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(54) **TANK FOR CONTAINING A COMPONENT FLUID, SUCH A PROPELLANT**

TANK ZUR AUFNAHME EINER KOMPONENTENFLÜSSIGKEIT, EIN SOLCHES TREIBMITTEL

RÉSERVOIR DESTINÉ À CONTENIR UN FLUIDE DE COMPOSANT, TEL QU'UN AGENT PROPULSEUR

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Description

TECHNICAL FIELD OF THE INVENTION

[0001] The present invention relates to a tank for containing a component fluid or a mixture of components, such as a propellant fluid, which is liquid, solid or gaseous for engines, as well as a supply unit for an engine.

STATE OF THE PRIOR ART

[0002] Many tanks for component fluids have been proposed, including clearly propellant tanks. Among the propellants, iodine, used to supply aerospace vehicles, is of particular interest.

[0003] In this regard, iodine has a triple point phase diagram and it is loaded into the tanks proposed so far at room temperature, at which the iodine is solid. Subsequently, by heating the iodine from about 80° C-90° C, sublimation begins, thereby obtaining the gas.

[0004] Moreover, plasma, obtained by means of special devices starting from iodine in the gaseous state, is often used for supplying aerospace vehicles.

[0005] The iodine flow rate must therefore be adjusted according to the needs of the engine.

[0006] It is also necessary to keep iodine in the gaseous state in the transfer ducts from the tank to the engine, since if the iodine were to condense, this would cause an obstruction of the ducts which, in particular when a vehicle is in flight, would cause the engine to shut down with ruinous consequences.

[0007] US2013026920A1 discloses a solution according to the state of the art.

OBJECTS OF THE INVENTION

[0008] An object of the present invention is to provide a new tank for containing a component fluid or a mixture of components, such as an engine propellant fluid, if desired a liquid, solid or gaseous propellant, for example iodine.

[0009] Another object of the present invention is to provide a tank for delivering gas, for example of iodine in the gaseous state to engines for the production of plasma, if desired for supplying aerospace vehicles.

[0010] Another object of the present invention is to provide a tank as indicated above which guarantees reliable and simple to be adjusted control of the gas flow rate at the outlet and which is also cheaper than the solutions proposed so far.

[0011] Another object of the present invention is to provide a tank as indicated above which is simple to manufacture also with 3D printing techniques or with other manufacturing techniques.

[0012] Another object of the present disclosure, not falling within the scope of the claims, is to provide a new engine supply unit, for example for propulsion of a vehicle or aerospace medium.

[0013] Another object of the present disclosure, not falling within the scope of the claims, is to provide a supply unit as indicated above, which, in addition to guaranteeing a reliable and simple control of the output gas flow rate to be transformed into plasma, is able to absorb or dampen any peaks of pressure or any pressure drop in the supply gas.

[0014] Another obj ect of the present disclosure, not falling within the scope of the claims, is to provide a unit as mentioned above in which controlled flow rate of outgoing gas is ensured, without the need to use active control elements, such as for example actively controlled valves.

[0015] Another object of the present disclosure, not falling within the scope of the claims, is to provide a supply unit as mentioned above, which is capable of ensuring an appropriate activation of a respective engine.

[0016] Another object of the present disclosure, not falling within the scope of the claims, is to provide a new propulsion group for a vehicle, in particular an aerospace vehicle.

[0017] Another object of the invention is to ensure uniform heating of the iodine throughout the entire operating life of the system, therefore from the condition of complete filling until the condition of complete emptying.

[0018] In accordance with an aspect of the invention, a tank according to claim 1 and a method according to claim 14 for controlling a flow rate from said tank are provided.

[0019] The dependent claims refer to preferred and advantageous embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] Other characteristics and advantages of the invention will be more evident from the description of an embodiment of a tank, a unit and a propulsion group, illustrated only by way of example in the accompanying drawings in which:

- figure 1 is a perspective view slightly from below of a tank according to the present invention;
- figure 2 is a side view of the tank of figure 1 with parts in transparency;
- figure 3 is a perspective view slightly from above of the tank of figure 1;
- figures 4 and 5 are perspective views slightly from above of a tank according to the present invention in an open configuration;
- figures 6, 7 and 8 illustrate details or components of the tank of figure 4;
- figures 9, 10 and 11 are perspective views of a connecting component not falling within the scope of the claims;
- figures 12 and 13 are perspective views of an engine supply unit according to the present invention; not falling within the scope of the claims;
- figure 14 is a schematic view of the unit of figures 12

and 13; and

- figures 15 and 16 are perspective views of a propulsion group not falling within the scope of the claims.

In the attached drawings equal parts or components are marked by the same reference numbers.

EMBODIMENTS OF THE INVENTION

[0021] With reference first to the attached figures, a tank 1 according to the present invention has been illustrated for containing a component fluid or a mixture of components, such as an engine propellant fluid, which is liquid, solid or gaseous. The propellant fluid can comprise iodine, for example for supplying a vehicle or aerospace means.

[0022] In particular, a tank according to the present invention is designed to supply gas, for example iodine in the gaseous state to engines for the production of plasma, if desired for supplying aerospace vehicles.

[0023] The tank 1 can comprise a first main wall or first portion of wall 2, a second main wall or second portion of wall 3. If desired, at least one side wall 4 is also provided for bridge connection between the first main wall 2 and the second main wall 3.

[0024] The walls 2, 3 and 4 delimit at least one housing area 5 of the component or mixture of components. In this regard, the walls 2, 3 and/or 4 are constrained to each other, if desired welded, screwed, bolted or made in a single piece, for example by 3D printing or molding in general, so as to be fluid-tight at the respective constraint edges. Clearly, the walls do not have holes or openings, except at one or more respective points specifically provided for the passage of the component fluid from the tank to components downstream of a respective supply unit, such as a connecting component which will be described later.

[0025] According to the non-limiting embodiment shown in the figures, the walls 2 and 3 have a square or rectangular base, while four side walls 4 are provided, each for bridge connection between a respective side of the first main wall 2 and one side of the second main wall 3. Clearly, the walls 2 and 3 could also have a different configuration.

[0026] If desired, the walls 2, 3 are substantially flat and parallel to each other.

[0027] The second main wall or second wall portion 3 delimits or defines the outlet 3a of the component fluid from the tank 1, while the first main wall or first wall portion 2 is distal from the outlet with respect to the second main wall or second wall portion 3.

[0028] The tank 1 is then also provided with first heating means 6 of the first wall 2 and second heating means 7 of the second wall 3.

[0029] The heating means 6, 7 could include heating plates, for example comprising a sandwich including two sheets or sheets of kapton with a circuit deposited in Inconel® in the middle. Such plates can also be very thin, even 50 microns. Of course, other suitable heating means can also be provided.

[0030] The heating means 6, 7 are powered for example with an electric cable, but, if desired, also with other modes, such as Wi-Fi.

[0031] Clearly, the heating means 6, 7 are constrained, for example glued to the first 2 and to the second 3 wall of the tank 1.

[0032] The tank 1 is then provided with or associated with at least one controller means 8 of the flow rate of the component fluid, if desired iodine leaving the tank 1.

[0033] The at least one controller means 8 could comprise a sensor designed to directly or indirectly detect the flow rate of the component fluid leaving the tank 1. In this regard, the controller means can comprise one or more pressure or temperature sensors 8. The sensors can be used, if necessary, in combination or individually.

[0034] This sensor 8 can be mounted at the outlet of tank 1 or, if desired, also on a component or duct 9 which protrudes from outlet 3a of tank 1.

[0035] Alternatively or additionally, temperature sensors could also be integrated into the heating means 6, 7.

[0036] The tank 1 then comprises a control unit CU designed to operate the heating means 6, 7 so as to keep the first wall 2 at a temperature lower than the second wall 3, the control unit CU being designed to receive the signals of the controller means 8 and consequently controlling the heating means 6, 7 so as to increase, decrease or keep constant the temperature difference between the first wall 2 and the second wall 3 depending on whether the flow rate of the component fluid evaluated or obtained by the control unit CU as a function of the signals received by the controller means 8 is respectively lower, greater than or equal to a given value or range of values.

[0037] Advantageously, the control unit CU sets the heating means 7 so as to obtain a temperature at the second wall 3 which is very high or in any case much higher, at least between 10°C and 30°C higher, of the first wall 2 and therefore it acts on the heating means 6 to raise or lower the temperature only of the first wall 2 to consequently adjust, if necessary, the flow rate of component fluid leaving the tank 1.

[0038] If the component fluid is iodine, then the temperature of the second wall 3 could be between 110°C-120°C, if desired between 110°C and 120°C, while the temperature of the first wall would be maintained or varied between 80°C and 95°C. The delivery pressure of the iodine in the gaseous state could in this case be approximately 37 millibar.

[0039] Actually, the CU unit is arranged to maintain a positive temperature gradient between the bottom or first wall 2 and the head or second wall 3 of the tank 1, since the temperature must always increase from the first to the second wall 3 and, as will also be said in the following, from the first wall 2 to the outlet of the supply unit to an engine, otherwise, this in particular if the component fluid was iodine, there would be the risk of condensation or recondensation of the iodine with clog of the orifices present on the line.

[0040] Each inlet temperature or in any case applied to the first wall 2, will be connected to the outlet pressure from tank 1, as established by Antoine's equation:

$$\log P^0 = A - B/(C+T)$$

[0041] The CU unit, on the base of the pressure values received by the sensor 8, varies, if necessary, the temperature of the heating means, if desired only the first heating means 6 according to any suitable control, for example proportional-derivative.

[0042] Preferably, the flow rate of the component fluid leaving the tank 1 is controlled only thanks to the action of the heating means 6, 7 or only of the first heating means 6.

[0043] The mass flow rate is therefore checked only by checking and adjusting the temperature of the walls or wall 2 of tank 1.

[0044] In this case, if the component fluid was iodine, it is loaded in the solid state and must be caused to sublimate to obtain gas to be transformed into plasma, so that the wall which will preferably control iodine sublimation will advantageously be the first 2, i.e. the less hot one.

[0045] In this regard, in the case of iodine, it has been verified that if the walls 2 and 3 are heated as above, the iodine will gradually compact or solidify on the first wall 2 and then its sublimation will be determined according to the temperature of the walls 2, 3, in particular of the wall 2.

[0046] If desired, the tank 1 can also comprise uprights 11, extending from the edges of the same in the direction of moving away from the first wall 2, for a reason which will be discussed later.

[0047] The tank 1 can also be provided with homogenization means 10 (see in particular figures 4 to 7) of the temperature in the housing area 5, which means 10 are designed to improve the transfer of the thermal energy between the first wall 2 or rather the internal face 2a of the same and the component fluid, such as iodine within the housing area 5 of the tank 1. The homogenization means of the temperature also serve to ensure uniform heating of the iodine during all the operating phases starting from the condition of complete filling to the condition of complete emptying of the tank.

[0048] The homogenization means 10 of the temperature can include for example lamellae, projections, thermal contactors or protrusions distributed within the housing area 5.

[0049] The projections or protrusions 10 can extend from the first wall 2, if desired being welded thereto or in one piece with the same.

[0050] Alternatively, the projections or protrusions 10 can be distributed or scattered within the housing area 5, without necessarily being in contact with the first wall 2. In this case, the projections or protrusions, for example metal shavings, would not be welded to the first wall 2, but placed in a loose configuration (therefore not constrained and free to move) inside the housing area 5 of the tank 1.

[0051] Advantageously, the lamellae or protrusions 10 are distributed according to a lattice or latex structure.

[0052] With reference to the non-limiting example of embodiment shown in the figures, the lamellae or protrusions 10 are distributed according to a configuration that includes a plurality of nodes 10a, 10b, 10c at which respective lamellae or protrusions 10 are joined.

[0053] If desired, the lamellae or protrusions 10 are distributed according to a double tetrahedron configuration. In this case, in the sense from the second wall 3 towards the first wall 2, a first row or plurality of end nodes 10a is provided from which four lamellae 10 depart towards the first wall 2, two, three or more rows or pluralities of intermediate nodes 10b from each of which four lamellae 10 depart towards the nodes of the first row 10a and four blades 10 towards the second wall 3, and a second row or plurality of end nodes 10c from which four lamellae 10 depart towards the intermediate nodes 10b.

[0054] This structure guarantees a sufficiently distributed lattice so as to uniform the temperature in the housing area 5 with a small mass and therefore good lightness of the lamellae or protrusions 10.

[0055] Clearly, gaps 10e are delimited between the lamellae or protrusions 10 for the component fluid, if desired iodine, so that they are not packed together.

[0056] In particular, with iodine as a component fluid, the presence of the lamellae or protrusions 10 is important, since the iodine is strongly insulating, so it would isolate the temperature transfer between the walls 2, 3 or the respective internal faces 2a, 3d and the housing area 5, while the lamellae or protrusions 10 would improve the distribution of the temperature in the housing area 5 and therefore of the iodine inside the same.

[0057] Clearly, the internal faces 2a, 3d of the walls 2, 3 are the faces of the latter inside the tank 1 and delimiting the housing area 5.

[0058] The lamellae or protrusions 10 are also used to crush any pieces of solid iodine that should float within the housing area. This of course can occur in particular if the tank 1 is in a vehicle in space and therefore in the absence of gravity or micro gravity.

[0059] Preferably, the projections or protrusions 10 are not in contact with the second wall 3 or in any case are in contact with an area of the second wall 3 of less than 10%, 20% or 30% of the extension thereof or of the respective internal face 3d . This ensures that the temperature difference between the two walls 2, 3 is maintained.

[0060] In this regard, it is possible to provide an edge or perimeter area in which projections or protrusions 10d are provided, if desired configured as a column, which extend from the first 2 to the second 3 wall and which, actually, support the second wall 3.

[0061] With reference to this aspect, the second wall 3 could comprise a perimeter part 3b in a single piece with the first wall 2 and a removable lid part 3c, which acts as a removable lid for the tank 1. In this case, clearly, the perimeter part 3b could constitute an annular part for the abutment of the removable lid part 3c or the perimeter part 3b could comprise an internal shoulder for the abutment of the part 3c. Clearly, this structure could alternatively be provided for the first wall 2.

[0062] The removable lid part 3c could be attached to the perimeter part 3b or in any case to the remaining components of the tank 1 by any suitable method, for example by means of screws or bolts or glue, if desired with interposition of suitable gaskets.

[0063] In this case, a spacing or support elements 10d could be provided, if desired column-shaped in the perimeter part 5a of the housing area 5 and the projections or protrusions 10 in the central part 5b of the housing area 5, with the spacing elements 10d extending between the first wall 2 and the perimeter part 3b, while the projections or protrusions 10 extend from the first wall 2, but are not directly in contact with the second wall 3, i.e. that a respective end distal from the first wall 2 does not touch the second wall 3 or better a central or intermediate part 3c1 of the removable lid part 3c. Clearly, the removable lid part 3c would also include a lateral part 3c2 resting or intended to be placed, in the closed condition of the tank 1, on the perimeter part 3b or on part of the latter, for example a shoulder 3b 1.

[0064] This arrangement would allow to print the wall 2 and the wall 3 or rather the wall 2 and the perimeter part 3b in one piece also in 3D, even with the direct laser sintering of metals or DMLS technique, which technique clearly does not make it possible to print undercut portions unless precautions, such as the spacing elements or support 10d, are provided.

[0065] In order to load the tank 1 with iodine, one can simply load the solid iodine, or a plate with a hole can be applied to the tank, at which hole a tubular connector is connected in fluid communication with a scale support where iodine is placed. Subsequently, the tubular connector is heated, the support is heated and the iodine fumes are sucked with re-condensation on the bottom of the tank and finally the tank is closed.

[0066] In accordance with the present disclosure, not falling within the scope of the claims, a connecting component or unit 12 of a tank containing a propellant is also provided (see in particular figures 9 to 11), if desired a tank 1 with an engine 13, for example for the propulsion of an aerospace vehicle or means.

[0067] The connecting component 12 can comprise a buffer tank 14, a first opening/closing valve 15, a second opening/closing valve 16, a first pressure reducing component 17a and a second pressure reducing component 17b.

[0068] The connecting component 12 then comprises a first duct or line 18 upstream of the buffer tank 14 intercepted by the first opening/closing valve 15 and by the first pressure reducing component 17a, as well as a second duct or line 19 downstream of the buffer tank 14 and intercepted by the second opening/closing valve 16 and by the second pressure reducing component 17b.

[0069] The first 17a and/or the second 17b pressure reducing component can comprise a calibrated orifice, if desired with a respective filter.

[0070] If desired, the first opening/closing valve 15 is upstream of the first pressure reducing component 17a, while the second opening/closing valve 16 is downstream of the second pressure reducing component 17b.

[0071] The connecting component 12 can also comprise an auxiliary tank 21, for example smaller than the buffer tank 14, between the second pressure reducing component 17b and the second closing/opening valve 16 designed to guarantee a given starting flow rate of propellant.

[0072] The auxiliary tank 21 is to provide, in some operating phases, an overflow required, for example, in the starting phases of the engine.

[0073] If desired, the connecting component 12 could include heaters 22. Thus, for example, heaters, for example heating plates such as heating means 6, 7, can be applied to all the free surfaces of the connecting component 12.

[0074] The connecting component 12 can comprise a box-shaped body delimiting the buffer tank 14 and, if provided, the auxiliary tank 21, if desired to be separated by means of a special septum or membrane.

[0075] In this case, the removable lid part 3c of the second wall could constitute the bottom of the connecting component 12 with walls 12a delimiting the buffer tank 14 and, if provided, the auxiliary tank 21 rising therefrom.

[0076] The connecting component 12 can comprise reinforcing beam elements 12b of a respective closure wall 12c distal from the tank 1.

[0077] If desired, the connecting component 12 also includes a spiral injector 20 which puts the outlet of the connecting component 12 or the respective second duct or line 19 and a respective engine 13 in fluid communication.

[0078] A subj ect-matter of the present disclosure, not falling within the scope of the claims, is also a supply unit or assembly 24 (see in particular figures 12 to 14) of an engine comprising a tank 1 and a connecting component 12 mounted or assembled at the outlet 3a of the tank 1. Advantageously, an unit according to the present invention is designed to feed gas, for example iodine in the gaseous state to engines for the production of plasma for the supply of aerospace vehicles.

[0079] As indicated above, the connecting component 12 can actually also perform the task of lid for the tank 1 and, in this case, they 1, 12 share the removable lid part 3c. Alternatively, the tank 1 could have a respective cover of the second wall 3 released from the connecting component 12 or from any other fittings or ducts.

[0080] Moreover, the connecting component 12 can be arranged, in use, in the area defined by the uprights 11.

[0081] Clearly, the connecting component 12 could also be connected to the tank 1 in another manner.

[0082] As an alternative to a connecting component 12, a special valve could be provided, such as a proportional valve mounted on the outlet or on the outlet line from tank 1.

[0083] The first pressure reducing component 17a serves, in fact, to obtain a certain flow rate, since a specific pressure corresponds to a given flow rate, so that by imposing to the component 17a a pressure of the component fluid, it automatically establishes the flow rate of the latter.

[0084] The second opening/closing valve 16, on the other hand, constitutes a real switch of the supply unit 24.

[0085] With the structure described above, if an overpressure in the unit 24 occurs, this is managed by a so-called bang bang or low pass system, or through a proportional valve, or through direct discharge of the overpressure via a single valve (also an overpressure valve).

[0086] In this respect, as regards in particular the bang bang, if the propellant gas pressure, in a supply unit 24 of an engine comprising a tank 1 and a connecting component 12 mounted at the outlet 3a of the tank 1, is too high (depending on the needs or specifications of the engine), i.e. greater than a first threshold value, the unit 10 closes the first valve 15 and so the buffer tank 14 slowly empties, just that this would naturally occur according to a step transient and in this regard, the second pressure reducing component 17b serves to dampen the pressure peak.

[0087] If then the propellant gas pressure in the supply unit 24 is too low, i.e. less than a second threshold value (always according to the needs or specifications of the engine), or in any case the first valve 15 must be reopened, if the pressure of the tank 1 is high or greater than a respective threshold value, this would cause a high increase in the pressure of the buffer tank 14 and, in this case, the second reducing component 17b would reduce such a pressure.

[0088] In this regard, should the first opening/closing valve 15 be reopened, after it has been closed for a given period, in the event that there is a risk of too high pressure leaving the tank 1, the low pass or better the calibrated orifice 17b adjusts the pressure leaving the buffer tank 14 towards the engine 13, while when the pressure rises too high, the CU unit closes the valve 15 and then reopens it when the pressure is low again.

[0089] With reference to this aspect, the CU unit can comprise a controller means, such as a first pressure or mass flow rate sensor 8 on the first duct or line 18, for example upstream of the first open/close valve 15.

[0090] A second pressure sensor 8a mounted on the buffer tank 14 and designed to measure the pressure in the latter and to communicate it to the control unit CU can also be provided.

[0091] For the operation of the unit 24, the first valve 15 opens, so that the components of this unit fill with sublimated gas, in a manner such that when the unit 24 is in the expected supply conditions (flow rate), then the unit 10 opens the second valve 16.

[0092] The buffer tank 14, as indicated above, in combination with the second pressure reducing component 17b can play the role of damper, since it serves to dampen the pressure peaks that can derive from the tank 1.

[0093] The flow rate is then adjusted according to the pressure in the buffer tank 14 and from the passage section in the second pressure reducing component 17b.

[0094] The first opening/closing valve 15 and/or the second closing/opening valve 16 can comprise a so-called normally-closed valve.

[0095] The unit 24 can be equipped with devices to increase the accuracy of the flow rate control, such as for example proportional valves, heated capillary tubes, volumes controlled in PWM by pairs of valves, etcetera.

[0096] In a unit according to the present invention, the component fluid, such as iodine is kept in the gaseous state from the tank 1 to the engine 13, and clearly, if provided, also in a connecting component 12. In the tank 1, as above indicated, iodine can also be present in the solid stage and sublimate a little at a time.

[0097] In this regard, the temperature within the unit 24 is always increasing in the passage from the tank 1 to the engine 13, otherwise the component fluid, if desired, the iodine would re-condense, thereby clogging the orifices of unit 24.

[0098] The unit 24 can also comprise special filters, for example a filter 25 at the outlet from the tank 1 designed to prevent the solid component fluid from entrying into the connecting component 12 at an inlet thereof, which, according to the embodiment illustrated in the figures also defines part of the outlet 3a of the component fluid from the tank 1, the other part of which can be defined on the bottom of the connecting component 12. The filter 25 could comprise a sintered disk in Inconel® or another material compatible with iodine or coated, such as for example titanium, gold, silver.

[0099] The filter 25 could be housed in a special seat 26 defined for example by the tank or by a section of wall extending from one of the walls 2, 3, 4 thereof.

[0100] If desired, the unit 24 is also equipped with temperature sensors, for example a first temperature sensor 8b designed to evaluate the temperature of the second wall 3 and/or a second temperature sensor 8c designed to evaluate the temperature of the connecting component or of a wall of the same.

[0101] One or each sensor 8, 8a, 8b, 8c is in electrical communication with the control unit CU.

[0102] Moreover, valves 15 and 16, if provided, are also in electrical communication with the control unit CU and controllable by the same.

[0103] The walls of the tank 1 and also of the connecting component 12 could be in a suitable resistant material, for example in nickel superalloy, if desired Inconel® 625, or in titanium or materials coated with gold or other compatible metals, for example silver.

[0104] Subj ect-matter of the present disclosure, not falling within the scope of the claims, is also a propulsion group or engine 27 (see in particular figures 15 and 16) of a vehicle, such as an aerospace vehicle, which comprises a unit 24 as well as an engine 13 in fluid communication with the outlet of the connecting component 12, for example connected by means of a special transfer duct 30 of the gas or propellant from the unit 24 to the engine 13. An engine according to the present invention is designed to produce plasma for supplying aerospace vehicles starting from a gas, for example starting from iodine in the gaseous state.

[0105] An engine according to the present invention or which can be powered by a tank or a unit in accordance with the present invention could for example be the subject-matter of the international application published under the number WO2016113707A1.

[0106] If desired, the uprights 11 are screwed to the frame 13a of the engine 13.

[0107] The external faces of the unit 24 or the external walls 28 of the propulsion group 27 can be suitably treated so as to isolate them properly, although a sufficient temperature passage towards the outside must be guaranteed, so that the propulsion group 27, if necessary, can be cooled more or less quickly.

[0108] In accordance with the present invention, a method for controlling the flow rate leaving from a tank 1 or from a supply unit 24 is also provided, according to which the flow rate of the component fluid leaving the tank 1 is detected directly or indirectly, and, if this flow rate is not in a predetermined range, then a control unit CU acts on the heating means 6, 7 so as to increase or decrease the temperature difference between the first wall 2 and the second wall 3.

[0109] Advantageously, the control unit CU sets the heating means 7 so as to have a temperature at the second wall 3 which is very high or in any case much higher than the first wall 2, and therefore acts on the heating means 6 to raise or lower the temperature of the first wall 2 to consequently adjust, if necessary, the flow rate of component fluid leaving the tank 1.

[0110] Clearly, what has been described with respect to tank 1 and unit 24 or better to their operation, it is applied to a method in accordance with the present invention.

[0111] Similar reasoning applies with reference to the management of an over pressure in the unit 24 by means of a so-called bang bang or low pass system.

[0112] As will be appreciated, the present invention generally relates to the adjustment of the flow rate of a component fluid, advantageously iodine leaving a tank 1.

[0113] The component fluid, such as iodine, is heated in order to have a solid phase and a vapor or gas phase in the tank 1.

[0114] The opening of a valve, if desired the first open/close valve 15, allows the delivery of iodine in the vapor phase to the users, for example a propulsion system, such as an engine 13.

[0115] The thermal dynamics of the system is very complex because, as indicated above, solid iodine acts as an insulator and tends to heat up only when it is in contact with hot surfaces, while remaining cold in the core or in the central part.

[0116] Moreover, if the system is to operate in the absence of gravity, it is plausible to expect that solid iodine will detach from the hot walls by floating in a vacuum, resulting in an extremely complex system dynamic. As indicated above, usually in systems or iodine tanks it is heated in such a way as to have sufficient pressure, then adjusting the leaving mass flow rate through a flow regulation system.

[0117] On the other hand, a tank according to the present invention comprises two parts, a second wall 3 placed at a high temperature with respect to the condensation temperature of the iodine, which has the purpose of not providing a condensation surface and a first wall 2, if desired equipped with lamellae or projections placed at the iodine fine control temperature set so as to allow a precise thermal control of the solidification of the same.

[0118] The possible presence of the lamellae 10 allows to increase the surface-volume ratio and therefore allows to warm the iodine deeply and in a uniform way and, at the same time, ensures that, in case of floating of the pieces of iodine, no pieces of iodine too far from hot surfaces are to be found.

[0119] Thanks to these measures, a precise iodine thermal control is obtained without the need for additional external control devices.

[0120] A direct or indirect measurement of the flow rate of the component fluid leaving the tank 1 is satisfactory to obtain a feedback control of the temperature of the first wall 2.

[0121] Clearly, the presence of a mass flow rate meter would increase the accuracy of the system, while increasing its costs.

[0122] If further external flow control is required, in any case the present invention would make it possible to substantially reduce the control authority required by such control.

[0123] Basically, the output gas flow rate is obtained, without the need to use active control elements, such as for example actively controlled valves, but only through the fine control of the tank temperature and the measurement of parameters, such as pressure or mass.

[0124] Changes and variations of the invention are possible within the scope defined by the claims.

Claims

1. Tank for containing a component fluid or a mixture of components, said tank comprising a first main wall or first wall portion (2), a second main wall or second wall portion (3), said walls delimiting at least one housing area (5) of said component fluid or mixture of components, first heating means (6) of said first wall (2) or first wall portion (2) and second heating means (7) of said second wall or second wall portion (3), at least one controller means (8) of the flow rate

of said component fluid leaving said tank, a control unit (CU) designed to operate said heating means (6, 7) so as to maintain said first wall (2) at a temperature lower than said second wall (3), said control unit (CU) being designed to receive the signals of said controller means (8) and to consequently control said heating means (6, 7) so as to increase, decrease or keep constant the temperature difference between said first wall (2) and said second wall (3) according to whether the flow rate of said component fluid evaluated or obtained by said control unit (CU) as a function of the signals received by said at least one controller means (8) is respectively less than, greater than or equal to a given value or range of values.

2. Tank according to claim 1, wherein said at least one control unit (CU) is designed to set said second heating means (7) so as to have a temperature at the second wall (3) higher than the temperature at the first wall (2) and is therefore designed to act on the first heating means (6) to raise or lower the temperature of the first wall (2) to consequently adjust, if necessary, the flow rate of component fluid leaving the tank.

3. Tank according to claim 1, wherein said flow rate of said first component leaving the tank is controlled only thanks to the action of the heating means (6, 7).

4. Tank according to claim 1, 2 or 3, wherein said at least one controller means (8) comprises a sensor designed to directly or indirectly detect the flow rate of said first component leaving the said tank.

5. Tank according to claim 4, wherein said at least one controller means comprises at least one pressure or temperature sensor.

6. Tank according to any of the preceding claims for containing a liquid, solid or gaseous propellant fluid for engines.

7. Tank according to claim 6, for the supply of gas to engines for the production of plasma, if desired to supply an aerospace vehicle.

8. Tank according to claim 6 or 7, wherein said propellant fluid is or comprises iodine.

9. Tank according to any one of the preceding claims, comprising homogenization means (10) of the temperature in said at least one housing area (5), said homogenization means (10) being designed to improve the transfer of thermal energy between said first wall (2) and the component fluid contained in the housing area.

10. Tank according to claim 9, wherein said temperature homogenization means (10) comprise lamellae, projections, thermal contactors or protrusions distributed within said at least one housing area (5).

11. Tank according to claim 10, wherein said lamellae or protrusions extend or are in a single piece with said first wall (2).

12. Tank according to claim 10 or 11, wherein said lamellae or protrusions are not in contact with said second wall (3) or in any case are in contact with an area of said second wall (3) of less than 10%, 20% or 30% of the extension of the same or of a respective internal face (3d).

13. Tank according to claim 9 or 10, wherein said lamellae or protrusions (10) are distributed along a lattice or latex structure.

14. Method for controlling the flow rate leaving from a tank according to any one of claims 1 to 13, comprising the following steps:

- detecting the flow rate of the component fluid leaving the tank (1),
- if this flow rate is not in a predetermined range then said control unit (CU) acts on the heating means (6, 7) so as to increase or decrease the temperature difference between the first wall (2) and the second wall (3).

15. Method according to claim 14, wherein said control unit (CU) sets the second heating means (7) so as to have a temperature at the second wall (3) higher than the first wall (2) and therefore acts on the first heating means (6) to raise or lower the temperature of the first wall (2) to consequently adjust, if necessary, the flow rate of component fluid leaving the tank.

Patentansprüche

1. Tank zur Aufnahme eines Komponentenfluids oder einer Mischung von Komponenten, der besagte Tank umfassend eine erste Hauptwand oder einen ersten Wandabschnitt (2), eine zweite Hauptwand oder einen zweiten Wandabschnitt (3), wobei die besagten Wände mindestens einen Aufnahmebereich (5) des besagten Komponentenfluids oder der besagten Mischung von Komponenten begrenzen, erste Heizmittel (6) der besagten ersten Wand (2) oder des besagten ersten Wandabschnitts (2) und zweite Heizmittel (7) der besagten zweiten Wand oder des besagten zweiten Wandabschnitts (3), mindestens ein Steuerungsmittel (8) der Durchflussmenge des besagten Komponentenfluids, das aus dem besagten Tank austritt, eine Steuereinheit (CU), die dazu ausgelegt ist, die besagten Heizmittel (6, 7) zu betreiben, um die besagte erste Wand (2) auf einer niedrigeren Temperatur als die besagte zweite Wand (3) zu halten, wobei die besagte Steuereinheit (CU) dazu ausgelegt ist, die Signale des besagten Steuerungsmittel (8) zu empfangen und folglich die besagten Heizmittel (6, 7) zu steuern, um die Temperaturdifferenz zwischen der besagten ersten Wand (2) und der besagten zweiten Wand (3) zu erhöhen, zu verringern oder konstant zu halten, je nachdem, ob die Durchflussmenge des besagten Komponentenfluids, die von der besagten Steuereinheit (CU) als eine Funktion der von dem besagten mindestens einen Steuerungsmittel (8) empfangenen Signale bewertet oder erhalten wird, jeweils kleiner als, größer als oder gleich einem gegebenen Wert oder Wertebereich ist.

2. Tank nach Anspruch 1, worin die besagte mindestens eine Steuereinheit (CU) dazu ausgelegt ist, das besagte zweite Heizmittel (7) einzustellen, um eine Temperatur an der zweiten Wand (3) zu erhalten, die höher ist als die Temperatur an der ersten Wand (2) und daher dazu ausgelegt ist, auf das erste Heizmittel (6) einzuwirken, um die Temperatur der ersten Wand (2) zu erhöhen oder zu senken, um folglich, bei Bedarf, die Durchflussmenge des aus dem Tank austretenden Komponentenfluids anzupassen.

3. Tank nach Anspruch 1, worin die besagte die Durchflussmenge der besagten ersten aus dem Tank austretenden Komponente nur dank der Wirkung der Heizmittel (6, 7) gesteuert wird.

4. Tank nach Anspruch 1, 2 oder 3, worin das besagte mindestens eine Steuerungsmittel (8) einen Sensor umfasst, der dazu ausgelegt ist, die Durchflussmenge der besagten ersten aus dem Tank austretenden Komponente direkt oder indirekt zu erfassen.

5. Tank nach Anspruch 4, worin das besagte mindestens eine Steuerungsmittel mindestens einen Druck- oder Temperatursensor umfasst.

6. Tank nach irgendeinem der vorangegangenen Ansprüche zur Aufnahme eines flüssigen, festen oder gasförmigen Treibstofffluids für Motoren.

7. Tank nach Anspruch 6 zur Gasversorgung von Motoren für die Erzeugung von Plasma, gegebenenfalls zur Versorgung eines Luft- und Raumfahrzeugs.

8. Tank nach Anspruch 6 oder 7, worin das besagte Treibstofffluid Jod ist oder umfasst.

9. Tank nach irgendeinem der vorangegangenen Ansprüche, umfassend Homogenisierungsmittel (10) der Temperatur in dem besagten mindestens einen Aufnahmebereich (5), wobei die besagten Homogenisierungsmittel (10) dazu ausgelegt sind, die Übertragung von Wärmeenergie zwischen der besagten ersten Wand (2) und des in dem Aufnahmebereich enthaltenen Komponentenfluids zu verbessern.

10. Tank nach Anspruch 9, worin die besagten Temperaturhomogenisierungsmittel (10) Lamellen, Überstände, thermische Schütze oder Vorsprünge umfassen, die in dem besagten mindestens einen Aufnahmebereich (5) verteilt sind.

11. Tank nach Anspruch 10, worin die besagten Lamellen oder Vorsprünge sich mit der besagten ersten Wand (2) erstrecken oder einstückig mit ihr sind.

12. Tank nach Anspruch 10 oder 11, worin die besagten Lamellen oder Vorsprünge nicht in Kontakt mit der besagten zweiten Wand (3) sind oder in jedem Fall in Kontakt mit einem Bereich der besagten zweiten Wand (3) von weniger als 10 %, 20 % oder 30 % der Erstreckung derselben oder einer jeweiligen Innenfläche (3d) sind.

13. Tank nach Anspruch 9 oder 10, worin die besagten Lamellen oder Vorsprünge (10) entlang einer Gitter- oder Latexstruktur verteilt sind.

14. Verfahren zur Steuerung einer aus einem Tank austretenden Durchflussmenge nach irgendeinem der Ansprüche 1 bis 13, umfassend die folgenden Schritte:

- Erfassen der Durchflussmenge des aus dem Tank (1) austretenden Komponentenfluids,
- wenn diese Durchflussmenge nicht in einem vorbestimmten Bereich liegt, wirkt die besagte Steuereinheit (CU) auf die Heizmittel (6, 7) ein, um die Temperaturdifferenz zwischen der ersten Wand (2) und der zweiten Wand (3) zu erhöhen oder zu verringern.

15. Verfahren nach Anspruch 14, worin die besagte Steuereinheit (CU) das zweite Heizmittel (7) einstellt, um eine Temperatur an der zweiten Wand (3) zu erhalten, die höher ist als die erste Wand (2) und daher auf das erste Heizmittel (6) einwirkt, um die Temperatur der ersten Wand (2) zu erhöhen oder zu senken, um folglich, bei Bedarf, die Durchflussmenge des aus dem Tank austretenden Komponentenfluids anzupassen.

Revendications

1. Réservoir contenant un composant fluide ou un mélange de composants, ledit réservoir comprenant une première paroi principale ou une première portion de paroi (2), une deuxième paroi principale ou une deuxième portion de paroi (3), lesdites parois délimitant au moins une zone de logement (5) dudit composant fluide ou mélange de composants, des premiers moyens de chauffage (6) de ladite première paroi (2) ou première portion de paroi (2) et des deuxièmes moyens de chauffage (7) de ladite deuxième paroi ou deuxième portion de paroi (3), au moins un moyen de contrôleur (8) du débit dudit composant fluide sortant dudit réservoir, une unité de commande (CU) conçue pour faire fonctionner lesdits moyens de chauffage (6, 7) de manière à maintenir ladite première paroi (2) à une température inférieure à celle de ladite deuxième paroi (3), ladite unité de commande (CU) étant conçue pour recevoir les signaux dudit moyen de contrôleur (8) et par conséquent pour contrôler lesdits moyens de chauffage (6, 7) de manière à augmenter, diminuer ou maintenir constante la différence de température entre ladite première paroi (2) et ladite deuxième paroi (3) selon que le débit dudit composant fluide évalué ou obtenu par ladite unité de commande (CU) en fonction des signaux reçus par ledit au moins un moyen de contrôleur (8) est respectivement inférieure, supérieure ou égale à une valeur ou plage de valeurs donnée.

2. Réservoir selon la revendication 1, dans lequel ladite au moins une unité de commande (CU) est conçue pour régler ledit deuxième moyen de chauffage (7) de manière à avoir une température au niveau de la deuxième paroi (3) supérieure à la température de la première paroi (2) et est donc conçue pour agir sur les premiers moyens de chauffage (6) pour élever ou abaisser la température de la première paroi (2) pour ajuster en conséquence, si nécessaire, le débit du composant fluide sortant du réservoir.

3. Réservoir selon la revendication 1, dans lequel ledit débit dudit premier composant sortant du réservoir n'est contrôlé que grâce à l'action des moyens de chauffage (6, 7) .

4. Réservoir selon la revendication 1, 2 ou 3, dans lequel ledit au moins un moyen de contrôleur (8) comprend un capteur conçu pour détecter directement ou indirectement le débit dudit premier composant sortant dudit réservoir.

5. Réservoir selon la revendication 4, dans lequel ledit au moins un moyen de contrôleur comprend au moins un capteur de pression ou de température.

6. Réservoir selon l'une quelconque des revendications précédentes pour contenir un fluide propulseur pour moteurs liquide, solide ou gazeux.

7. Réservoir selon la revendication 6, pour l'alimentation en gaz de moteurs pour la production de plasma, si désiré pour alimenter un véhicule aérospatial.

8. Réservoir selon la revendication 6 ou 7, dans lequel ledit fluide propulseur est ou comprend de l'iode.

9. Réservoir selon l'une quelconque des revendications précédentes, comprenant des moyens d'homogénéisation (10) de la température dans ladite au moins une zone de logement (5), lesdits moyens d'homogénéisation (10) étant conçus pour améliorer le transfert d'énergie thermique entre ladite première paroi (2) et le composant fluide contenu dans la zone de logement.

10. Réservoir selon la revendication 9, dans lequel lesdits moyens d'homogénéisation (10) de la température comprennent des lamelles, des saillies, des contacteurs thermiques ou des protubérances répartis dans ladite au moins une zone de logement (5).

11. Réservoir selon la revendication 10, dans lequel lesdites lamelles ou protubérances s'étendent ou sont en une seule pièce avec ladite première paroi (2).

12. Réservoir selon la revendication 10 ou 11, dans lequel lesdites lamelles ou protubérances ne sont pas en contact avec ladite deuxième paroi (3) ou en tous cas sont en contact avec une zone de ladite deuxième paroi (3) inférieure à 10 %, 20 % ou 30 % de l'extension de celle-ci ou d'une face interne respective (3d).

13. Réservoir selon la revendication 9 ou 10, dans lequel lesdites lamelles ou protubérances (10) sont réparties le long d'une structure en treillis ou en latex.

14. Procédé pour contrôler le débit sortant d'un réservoir selon l'une quelconque des revendications 1 à 13, comprenant les étapes suivantes :

- détection du débit du composant fluide sortant du réservoir (1),
- si ce débit n'est pas dans une plage prédéterminée, alors ladite unité de commande (CU) agit sur les moyens de chauffage (6, 7) de manière à augmenter ou diminuer la différence de température entre la première paroi (2) et la deuxième paroi (3).

15. Procédé selon la revendication 14, dans lequel ladite unité de commande (CU) règle le deuxième moyen de chauffage (7) de manière à avoir une température au niveau de la deuxième paroi (3) supérieure à celle de la première paroi (2) et agit donc sur les premiers moyens de chauffage (6) pour augmenter ou abaisser la température de la première paroi (2) pour ajuster en conséquence, si nécessaire, le débit du composant fluide sortant du réservoir.

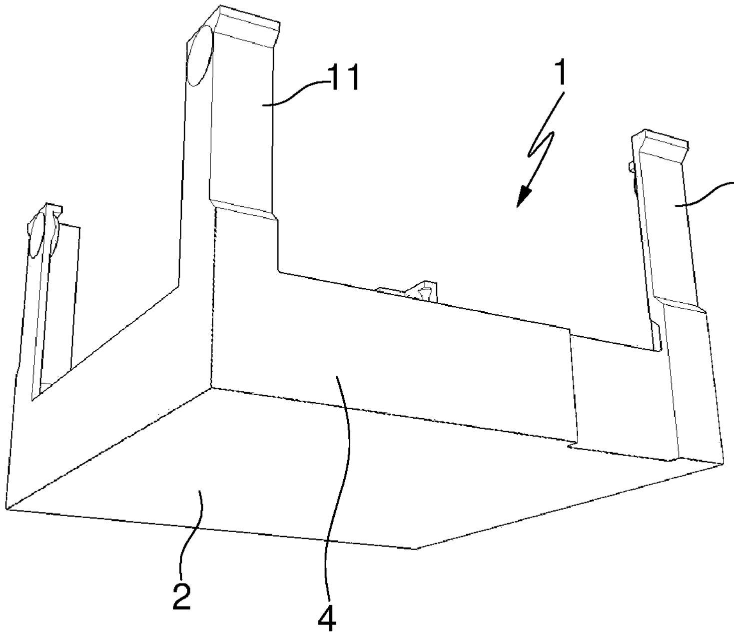

FIG. 1

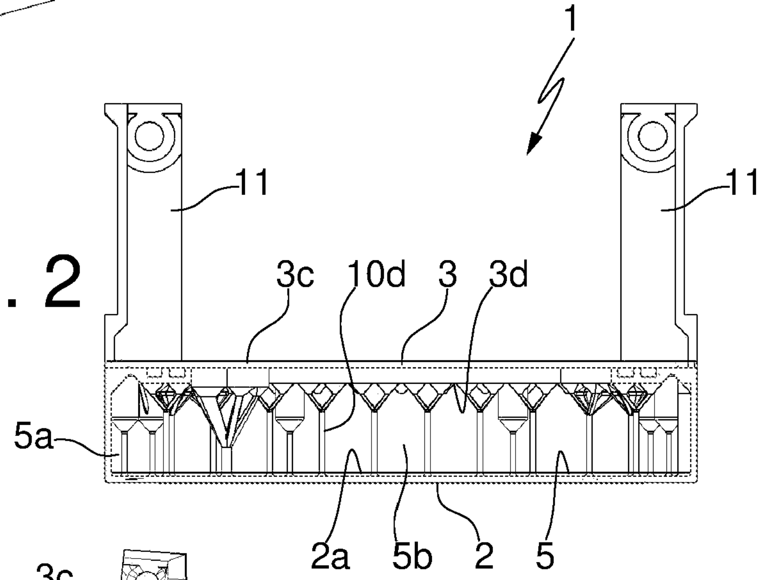

FIG. 2

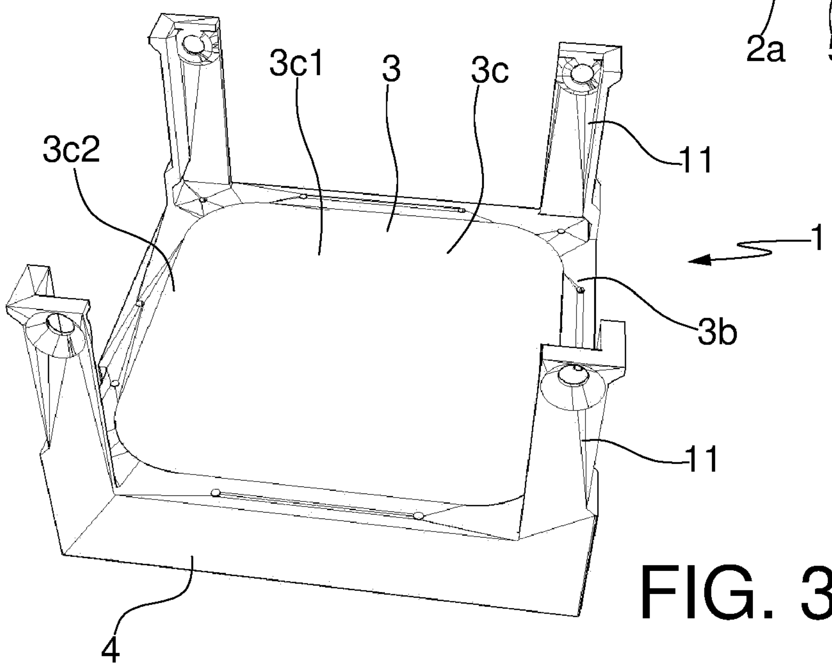

FIG. 3

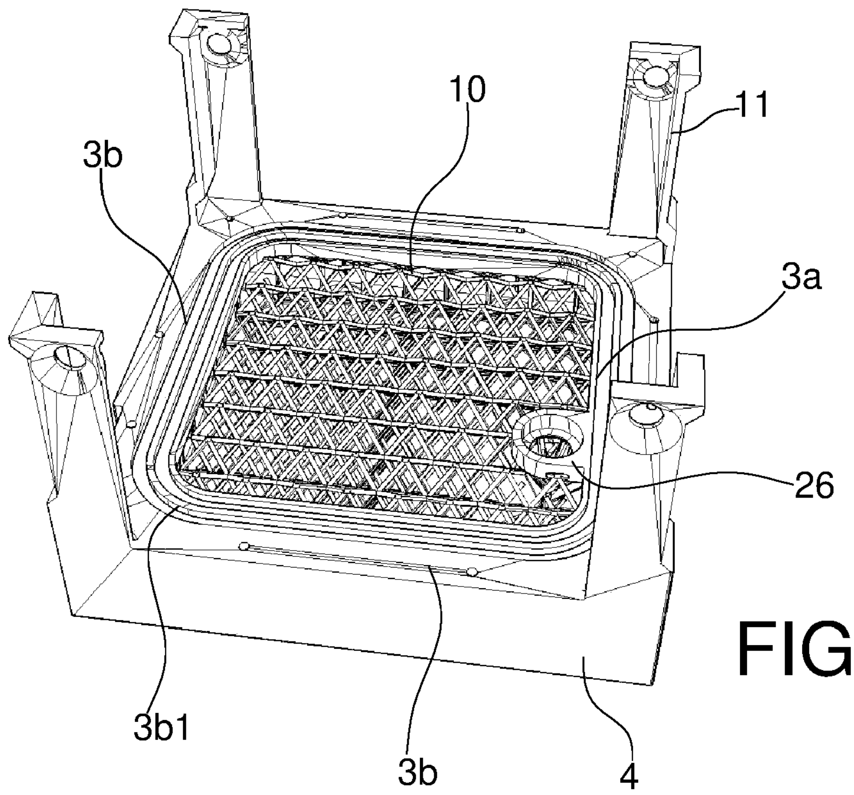

FIG. 4

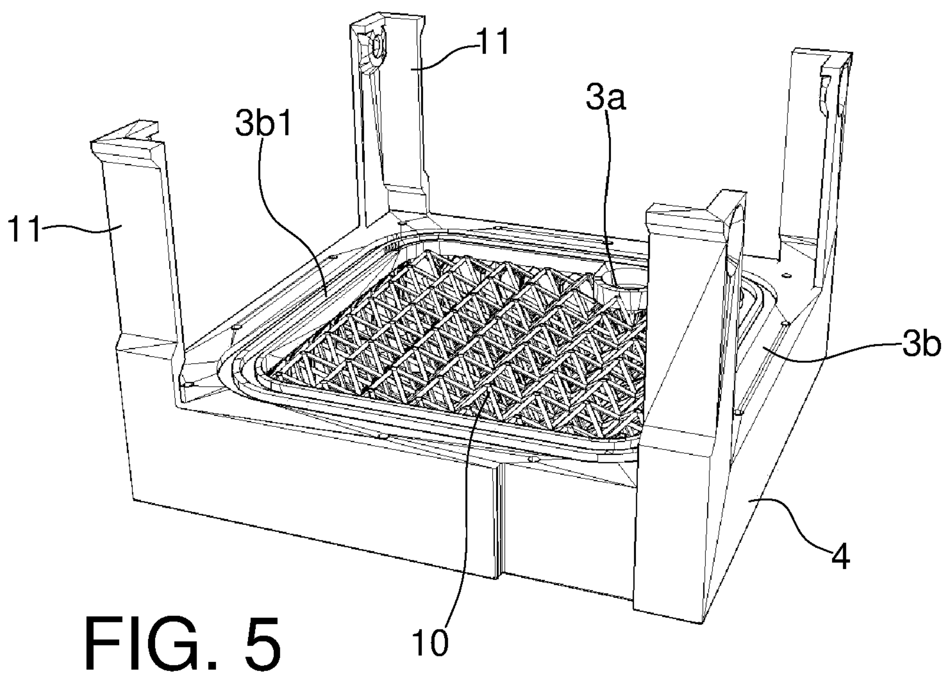

FIG. 5

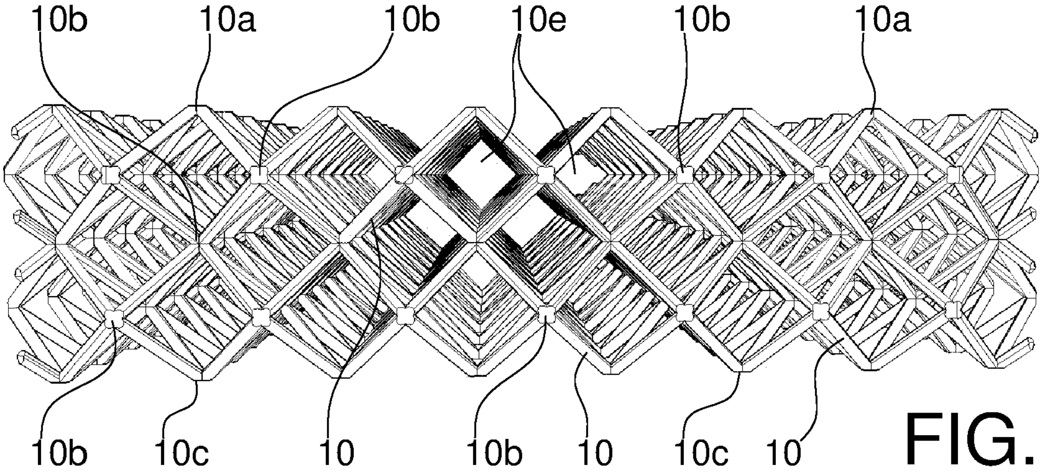

FIG. 6

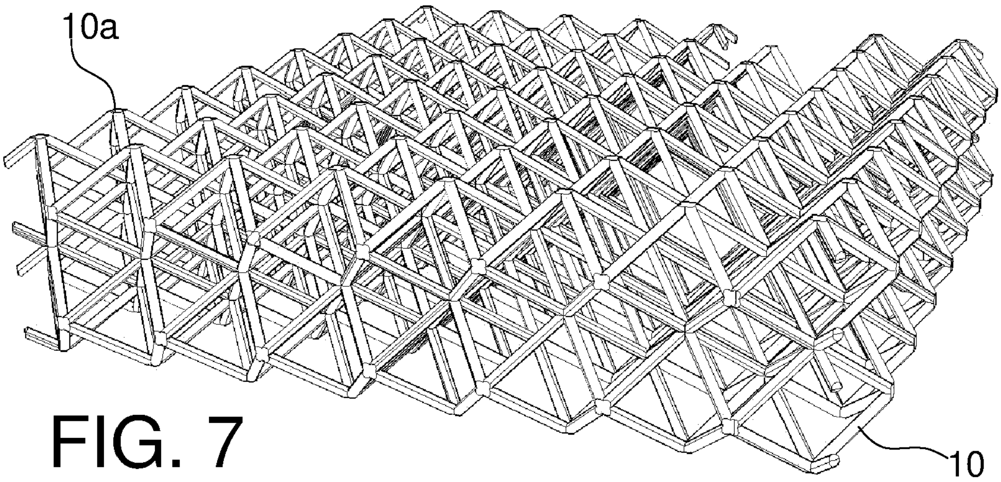

FIG. 7

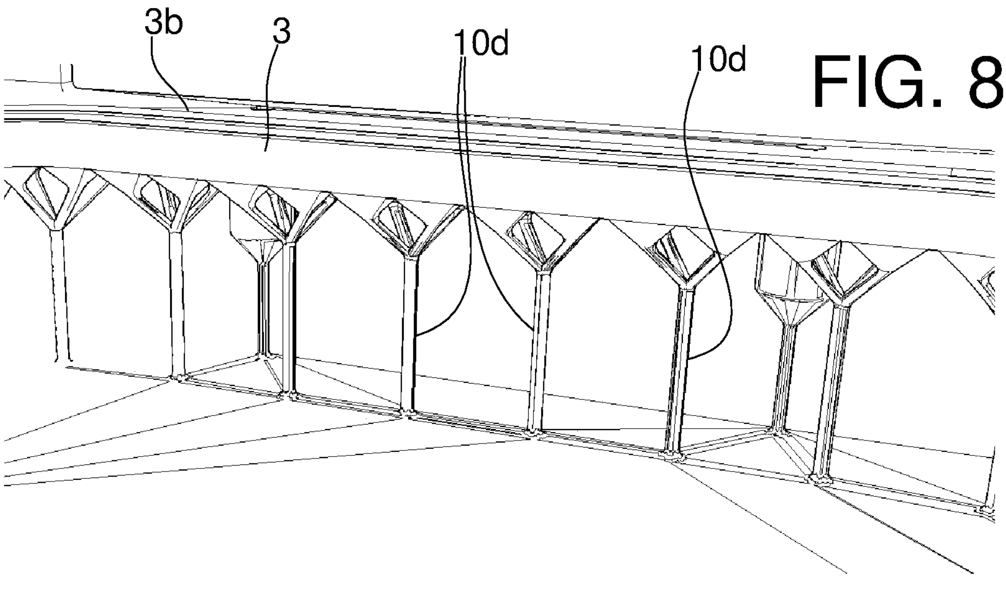

FIG. 8

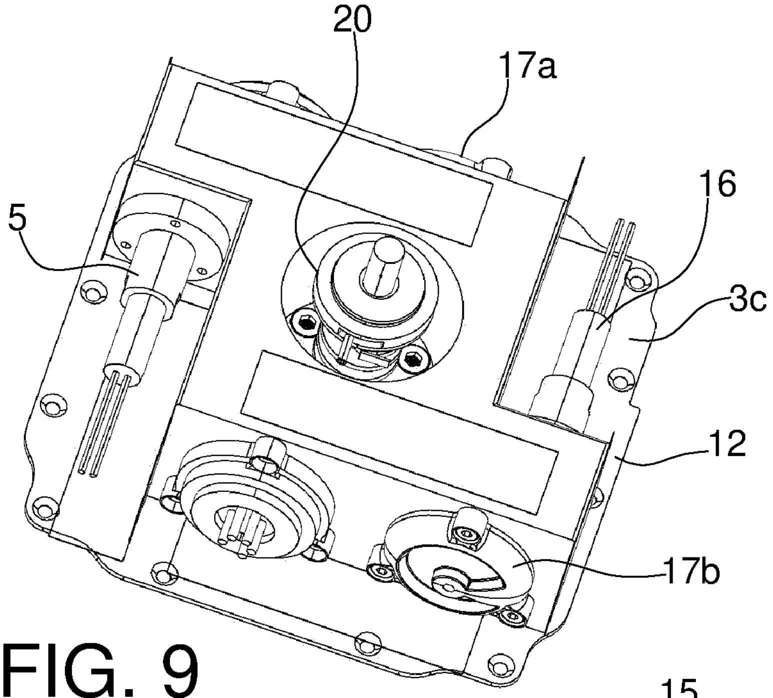

FIG. 9

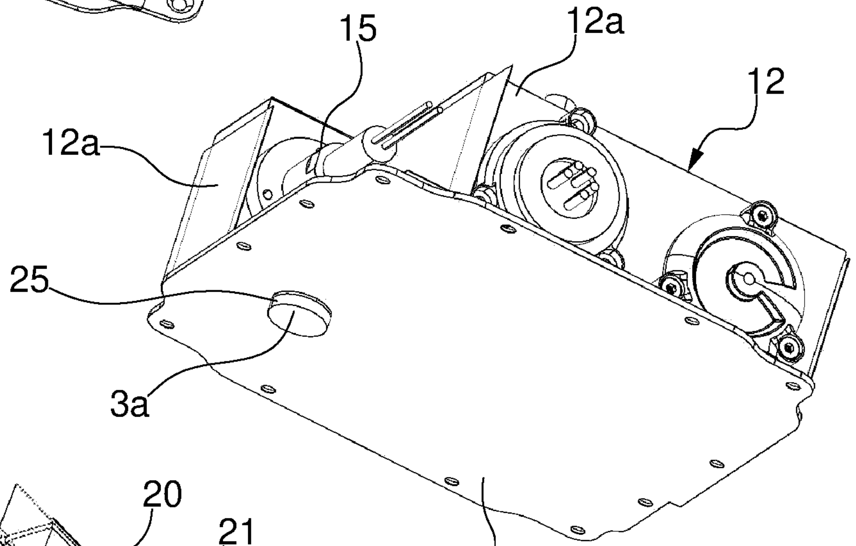

FIG. 10

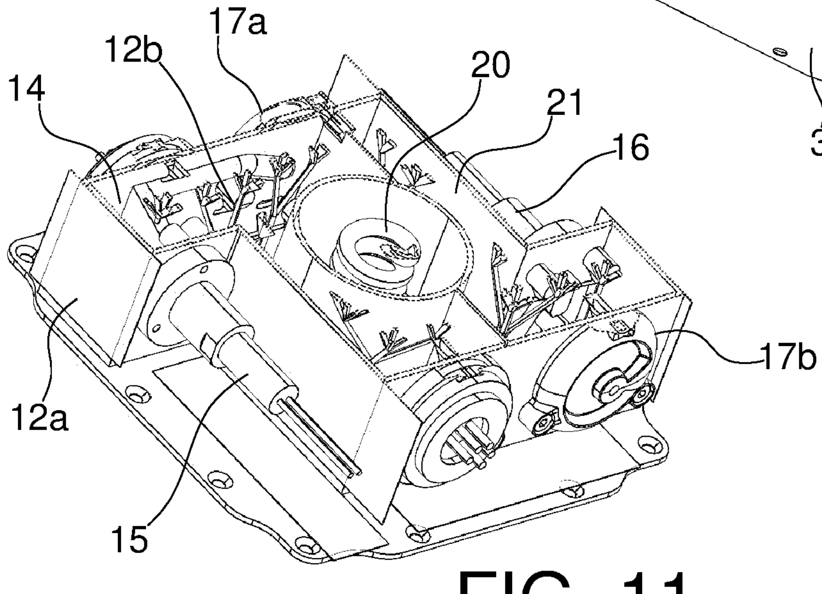

FIG. 11

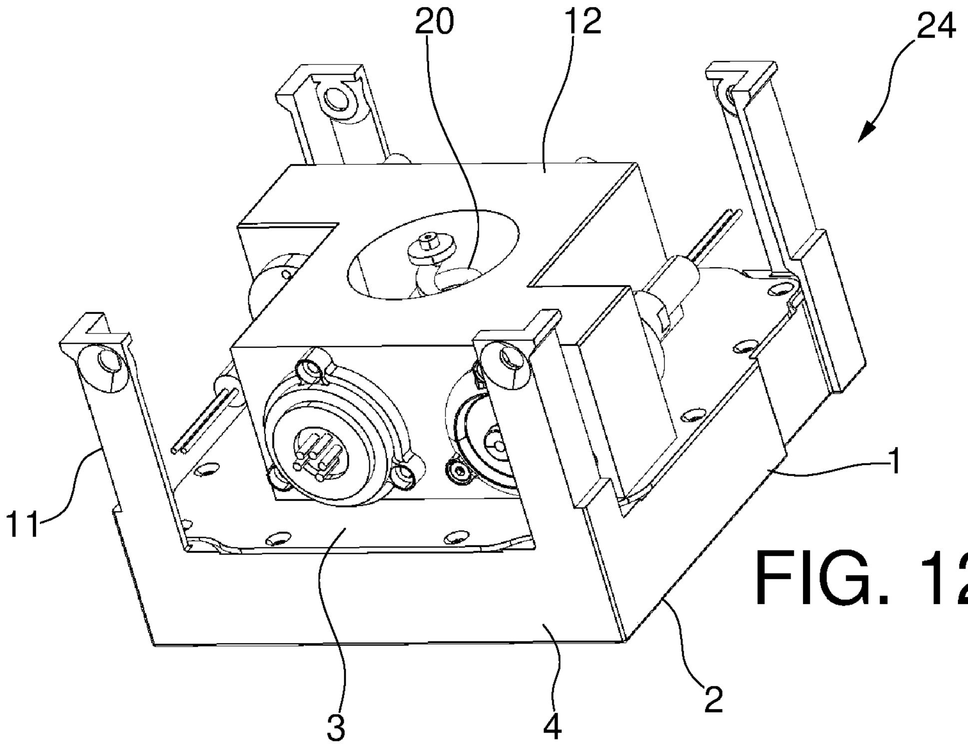

FIG. 12

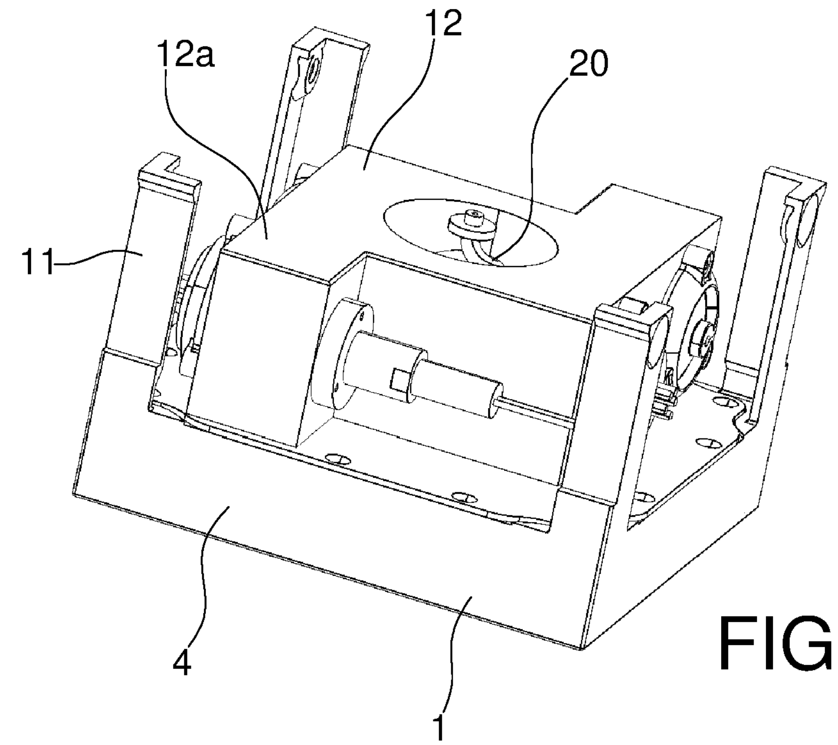

FIG. 13

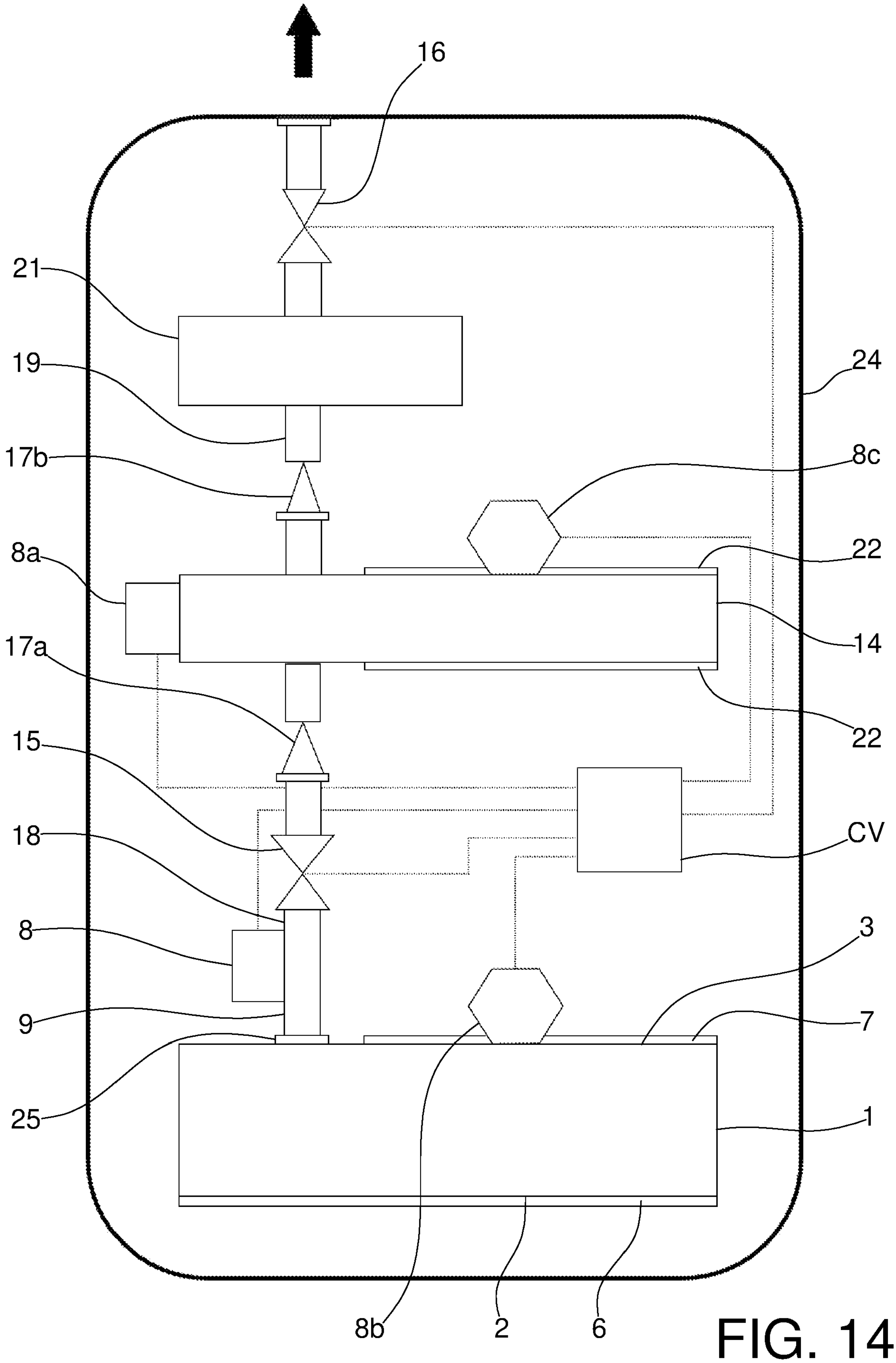

FIG. 14

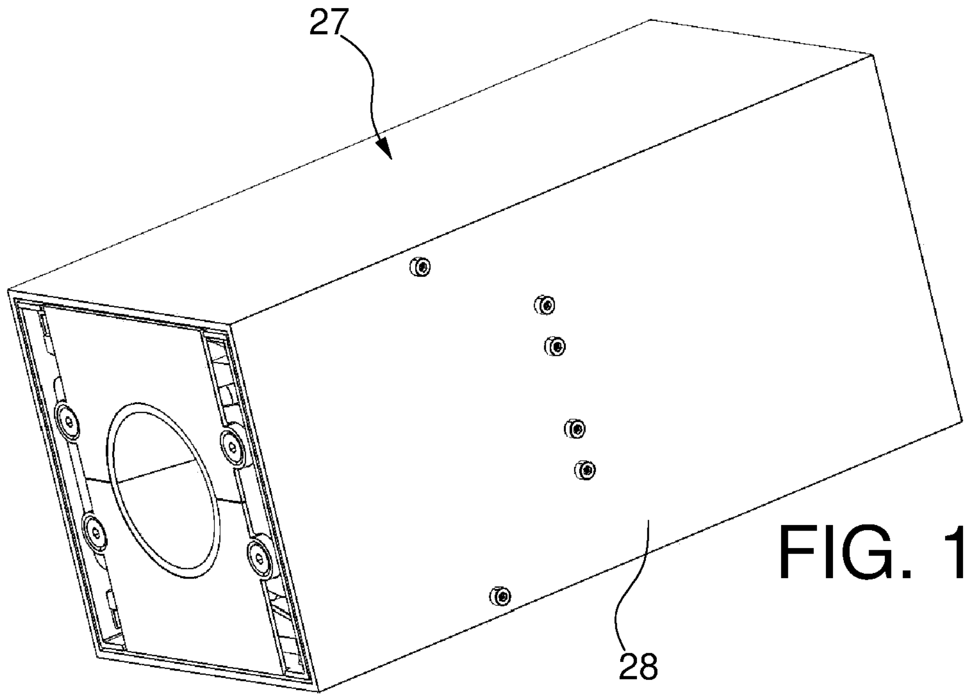

FIG. 15

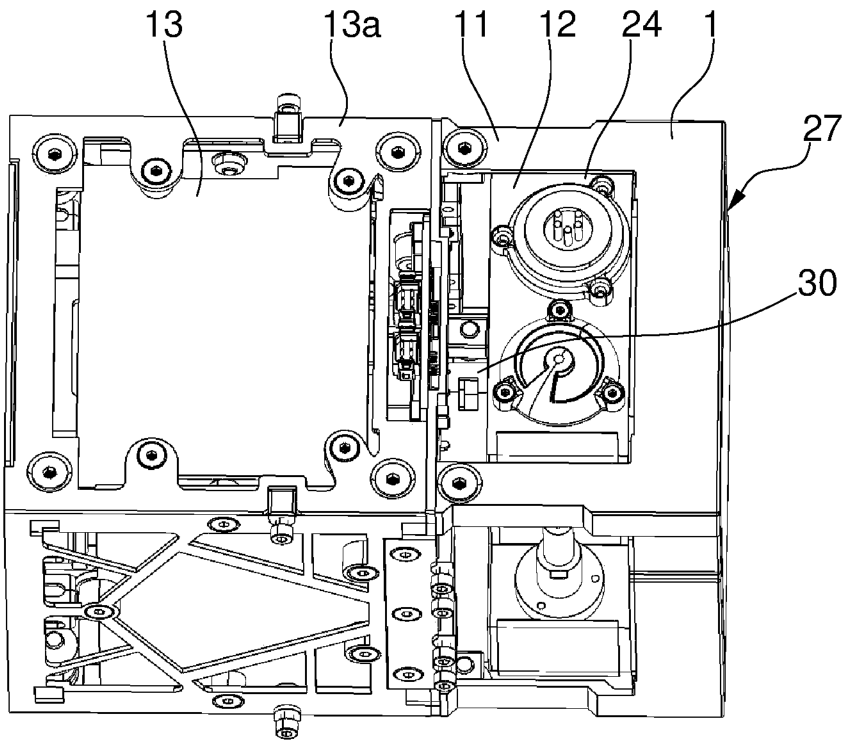

FIG. 16

REFERENCES CITED IN THE DESCRIPTION

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- WO 2016113707 A1 **[0105]**