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(54) GASIFICATION STOVE

(57) A gasification stove comprising a containment structure (2) which accommodates a storage tank (3) for biomass fuel (4), a gasification crucible (6) connected to an expansion chamber (13) which in turn is connected to a combustion chamber (15), and an air-air heat exchanger. The expansion chamber (13), which lies above the gasification crucible (6) and below the combustion chamber (15), has an intermediate section (18) that has larger dimensions than a section (17) for input from the gasification crucible (6). The gasification crucible (6), having a substantially tubular shape with constant circular or rectangular cross-section, is delimited, at the lower end (7), by a first opening (8) adapted to allow the passage of a first gasification air (9) that originates from a first plenum (10a). The gasification crucible (6) has, at an upper end (11), a series of second openings (12) adapted to allow the passage of a second combustion air (28) at a first passage toward the overlying gas expansion chamber (13).

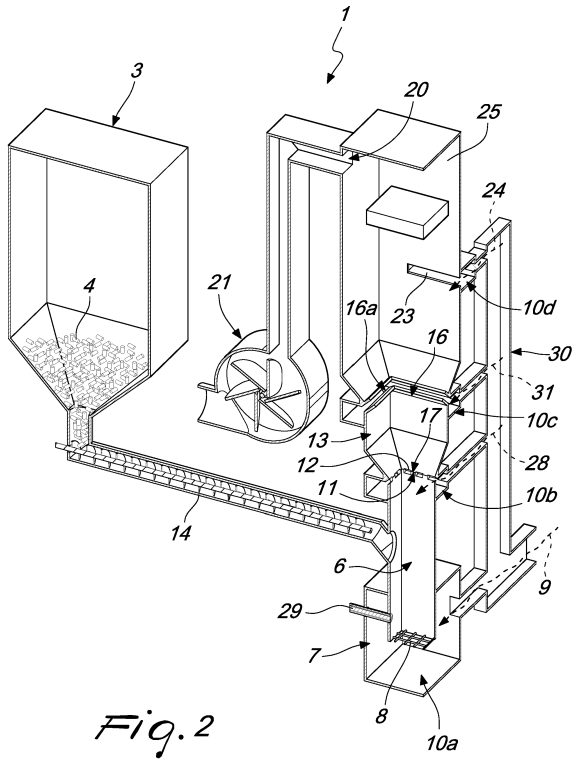

Fig. 2

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Description

[0001] The present invention relates to a gasification stove.

[0002] Heating apparatuses, such as in particular stoves or boilers, which can be fed with solid fuel, for example wood or pellets, are known and widely used for heating air and/or water of living spaces.

[0003] Such apparatuses of a known type usually comprise a containment structure which accommodates respectively a combustion chamber, an electrical lighter, a storage tank for the solid fuel, means for moving the fuel in the combustion chamber, a first pumping means, or fan, for moving the combustion air by propulsion or suction, an air-air heat exchanger and a second pumping means, or fan, for the forced exchange of heat and the conveyance of warm air into the home environment.

[0004] The combustion chamber accommodates usually a brazier inside which the fuel is deposited by means of adapted devices usually of the screw feeder type.

[0005] The combustion air is drawn externally to the containment structure by virtue of the action of first pumping means, such as for example a first bladed fan which can be actuated by an electrically powered motor, and conveyed through an inlet duct at the brazier; here, by means of appropriate lighting means, combustion is triggered, generating high-temperature combustion gases.

[0006] The gases then pass through a heat exchanger, usually located downstream of the combustion chamber, to exchange heat with the containment structure of the apparatus, which in turn dissipates it, by radiation and/or natural convection, in the home environment of installation.

[0007] Optionally, second pumping means, such as a second fan which can be driven by an electric motor, can be provided to distribute heat in the external environment in a forced convective manner, improving the thermal efficiency of the apparatus and allowing the heating also of environments other than the one of installation.

[0008] The combustion gases are expelled from the apparatus through an appropriate exhaust duct by virtue of the action of said first pumping means.

[0009] Control and actuation means, such as a suitably programmed electronic board, are generally provided to manage and coordinate the various electrical apparatuses provided in the apparatus in order to enable its proper operation.

[0010] In the case of pellet stoves for domestic use, a flame visible through a glass pane is generated and the heat is released into the environment through a combination of radiation and forced and natural convection implemented in the structure of the stove.

[0011] An example of a gasification stove is illustrated in WO2019/033044A1, in which the amount of pellets present in the brazier has constant loading and allows a combustion rate of the generated gases at a preset power level.

[0012] Moreover, the presence of the pellets in the brazier is entrusted to a manual or gravity filling, without the possibility of modifying the power output of the apparatus.

[0013] The drawbacks which can be ascribed to the background art consist essentially in the fact that pollutants are generated which are typically a byproduct of biomass combustion; these pollutants take the form of harmful gases (including nitrogen oxides and mixtures thereof -NOx- and carbon monoxide -CO-) and the form of fine dust (PM10 and PM2.5 particulate matter) which is a threat to health and to the environment.

[0014] In the background art, the flame anchored to the wood mass increases in size and spatial extension as the flow rate of pellets introduced in the unit time increases.

[0015] At maximum power there is a high supply of pellets and therefore a spatially very diffused flame, while at minimum power there is a small flame that is distributed only proximate to the burning embers and almost totally hidden in the brazier.

[0016] A widespread way to reduce emissions, specifically for particulate matter, is to provide staged combustion, in which first pyrolysis and gasification take place and then complete oxidation is realized and therefore the flame is visible in a position that is distant from the original biomass.

[0017] This contrivance, combined with the use of a glass pane for viewing the flame, while reducing particulate emissions, generates a flame that is visually less attractive than the one anchored to the wood mass, with an aesthetically unappealing shape and color.

[0018] The aim of the subject matter of the present invention is therefore to solve the highlighted technical problems, eliminating the drawbacks of the cited background art and thus devising a gasification stove that allows containing the generation of pollutants.

[0019] Within this aim, an object of the invention is to provide a gasification stove which generates a flame with aesthetically appealing shape and color, volumetrically extended so as to be in front of a glass pane for flame inspection.

[0020] Another object is to provide a gasification stove which makes it possible to transmit the heat of combustion as much as possible toward the surrounding home environment, containing losses through the exhaust gases that are conveyed outside through the flue.

[0021] Another object of the present invention is to provide a gasification stove that is structurally simple, has low manufacturing costs and can be manufactured with ordinary known plants.

[0022] This aim and these and other objects which will become more apparent hereinafter are achieved by a gasification stove comprising a containment structure which accommodates a storage tank for biomass fuel, a gasification crucible connected to an expansion chamber which in turn is connected to a combustion chamber, an air-air heat exchanger, characterized in that said expansion chamber, which lies above said gasification crucible and lies below said combustion chamber, has an inter-

mediate section that has larger dimensions than a section for input from said gasification crucible, said gasification crucible, having a substantially tubular shape with constant circular or rectangular cross-section, being delimited, at the lower end, by a first opening adapted to allow the flow of first gasification air that originates from a first plenum, said gasification crucible having, at an upper end, a series of second openings adapted to allow the flow of second combustion air, at a first passage toward said overlying gas expansion chamber.

[0023] Conveniently, the expansion chamber has an intermediate section that has greater dimensions than the output section to said combustion chamber.

[0024] Further characteristics and advantages of the invention will become more apparent from the detailed description of a particular but not exclusive embodiment, illustrated by way of non-limiting example in the accompanying drawings, wherein:

Figure 1 is a schematic lateral perspective view of the gasification stove;
Figure 2 is a partially sectional lateral perspective view of the stove;
Figure 3 is a sectional view of the stove, taken along the plane III-III of Figure 1;
Figure 4 is a view of a detail of the crucible;
Figure 5 is a schematic lateral view of the stove;
Figure 6 is a schematic detail view of the second passage of a third combustion air;
Figure 7 is a schematic detail view of the first passage of a second combustion air;
Figure 8 is a view of a different embodiment.

[0025] In the exemplary embodiments that follow, individual characteristics, given in relation to specific examples, may actually be interchanged with other different characteristics that exist in other exemplary embodiments.

[0026] With reference to the figures, a gasification stove comprising a containment structure 2, of a chosen shape, which accommodates a storage tank 3 for biomass fuel, such as pellets 4, has been designated by the reference numeral 1.

[0027] The tank 3 is connected in a downward region to a discharge duct 14 of the pellets 4.

[0028] The tank 3 is furthermore rendered hermetic and therefore does not allow the entry of air from the discharge duct 14 of the pellets 4.

[0029] There is a gasification crucible 6, having a substantially tubular shape with a constant circular or rectangular cross-section.

[0030] The gasification crucible 6 is delimited, at the lower end 7, by a first opening 8 adapted to allow the flow of a first gasification air 9.

[0031] The air inputs all originate from a duct portion termed plenum, this term meaning a ducting portion for the containment in the "calm" state of more or less intense air flow rate the main function of which is that of dispenser or general manifold.

[0032] In general, plenums are sized so that the speed inside them is significantly lower than the speed inside the inlet channel and outlet channel of the portion in question.

[0033] The first opening 8, through which the first air 9 for gasification passes, is connected to a first plenum 10a fed by a ducted inlet which in turn is fed by a general air supply duct 30.

[0034] The gasification crucible 6 is delimited at the upper end 11 by a series of second openings 12 adapted to allow the flow of a second combustion air 28, at the first passage toward an overlying gas expansion chamber 13 and moreover has a transverse cross-section comprised between 3000 and 7000 mm^2, preferably 5000 mm^2.

[0035] Furthermore, externally to the gasification crucible 6 and proximate to the upper end 11 there is a second plenum 10b, which advantageously surrounds externally the gasification crucible 6, provided with a series of second openings 12, for the second combustion air 28, and therefore coinciding between the first passage from the tubular section of the gasification crucible 6 and the expansion chamber 13.

[0036] The expansion chamber 13 is delimited at the lower end by the series of second openings 12 adapted to allow the flow of the second combustion air 28 at the point of communication with the gasification crucible 6.

[0037] The expansion chamber 13 communicates in an upper region with a combustion chamber 15 and has an output section 16 and an input section 17.

[0038] The combustion chamber 15 has, at the output section 16, from the expansion chamber 13, third openings 16a adapted to allow the flow of a third combustion air 31.

[0039] The expansion chamber 13 has a box-like shape in which there is a section 18, which is intermediate between the section 16, for output toward the combustion chamber 15, and the section 17, for input from the gasification crucible 6, which has larger dimensions than the output section 16 and the input section 17 and is comprised between 7000 and 16.000 mm^2, preferably 13.000 mm^2.

[0040] The input section 17 preferably has an area that is smaller than the intermediate section 18 and is comprised between 5000 and 9000 mm^2.

[0041] Moreover, there is, outside the output section 16, a third plenum 10c, which advantageously surrounds externally the expansion chamber 13 and contains the series of third openings 16a for the third combustion air 31, coinciding between the second passage from the expansion chamber 13 and the combustion chamber 15.

[0042] The area of the section of the combustion chamber 15 arranged above the section 17, for input from the expansion chamber 13 toward the combustion chamber 15, is larger than the area of said section 17 and is comprised between 15.000 and 50.000 mm^2, preferably 33.000 mm^2.

[0043] Coinciding with the combustion chamber 15 there is moreover a glass pane 19 that makes it possible to view the flame from outside and allows the transmission of heat by radiation from the inside of the stove to the surrounding home environment.

[0044] The combustion chamber 15 then has, at the output section 16 of the expansion chamber 13, the third openings 16a, which substantially coincide with the underlying output section 16, and a second upper opening 20 which connects it to the system for heat exchange and expulsion of the exhaust gases.

[0045] The combustion chamber 15 has an additional inlet 23 for a fourth combustion air 24 which is provided on one of its walls 25 and is connected to a fourth plenum 10d, which is connected to the air supply duct 30.

[0046] There is a lighter 29 which communicates with the inside of the gasification crucible 6.

[0047] Figures 1 to 7 relate to a geometry which combines the facts that the intermediate section 18 is larger than the section 17 for input to the expansion chamber 13 and that it is larger than the section 16 for output from the expansion chamber 13.

[0048] Figure 8 relates to the geometry in which the intermediate section 18 is only larger than the section 17 for input to the expansion chamber 13.

[0049] The combustion circuit is thus composed of separate chambers defined by the gasification crucible 6, which extends from the lower end 7 for input of the first gasification air 9, which passes through the first openings 8 up to the section for input of the second combustion air 28 which passes through the second openings 12, from the expansion chamber 13, which extends from the section for input of the second combustion air 28, through the second openings 12 up to the section 16 for output of the third air 31 through the third openings 16a, and from the combustion chamber 15 which extends beyond the output section 16 and comprises the additional inlet 23 for the fourth combustion air 24.

[0050] The combustion chamber 15 is then connected to the rest of the containment structure 2 in order to convey the gases resulting from combustion toward a heat exchanger and then to the combustion gas exhaust system via flue ducts of a known type.

[0051] What defines the beginning and the end of the components is the position of the air inlet points.

[0052] The fan adapted for pumping can operate by propulsion, if it is mounted at the combustion air inlet (positive pressure combustion system), or by suction, if mounted at the stove outlet, before the flue duct (negative pressure combustion system).

[0053] Operating by suction, the air enters from one or more ducts which are connected to the various plenums; each plenum performs the function of distributing the air over all the adapted passage openings.

[0054] Appropriately, but not necessarily, each plenum allows distribution over the entire perimeter of the region affected by the input of air.

[0055] Conveniently, but not necessarily, two or more plenums can be merged into a single larger plenum, leaving the air output points unchanged.

[0056] Operation is as follows: the pellets 4, contained in the hermetic tank 3, are conveyed through the duct 14 into the gasification crucible 6 by using a worm screw, or a helical element, or a motorized screw feeder with appropriate motorized means.

[0057] The pellets 4 fall into the gasification crucible 6 and is retained by the first opening 8: the full/empty ratio of the first opening 8 is such as to retain the intact pellet pieces and allow the flow of air that an optional pumping means 21 or 22, such as a fan, pushes into the crucible 6.

[0058] Once the gasification crucible 6 is partially full, the lighter 29, of the glow plug type, heats it; the chemical phenomenon of pyrolysis is triggered in the internal wooden part in the absence of air (endothermic reaction with release of gases, liquid compounds and combustible solids) and the phenomenon of gasification (exothermic reaction of partial oxidation) where there is a minimum amount of air.

[0059] The accumulated pieces of pellets 4 do not allow an adequate flow of air, therefore creating a situation of heating of the wood mass in an oxygen-deprived condition that does not allow the reaction to proceed to complete combustion, and therefore a syngas and a weak flame that consumes a minimum part thereof are generated.

[0060] The gasification phenomenon, being exothermic, makes it possible to self-sustain the entire pyro-gasification process inside the crucible 6.

[0061] The gas generated inside the gasification crucible 6, which is not involved in combustion, rises upward until it encounters second combustion air 28 coming from the second plenum 10b through the second openings 12.

[0062] It is at that time and in that position that the mixing of syngas and oxygen sufficient to develop the actual flame is triggered.

[0063] The expansion chamber 13 has two specific functions: to allow partial mixing of the syngas with the input oxygen at an expansion of the ducting through the second openings 12, and through the third openings 16a air-syngas recirculations are triggered which reduce particulate emissions in addition to spatially expanding the flame.

[0064] Moreover, the combustion chamber 15 has an additional inlet 23 for the sole purpose of providing the excess of air necessary to ensure completion of the combustion of every molecule of combustible gas.

[0065] The air needed for the gasification and combustion processes flows inside the stove by virtue of one or more suitable pumping means, or fans, such as a first pumping means 22 operating by propulsion or a second pumping means 21 operating by suction.

[0066] The air path goes from a generic inlet at the boundary of the stove, passes inside the general air supply duct 30 of the various plenums flowing inside the first plenum 10a, the second plenum 10b, the third plenum 10c and the fourth plenum 10d, is distributed through the

first opening 8, the second openings 12, the third openings 16a and the additional inlet 23, ends up in the fluid volume comprised in the gasification crucible 6, in the expansion chamber 13 and in the combustion chamber 15; then in the form of combustion gases everything flows into an adapted air-air exchanger (not shown) and then into an exhaust gas expulsion duct.

[0067] The throttling of the air at the various inlets with a possible single pumping means, by propulsion or suction, is ensured by appropriate geometries of air passages placed downstream of the various plenums.

[0068] It has thus been found that the invention achieves the intended aim and objects, a stove having been obtained which allows to activate the pyrolytic and gasifying phenomena in one region of the stove and then the complete oxidation of the syngas in another region with appropriate inputs of air, which although always in hyper-stoichiometric conditions, generate a flame that is visibly equivalent to that of the classic combustion of wood.

[0069] The flame inside the combustion chamber is smooth, i.e., without the tongues of fire that are typical of all pellet-fired stoves, and therefore has a conspicuously much larger volumetric extension, to the benefit of attractive aesthetics.

[0070] A further advantage is that while common pellet-fired stoves of the background art, as the burned power varies, have a flame that is greatly reduced and located almost completely inside the brazier, being invisible to the eye through the glass pane, the flame according to the present solution is in any case developed inside the combustion chamber, in front of the glass pane, even at the corresponding minimum power level and in a much more conspicuous way with respect to stoves of the background art.

[0071] A further advantage of the present invention is that staged combustion, passing through separate positions in which gasification and combustion of the syngas take place, emits particulate matter in smaller quantities than combustion with a flame anchored to the actual wood mass.

[0072] Yet another advantage of the present invention is the possibility to increase or decrease the presence of air inside the stove by virtue of the first pumping means, operating by suction or propulsion, which, appropriately split over the various inlets to the various plenums, distributes the air to the various inlets.

[0073] The presence of the means for conveying the pellets 4 from the tank 3 to the gasification crucible 6 also makes it possible to increase or decrease the addition of the wood mass or pellets 4.

[0074] The two actions, coordinated through the electronic controls, allow the stove according to the present invention to operate at different power levels.

[0075] The materials used, as well as the dimensions that constitute the individual components of the invention, may of course be more pertinent according to the specific requirements.

[0076] The characteristics indicated as advantageous, convenient or the like may also be omitted or replaced with equivalents.

[0077] The disclosures in Italian Patent Application no. 102020000003047, from which this application claims priority, are incorporated herein by reference.

[0078] Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly such reference signs do not have any limiting effect on the interpretation of each element identified by way of example by such reference signs.

Claims

1. A gasification stove (1) comprising a containment structure (2) which accommodates a storage tank (3) for biomass fuel (4), a gasification crucible (6) connected to an expansion chamber (13) which in turn is connected to a combustion chamber (15), an air-air heat exchanger, **characterized in that** said expansion chamber (13), which lies above said gasification crucible (6) and lies below said combustion chamber (15), has an intermediate section (18) that has larger dimensions than a section (17) for input from said gasification crucible (6), said gasification crucible (6), having a substantially tubular shape with constant circular or rectangular cross-section, being delimited, at the lower end (7), by a first opening (8) adapted to allow the passage of a first gasification air (9) that originates from a first plenum (10a), said gasification crucible (6) having, at an upper end (11), a series of second openings (12) adapted to allow the passage of a second combustion air (28) at a first passage toward said overlying gas expansion chamber (13).

2. The gasification stove according to claim 1, **characterized in that** said intermediate section (18) of said expansion chamber (13) has larger dimensions than a section (16) for output toward said combustion chamber (15).

3. The gasification stove according to one or more of the preceding claims, **characterized in that** said expansion chamber (13) communicates in a downward region with said gasification crucible (6) and that its section (17) for input to said expansion chamber (13) has an area that is equal or substantially equal to that of said gasification crucible (6).

4. The gasification stove according to one or more of the preceding claims, **characterized in that** said expansion chamber (13) has a box-like shape in which there is said section (18), which is intermediate between said section (16), for output to said combus-

tion chamber (15), and said section (17), for input toward said expansion chamber (13), which has larger dimensions than said input section (17) and is comprised between 7000 and 16.000 mm^2.

5. The gasification stove according to one or more of the preceding claims, **characterized in that** said expansion chamber (13) has a box-like shape in which there is said section (18), which is intermediate between said section (16), for output to said combustion chamber (15), and said section (17), for input toward said expansion chamber (13), which has larger dimensions than said input section (17) equal to 13.000 mm^2.

6. The gasification stove according to one or more of the preceding claims, **characterized in that** said expansion chamber (13) has a box-like shape in which there is said section (18), which is intermediate between said section (16), for output to said combustion chamber (15), and said section (17), for input toward said expansion chamber (13), said output section (16) being comprised between 5000 and 9000 mm^2.

7. The gasification stove according to one or more of the preceding claims, **characterized in that** the area of the section of said combustion chamber (15) that is arranged above said section (16) for output from said expansion chamber (13) is larger than the area of said section (16) and is comprised between 15.000 and 50.000 mm^2.

8. The gasification stove according to one or more of the preceding claims, **characterized in that** externally to said gasification crucible (6) and proximate to said upper end (11) there is a second plenum (10b), which surrounds externally said gasification crucible (6), provided with a series of second openings (12), for a second combustion air (28), which are arranged at said first passage from the tubular section of said gasification crucible (6) and said expansion chamber (13).

9. The gasification stove according to one or more of the preceding claims, **characterized in that** externally to said expansion chamber (13) and proximate to said output section (16) there is a third plenum (10c), which is provided with a series of third openings (16a), for a third combustion air (31), which are arranged at a second passage from said expansion chamber (13) and said combustion chamber (15).

10. The gasification stove according to one or more of the preceding claims, **characterized in that** said combustion chamber (15) has an additional inlet (23) for a fourth combustion air (24), which is provided on one of its walls (25) and is connected to a fourth plenum (10d), which is connected to a general air supply duct (30).

11. The gasification stove according to one or more of the preceding claims, **characterized in that** it comprises a duct (14) for the discharge of said biomass fuel (4) which comprises a worm screw or a helical element or a motorized screw feeder with appropriate motorized means adapted to increase or decrease the presence of pellets in said gasification crucible (6) and second pumping means (21) or first pumping means (22) adapted to increase or decrease the presence of air inside said stove, said second pumping means (21) or first pumping means (22) and said motorized discharge duct (14) of said biomass fuel (4) allowing said gasification stove to operate at different power levels.

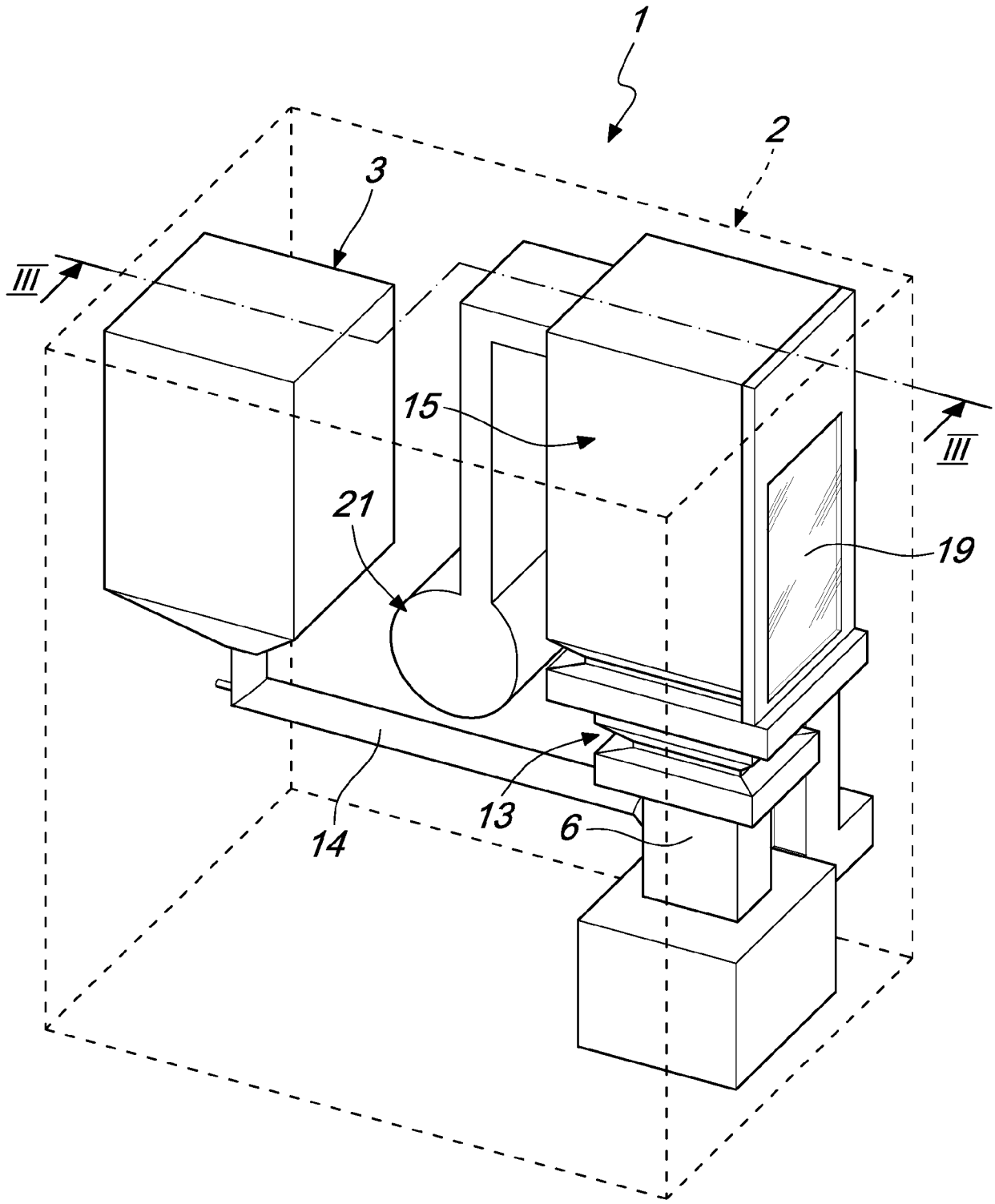

Fig. 1

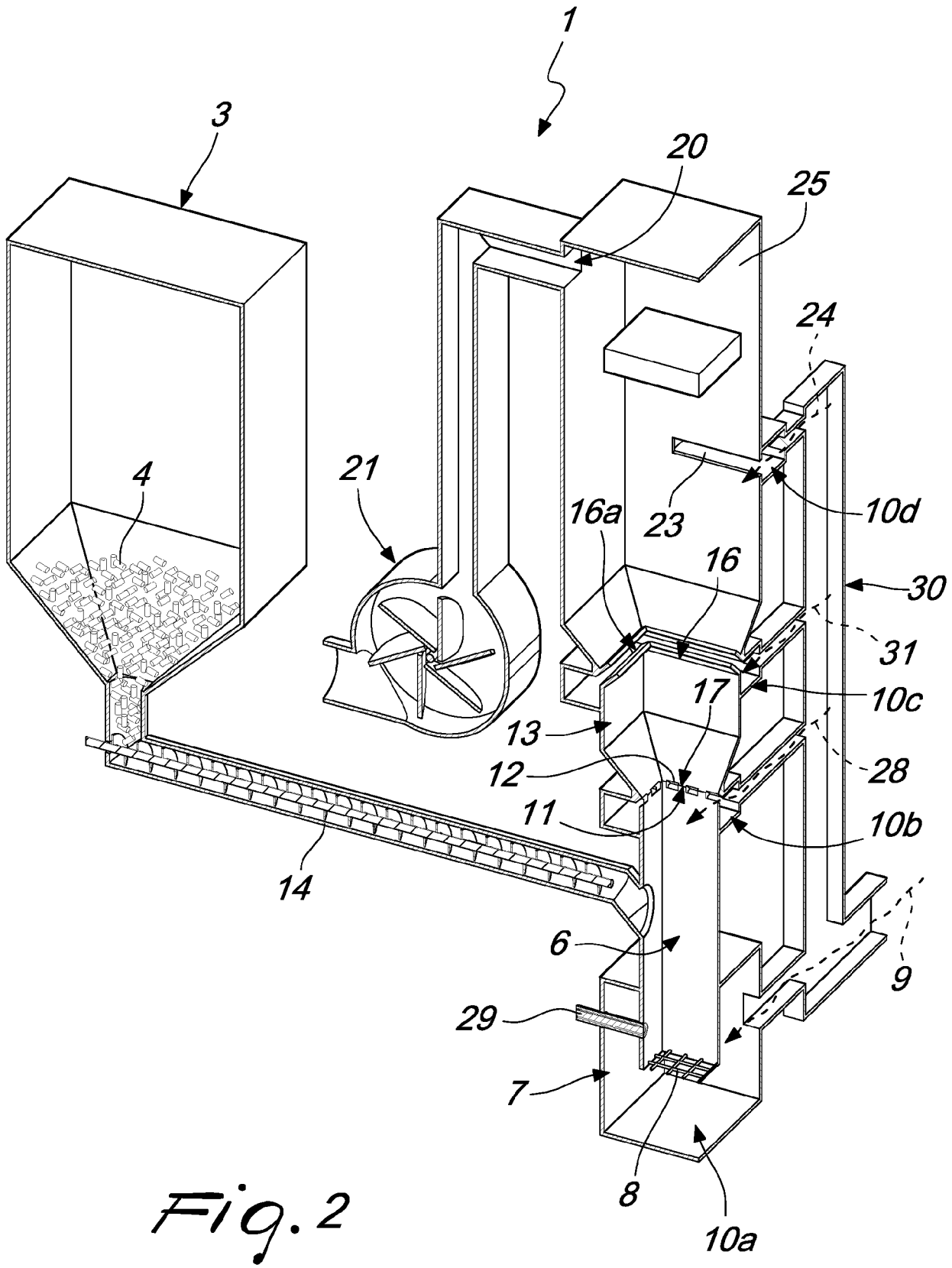
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Fig. 2

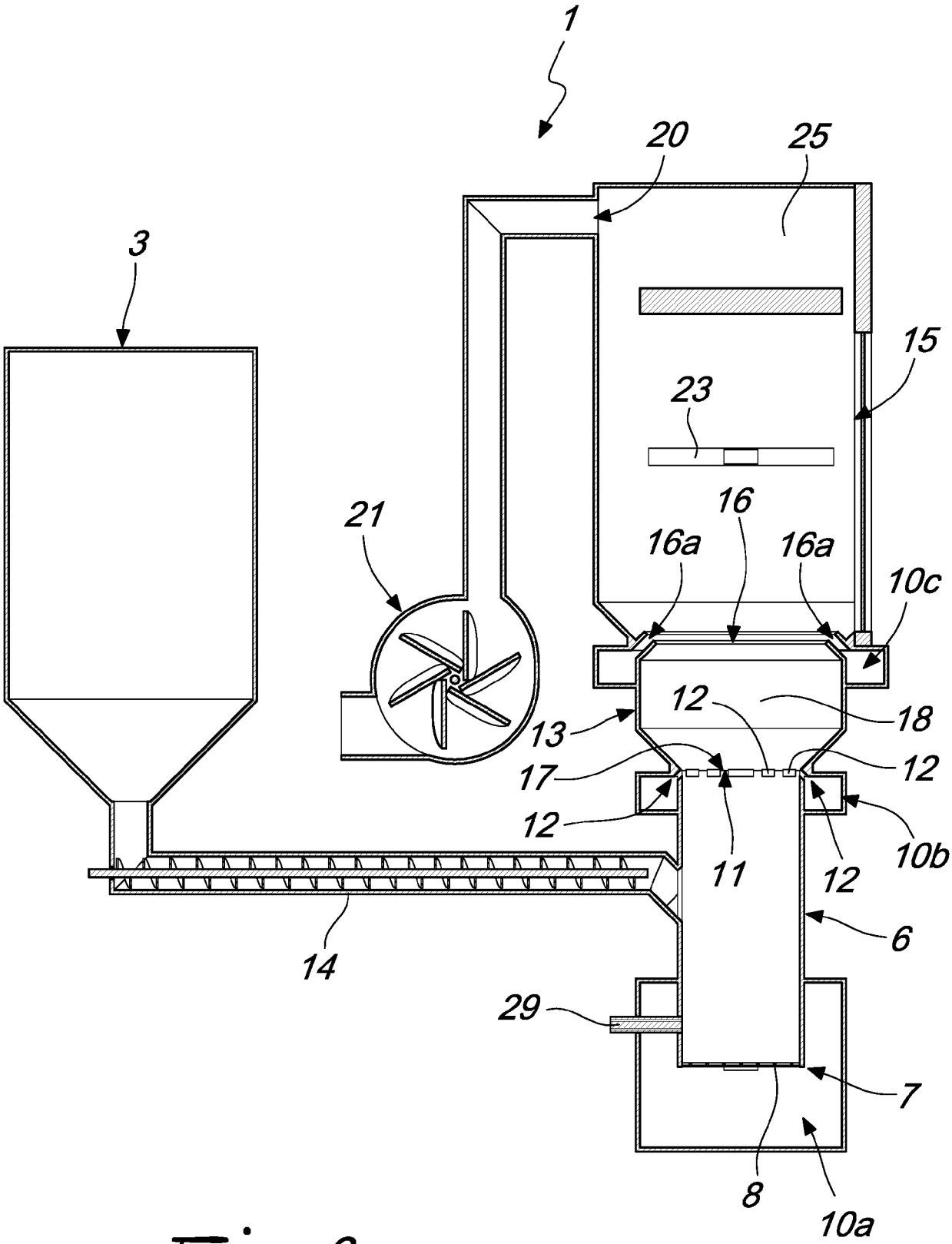
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Fig. 3

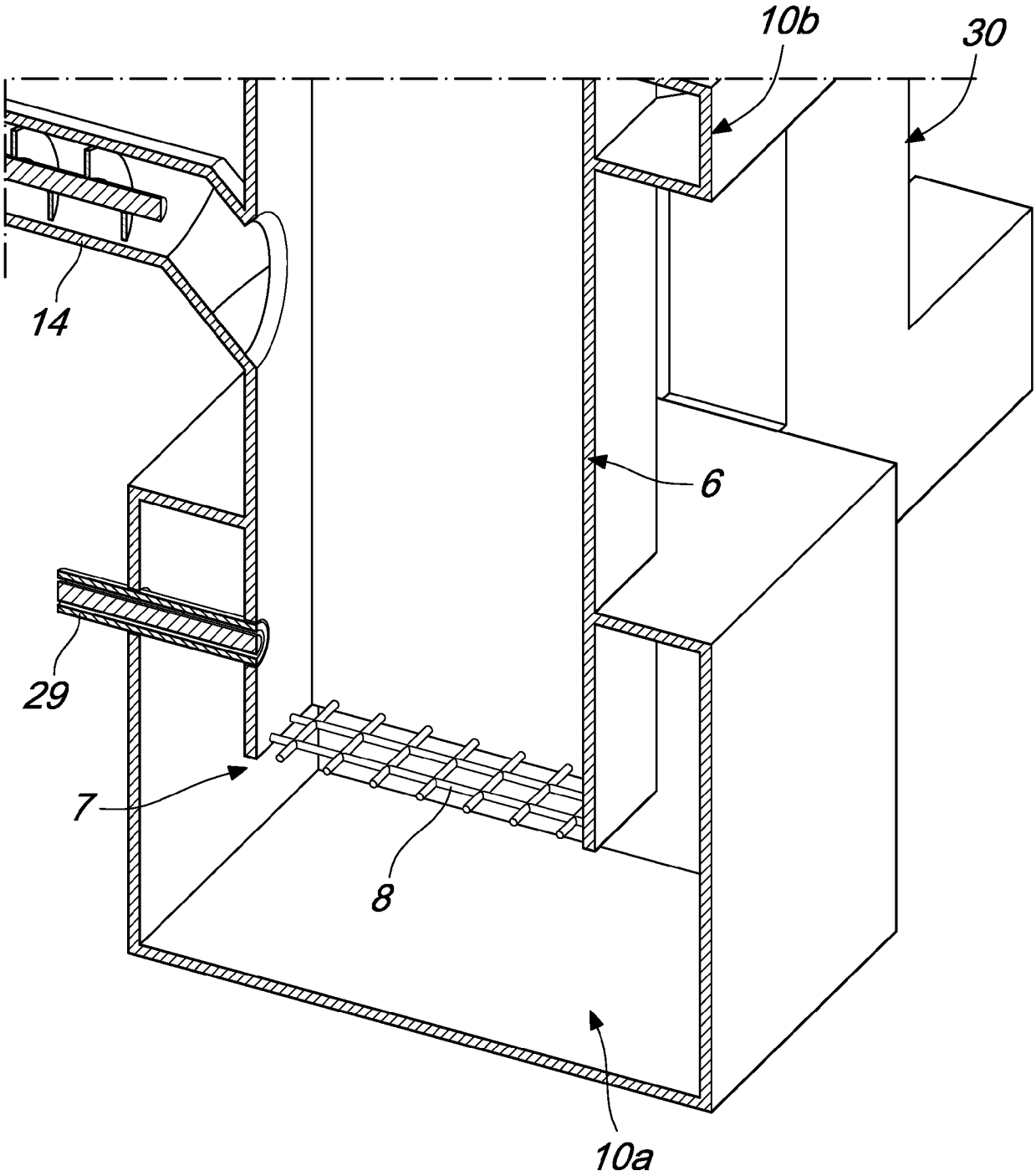

Fig. 4

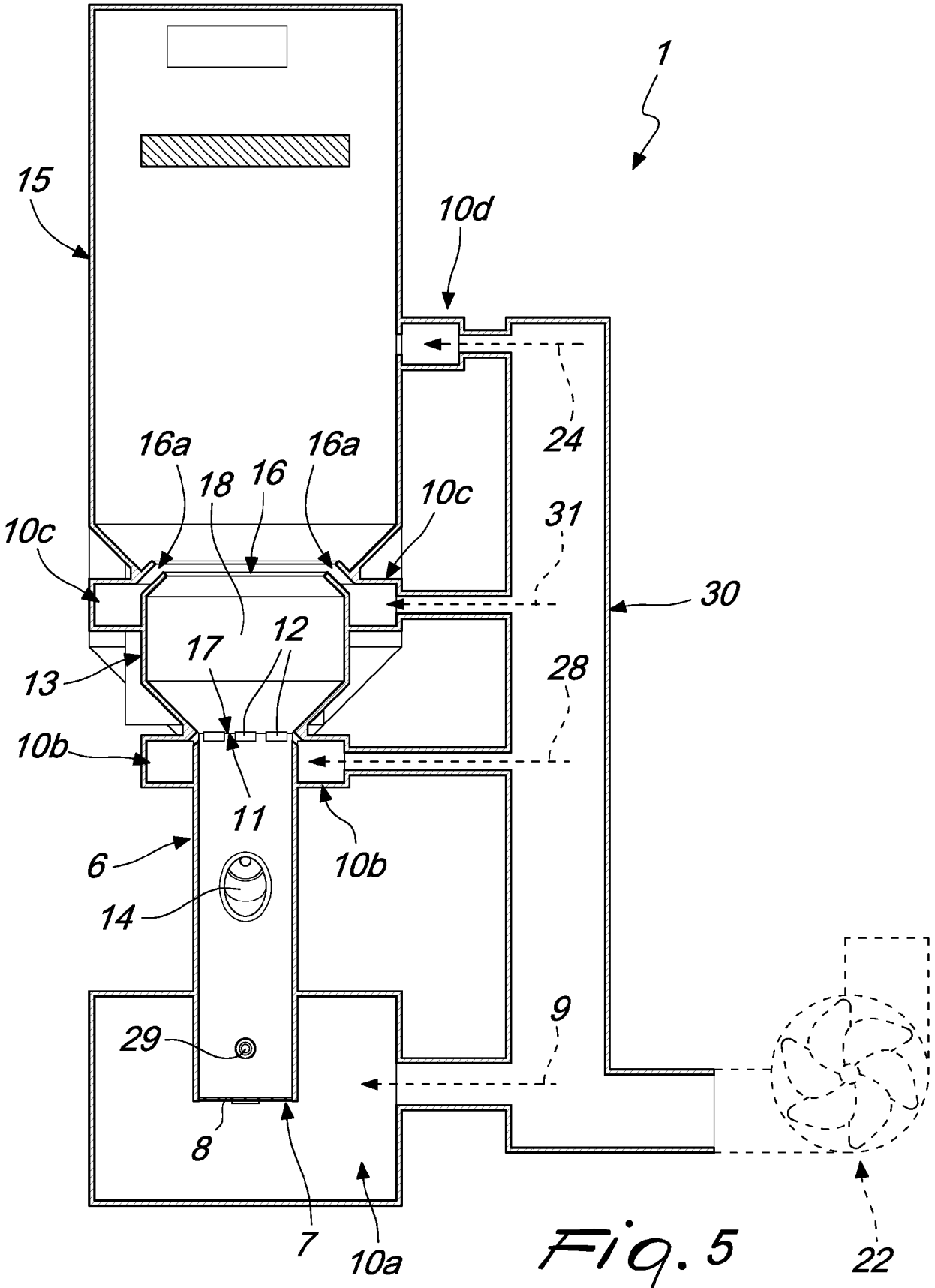
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Fig. 5

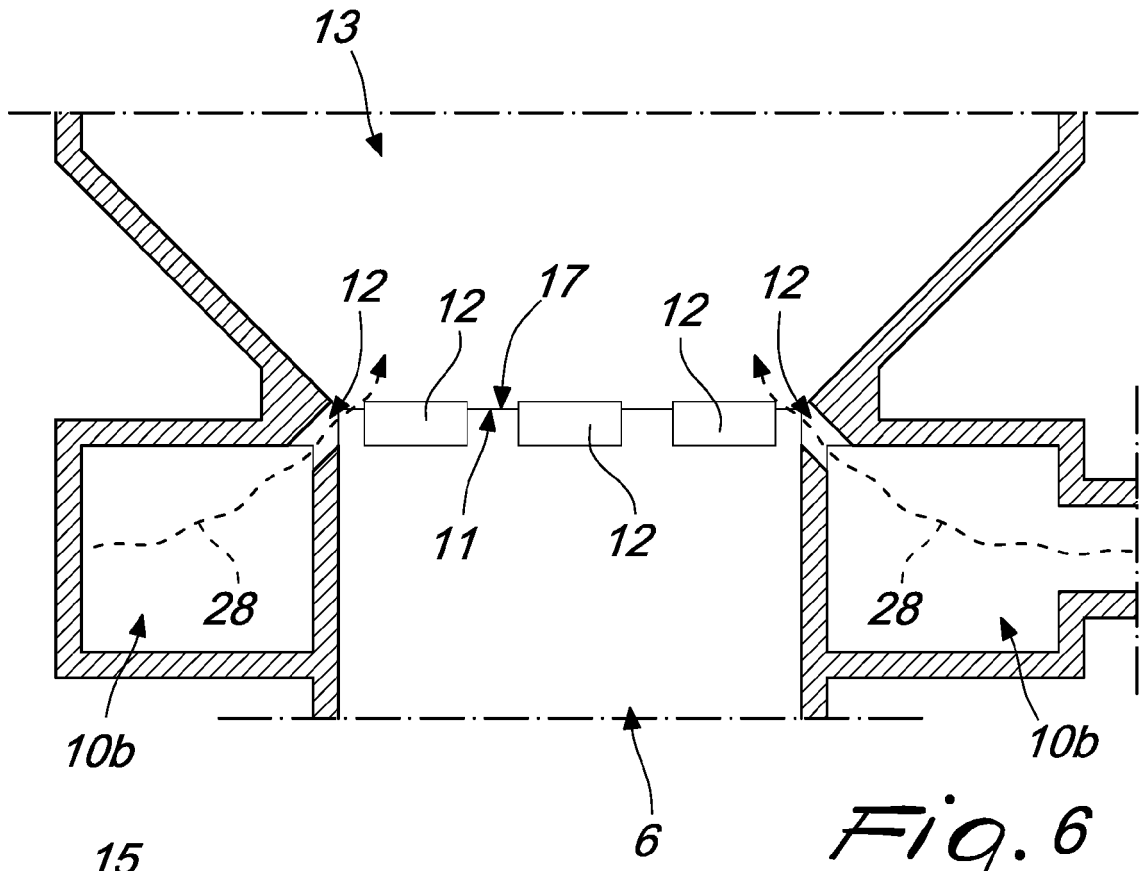

Fig. 6

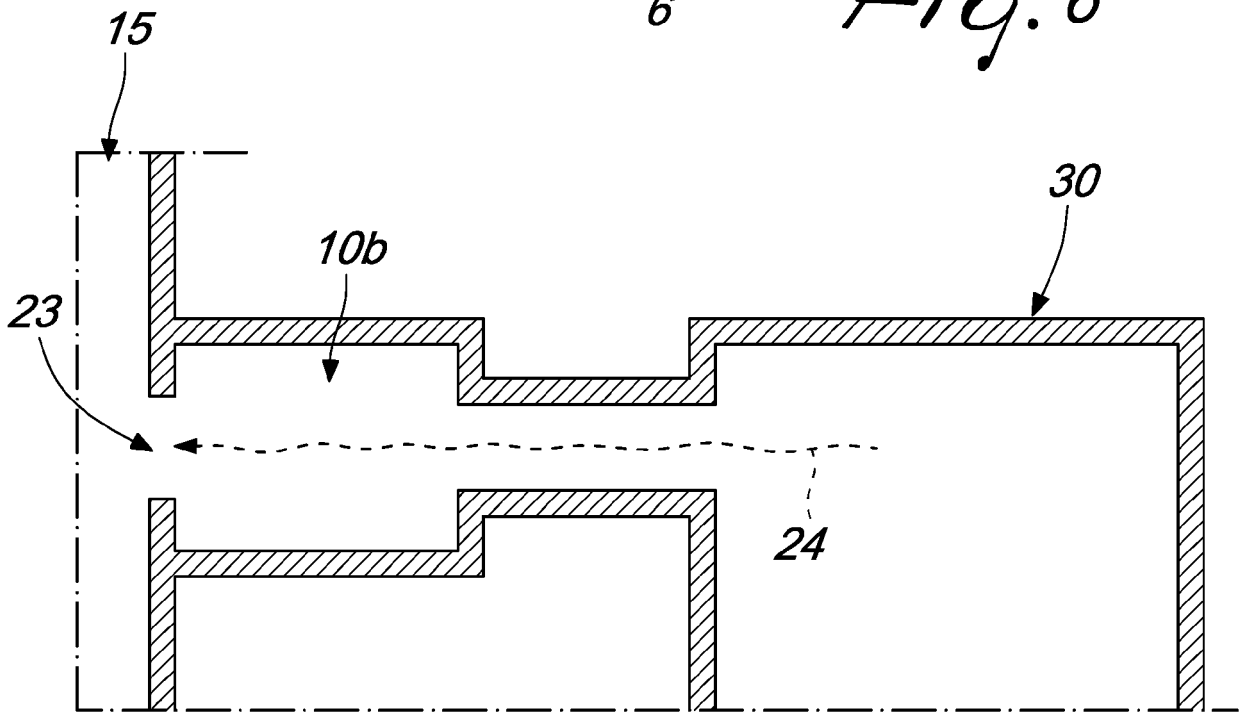

Fig. 7

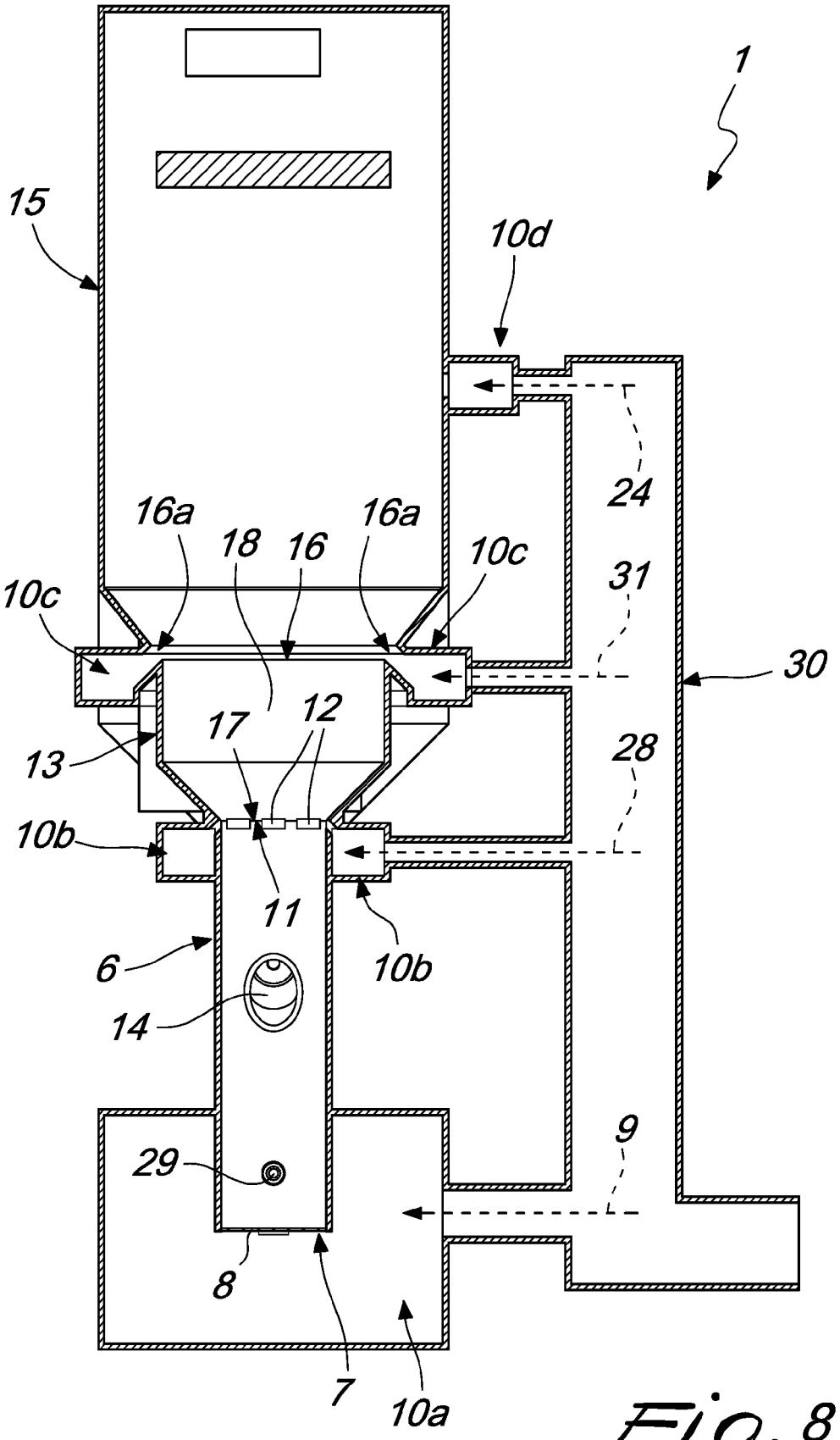
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Fig. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 21 15 7545

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2010/126491 A1 (SWANSON HAROLD ANGUS [CA]) 27 May 2010 (2010-05-27) * paragraphs [0022] - [0024], [0033] * * figures 1, 4 * -----	1,3,8,11	INV. F23B10/02 F23B50/12 F23B60/02 F23B80/04
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Place of search	Date of completion of the search	Examiner
Munich	7 May 2021	Vogl, Paul

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