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(54) Benævnelse: **Forstøver, især inhalator, til forstøvning af et flydende lægemiddelstof til et aerosol samt en tilsvarende fremgangsmåde**

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ATOMISER, IN PARTICULAR INHALER, FOR ATOMISING A LIQUID ACTIVE AGENT TO FORM AN AEROSOL AND A CORRESPONDING METHOD

Description

The invention relates to an atomizer, in particular an inhaler, for atomizing a liquid active substance to form an aerosol, and a corresponding method. The atomizer has an active substance reservoir, an atomizing nozzle and a pump arrangement, wherein a suction side of the pump arrangement opens into the active substance reservoir and a pressure side of the pump arrangement opens into the atomizing nozzle. The pump arrangement has a piston which is adjustable in a cylinder in an axial direction of the cylinder. Such an atomizer is known from US 7,104,470 B2 and from US 5,662,271 A, for example. An example of an atomizing nozzle is known from DE 10 2012 014 965 A1. US2015/0040891 describes a pump arrangement and a cylinder which contains a piston for atomizing a liquid active substance.

In the atomizers known from the prior art, an inlet valve is often provided which closes a pump chamber of the pump arrangement relative to the active substance reservoir when an overpressure is generated in the pump chamber for the expulsion of an aerosol via the atomizing nozzle, so that the active substance is prevented from flowing back out of the pump chamber into the active substance reservoir. When the pump chamber is to be refilled, a negative pressure is generated in the pump chamber by moving the piston, whereby the active substance is transported from the active substance reservoir through the open inlet valve into the pump chamber. During the suction process, an outlet valve associated with the atomizing nozzle is closed in order to prevent liquid or air from flowing back from the atomizing nozzle into the pump chamber.

For the suction of the active substance from the reservoir, the piston of the pump arrangement is often designed as a capillary or as a hollow piston, with a check valve which, with a ball movable in the capillary, serves as a closure element for the capillary when an overpressure is generated in the pump chamber in order to expel the aerosol through the atomizing nozzle. Such pump pistons designed as capillaries, however, are complex to manufacture and accordingly costly.

It is therefore the object of the invention to further develop an atomizer of the type described at the outset and a corresponding method in such a way that they are simple and inexpensive to manufacture.

This object is achieved by an atomizer having the features of claim 1 and a corresponding method having the features of claim 12. The dependent claims each relate to

advantageous embodiments of the invention.

Accordingly, the piston, along its outer circumference, bears in part with form-fit engagement on an inner wall of the cylinder, wherein moreover a gap is formed in part between the inner wall of the cylinder and the piston. The piston is mounted rotatably about its longitudinal axis in the cylinder and is adjustable between a suction position in which a pump chamber of the pump arrangement is connected to the suction side via the gap and a pump position in which the piston closes the suction side.

In comparison to the atomizers known from the prior art, the described design of the pump arrangement in particular makes it possible for the piston to be designed as a solid component and no longer as a capillary with an integrated (ball) check valve. A solid and integrally formed piston is much easier to manufacture and therefore more cost-effective than the piston described above with an integrated capillary and ball check valve.

Where the piston bears along the outer circumference with form-fit engagement on the inner wall of the cylinder, the outer circumference of the piston can have an external diameter which corresponds substantially to an internal diameter of the cylinder. The external diameter of the piston can be between 0.1 mm and 3 mm, and particularly preferably between 0.2 and 1 mm. The piston can be guided in the cylinder between the pump position and the suction position along the surfaces of the piston and cylinder that adjoin one another with form-fit engagement.

Where the gap is formed between the inner wall of the cylinder and the outer circumference of the piston, the outer circumference of the piston can be non-round and in particular be flattened. For example, the piston can be designed as a round rod, which is flattened on one side at an end with which it protrudes into the pump chamber, wherein the flattening can be formed, for example, by local, lateral removal of material, for example milling of the round rod.

The suction side of the pump arrangement can be connected to the pump chamber via a passage extending in the radial direction of the cylinder and opening into the gap in the suction position.

An inner shell surface on the inner circumference of the cylinder can have a constant radius of curvature across its entire surface and can be interrupted only by the passage. A sealing element surrounding the passage can be arranged at a transition between the passage and the inner wall of the cylinder, in order to further improve the sealing of the passage with respect to the pump chamber in the pump position of the piston.

The gap, in the suction position, can face towards the passage and, in the pump position, can face away from the passage, wherein the suction position and the pump position are

two adjustment positions of the piston that are rotated in relation to each other by substantially 180°. To close the passage in the pump position, it is not absolutely necessary for the piston to be rotated through 180° in relation to the suction position in which the gap faces towards the passage. Depending on the feasible manufacturing tolerance between the outer circumference of the piston and the inner circumference of the cylinder and the resulting pressure tightness between the passage and the pump chamber in the pump position, the pump position can also be rotated by less than 180°, for example by only 90°, compared to the suction position.

The piston can, for example, be a circular cylinder which has a recess on a side running parallel to the longitudinal axis of the piston. In particular, the piston can be a circular cylinder flattened on one side. A connection surface between the circular shell surface of the piston and the recess or a flattened side can be rounded. This embodiment helps to ensure that any sealing element that may be provided, which encloses the passage on the inner wall of the cylinder, is not damaged during the rotation of the piston between the suction position and the pump position. According to another aspect, the invention relates to a method for operating an atomizer of the type described above. The method comprises moving the piston in relation to the cylinder, in the longitudinal direction of piston and cylinder, between an extended position and an inserted position.

It can be provided that, when the piston is moved from the extended position to the inserted position, the piston closes the suction side, while, when the piston is moved from the inserted position to the extended position, the gap connects the suction side to the pump chamber.

To close the suction side, the piston can be rotated about its longitudinal axis from the suction position into the pump position.

The method can furthermore have the following steps:

a) movement of the piston along its longitudinal direction from the inserted position into the extended position, wherein the piston is in the suction position and wherein a negative pressure is generated in the pump chamber, so that a liquid active substance is drawn from the active substance reservoir into the pump chamber, then

b) rotation of the piston from the suction position to the pump position; then

c) movement of the piston from the extended position to the inserted position, wherein the plunger is still in the pump position, and wherein an overpressure is generated in the pump chamber and the liquid active substance in the pump chamber is expelled from the atomizer via the atomizing nozzle; then

d) rotation of the piston from the pump position to the suction position.

In order to expel further aerosol, steps a) to d) can be repeated at least once according to the desired amount of aerosol.

Description of the figures

Further details of the invention are explained with reference to the following figures. In the figures:

Figure 1 shows an atomizer according to the prior art;

Figure 2 shows a schematic cross-sectional view perpendicular to the longitudinal axis of a pump arrangement of an embodiment of an atomizer according to the invention;

Figures 3 to 6 schematically show an embodiment of an atomizer according to the invention in different adjustment positions of the piston in relation to the cylinder.

Figure 1 shows an atomizer according to the prior art. This consists substantially of an active substance reservoir 1 and an atomizing nozzle 2, which are fluidically connected to one another via a pump arrangement 3. Via the pump arrangement 3, an active substance stored in the active substance reservoir 1 can be pressed under pressure through the atomizing nozzle 2, so that it is atomized into extremely fine particles and forms an aerosol. A suitable atomizing nozzle is described in DE 10 2012 014 965 A1. The atomizer can be used, for example, as an inhaler.

The pump arrangement 3 has a suction side 4 and a pressure side 5, the suction side being fluidically connected to the active substance reservoir 1 via a capillary 7.1 in a piston 7 of the pump arrangement 3. Furthermore, the pump chamber 11 is fluidically connected to the atomizing nozzle 2.

The piston 7 is displaceable in the cylinder 6 in its longitudinal direction x. At its end protruding into the pump chamber 11, the piston 7 has a ball valve 12 which releases the capillary 7.1 when the piston 7 is at least partially pulled out of the pump chamber 11 in a suction movement, and the capillary 7.1 closes when the piston 7 is inserted further into the pump chamber 1 in a pumping movement. When the piston 7 is thus at least partially withdrawn from the pump chamber 11, an active substance can enter the pump chamber 11 from the active substance reservoir 1 through the capillary 7.1 as a result of the negative pressure generated in the pump chamber 11.

When the piston 7 is then inserted further into the pump chamber 11 in a subsequent step, the ball valve closes the capillary 7.1 due to the overpressure created in the pump

chamber 11, so that the active substance located in the pump chamber 11 can only emerge from the pump chamber 11 via the atomizing nozzle 2 and in particular cannot flow back into the active substance reservoir 1 through the capillary 7.1.

In the region of the active substance atomizer, the pistons 7 usually have a diameter of approximately 0.9 to 1.5 mm, so that the capillary extending in the interior of the piston 7 in the longitudinal direction of the piston must have a correspondingly smaller diameter. In particular, the design of the ball check valve 12 is highly complex, wherein manufacturing tolerances in the micrometer range must be adhered to in order to ensure the functionality of the valve 12, making the atomizer very complex to manufacture and thus costly.

Figure 2 shows a cross section perpendicular to the longitudinal direction of the piston 7 and the cylinder 6 of a pump arrangement 3 according to an embodiment of the invention. Accordingly, the piston has a recess 10 along its outer circumference 8, so that the piston bears on the inner wall 9 of the cylinder 6 with form-fit engagement along its outer circumference, and forms a gap 10 in part between the inner wall 9 of the cylinder and the piston 7. The piston 7 is mounted in the cylinder 6 so as to be rotatable about its longitudinal axis x, which extends perpendicular to the plane of the drawing in the illustration according to Figure 2. In Figure 2, the piston 7 is arranged in the suction position in relation to the cylinder 6. In the suction position, the gap 10 faces towards a side of the cylinder 6 through which a passage 13 extends in the radial direction of the cylinder 6. The suction side 4 of the pump arrangement 3 can be connected via the passage 13, so that a fluidic connection between an active substance reservoir 1 connected via the suction side 4 and a pump chamber 11 of the pump arrangement 3 can be established via the passage 13 and the gap 10 (not shown in Figure 2, see Figures 3 to 6).

The piston 7 can be rotated about its longitudinal axis x running perpendicular to the plane of the drawing in Figure 2. If, for example, the piston 7 is rotated by 180° around the axis x with respect to the position shown in Figure 2, the gap 10 faces towards a side wall section of the cylinder 6 facing away from the passage 13. In this case, the cylinder 7 closes the passage 13 with its outer circumference adjoining the recess 15. In order to improve the seal between the inner circumference 9 of the cylinder 6 and the outer circumference 8 of the piston 7 in the area of the passage 13, the passage 13 has a sealing element 14 at its transition to the inner wall 9 of the cylinder 6. So that the sealing element 14 is not damaged by the rotation of the piston 7 within the cylinder 6, the connecting surfaces 17, which connect the circularly symmetrical outer circumference 8

of the piston to the recess 5, are each rounded.

The recess 15 forming the gap 10 between the piston 7 and the inner wall 9 of the cylinder 6 is designed as a lateral flattening of the otherwise substantially circular cylinder-shaped piston 7.

Figures 3 to 6 show four different adjustment positions of the piston 7 in relation to the cylinder 6. In Figures 3 and 3a, the gap 10 is arranged facing away from the passage 13, so that the piston 7 closes the passage 13. Furthermore, the piston 7 is displaced along its longitudinal direction x from an extended position into an inserted position. Since the piston 7 closes the passage 13, an overpressure can be generated in the pump chamber 11, so that a liquid active substance located in the pump chamber is expelled from the atomizer via the atomizing nozzle 2.

When the piston 7 is in the inserted position, the piston is, as shown in Figures 4 and 4a, rotated from the pump position shown in Figures 3 and 3a into the suction position shown in Figures 4 and 4a, in which the gap 10 faces towards the passage 13 and thus a fluidic connection is established between the pump chamber 11 and the active substance reservoir 1 via the gap 10, the passage 13 and the suction side 4. In this rotative orientation of the piston 7 in relation to the cylinder 6, the piston 7 can be pulled at least in part from of the pump chamber 11 for filling the pump chamber 11, so that a negative pressure is created in the pump chamber 11. This is shown in Figures 5 and 5a. Due to the negative pressure, an active substance located in the active substance reservoir 1 can be conveyed into the pump chamber 11 via the suction side 4, the passage 13 and the gap 10. For this purpose, the atomizing nozzle 2 can have a check valve which, when there is a negative pressure in the pump chamber 11, closes the nozzle 2 with respect to the external environment of the pump arrangement 3.

After the pump chamber 11 has been at least partially filled with active substance, the piston 7 in the cylinder 6 is rotated again by 180°, so that the piston 7 closes the passage 13 in the cylinder.

The pump arrangement 3 is thus prepared to generate an overpressure in the pump chamber 11 in accordance with the situation shown in Figures 3 and 3a by again displacing the piston 7 along the longitudinal direction x from the extended position to the inserted position, so that further liquid active substance is expelled from the atomizer via the atomizing nozzle 2.

In the embodiments shown in Figures 2 to 6a, the piston 7 is designed as a circular cylinder which is flattened on one side in cross section perpendicular to the longitudinal direction of the piston and can thus be produced simply and therefore inexpensively by

flattening a circular cylinder-shaped piston on one side, in places. It can also be seen that the recess 15 is only formed on the end of the piston 7 protruding into the pump chamber 11, wherein the piston is circularly symmetrical in cross section perpendicular to its longitudinal axis, in particular in a sealing area 18 in which the piston 7 is sealed off from the pump chamber 11, so that the piston 7 can be sealed off from the pump chamber 11 with simple sealing means, for example with an O-ring.

The features of the invention disclosed in the above description, in the drawings and in the claims can be vital for realising the invention both individually and in any combination.

List of reference symbols

1	Active substance reservoir
2	Atomizing nozzle
3	Pump arrangement
4	Suction side of the pump arrangement
5	Pressure side of the pump arrangement
6	Cylinder
7	Piston
7.1	Capillary
8	Outer circumference
9	Inner wall
10	Gap
11	Pump chamber
12	Ball valve
13	Passage
14	Sealing element
15	Recess
16	Transition
17	Connecting surface
18	Sealing region
d	External diameter of the piston
x	Longitudinal axis

Forstøver, især inhalator, til forstøvning af et flydende lægemiddelstof til et aerosol samt en tilsvarende fremgangsmåde

Patentkrav

1. Forstøver, især inhalator, til forstøvning af et flydende lægemiddelstof til et aerosol, med et lægemiddelstofreservoir (1), en forstøvningsdyse (2) og en pumpeanordning (3), hvor en sugeside (4) på pumpeanordningen (3) munder ud i lægemiddelstofreservoiret (1), og hvor en trykside (5) på pumpeanordningen (3) munder ud i forstøvningsdysen (2), og hvor pumpeanordningen (3) har et stempel (7), der i en cylinder (6) kan justeres i cylinderens (6) aksialretning (x), kendetegnet ved, at stemplet (7) langs dets udvendige omfang (8) proportionelt formsluttende ligger an imod en indervæg (9) i cylinderen (6), og en spalte (10) proportionelt er placeret imellem cylinderens (6) indervæg (9) og stemplet (7), hvor stemplet (7) flyttes drejeligt omkring sin længdeakse (x) ind i cylinderen (6) og kan justeres imellem en sugestilling, hvor et pumpekammer (11) i pumpeanordningen (3) via spalten (10) er forbundet med sugesiden (4), og en pumpestilling, hvor stemplet (7) lukker sugesiden (4).

2. Forstøver ifølge krav 1, hvor stemplet (7) er massivt.

3. Forstøver ifølge krav 1 eller 2, hvor stemplets (7) udvendige omfang (8), for så vidt stemplet (7) formsluttende ligger an imod cylinderens (6) indervæg (9) langs dets udvendige omfang (8), har en udvendig diameter (d), der i det væsentlige svarer til en indvendig diameter af cylinderen (6), hvor stemplets udvendige diameter (d) fortrinsvis er mellem 0,1 mm og 3 mm, og mere fortrinsvis imellem 0,2 og 1 mm.

4. Forstøver ifølge et af de foregående krav, hvor stemplets (7) udvendige omfang (8), for så vidt spalten (10) er placeret imellem cylinderens (6) indervæg (9) og stemplets (7) udvendige omfang (8), ikke er rund og især er plan.

5. Forstøver ifølge et af de foregående krav, hvor pumpeanordningens (3) sugeside (4) via en gennemgang (13), der strækker sig i cylinderens (6) radialretning og i sugestilling munder ud i spalten (10), er forbundet med pumpekammeret (11).

6. Forstøver ifølge krav 5, hvor en indvendig kappeflade (13) ved cylinderens (6) indvendige omfang via hele dens flade har en konstant krumningsradius og kun er afbrudt via gennemgangen (13).

7. Forstøver ifølge krav 5 eller 6, hvor et tætningselement (14), der omslutter gennemgangen (13), er placeret ved en overgang (16) imellem gennemgangen (13) og cylinderens (6) indvendige væg (9).

8. Forstøver ifølge et af kravene 5 til 7, hvor spalten (10) i sugestilling er vendt imod gennemgangen (13) og i pumpestilling er vendt væk fra gennemgangen (13), hvor sugestillingen og pumpestillingen er to indstillingspositioner for stemplet (7), der i det væsentlige er drejet 180° imod hinanden.

9. Forstøver ifølge et af de foregående krav, hvor stemplet (7) er en rund cylinder, der ved en side, der løber parallelt med stemplets (7) længdeakse (x), har en åbning (15).

10. Forstøver ifølge krav 9, hvor stemplet (7) er en cirkulær cylinder, der er flad i den ene side.

11. Forstøver ifølge krav 9 eller 10, hvor en forbindelsesflade (17) imellem stemplets (7) cirkelformede kappeflade (13) og åbningen (15) eller en flad side er afrundet.

12. Fremgangsmåde til drift af en forstøver ifølge et af de foregående krav, kendetegnet ved, at den udgør flytning af stemplet (7) i forhold til cylinderen (6) i længderetning (x) for stempel (7) og cylinder (6) imellem en udtrukket position til en indført position.

13. Fremgangsmåde ifølge krav 12, hvor stemplet (7) ved flytning af stemplet (7) fra stemplets udtrukne position til den indførte position lukker sugesiden (4), og hvor spalten (10) ved flytning af stemplet (7) fra den indførte position til den udtrukne position forbinder sugesiden (4) med pumpekammeret (11).

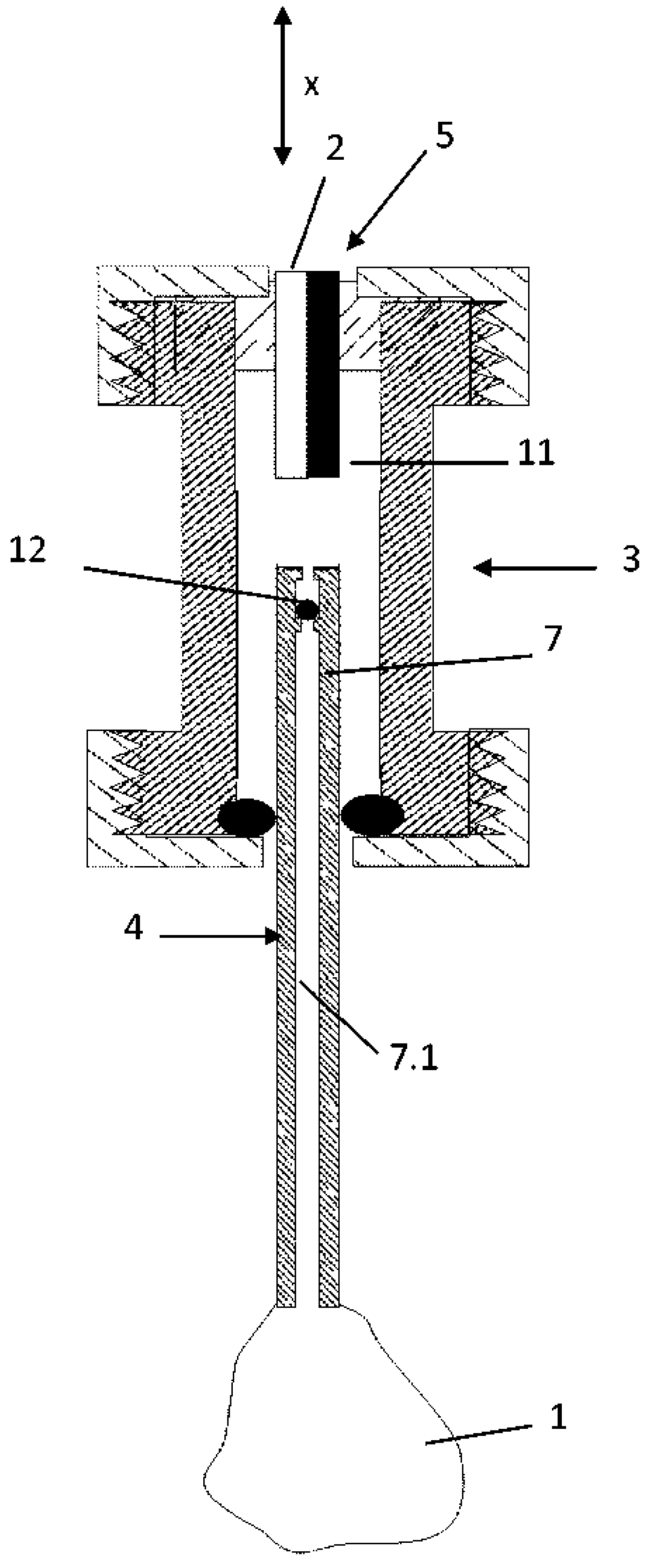


Fig. 1

Prior art

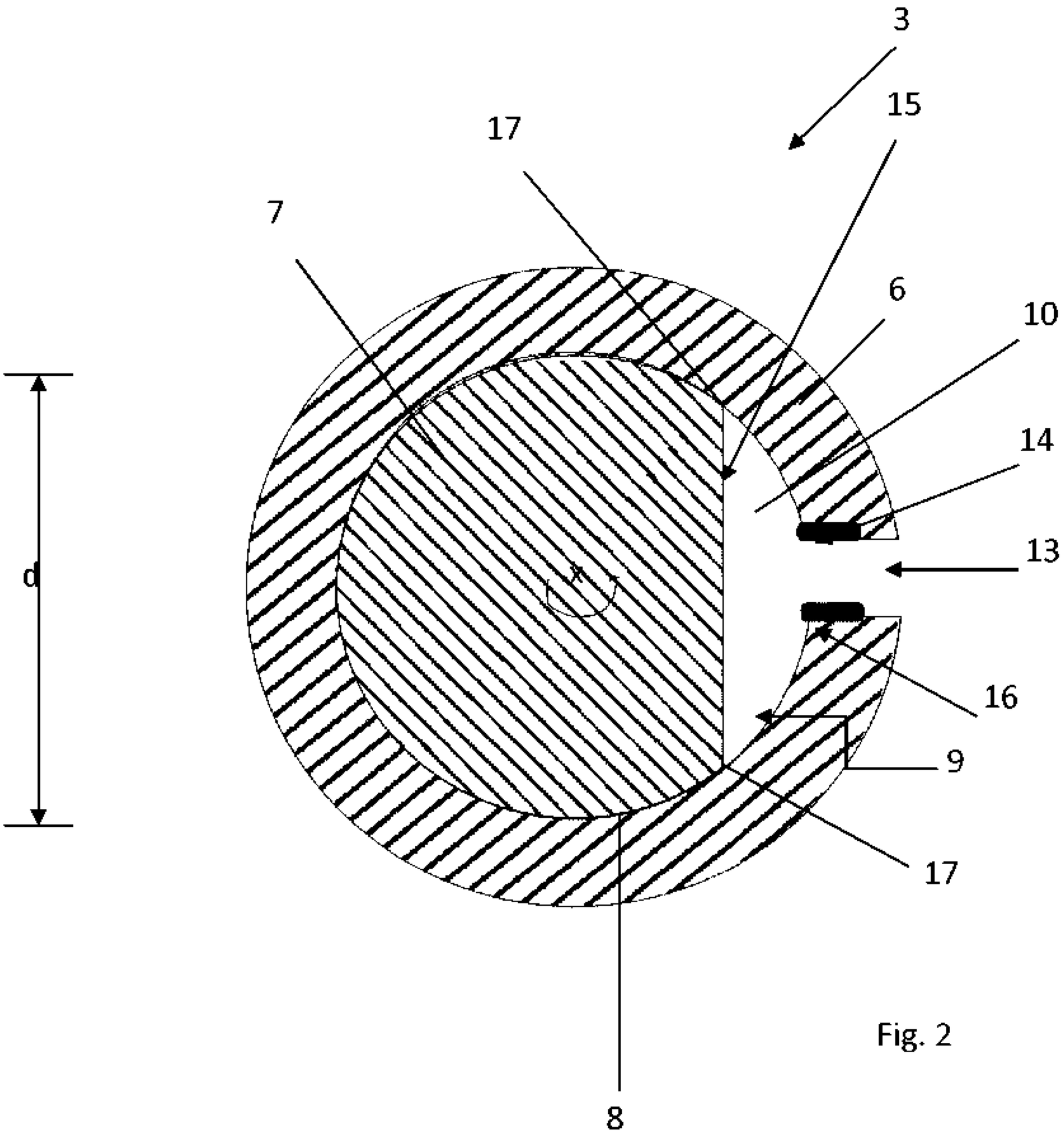


Fig. 2

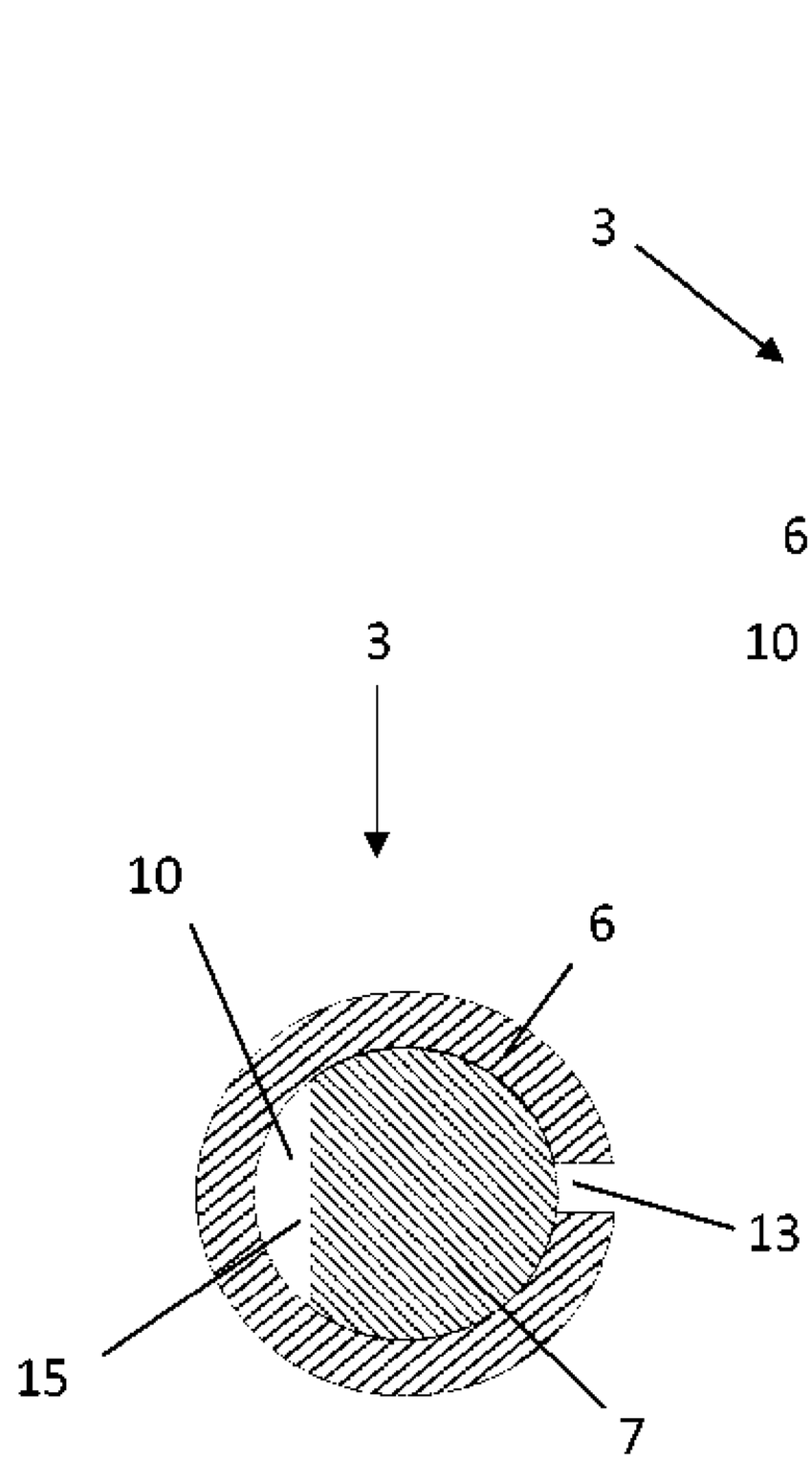


Fig. 3a

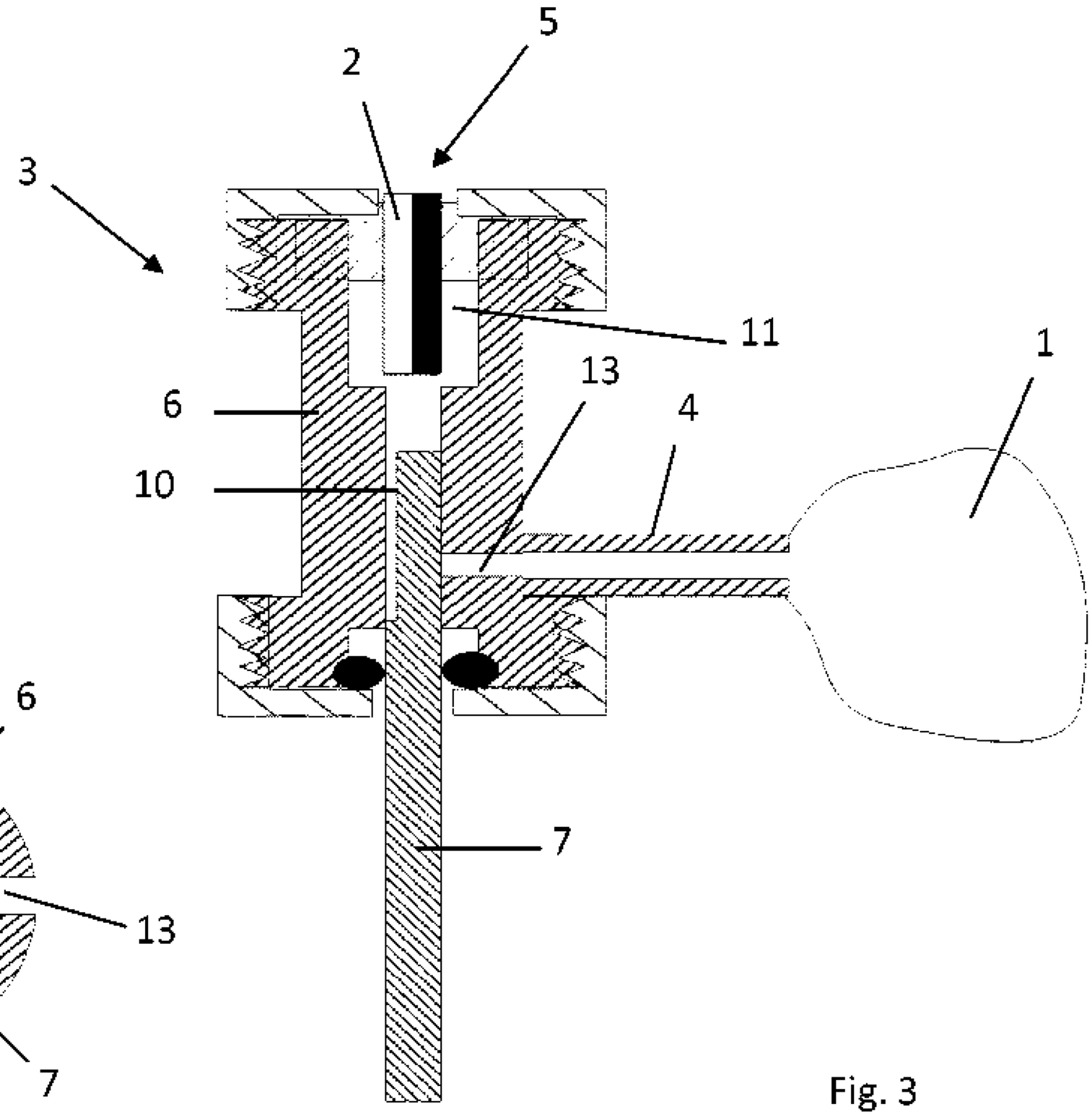
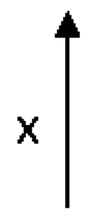


Fig. 3



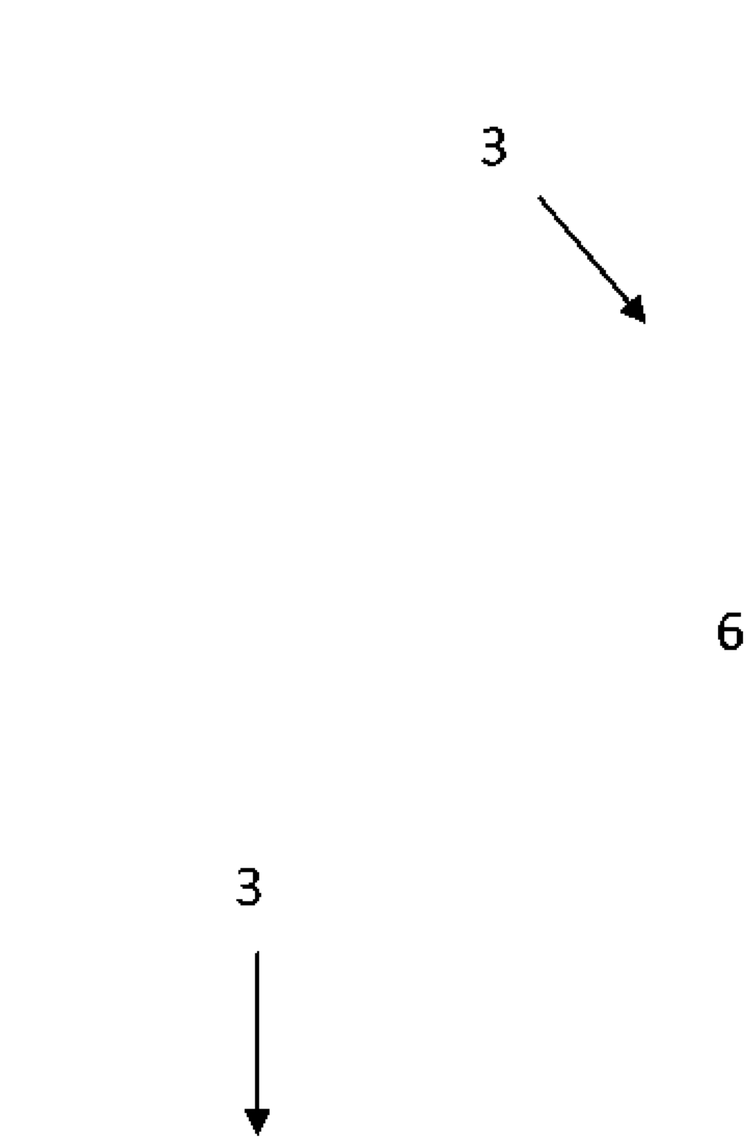


Fig. 4a

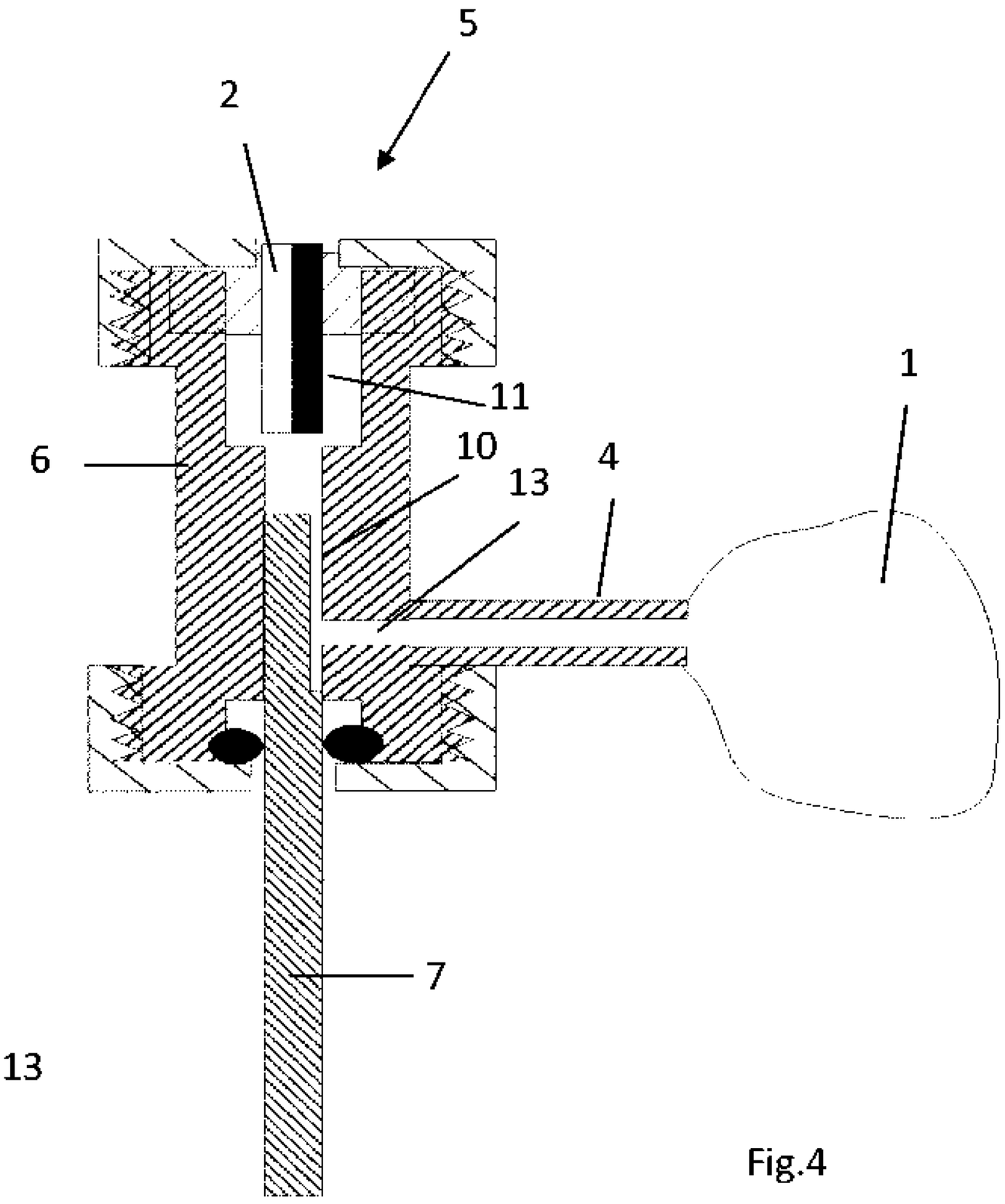


Fig.4

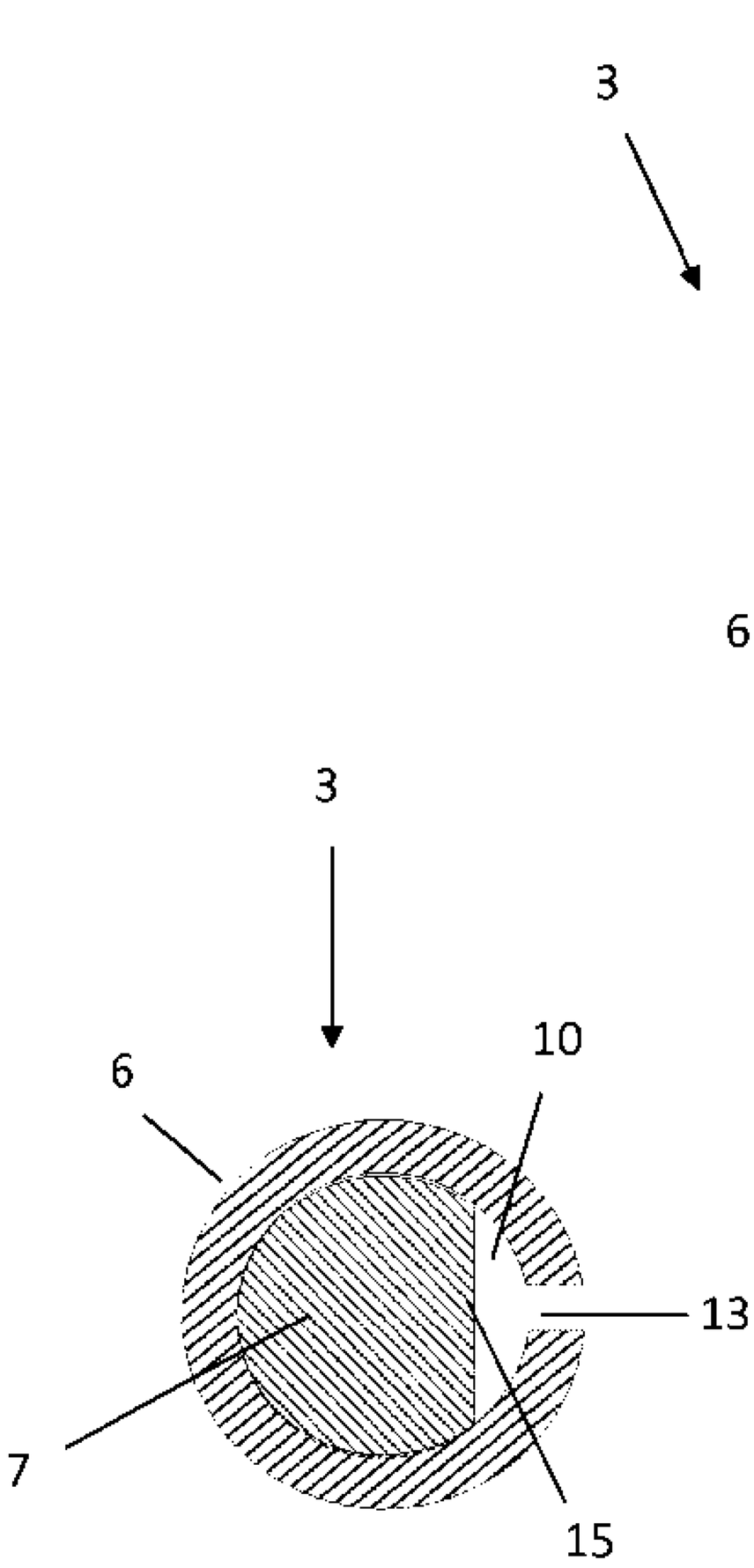


Fig. 5a

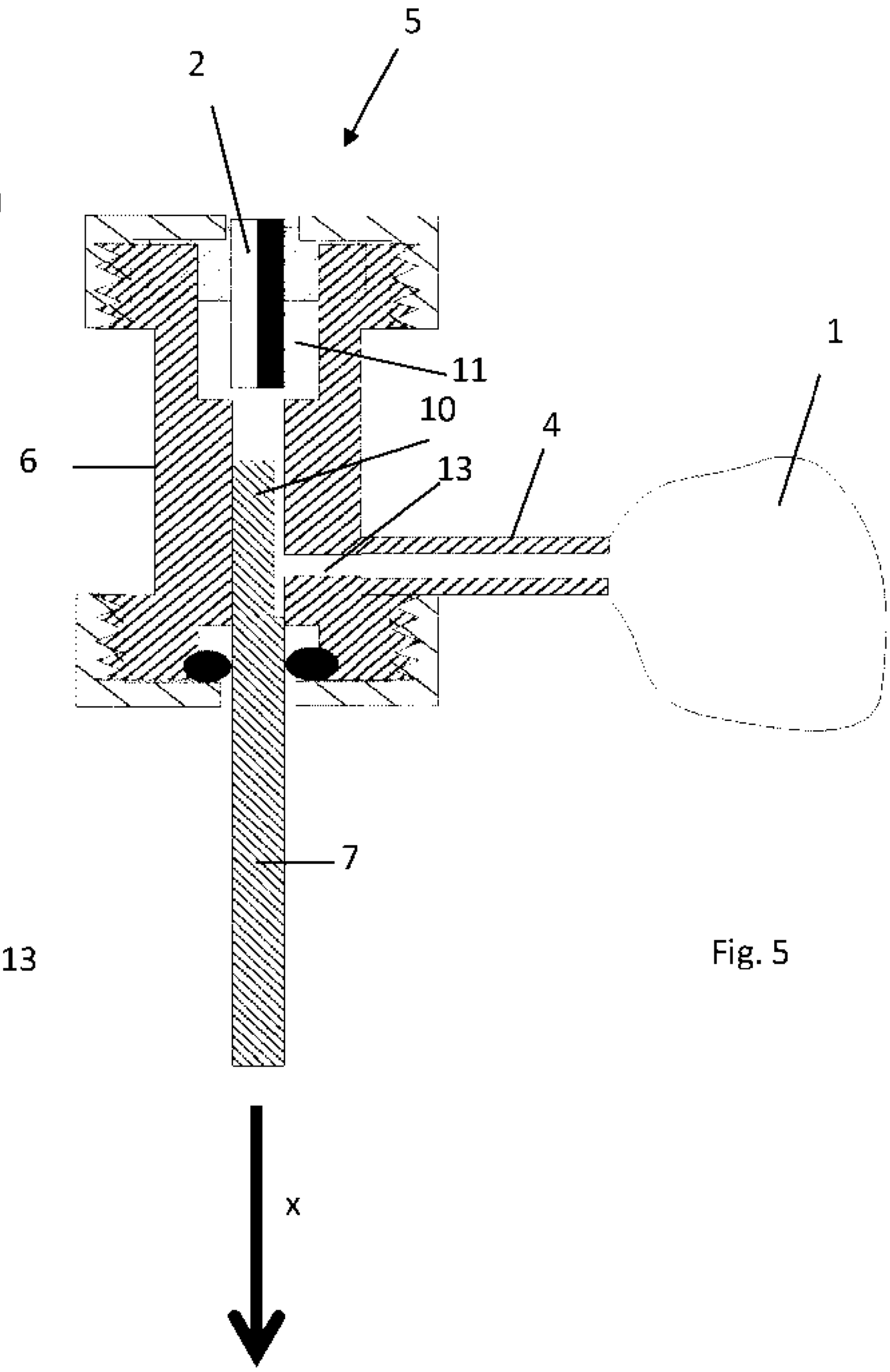


Fig. 5

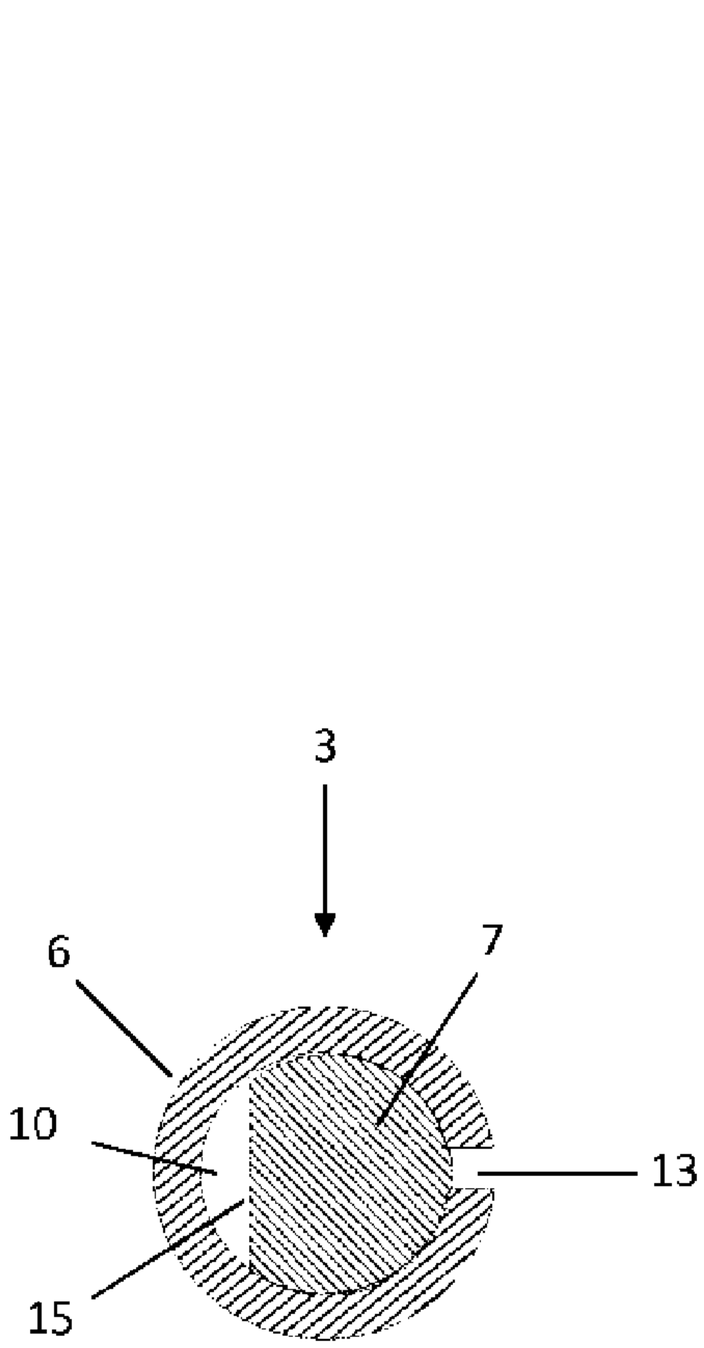


Fig. 6a

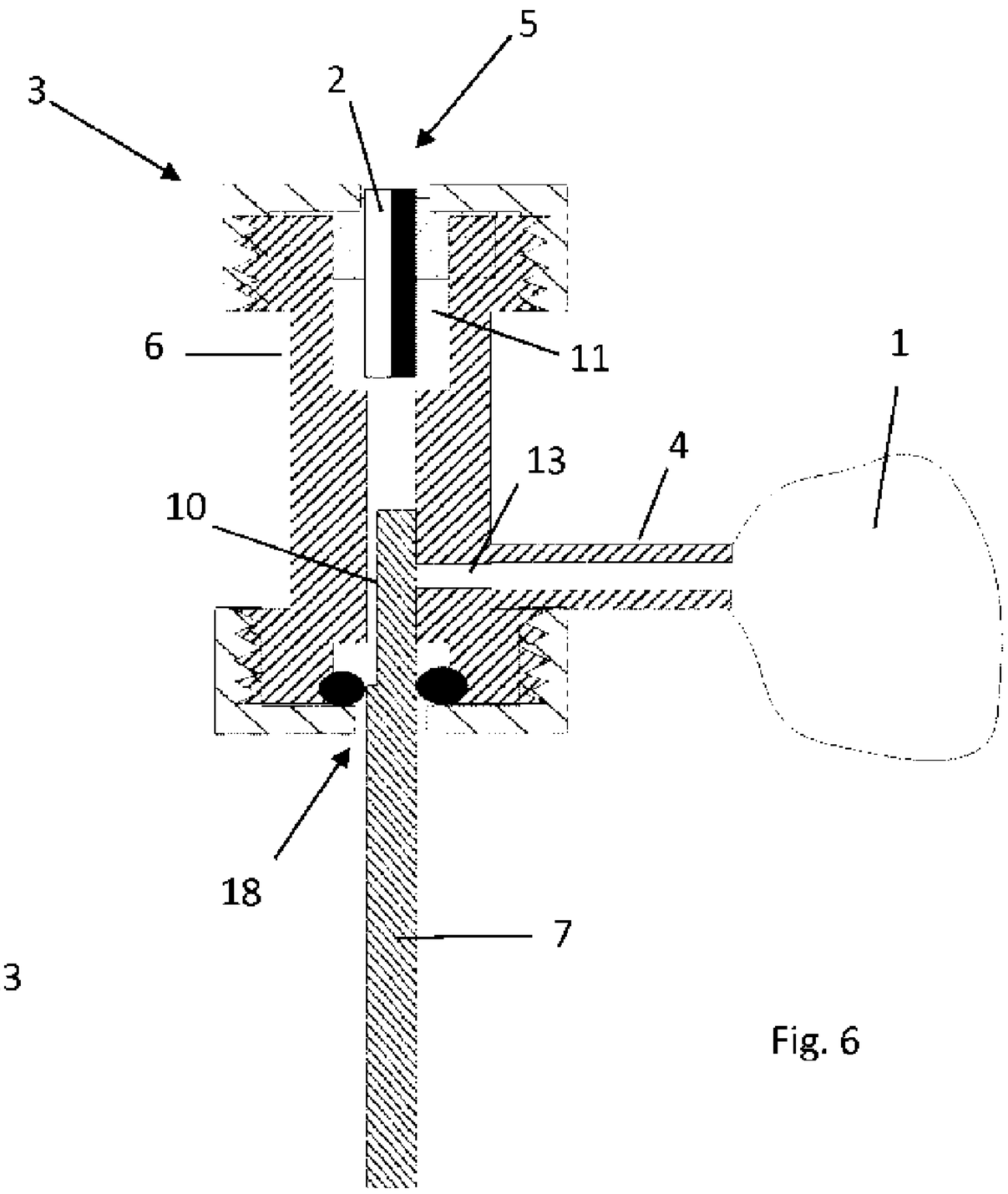


Fig. 6