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Gehl [DK/DK]; St. Valbyvej 206, DK-4000 Roskilde (DK).

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(74) Agent: **LARSEN & BIRKEHOLM A/S**; Skandinavisk Patentbureau, Banegårdspladsen 1, P.O. Box 362, DK-1570 Copenhagen V (DK).

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(71) Applicant (*for all designated States except US*): **ASJ HOLDING APS** [DK/DK]; Mølleåparken 50, DK-2800 Kongens Lyngby (DK).

(72) Inventors; and

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(75) Inventors/Applicants (*for US only*): **JENSEN, Arne, Sloth** [DK/DK]; c/o ASJ Holding ApS, Mølleåparken 50, DK-2800 Kongens Lyngby (DK). **LARSEN, Kasper,**

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(54) Title: A SYSTEM AND A METHOD FOR THE WITHDRAWAL OF PARTICULATE SOLID MATTER FROM A PRESSURIZED CONTAINER CONTAINING A GAS, AND USE THEREOF

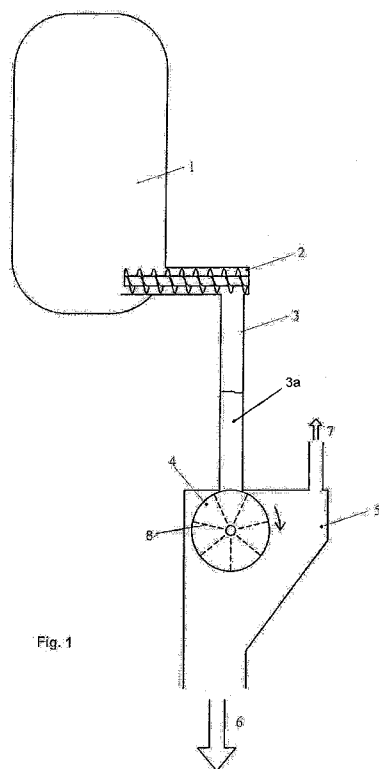


Fig. 1

(57) Abstract: A method and a system for the withdrawal of solid matter particles from a pressurized container, and use thereof The method comprises withdrawal of solid matter particles from a container (1) pressurized by a gas, wherein the particles are transported out of the container (1), are conveyed through a zone with relatively densely packed particles (3a), and pass a metering mechanism (4, 4', 4''), across which there is a significantly reduced or no gas pressure difference, said gas being subjected to a pressure loss at the passage between the densely packed particles in the zone (3a) forwardly to the metering mechanism (4, 4', 4''). The system comprises a transport pipe (3), in which a zone (3a) of relatively densely packed particles is created, said gas being subjected to a pressure loss at its passage through this zone of particles because of the flow resistance in it. The transport pipe (3) is dimensioned so that there is a significantly reduced or no gas pressure difference across the subsequent metering mechanism (4, 4', 4''). A low steam loss is achieved by the use of the system and the method when particles are dried with superheated steam.



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A system and a method for the withdrawal of particulate solid matter from a pressurized container containing a gas, and use thereof

Technical field

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The invention relates to a system and a method for the withdrawal of particles from a container or a chamber which is pressurized by a gas or a gas mixture. The invention also relates to use thereof.

10 In various processes, there is a need for discharging solid matter particles continuously out of a pressurized chamber containing a gas, so that a minimum of the gas flows out together with the solid matter particles.

15 An example of this is the need which exists when particles are dried in a chamber or a container with superheated steam under pressure. The dried particles must be discharged from the pressure system without entraining too much steam, which would be a waste, and which might perhaps also be a source of pollution.

20 In the following, the invention will be described on the basis of an embodiment in which steam or superheated steam is used for pressurizing the container or the chamber from which particles are to be withdrawn. However, the invention is not restricted to methods, systems or uses where steam or superheated steam is used for creating a pressure in the container or the chamber. Thus, the system and the method may also be used
25 in connection with the use of other gases which pressurize the container or the chamber. Thus, the gas which pressurizes the container, may also be other gases or gas mixtures, including e.g. air, which is used e.g. for the drying of the particles or is used as a carrier gas during pneumatic transport
30 of the particles to the container or the chamber.

The prior art

5 The prior art withdraws particles from a pressurized container with a rotary valve, where a rotor having chambers rotates in a housing, see e.g. US 2005/0098586 A1. The product mixed with steam drops down into the chambers, e.g. from a worm conveyor which connects the pressurized container and the rotary valve. When the rotor has rotated approx. $\frac{1}{2}$ a revolution, the solid matter particles can drop out. In case of major pressure differences, such as e.g. from 4 bars to 1 bar, it is impossible to avoid the
10 situation that much steam is discharged together with the particles, because the steam expands from the 4 bars to 1 bar at the moment when outflow from one of the chambers in the rotary valve is allowed.

15 There will always be a small leak between the rotor and the stationary parts of the rotary valve. A small leak expands rapidly, because the flowing steam entrains solid matter particles which wear the parts of the rotary valve around the leak area. This increases the leak, as a larger opening is created, so that the steam flows more rapidly and the wear enhances, thus intensifying the wear problem.

20 Another wear problem occurs each time a chamber opens. The expansion of the steam takes place like an explosion at the opening moment and causes steam and solid matter speeds which give rise to strong wear on the parts of the rotary valve in the opening area.

25 The object of the invention

Accordingly, it is the object of the invention to avoid great local pressure changes which may cause local wear when particles are withdrawn from a
30 container which is pressurized by a gas, such as e.g. steam.

Summary of the invention

5 This is achieved by the method according to claim 1, which is characterized in that the particles are transported out of the container and are then conveyed through a zone with relatively densely packed particles, following which the particles pass a metering mechanism across which there is a significantly reduced or no gas pressure difference, said gas being subjected to a pressure loss at the passage through the densely packed particles in the zone forwards to the metering mechanism.

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When the solid matter particles are allowed to move slowly in a relatively densely packed flow toward the location where the particles are withdrawn, steam will flow in co-current between the packed particles.

15 The pressure of the steam will decrease because of the flow resistance which occurs at the passage between the particles. As a consequence of the pressure loss of the steam, an acceptable amount of steam will then flow out together with the particles. In this manner, an acceptably low waste of steam is achieved, and, at the same time, the wear of the metering
20 mechanism will be reduced significantly, which also adds considerably to the service life of the metering mechanism.

When, as stated in claims 2 and 11, the withdrawal of particles is controlled such that the layer of particles is kept within desired upper and lower limits,
25 an approximately constant pressure loss across the metering mechanism and thereby also a stable operation are achieved.

When, as stated in claims 3 and 9, the metering mechanism allows passage of steam, while particles are kept back in the transport pipe and the
30 metering mechanism, the wear occurring when the steam expands in a traditionally closed rotary valve, is eliminated.

Other advantageous features of the method are stated in the dependent claims 4 – 7.

5 The object of the invention is also achieved by a system according to claim 8 for performing the method according to claims 1 – 7, which is characterized in that it comprises a transport pipe to which the particles are transferred when they have been discharged from the pressurized container, and in which a zone of relatively densely packed particles is created, said
10 gas being subjected to a pressure loss at its passage through this zone of particles because of the flow resistance therein, as well as a metering mechanism for withdrawing particles from the transport pipe, wherein the transport pipe is dimensioned such that there is a significantly reduced or no gas pressure difference across the subsequent metering mechanism because of the pressure loss achieved for the gas at the passage through
15 the zone of particles in the transport pipe.

As stated in claim 10, the metering mechanism is preferably selected from an adjustable flap, a cell wheel, a rotary plate with ribs or a worm conveyor, which may be provided with an outlet flap, and, as stated in claim 12, a
20 transport mechanism is preferably arranged between the container and the transport pipe, said transport mechanism conveying the particles from the container to the transport pipe.

As stated in claims 14 – 15, the method and the system may preferably be
25 used for the drying of residual products from sugar and/or ethanol production, including e.g. beet pulp, bagasse or distillers grains.

Detailed description of the invention

30 Below, the invention will be described in detail, and embodiments of it will be described with reference to the drawing, in which

fig. 1 shows a first embodiment of a system for the withdrawal of particles from a pressurized container having a transport pipe and a metering mechanism in the form of a rotary valve,

5 fig. 2 shows an alternative embodiment of the system having a conical transport pipe and a rotary valve,

fig. 3 shows a further embodiment of the system having a conical transport pipe and a rotary valve,

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fig. 4 shows a further embodiment of the system of fig. 1, where the metering mechanism is a horizontally rotating plate having ribs,

15 fig. 5 shows a further embodiment of the system of fig. 1, where the metering mechanism is a worm conveyor, which may be equipped with a flap in the outlet opening, and

20 fig. 6 shows an alternative embodiment, where the transport pipe is mounted directly on the pressurized container, from which particles are to be withdrawn.

The system for the withdrawal of particles from a container, which is pressurized by a gas, operates by feeding the particles from a pressurized container (1) to a transport pipe (3), where the particles are pushed through slowly by the pressure which prevails in the container (1). A flow controlling mechanism or a metering mechanism (4) is arranged at the end of the pipe, allowing the particles to pass continuously together with some steam and in such an amount that the pipe is constantly kept filled with particles at an approximately constant degree of filling. The steam will lose its pressure by the flow through the mass of particles, and by suitable selection of the length and the diameter of the pipe it may be ensured that the amount of

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steam flowing out together with the particles is acceptably low.

An example of an embodiment of the system for the withdrawal of particles from a container which is pressurized by a gas, is shown in fig. 1. The particles are transported from the pressurized container (1) by a transport mechanism (2) to the transport pipe (3). A predetermined degree of filling is maintained in this, so that the zone with packed particles (3a) is kept essentially constant by controlling the emptying rate from the transport pipe (3) by a metering mechanism (4). The particles are metered from the transport pipe (3) to a chamber (5), from which they are withdrawn, as shown by the arrow (6). The steam accompanying the particles out into the chamber (5), are withdrawn through the pipe (7).

The transport mechanism (2) is shown as a worm conveyor, but is not restricted to this. Thus, the worm conveyor may also be replaced by other generally available transport mechanisms for pressurized containers, e.g. chain scrapers, or be omitted completely, see figure 6.

In figure 1, the metering mechanism (4) is shown as a cell wheel, which is not to close off the steam, but just to meter the amount of particles. This may be done e.g. in that the rotating walls (8) of the cell wheel are perforated, e.g. with holes or slits which allow steam or other gas to pass, but retain the particles in the chambers of the cell wheel.

In its simplest embodiment, the metering mechanism (4) may also be configured as a simple flap (not shown). The opening of the flap is controlled, e.g. by a hydraulic cylinder or the like. The degree of filling in the transport pipe (3) is controlled by varying the degree of opening of the flap, which is controlled e.g. by level measurements in the transport pipe (3).

30

As shown in figure 2, the transport pipe (3) may be slightly conical, as the

diameter of the transport pipe decreases with the distance from the container (1). Alternatively, the radius of the transport pipe (3) increases with the distance from the container, as shown in figure 3, whereby clogging in the transport pipe (3) may essentially be avoided.

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Figure 4 shows an alternative embodiment, in which the metering mechanism (4') is constructed as a horizontally rotating plate having radial ribs or the like, which is capable of metering the withdrawal of particles from the transport pipe (3), so that the pipe always has the desired degree of filling.

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The ribs may be straight and be disposed radially on the rotating plate, or they may be radial ribs of curve shape or other non-linear shape.

Figure 5 shows an alternative embodiment, in which the metering mechanism (4'') is constructed as a worm conveyor (9a) having a pressure-controlled outlet flap (9b). A resistance is preferably applied to the flap, e.g. by a spring, a piston or the like. The flap allows outflow when the particles apply a predetermined load to the flap. This outlet mechanism may be controlled by allowing a control system to determine the speed of rotation of the worm conveyor (9a).

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In the same manner as described for the cell wheel above, the alternative embodiments of the metering mechanisms (4', 4'') as well as the adjustable flap (not shown) allow free passage of gases and/or steam, while the particles are kept back in the metering mechanism. Preferably, these embodiments also have slits and/or perforations which allow passage of steam, but retain the particles in the metering mechanism. For instance, the surrounding shield or jacket of the worm conveyor (9a) may have slits and/or perforations which discharge the steam out into the chamber (5) during the transport of the particles forwards to the opening (9b).

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Figure 6 shows a system for the withdrawal of particles corresponding to

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the system shown in figure 1, but where the worm conveyor (2) is omitted. The pressurized container (1) therefore feeds particles directly down into the transport pipe (3). Correspondingly, it is possible to omit the worm conveyor (2) in the other shown and/or mentioned embodiments.

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In the embodiments shown, the transport pipe (3) is disposed so as to extend essentially vertically downwards, as the free fall of the particles in the pipe contributes to achieving a dense packing of the layer (3a) of particles in the transport pipe (3). Basically, the transport pipe (3) may extend in all other directions, including also approximately vertically upwards, if only the pressure in the container (1) is sufficiently high to achieve a satisfactory transport of the particles. Likewise, the transport pipe (3) may contain additional transport mechanisms, e.g. a worm conveyor, which is particularly advantageous if the transport pipe (3) is disposed so as to extend approximately horizontally or e.g. vertically upwards. The transport pipe (3) may also be equipped with a closing mechanism (not shown) at the end which is closest to the container (1), so that the transport of particles from the container (1) to the chamber (5) may be closed. The closing mechanism is e.g. a slide valve.

20

Moreover, it is advantageous to equip the transport pipe (3) with measuring equipment (not shown) which is capable of measuring the height/length of the layer (3a) of particles which is present in the transport pipe (3). In particular, the measuring equipment comprises level meters of a generally known type.

25

It is also possible to allow the metering mechanism (4, 4', 4'') to withdraw the particles from the transport (3) and convey them directly into another container (not shown) or a further transport mechanism, e.g. a worm conveyor (not shown). Hereby, the chamber (5) may be omitted. The steam discharged from the metering mechanism (4, 4', 4''), however, should still

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be capable of being withdrawn separately. Therefore, the further container or transport mechanism should comprise means for discharging the steam or the gas from the particles, e.g. in a manner corresponding to what has been described for the chamber (5). The chamber (5) may also be a feed
5 hopper for a further transport mechanism, including a worm conveyor, or to a container.

The pressure container (1) is e.g. a fluid bed which is used for the drying of particulate material, e.g. with superheated steam. However, the invention is
10 not restricted to the use for fluid bed drying with steam, but may basically be used when withdrawing particles from all containers which are pressurized by a gas or a gas mixture.

Optionally, the system may be equipped with means for the feeding of further products to the particulate material, e.g. in the transport pipe (3) and/or
15 in the chamber (5).

The steam or gas discharged from the chamber may be recycled for further use, e.g. for preheating material to be dried, if the system is used in connection with steam drying of particles.
20

The invention also comprises a method of withdrawing particles from a pressurized container by supplying the particles from the pressurized container (1) itself to a transport pipe (3), in which the particles (3a) are pushed
25 through slowly, e.g. by the pressure prevailing in the container (1). A flow controlling mechanism or a metering mechanism is arranged at the end of the pipe, allowing the particles to pass together with some steam and in such an amount that the pipe is constantly kept filled with particles to an approximately constant degree of filling. The steam will lose its pressure at
30 its flow through the mass of particles, and by suitable selection of the length and diameter of the pipe and the speed of the particles it is possible to en-

sure that the amount of steam flowing out together with the particles is acceptably low. The transport pipe (3) should preferably be dimensioned such that the particles may reach a speed of 0.01 – 1 m/sec, in particular 0.2 – 0.8 m/sec, and preferably 0.4 – 0.6 m/sec, which makes it possible in practice to control the length/depth of the zone (3a) of particles in the transport pipe (3) in a stable manner. It is preferred that the speed of the particles is around 0.5 m/sec in the transport pipe.

Normally, the level meters in the transport pipe are coupled to a control system, where the measurement results from the level meters are used for controlling the metering mechanism (4, 4', 4"). The degree of filling of the transport pipe (3) should be adjusted such that the transport pipe (3) is constantly kept filled with particles within a predetermined range, so that the transport pipe (3) always has an approximately constant degree of filling.

The transport pipe (3) may be filled completely, be half-filled or filled less by the particles, which depends on the steam loss which is acceptable for the system. The cross-section of the transport pipe (3) is proportional to the amount of treated particles and must thus be adapted to the capacity of the system, it being also necessary to take available dimensions of the metering mechanism (4, 4', 4") into consideration. The length of the transport pipe (3) is adapted accordingly, so that the zone of packed particles (3a) may be sufficiently large to allow a sufficiently low steam loss to be achieved at the desired particle speed in the transport pipe (3). If the container (1) has a relatively high pressure, it is necessary to have a deeper/longer packed zone (3a) of particles in the transport pipe (3) to achieve a sufficiently large pressure loss during the passage of the steam through the layer of particles and a consequent low waste of steam.

The system and the method are suitable for both batchwise and continuous withdrawal of particles from a pressurized container, but are preferably

used for continuous withdrawal of particles.

5 The system and the method are particularly suitable for continuous withdrawal of particles from a fluid bed for the drying of particles with superheated steam. The particles to be dried are e.g. wood chips or residual products from sugar and/or ethanol production, including e.g. beet pulp, bagasse or distillers grains.

PATENT CLAIMS

1. A method of withdrawing solid matter particles from a container (1) pressurized by a gas, characterized in that the particles are transported
5 out of the container (1) and are then conveyed through a zone (3a) with relatively densely packed particles, following which the particles pass a metering mechanism (4, 4', 4'') across which there is a significantly reduced or no gas pressure difference, said gas being subjected to a pressure loss
10 by the passage between the densely packed particles in the zone (3a) forwards to the metering mechanism (4, 4', 4'').
2. A method according to claim 1, characterized in that the zone with densely packed particles (3a) is present in a transport pipe (3), and that the metering mechanism (4, 4', 4'') controls the flow of particles which
15 are withdrawn from the transport pipe (3), and thereby controls the depth or the length of the layer of particles in the transport pipe (3) on the basis of measurements of the depth or length of the zone (3a) with densely packed particles in the transport pipe (3).
- 20 3. A method according to any one of claims 1 – 2, characterized in that the metering mechanism (4, 4', 4'') allows free passage of gases and simultaneously retains the particles in the metering mechanism (4, 4', 4'').
- 25 4. A method according to any one of claims 1 – 3, characterized in that the particles are withdrawn continuously or batchwise from the container, including in particular continuously.
- 30 5. A method according to any one of claims 1 – 4, characterized in that the gas pressurizing the container (1) is steam, including preferably superheated steam.

6. A method according to claim 5, c h a r a c t e r i z e d in that the steam discharged through the metering mechanism (4, 4', 4'') as well as the flash steam occurring when the particles are discharged from the metering mechanism (4, 4', 4''), are conveyed back to the initial process step, in particular preheating of the particles.

7. A method according to any one of claims 1 – 6, c h a r a c t e r i z e d in that the pressurized container (1) is a fluid bed for the drying of solid matter particles with superheated steam.

8. A system for performing the method according to any one of claims 1 – 7 for the withdrawal of solid matter particles from a container (1) pressurised by a gas, c h a r a c t e r i z e d in that it comprises

- a transport pipe (3) to which the particles are transferred when they have been discharged from the pressurized container (1), and in which a zone of relatively densely packed particles (3a) is created, said gas being subjected to a pressure loss at its passage through this zone of particles (3a) because of the flow resistance therein, as well as

- a metering mechanism (4, 4', 4'') for withdrawing particles from the transport pipe (3), and

wherein the transport pipe (3) is dimensioned such that there is a significantly reduced or no gas pressure difference across the subsequent metering mechanism (4, 4', 4'') because of the pressure loss achieved for the gas at the passage through the zone of particles (3a) in the transport pipe (3).

9. A system according to claim 8, c h a r a c t e r i z e d in that the metering mechanism (4, 4', 4'') is constructed to allow free passage of gases and

simultaneously retain the particles in the metering mechanism (4, 4', 4'').

10. A system according to any one of claims 8 – 9, c h a r a c t e r i z e d in that the metering mechanism (4, 4', 4'') is selected among an adjustable
5 flap, a cell wheel (4), a rotating plate with ribs (4') or a worm conveyor (9a), which may be provided with an outlet flap (9b).

11. A system according to any one of claims 8 – 10, c h a r a c t e r i z e d in that the transport pipe (3) is provided with equipment for measuring the
10 depth and/or length of the zone of particles (3a) in the transport pipe (3), which measurements determine the flow of particles out through the metering mechanism (4, 4', 4'').

12. A system according to any one of claims 8 – 11, c h a r a c t e r i z e d in that a transport mechanism (2) is arranged between the container (1) and
15 the transport pipe (3) to convey the particles from the container (1) to the transport pipe (3).

13. A system according to any one of claims 8 – 12, c h a r a c t e r i z e d in that the pressurized container (1) comprises a fluid bed for the drying of
20 solid matter particles with superheated steam.

14. Use of the system according to any one of claims 8 – 13 for the drying of residual products from sugar and/or ethanol production, including e.g.
25 beet pulp, bagasse or distillers grains.

15. Use of the method according to any one of claims 1 – 7 for the drying of residual products from sugar and/or ethanol production, including e.g. beet pulp, bagasse or distillers grains.

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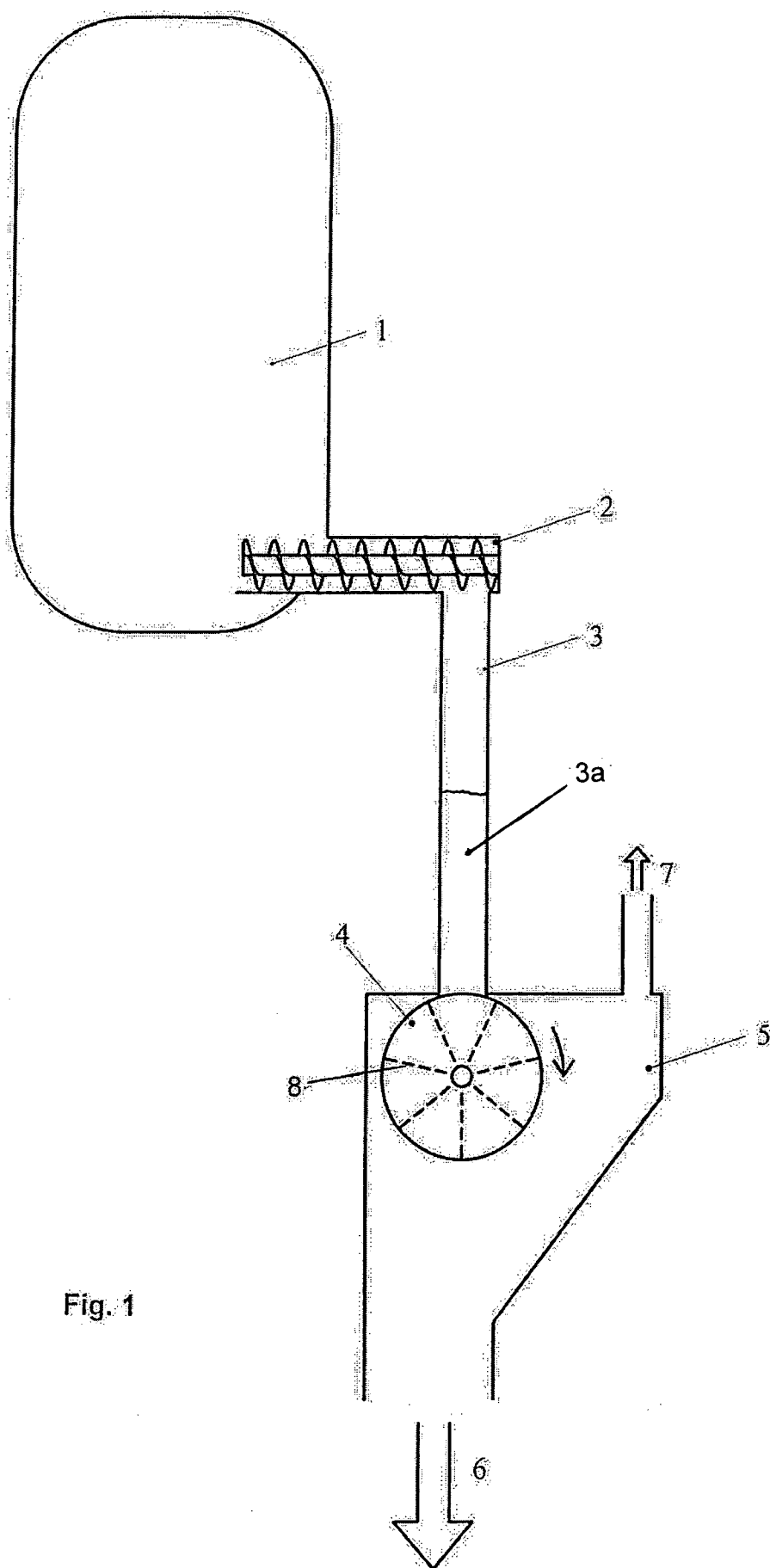


Fig. 1

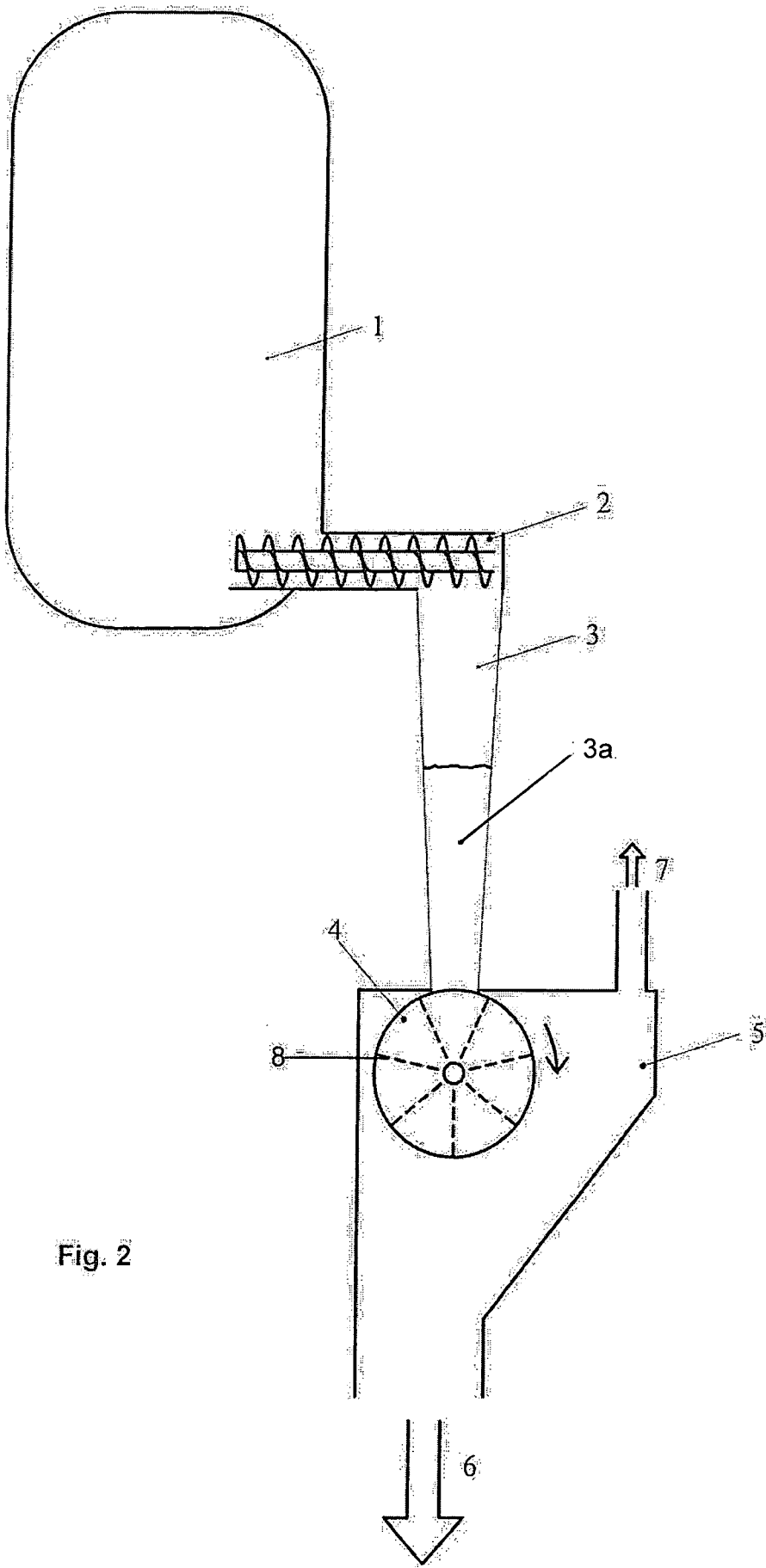


Fig. 2

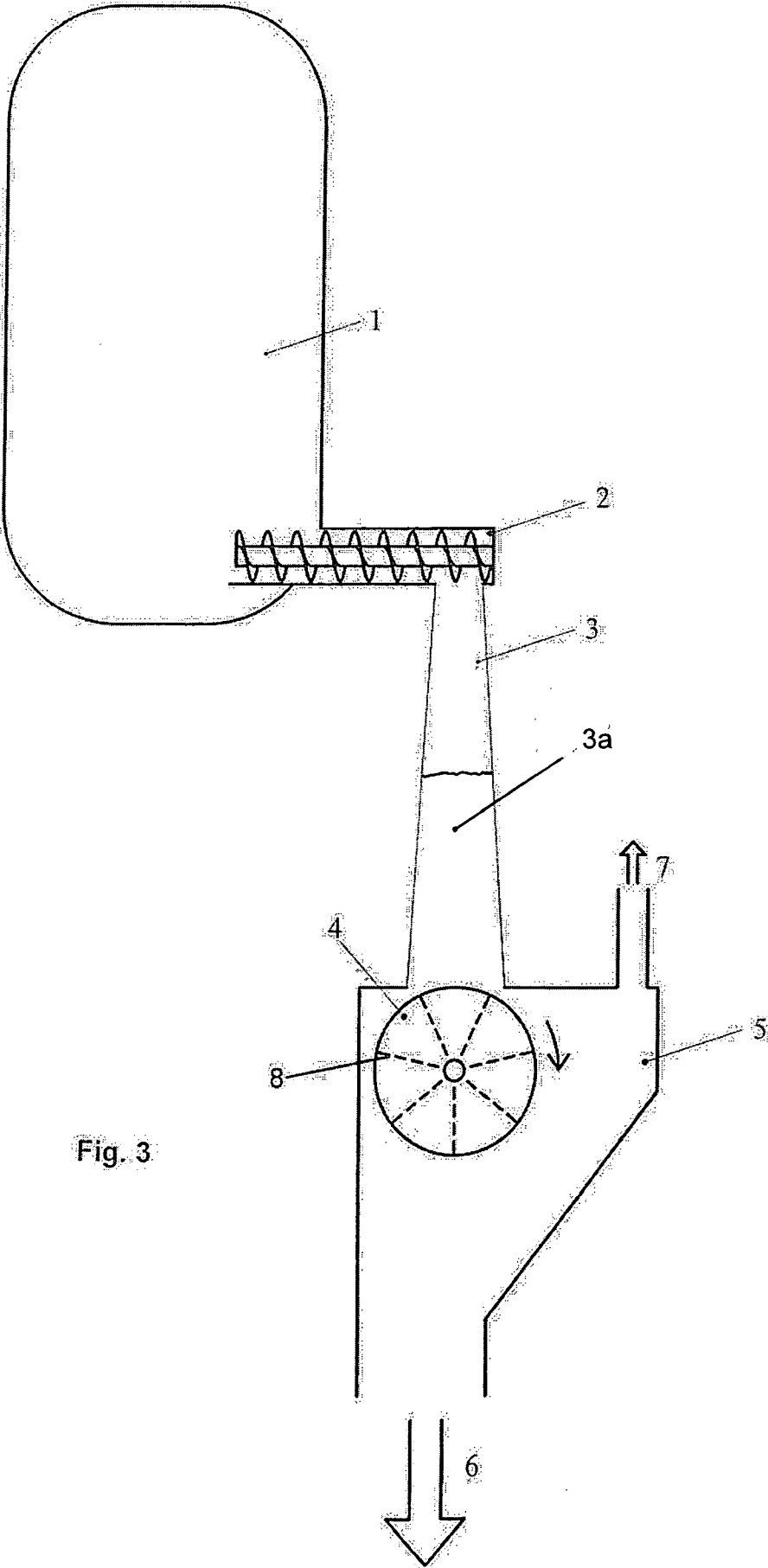


Fig. 3

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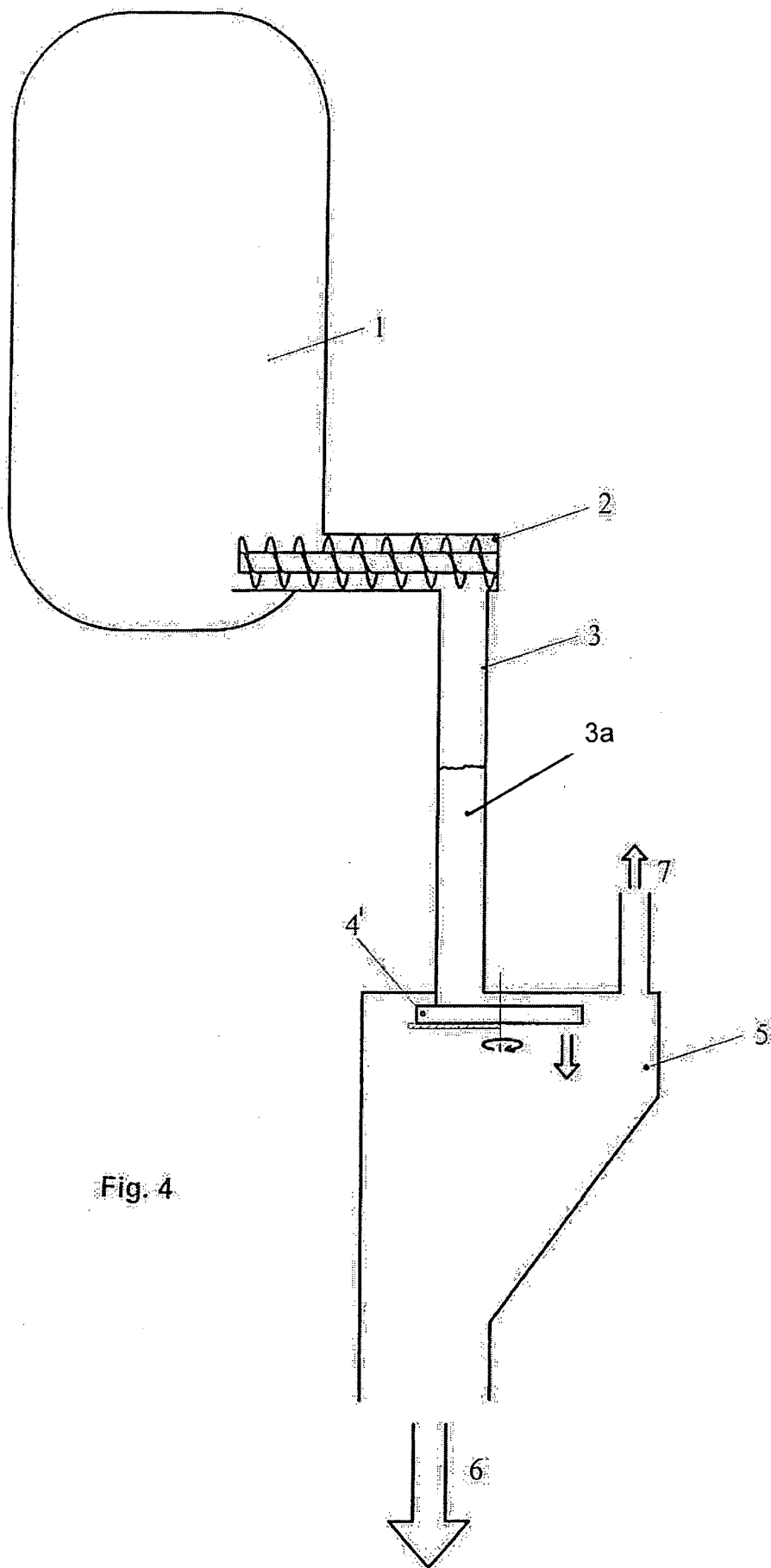
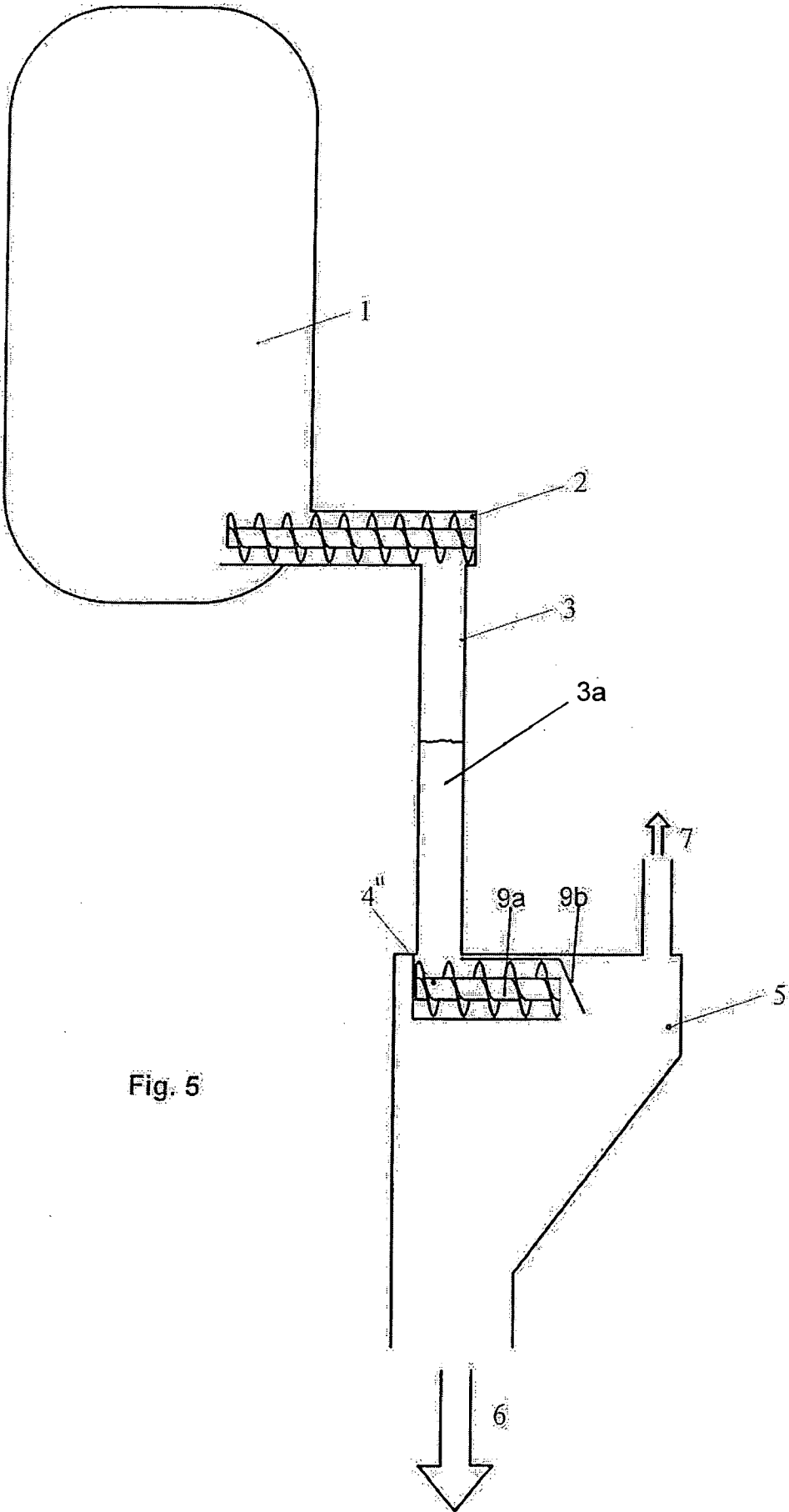


Fig. 4

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