphorus alloy, the coating layer has a very high corrosive resistance.

**[0024]** In one embodiment the coating layer is applied to the insert part by means of chemical deposition. Chemical deposition, which is also known as electroless plating, is a non-galvanic plating method that involves several simultaneous reactions in an aqueous solution. The reactions occur without the use of external electrical power. This deposition method is cheap and can be used to coat high numbers of main bodies of insert parts in short time. This helps to reduce the costs of applying the coating layer on all of the surfaces of the main body of the insert part. In addition, this deposition method is reliable to apply the coating layer to all of the surfaces which define the main body.

**[0025]** In one embodiment, the fluid injector comprises an electromagnetic actuator assembly which controls the fluid outflow out of the outlet portion of the fluid injector, wherein the insert part is a part of the electromagnetic actuator assembly. The electromagnetic actuator assembly is an assembly of different parts which work together to control the fluid outflow out of the fluid injector. The different parts are for example attached rigidly to the housing or are for example arranged axially moveable with respect to the longitudinal axis in the cavity of the housing. Different parts of the electromagnetic actuator assembly are in contact with the fluid during operation of the fluid injector. Therefore, it is reasonable according to this embodiment that the insert part is a part of the electromagnetic actuator assembly. The coating layer on the main body of the insert part helps to improve the corrosive resistance properties of the electromagnetic actuator assembly.

**[0026]** In one embodiment, the part of the electromagnetic actuator assembly is a pole piece with is arranged rigidly to the housing of the fluid injector. The pole piece is arranged to guide a magnetic flow created by the electromagnetic actuator assembly. The pole piece is arranged rigidly in the cavity of the housing for example by means of a press-fit connection. The pole piece is in contact with the corrosive fluid during operation of the fluid

injector. Additionally, the pole piece is used as a stop for other parts of the electromagnetic actuator assembly in one embodiment. If this is the case, the pole piece must also withstand mechanical hits by the other parts of the electromagnetic actuator assembly. Therefore, the coating layer applied to the pole piece can help to withstand the hits by the other part of the electromagnetic actuator assembly. With the coating layer applied to all of the surfaces which define the main body of the pole piece as insert part it is possible to achieve small wear.

**[0027]** In one embodiment, the part of the electromagnetic actuator assembly is an armature which is arranged axially moveable with respect to the longitudinal axis in the cavity. The armature is a part of the electromagnetic actuator assembly which is coupled to other parts of the electromagnetic actuator assembly and which is arranged to displace these other parts to allow the fluid to flow out of the cavity. The armature is movable towards the pole piece when the electromagnetic actuator assembly is energized. This movement is in one embodiment stopped by the pole piece when the armature hits the pole piece. The armature is therefore exposed to the corrosive fluid during the operation of the fluid injector and should withstand the hits with the pole piece. If the armature is the part which is coated with the coating layer it is possible to reduce the wear caused by the hits with the pole piece. It is conceivable that the armature comprises openings through which fluid flows. When the armature comprises such openings, the surface of these openings is a portion of the surfaces which define the main body of the armature and the surface of the openings is also completely coated.

**[0028]** In one embodiment, the insert part is a valve seat which is arranged rigidly to the housing of the fluid injector and which forms a fluid tight sealing with a valve needle of the fluid injector when the valve needle is in a closed position in which the valve needle and the valve seat inhibit the fluid flow out of the outlet portion of the fluid injector when the fluid injector is in operation. The valve seat is a part of the fluid injector which is arranged in the area of the outlet portion. The valve seat determines the outflow of the fluid out of the fluid injector when the fluid injector is in operation. In addition, the valve seat forms the fluid tight sealing with the valve needle when the fluid injector is in operation. The valve needle is a part of the fluid injector which is axially moveable with respect to the longitudinal axis. The valve needle is arranged within the cavity of the housing and can be displaced in a direction away from the valve seat to enable the fluid to flow out of the fluid injector. The valve needle has therefore two operating positions, the first is the closed position in which the valve needle and the valve seat inhibit the fluid to flow out of the outlet portion of the fluid injector and the second is the open position in which the valve needle and the valve seat allow the fluid to flow out of the outlet portion of the fluid injector. The valve seat is therefore in contact with the corrosive fluid during operation of the fluid injector. In addition, the valve seat and the valve needle form the fluid tight sealing. During operation of the fluid injector the valve needle hits the valve seat. The coating layer on all of the surfaces which define the main body of the valve seat can therefore help to withstand the hits from the valve needle.

**[0029]** In one embodiment, the main component of the material of the main body of the insert part is an alloy of iron and of at least one element selected from a group which consists of silicon, carbon and cobalt. Conventional materials for the main body of the insert part which is in contact with the corrosive fluid are for example stainless steels. The stainless steels are conventionally used because of the required corrosive resistance properties. With the coating layer which is applied to all of the surfaces which define the main body of the insert part it is no longer necessary that the main body of the insert part is made out of such an expensive material like a special stainless steel. Therefore, it is conceivable that the main component of the material of the main body of the insert part is for example an alloy of iron and silicone, or an alloy of iron and carbon, or an alloy of iron and cobalt. The alloys according to this embodiment are compared to conventional materials for the main body of the insert parts cost efficient. Examples for the alloys for the main body of the insert parts are AISI 430, 1.4016, CC13, CC13XP, UGIPERM or Vacoflux.

**[0030]** In one embodiment, the coating layer has a thickness from 5 μm to 15 μm. In another embodiment, the coating layer has a thickness from 7,5 μm to 12 μm and in even another embodiment a thickness from 8 μm to 10 μm. A thickness of 5 μm to 15 μm can be applied fast and is sufficient thick for the desired coating layer properties. If the thickness is thinner than 15 μm the coating layer could be applied even faster.

**[0031]** In one embodiment, the fluid injector comprises two or more insert parts which are arranged at least partially within the cavity and are in contact with the fluid during operation of the fluid injector, wherein all of the surfaces which define the respective main body of the insert part are completely coated with the coating layer. It is for example conceivable that the fluid injector comprises an electromagnetic actuator assembly, wherein the main body of the pole piece of the electromagnetic actuator assembly is completely coated with the coating layer, and wherein the main body of the armature of the electromagnetic actuator assembly is completely coated with the coating layer.

**[0032]** It is also conceivable that one of the insert parts which is completely coated with the coating layer is one part of the electromagnetic actuator assembly and another insert part which is completely coated with the coating layer is the valve seat.

**[0033]** A cylinder head assembly group is also disclosed which comprises the fluid injector, wherein the fluid injector is received at a cylinder head and wherein the fluid injector injects fuel into a combustion chamber of an internal combustion engine when the fluid injector is in operation. With the fluid injector which comprises

the insert part, wherein all of the surfaces which define the main body of the insert part are completely coated with the coating layer, it is possible to produce and assemble the entire cylinder head assembly group cost efficient.

**[0034]** Further advantages and advantageous embodiments of the fluid injector will become apparent from the detailed description of exemplary embodiments in connection with the figures. In the figures:

Fig. 1 shows a longitudinal section of a fluid injector according to a first exemplary embodiment;

Fig. 2a shows a perspective view of an exemplary embodiment of a pole piece;

Fig. 2b shows a cross-sectional profile of the exemplary embodiment of the pole piece;

Fig. 3a shows perspective views of an exemplary embodiment of an armature;

Fig. 3b shows a cross-sectional profile of the exemplary embodiment of the armature;

Fig. 4 shows a cross-sectional profile of an outlet portion of a fluid injector according to a second exemplary embodiment.

**[0035]** Fig. 1 shows a fluid injector 10 according to a first exemplary embodiment in a longitudinal section view. The fluid injector 10 comprises a housing 70 which extends along a longitudinal axis 20. The housing 70 defines a cavity 50 within the housing 70. The housing 70 comprises an inlet portion 30 and an outlet portion 40. The inlet portion 30 is arranged to enable the fluid to flow into the cavity 50 and the outlet portion 40 is arranged to enable the fluid to flow out of the cavity 50. The fluid injector 10 shown in fig. 1 further comprises an electromagnetic actuator assembly which is designed to control the fluid outflow out of the outlet portion 40 of the fluid injector 10. The electromagnetic actuator assembly comprises a pole piece 100 and an armature 200. The pole piece 100 is attached rigidly to the housing 70 of the fluid injector 10 by means of a press fit connection. The armature 200 is arranged axially moveable with respect to the longitudinal axis 20 in the cavity 50. The fluid injector 10 as shown in fig. 1 further comprises a valve needle 60 which is mechanically coupled with the armature 200 and which is axially displaceable with respect to the longitudinal axis 20. The fluid injector 10 as shown in fig. 1 further comprises a valve seat 300 which is arranged rigidly to the housing 70 of the fluid injector 10 and which forms a fluid tight sealing with the valve needle 60 when the valve needle 60 is in a closed position in which the valve needle 60 and the valve seat 300 inhibit the fluid to flow out of the outlet portion 40 of the fluid injector 10.

**[0036]** The pole piece 100, the armature 200 or the valve seat 300 are insert parts 80 which are arranged at least partially within the cavity 50 and which are in contact with the fluid during operation of the fluid injector 10. The insert parts 80 comprise a main body 82 and a coating layer 90. The main body 82 of the insert parts 80 is defined by its surfaces, wherein all of the surfaces which define the main body 82 of the insert parts 80 are completely coated with a coating layer 90. The coating layer 90 is applied to all of the surfaces which define the main body 82 and the coating layer 90 has compared to the main body 82 a higher corrosive resistance against the corrosive fluid.

**[0037]** Fig. 2a shows a perspective view of an exemplary embodiment of a pole piece 100. The pole piece 100 comprises a central axial opening 110 and a press fit portion 120 which contacts the housing 70 by means of a press fit connection when the pole piece 100 is attached to the housing 70. The central axial opening 110 of the pole piece 100 is arranged so that fluid can flow through the pole piece 100. During operation of the fluid injector 10 fluid flows through the central axial opening 110 of the pole piece 100. The corrosive fluid is thus at least in contact with the central axial opening 110 of the pole piece 100 according to this embodiment.

**[0038]** Fig. 2b shows a cross-sectional profile of the exemplary embodiment of the pole piece 100 of fig. 2a. The pole piece 100 further comprises impact surfaces 130 which are operable to work as a stop for other parts of the electromagnetic actuator assembly. The pole piece 100 further comprises guide surfaces 140 for guiding other parts of the electromagnetic actuator assembly. Fig. 2b further shows in a schematic manner by means of dashed lines the coating layer 150 applied to all of the surfaces which define the main body of the pole piece 100.

**[0039]** Figs. 3a and 3b show an exemplary embodiment of an armature 200. Fig. 3a shows a perspective view of the armature 200. Fig. 3b shows a cross-sectional profile of the armature 200. The armature 200 comprises a central axial opening 210, an impact surface 220, a through hole 230 and a guide surface 240. It is conceivable that the valve needle 60 is arranged in the central axial opening 210 and that the guide surface 240 of the armature 200 is in sliding contact with the valve needle 60. The impact surface 220 in combination with the impact surface 130 of the pole piece 100 work as a stop for the movement of the armature 200. The through hole 230 guides at least some fluid through the armature 200. Fig. 3b shows in addition in a schematic manner by means of dashed lines a coating layer 250 applied to the main body of the armature 200.

**[0040]** Fig. 4 shows a cross-sectional profile of an outlet portion 40 of a fluid injector according to a second exemplary embodiment. The outlet portion 40 comprises a valve seat 300 which is arranged within the cavity 50. The valve seat 300 as shown in fig. 4 comprises a contact surface 320 which is in contact with the valve needle 60 when the valve needle 60 is in the closed position. The

valve seat 300 further comprises a radial outer surface 330 which is in contact with the housing 70 for example by means of a press fit connection when the valve seat 300 is attached to the housing 70. The valve seat 300 further comprises a guide surface 340 which is arranged to guide the valve needle 60 when the valve needle 60 is axially displaced away from the closed position with respect to the longitudinal axis 20. The valve seat 300 further comprise an orifice 310 which is closed by the valve needle 60 when the valve needle 60 is in the closed position and which is open to release fluid to flow out of the fluid injector 10 when the valve needle 60 is displaced away from the closed position. Fig. 4 further shows in a schematic manner by means of dashed lines the coating layer 350 applied to all of the surfaces which define the main body of the valve seat 300. As it can be seen in fig. 4 all of the surfaces which define the main body of the valve seat 300 are completely coated with the coating layer 350. Therefore, the bore-surfaces of the orifice 310 are also coated with the coating layer 350.

## Claims

**1.** A fluid injector (10) for injecting a corrosive fluid, wherein the fluid injector (10) comprises:

- a housing (70) extending along a longitudinal axis (20), wherein the housing (70) defines a cavity (50) within the housing (70) and wherein the housing (70) comprises:
  - an inlet portion (30) which is arranged to enable the fluid to flow into the cavity (50) and
  - an outlet portion (40) which is arranged to enable the fluid to flow out of the cavity (50),
- the fluid injector (10) further comprises an insert part (80) which is arranged at least partially within the cavity (50) and which comprises a main body (82) and a coating layer (90), wherein the coating layer (90) is in contact with the corrosive fluid during operation of the fluid injector (10), wherein all of the surfaces which define the main body (82) of the insert part (80) are completely coated with the coating layer (90).

**2.** The fluid injector (10) according to claim 1, wherein the coating layer (90) of the insert part (80) has higher corrosive resistance properties against the corrosive fluid than the main body (82) of the insert part (80).

**3.** The fluid injector (10) according to any one of the preceding claims, wherein the main component of the coating layer (90) is nickel.

**4.** The fluid injector (10) according to claim 1 or 2, wherein the main component of the coating layer (90) is an alloy made of at least two components selected out of a group which consists of nickel, phosphorus, copper, zinc, tin, silver and gold.

**5.** The fluid injector (10) according to claim 1 or 2, wherein the main component of the coating layer (90) is a nickel-phosphorus alloy.

**6.** The fluid injector (10) according to any one of the preceding claims, wherein the coating layer (90) is applied to the insert part (90) by means of chemical deposition.

**7.** The fluid injector (10) according to any one of the preceding claims, wherein the fluid injector (10) comprises an electro-magnetic actuator assembly which controls the fluid outflow out of the outlet portion (40) of the fluid injector (10), wherein the insert part (80) is a part of the electro-magnetic actuator assembly.

**8.** The fluid injector (10) according to claim 7, wherein the part of the electro-magnetic actuator assembly is a pole piece (100) which is attached rigidly to the housing (70) of the fluid injector (10) in the cavity (50).

**9.** The fluid injector (10) according to claim 7, wherein the part of the electro-magnetic actuator assembly is an armature (200) which is arranged axially movable with respect to the longitudinal axis (20) in the cavity (50).

**10.** The fluid injector (10) according to any one of the claims 1 to 6, wherein the insert part (80) is a valve seat (300) which is attached rigidly to the housing (70) of the fluid injector (10) and which forms a fluid tight sealing with a valve needle (60) of the fluid injector (10) when the valve needle (60) is in a closed position in which the valve needle (60) and the valve seat (300) inhibit the fluid to flow out of the outlet portion (40) of the fluid injector (10) during operation of the fluid injector (10).

**11.** The fluid injector (10) according to any one of the preceding claims, wherein the main component of the main body (82) of the insert part (80) is an alloy of iron and at least one element selected from a group which consists of silicon, carbon and cobalt.

**12.** The fluid injector (10) according to any one of the preceding claims, wherein the coating layer has a thickness from 5 $\mu$m to 15 $\mu$m.

**13.** The fluid injector (10) according to any one of the preceding claims, wherein the fluid injector (10) comprises two or more insert parts (80) which are arranged at least partially within the cavity (50) and are in contact with the fluid during operation of the fluid

injector (10), wherein all of the surfaces which define the respective insert part (80) are completely coated with the coating layer (90).

**14.** The fluid injector (10) according to claim 13, wherein one of the insert parts (80) is one part of the electro-magnetic actuator assembly and wherein another one of the insert parts (80) is the valve seat (300).

**15.** A cylinder head assembly group with the fluid injector (10) according to any one of the preceding claims, wherein the fluid injector (10) is received in a cylinder head and wherein the fluid injector (10) is operable to inject fuel into a combustion chamber of an internal combustion engine.

FIG 1

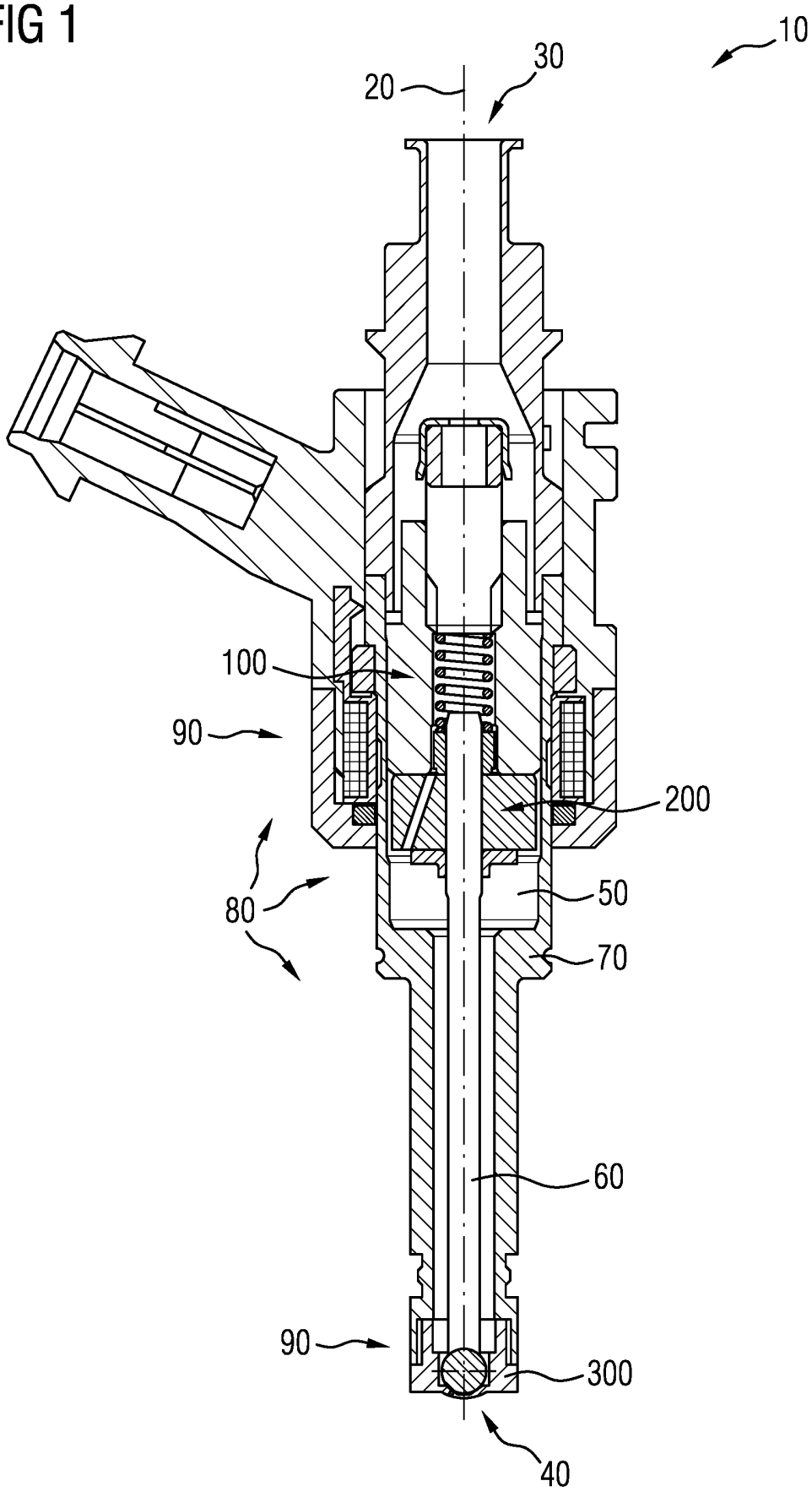


FIG 2a

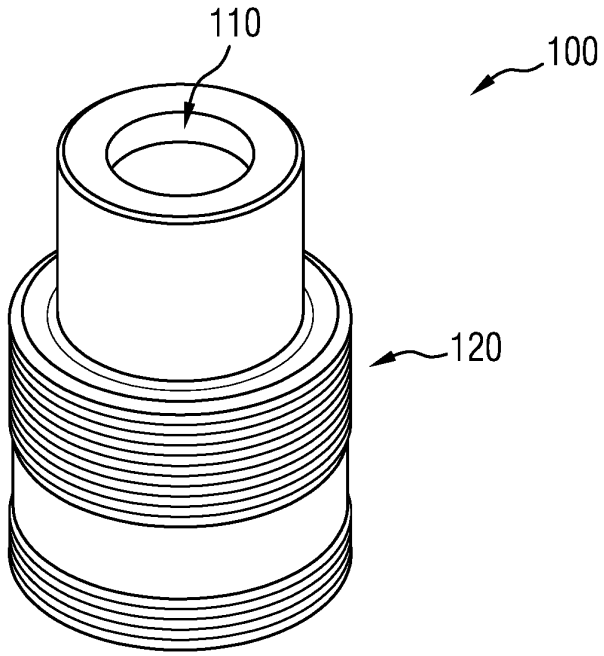



FIG 2b

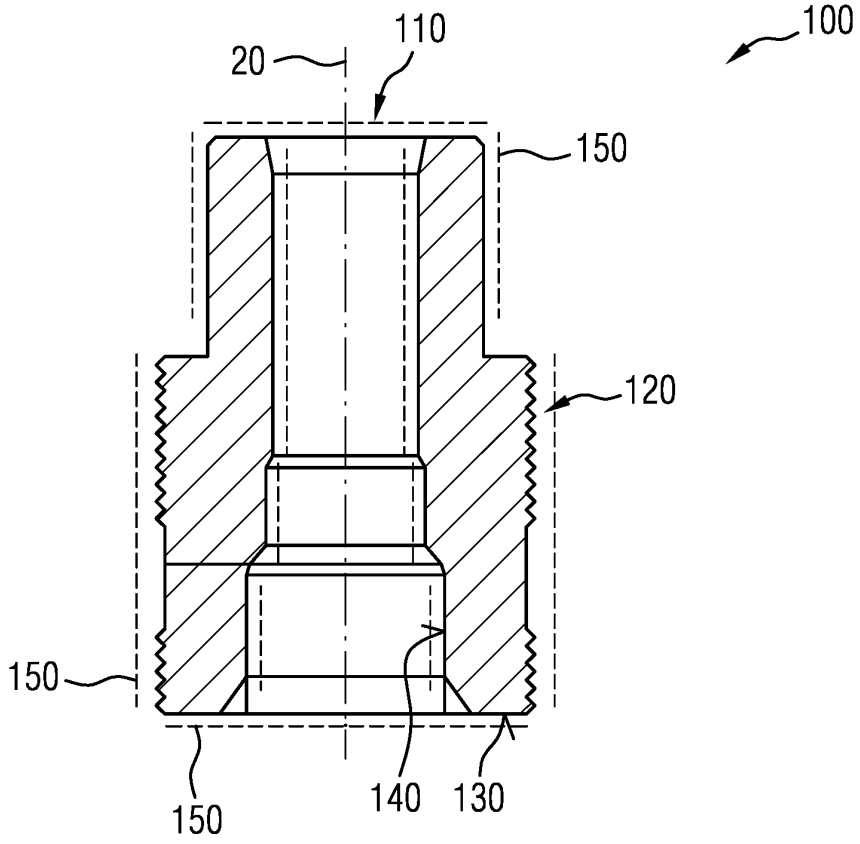
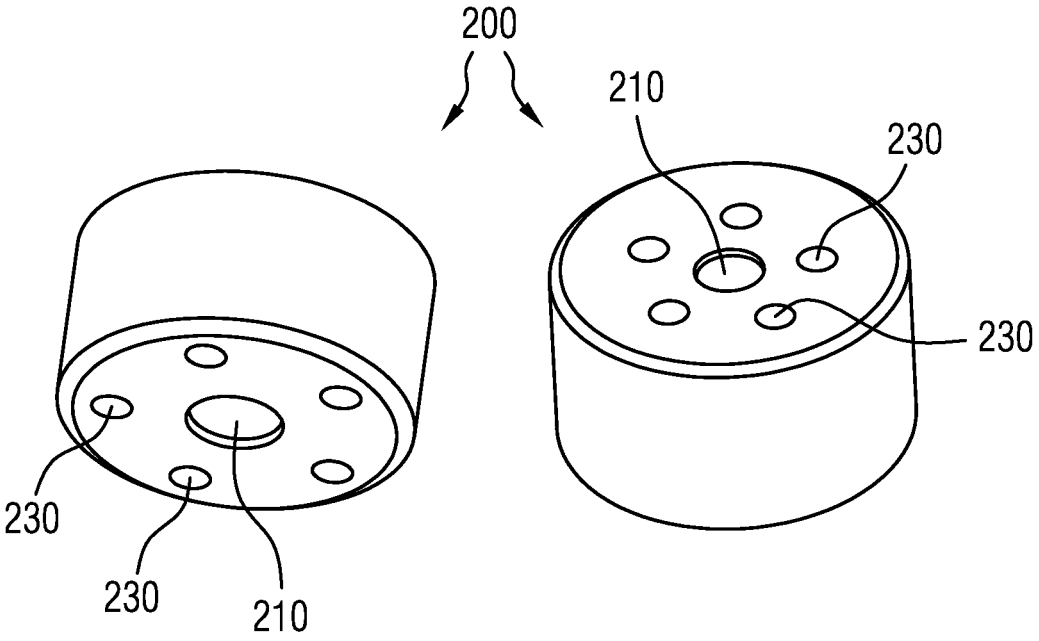


FIG 3a


200
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210

FIG 3b

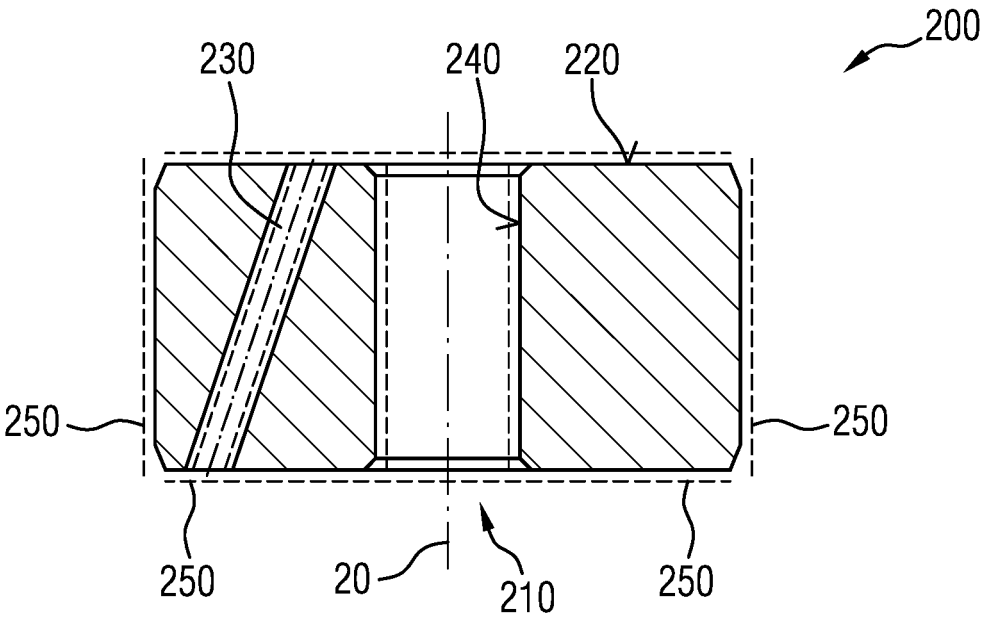
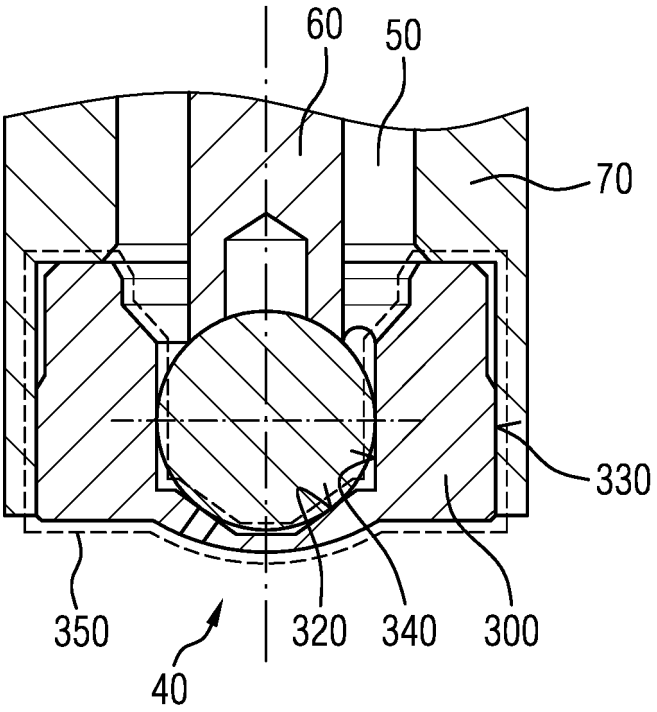

200
230
240
220
250
250
250
20
210
250

FIG 4



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# EUROPEAN SEARCH REPORT

Application Number
EP 19 16 1071

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
|---|---|---|---|
| X | US 2009/200405 A1 (YOSHIMARU KIYOTAKA [JP] ET AL) 13 August 2009 (2009-08-13)<br>* abstract; figures 1,3,8 *<br>* paragraph [0023] *<br>* paragraph [0027] *<br>* paragraph [0034] *<br>* paragraph [0037] *<br>* paragraph [0038] *<br>* paragraph [0026] *<br>* paragraph [0029] *<br>* paragraph [0019] *<br>* paragraph [0018] *<br>* paragraph [0040] *<br>* paragraph [0039] * | 1-7,9, 11,12,15 | INV.<br>F02M51/06<br>F02M61/16 |
| X<br>Y | US 2003/226914 A1 (MILLS JOHN R [US] ET AL) 11 December 2003 (2003-12-11)<br>* abstract; figures 1,2 *<br>* claims 1,2,9,10,11,12,13 *<br>* paragraph [0039] *<br>* paragraph [0005] *<br>* paragraph [0025] *<br>* paragraph [0037] *<br>* paragraph [0036] * | 1-5,11, 15<br>13,14 | TECHNICAL FIELDS SEARCHED (IPC)<br>F02M |
| X<br>Y | US 2005/098664 A1 (CATASUS-SERVIA JORDI J [US]) 12 May 2005 (2005-05-12)<br>* abstract; figures 3,4,5,6,7,8 *<br>* paragraph [0033] *<br>* paragraph [0034] *<br>* paragraph [0005] * | 1-11,15<br>13,14 | |

-/--

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 2019 | Barunovic, Robert |

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# EUROPEAN SEARCH REPORT

Application Number
EP 19 16 1071

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
|---|---|---|---|
| X | JP H11 82800 A (UNISIA JECS CORP)<br>26 March 1999 (1999-03-26)<br>* abstract; figures 2,4 *<br>* claims 1-4 *<br>* paragraph [0053] *<br>* paragraph [0051] *<br>* paragraph [0055] *<br>* paragraph [0001] *<br>* paragraph [0047] *<br>* paragraph [0031] *<br>* paragraph [0057] - paragraph [0060] *<br>* paragraph [0037] *<br>* paragraph [0034] *<br>* paragraph [0035] *<br>* paragraph [0005] *<br>----- | 1-3,6-9,<br>13,15 | |
| X | JP 2007 285246 A (DENSO CORP)<br>1 November 2007 (2007-11-01)<br>* abstract; figures 1,2 *<br>* paragraph [0007] *<br>* paragraph [0006] *<br>* paragraph [0021] *<br>* paragraph [0005] *<br>* paragraph [0020] *<br>----- | 1-5,8,9,<br>11 | TECHNICAL FIELDS SEARCHED (IPC) |

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 2019 | Barunovic, Robert |

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| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| US 2009200405 A1 | 13-08-2009 | JP 4591593 B2 | 01-12-2010 |
| | | JP 2009216081 A | 24-09-2009 |
| | | US 2009200405 A1 | 13-08-2009 |
| US 2003226914 A1 | 11-12-2003 | AU 2003238891 A1 | 22-12-2003 |
| | | EP 1511574 A1 | 09-03-2005 |
| | | JP 4355286 B2 | 28-10-2009 |
| | | JP 2005529270 A | 29-09-2005 |
| | | US 2003226914 A1 | 11-12-2003 |
| | | WO 03103846 A1 | 18-12-2003 |
| US 2005098664 A1 | 12-05-2005 | AT 431501 T | 15-05-2009 |
| | | EP 1687525 A1 | 09-08-2006 |
| | | JP 2007510093 A | 19-04-2007 |
| | | US 2005098664 A1 | 12-05-2005 |
| | | WO 2005045235 A1 | 19-05-2005 |
| JP H1182800 A | 26-03-1999 | NONE | |
| JP 2007285246 A | 01-11-2007 | NONE | |

EPO FORM P0459

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