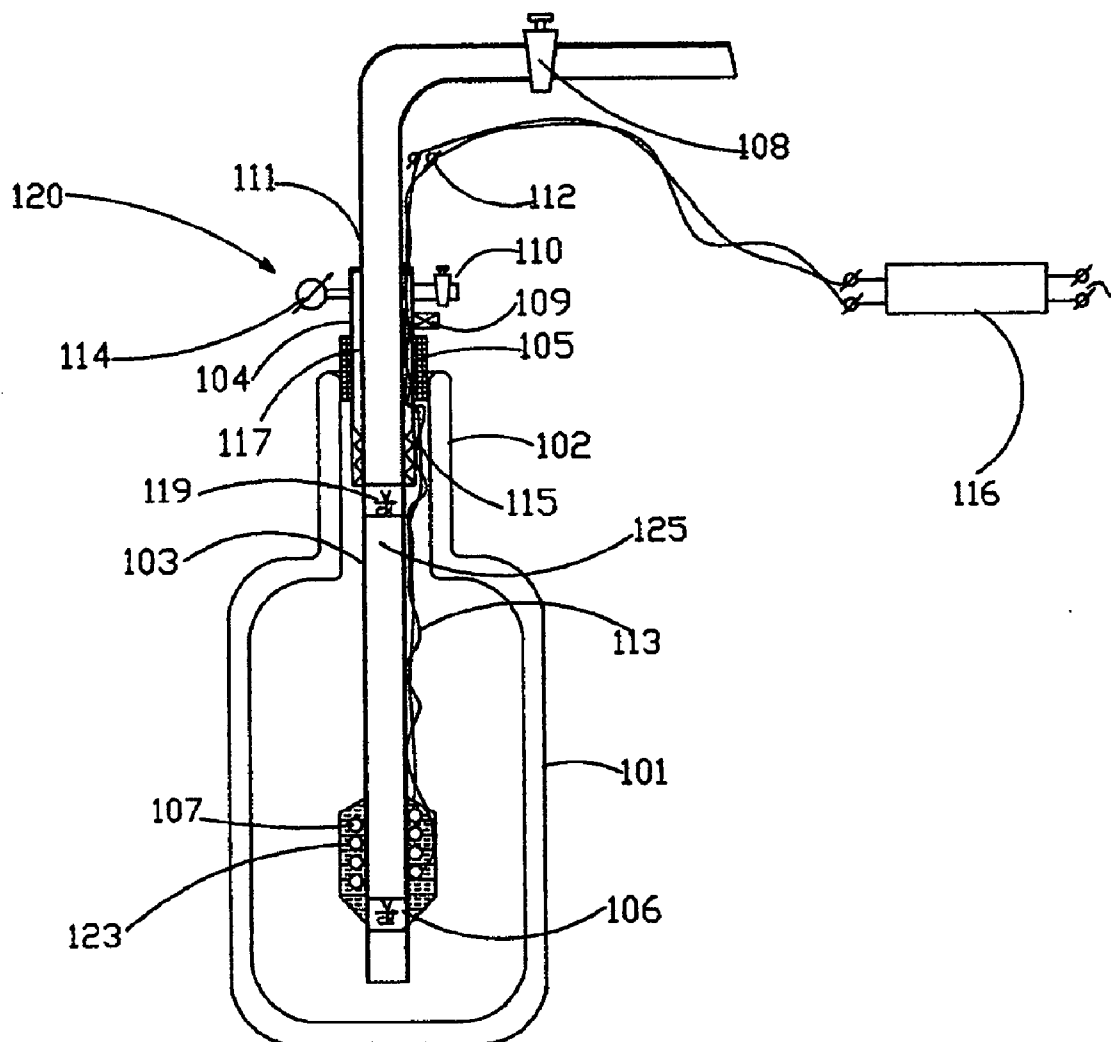




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(19) **United States**(12) **Patent Application Publication**
Toubia et al.(10) **Pub. No.: US 2009/0129946 A1**(43) **Pub. Date: May 21, 2009**(54) **PUMPING UNIT FOR DELIVERY OF LIQUID
MEDIUM FROM A VESSEL**(22) Filed: **Nov. 21, 2008****Related U.S. Application Data**(75) Inventors: **Didier Toubia**, Raanana (IL);
Alexander Levin, Binyamina (IL);
Miron Kaganovich, Haifa (IL)(60) Provisional application No. 60/989,744, filed on Nov.
21, 2007.**Publication Classification**Correspondence Address:
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ALBANY, NY 12203 (US)(51) **Int. Cl.**
F04B 19/24 (2006.01)(52) **U.S. Cl.** **417/208**(57) **ABSTRACT**(73) Assignee: **Arbel Medical, Ltd.**, Caesarea (IL)(21) Appl. No.: **12/313,611**A pumping unit for delivering a liquid medium from a low
pressure vessel such that the delivered medium has suffi-
ciently high pressure, by providing the liquid medium in the
form of separated pulses.

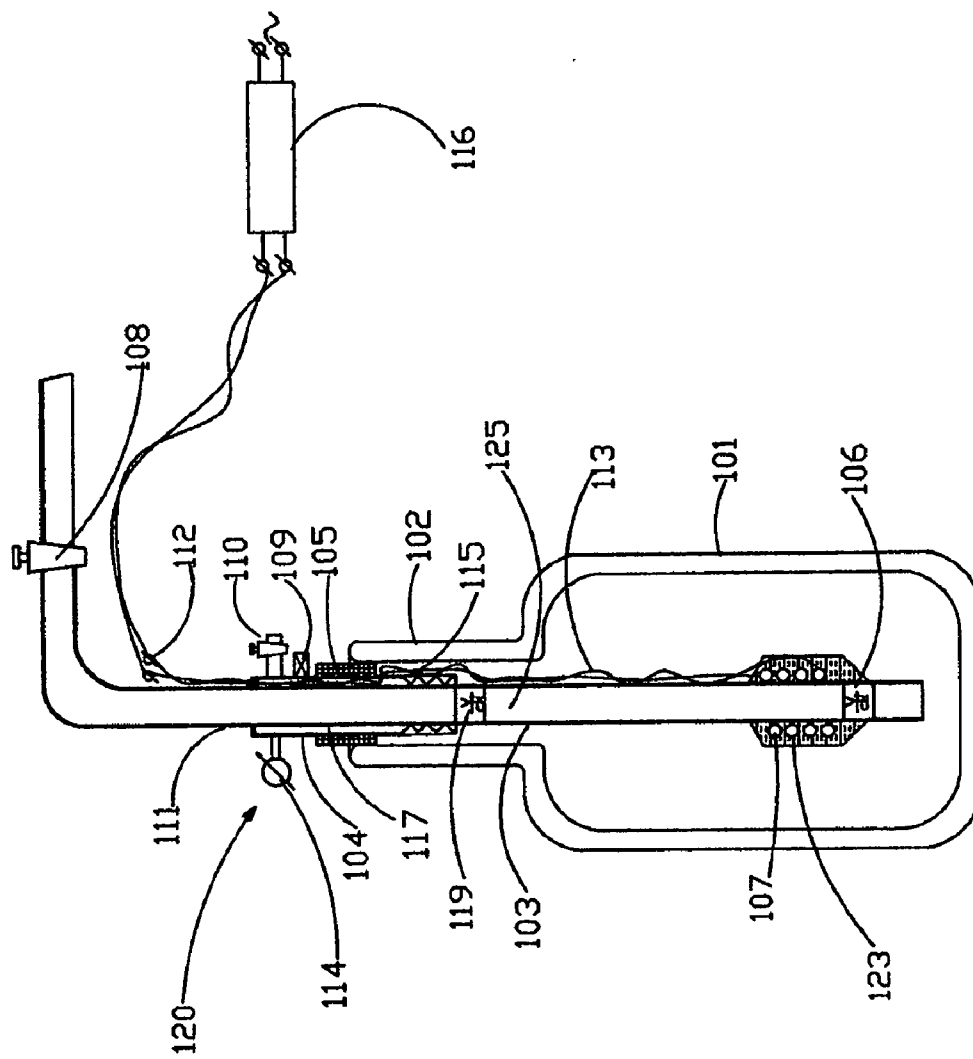


FIG. 1a

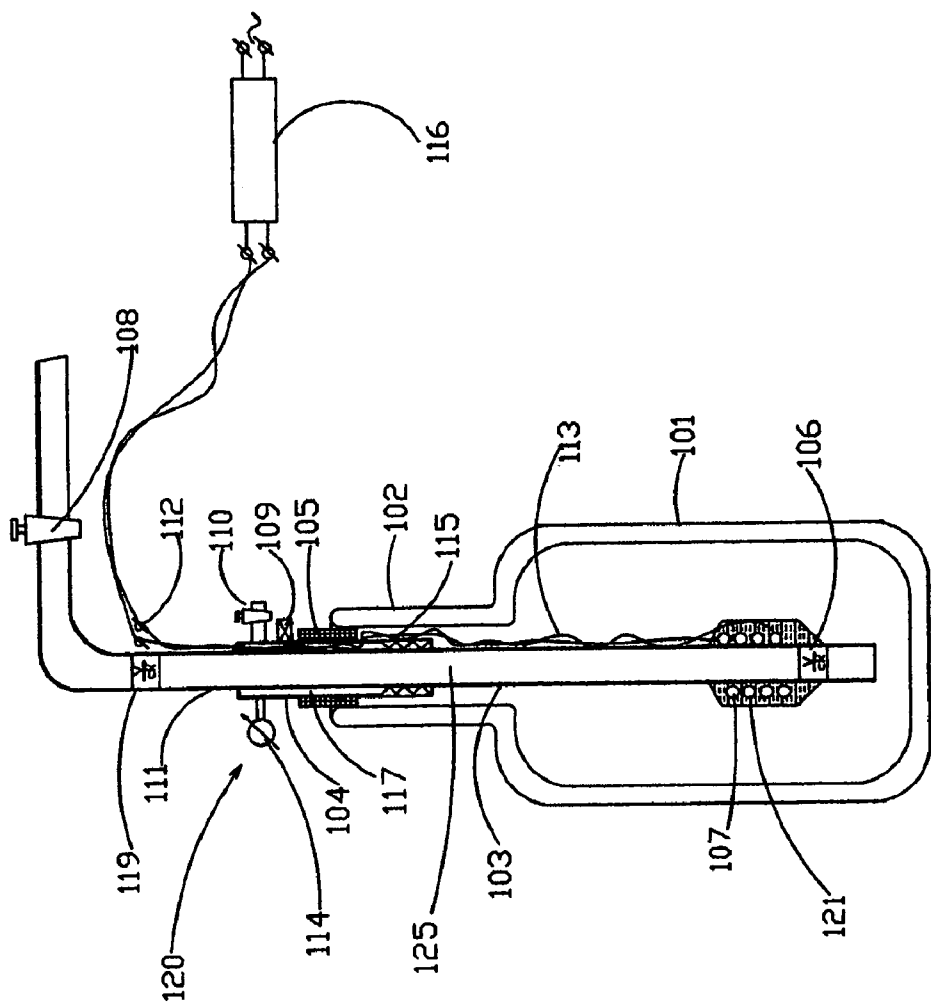


Fig. 1b

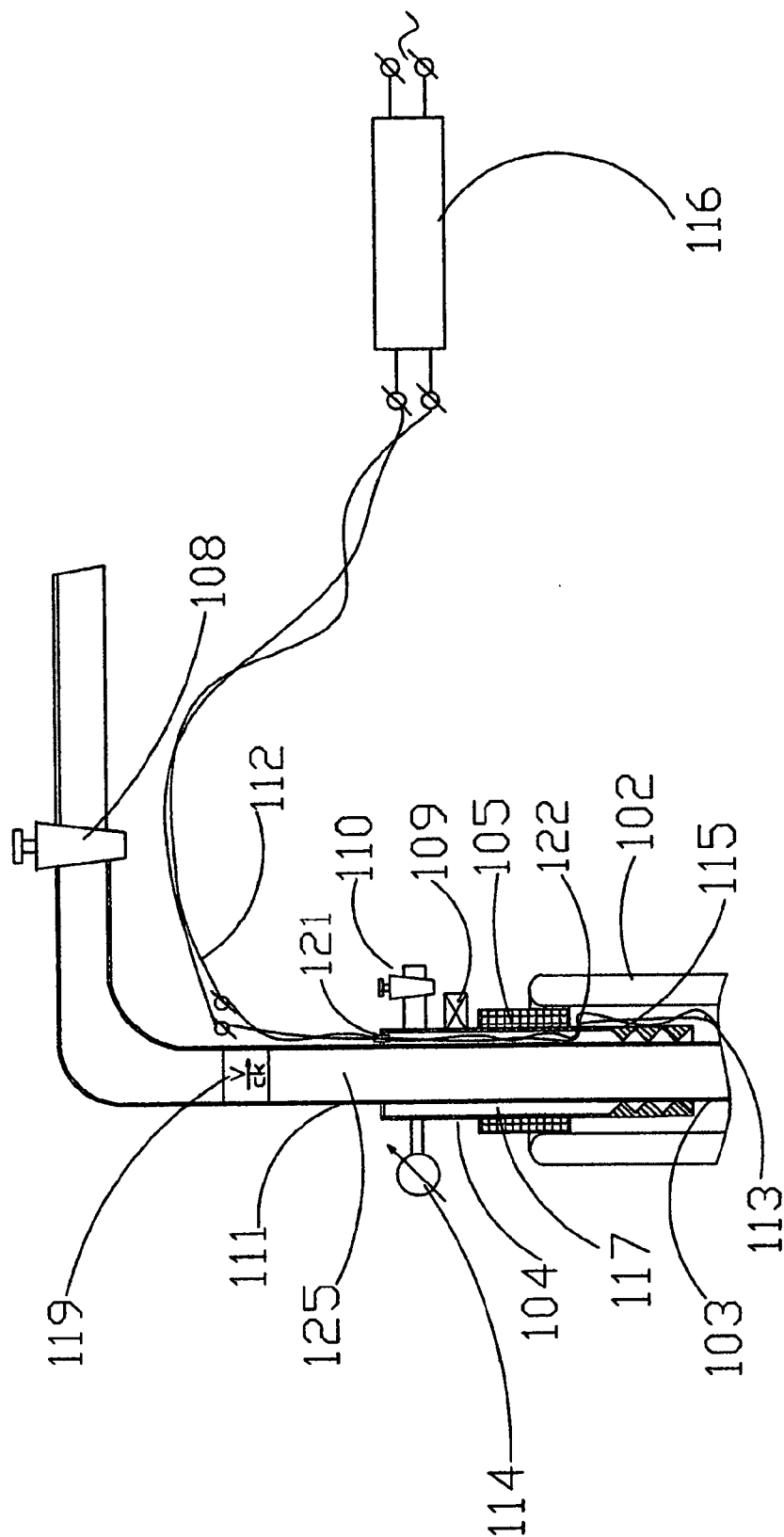


Fig. 1c

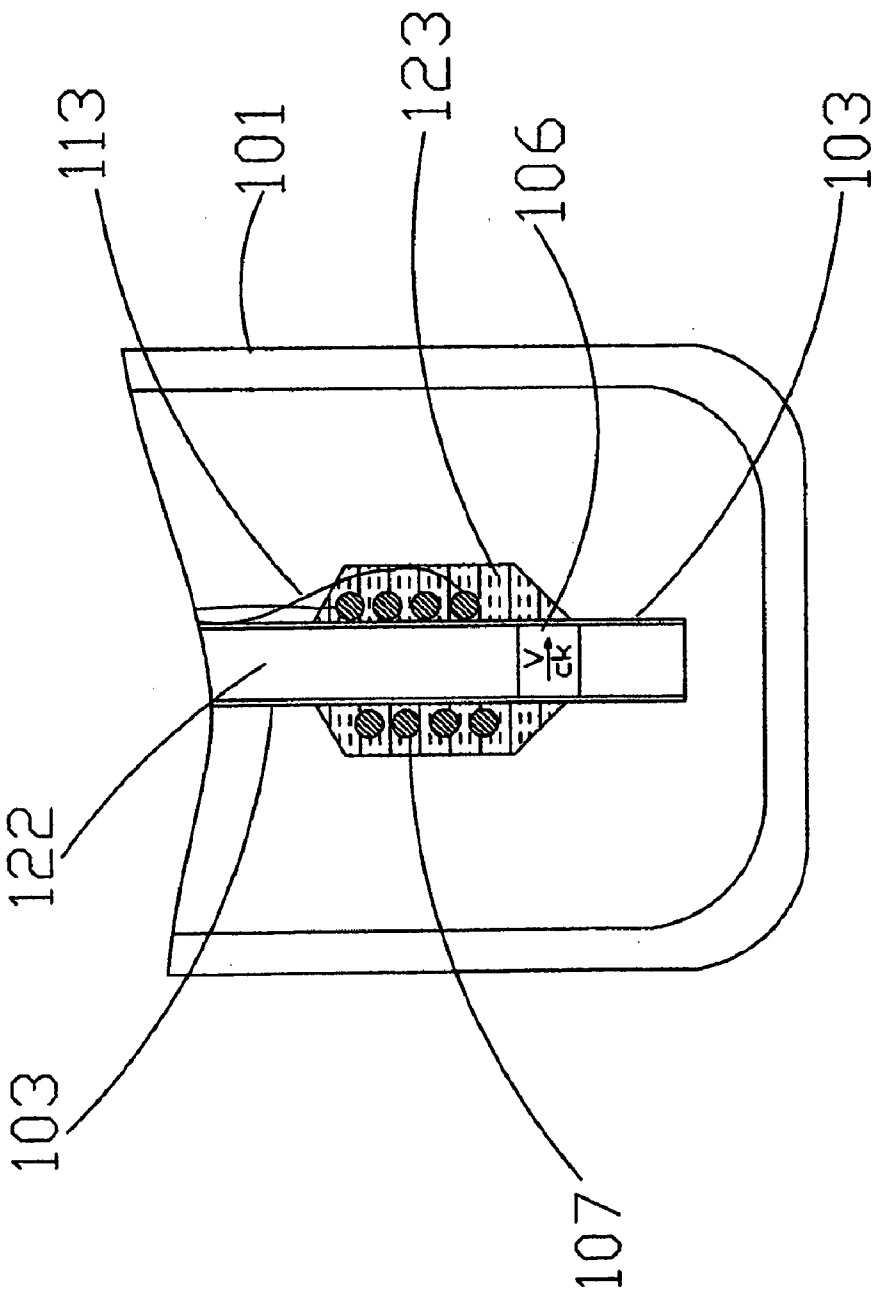


Fig. 1d

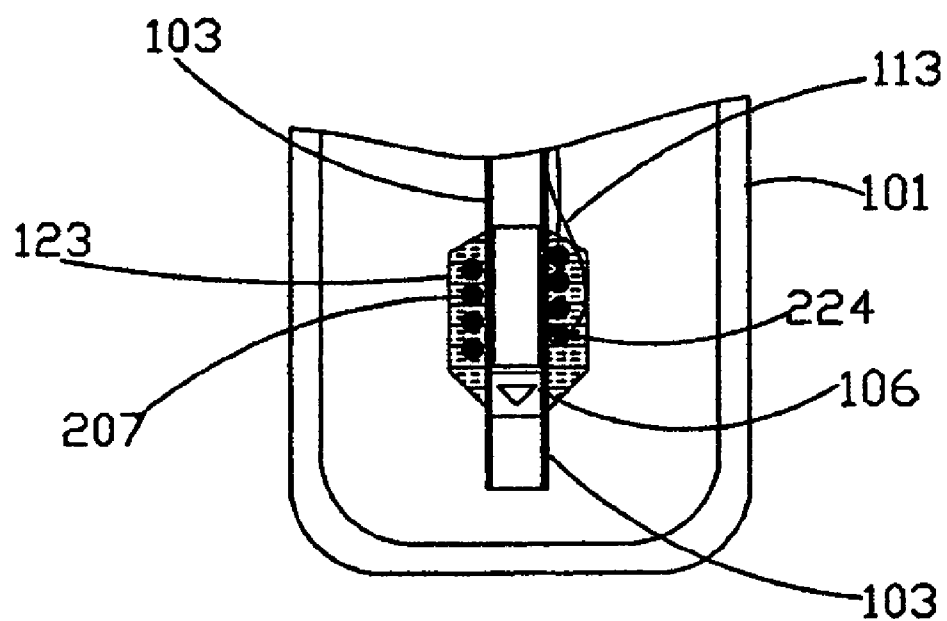


Fig. 2

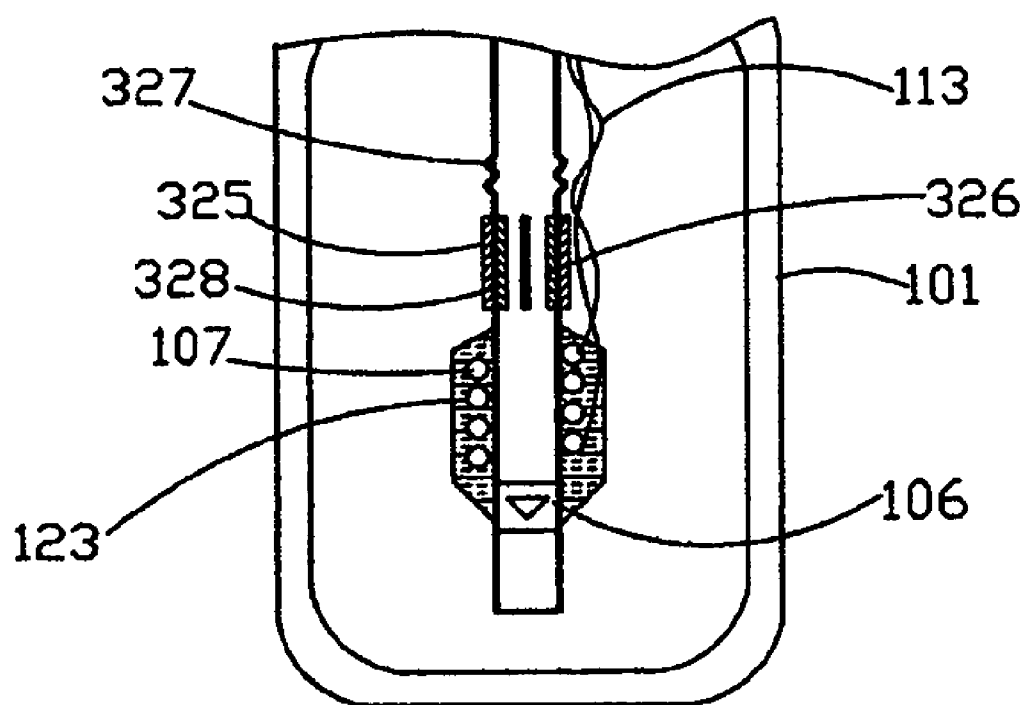


Fig. 3

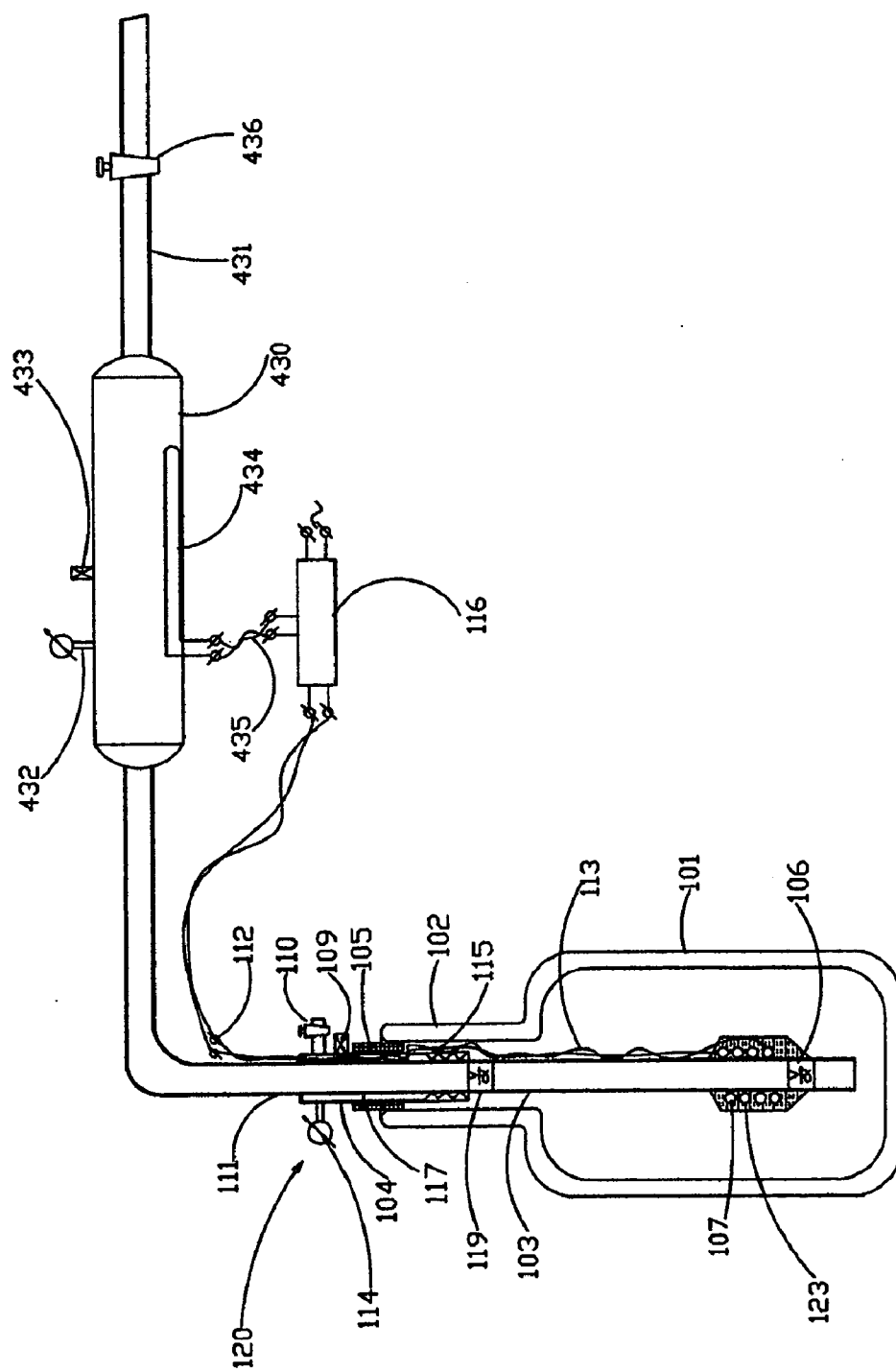


Fig. 4

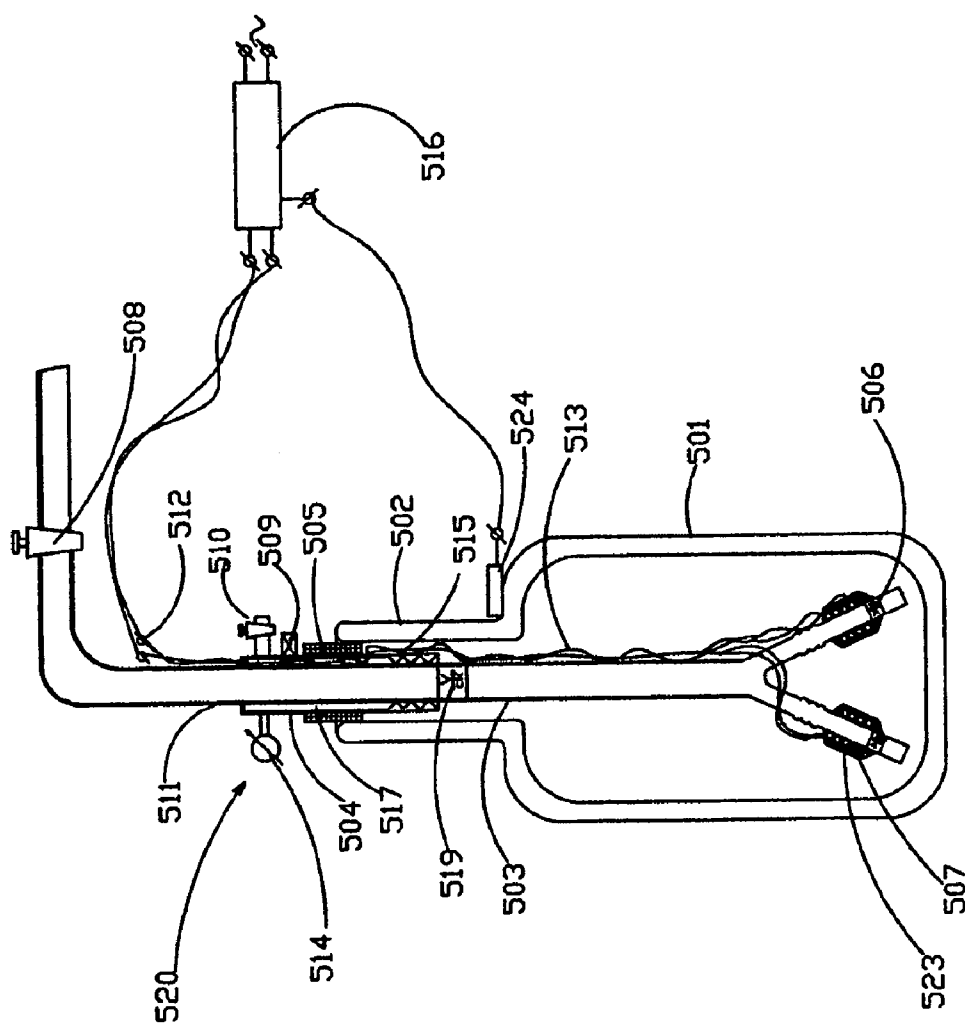


Fig. 5a

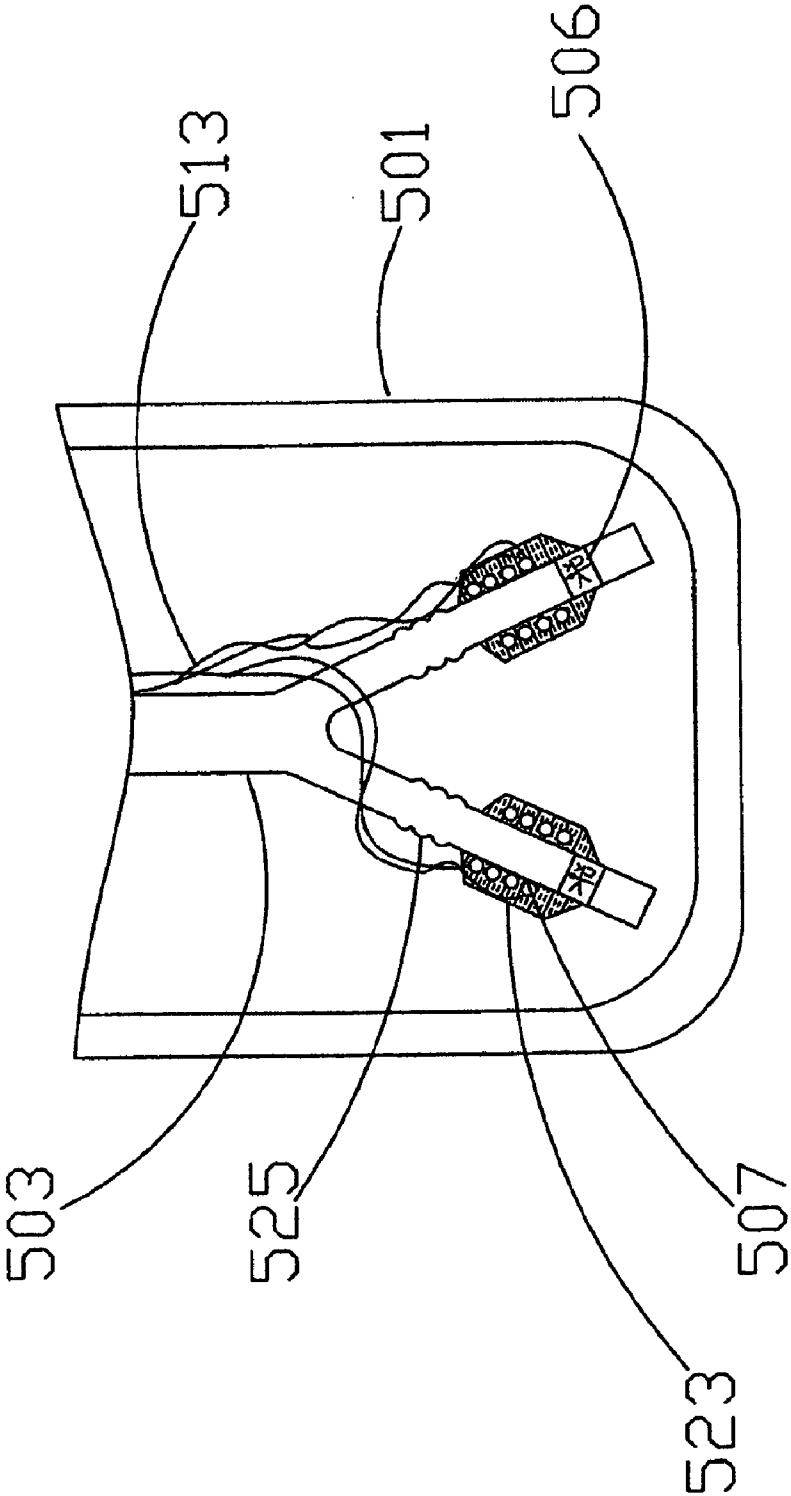


Fig. 5b

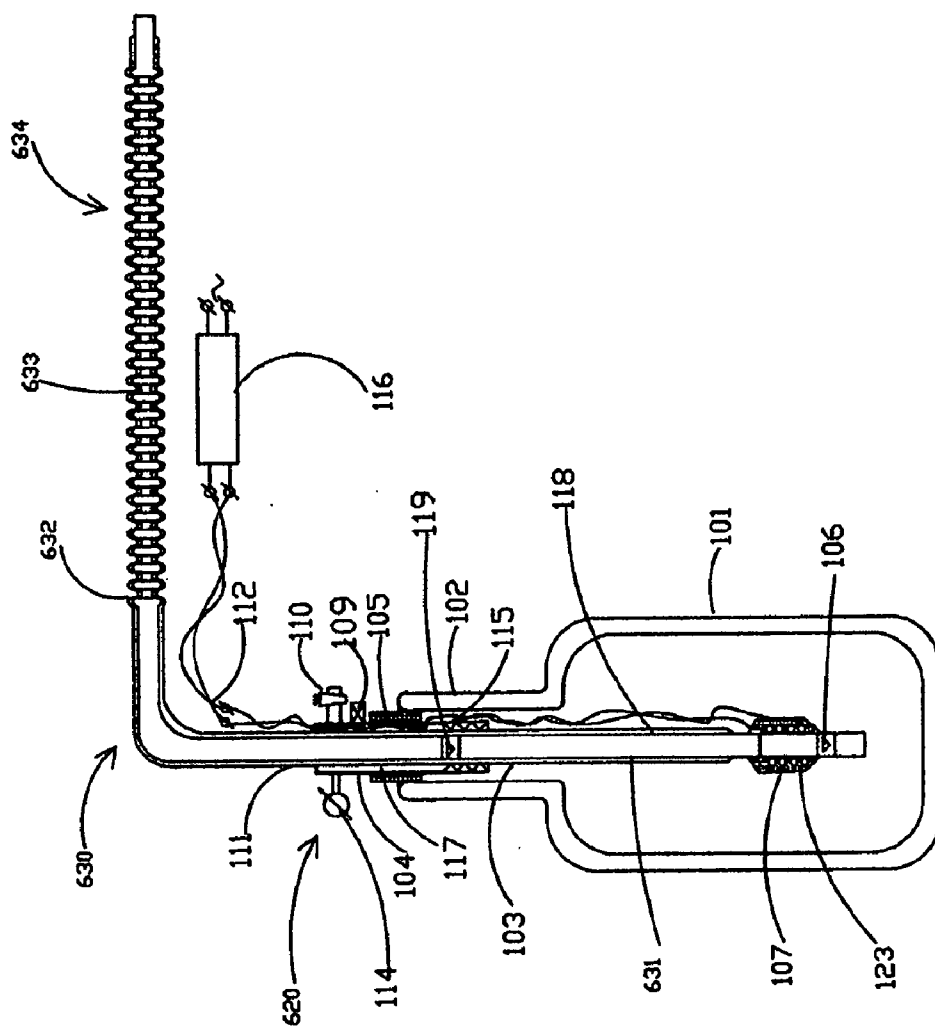


FIG. 6

PUMPING UNIT FOR DELIVERY OF LIQUID MEDIUM FROM A VESSEL

FIELD OF THE INVENTION

[0001] The invention relates to a pumping unit and, in particular, to a high pressure pump, for example for delivery of a liquid medium such as liquid cryogen from a vessel with sufficiently high pressure, while maintaining low pressure in the vessel itself.

BACKGROUND OF THE INVENTION

[0002] There are some US patents describing pumping systems, which operate on the basis of a geyser principle.

[0003] U.S. Pat. No. 4,552,208 describes an apparatus and method for circulating a heat transfer liquid from a heat collector to a heat exchanger which is located at a level below that of the heat collector by at least partially vaporizing the heat transfer liquid in the steeply sloped collector and the vapor/liquid rises in a series of "slugs" to a condenser located adjacent the top end thereof. The vapor is condensed and the hot liquid is forced downwardly to the heat exchanger by the pressure of the rising slugs of vapor and liquid. After giving up useful heat in the heat exchanger the now cooled liquid is recirculated to the condenser and thence to the collector.

[0004] U.S. Pat. No. 4,611,654 teaches a passive heat transfer system wherein the vapor generated by the boiling of a working fluid is harnessed to transport the working fluid from a heat source to a heat sink below the heat source. A passive circulation unit is installed in a heat transfer system between the outlet port of a heat collector and a collector drain duct that leads to a heat sink that is positioned below the heat collector. In preferred embodiments, a collector feed duct permits fluid to return to the heat collector from the heat sink and a check valve prevents flow in the opposite direction. The passive circulation unit includes an upper chamber and a lower chamber disposed in vertical array, with the lower end of the lower chamber being positioned above the heat collector outlet port. In the simplest embodiment, the two chambers are connected by a vent duct that leads from the bottom region of the lower chamber to the top region of the upper chamber. The collector drain duct connects to an opening in the lower end of the upper chamber. In a second disclosed embodiment, the passive circulation unit is fitted with a valve that intermittently interrupts the flow of working vapor through the lower chamber and thereby causes working fluid to be displaced into the vent duct and expelled therefrom into the upper chamber in a cyclical manner.

[0005] U.S. Pat. No. 4,676,225 describes a geyser pump and a geyser pumped heat transfer system having a multitude of heat absorbing tubes from which heated liquid is pumped into a vapor/liquid separator by geyser action enhanced by positive vapor bubble generation apparatus and flow control methods. A vapor condenser in communication with the separator recovers heat contained in the vapor bubbles and maintains low separator pressure. Pumping starts and stops in response to temperature differences and the pumping rate is proportional to the heating rate. For bubble generation a small volume of the working fluid is isolated in good thermal contact with the absorbing tube and an aperture is formed in communication between the isolated volume and the main volume of working fluid. The small volume of working fluid can be enclosed by inserting into the geyser pump tube a device in the form of a flanged cylinder or a U-shaped tube.

Vapor forms readily in the isolated volume and a vapor+-liquid interface at the aperture minimizes superheating in the liquid. A directional flow constriction in the absorbing tube which may be in the form of a check valve improves pumping rates and minimizes oscillations which may be produced by the pulsed flow inherent in a geyser pump system. A flow restriction which may be in the form of an orifice or reduced tube diameter moderates peak flow rates by locally and transiently increasing static pressure in expanding bubbles.

[0006] U.S. Pat. No. 6,042,342 describes a fluid displacement system having a pressure vessel, an expansion vessel, first and second tubes in fluid communication with the two vessels, and an energy source. Fluid contained within the system is transferred from one vessel to the other by activating the energy source, which in turn generates pressure in the pressure vessel. The generated pressure in the pressure vessel, in turn, displaces the fluid in the expansion vessel.

[0007] Each of the above patents teach a proposed solution which is not useful for cryogenic devices, but instead is only useful for the taught application.

SUMMARY OF THE INVENTION

[0008] None of the above background art references teaches or describes a high pressure pump of the geyser type that is at least partially inserted into a vessel that is capable of delivering a liquid or liquid-gaseous medium at high pressure while maintaining low pressure in the vessel itself. A pumping unit according to the present invention overcomes these drawbacks by providing such a pump that delivers a liquid medium (and/or a liquid-gaseous medium) from a low pressure vessel such that the delivered medium has sufficiently high pressure, by providing the liquid medium in the form of separated pulses. The pump preferably features a conduit embedded into the vessel, such that the proximal end of this conduit is situated in the vicinity to the bottom of the vessel.

[0009] By "high pressure" it is meant at least about 1.5 atmospheres, preferably at least about 2 atmospheres and more preferably at least about 10 atmospheres.

[0010] The lower section of the conduit is preferably provided with at least a first check valve, which, preferably, is normally open. In addition, the lower (boiling) section of the conduit is preferably provided with an electrical heating element, more preferably of low thermal inertia, and a layer of an outer thermal insulation to reduce heating of the surrounding liquid medium by the electrical heating element. The electrical heating element can be a resistive heating element, or a heating inductive element. The electrical heating element receives pulses of DC or AC, for example preferably from an outer power-control unit.

[0011] There is preferably a condensation section of the conduit; this section is situated in immediate vicinity of the aforementioned boiling section and, preferably, in the immediate vicinity of the bottom of the vessel; therefore, this condensation section in the operation state of the pumping means is immersed into the liquid medium in the vessel.

[0012] It should be noted that the duration of the electrical heating pulses is preferably significantly less than the time required for vapor that is generated by these pulses to rise to the upper section of the central feeding conduit. Instead, preferably the gas is formed but then cools in the upper section of the central feeding conduit, returning to a liquid state before exiting the conduit. The upper section of the conduit is provided with a second check valve of open or closed types.

[0013] As described in greater detail below, an exemplary, non-limiting embodiment of a pump according to the present invention may be provided wherein the vessel is a Dewar flask and the liquid or liquid-gaseous medium is a liquid cryogen. In this case, the pump is called a siphon.

[0014] The pumping unit of the present invention comprises a central feeding conduit, which is preferably largely positioned within the Dewar flask such that at least about 50% and more preferably at least about 60%, and most preferably at least about 75% of the central feeding conduit is positioned within the Dewar flask. Its lower section is situated in the Dewar flask and the upper section is located outside the Dewar flask; a sealing unit, preferably in the form of an annular rubber ring, allows installation of the pumping unit in the Dewar flask neck. A section of a tubular piece surrounding the central feeding conduit is joined sealingly with the annular rubber ring. The tubular piece acts as a jacket and will be named in the following text "jacket".

[0015] According to preferred embodiments of the present invention, the central feeding conduit is preferably fabricated from a metal including but not limited to brass, stainless steel etc.

[0016] The upper edge of the external conduit or jacket is sealed with the outer section of the central feeding conduit.

[0017] Two check valves are installed on the central feeding conduit: a lower check valve and an upper one. The upper check valve can be positioned in the upper or middle internal spaces of the Dewar flask or outside the Dewar flask. The lower check valve is positioned near the lower end of the central feeding conduit.

[0018] The upper check valve may optionally be either of the type that is normally closed or normally open, and the lower check valve may optionally be of the normally closed type or of the normally open type. When the first or lower check valve is open, cryogen enters into the central feeding conduit via this first check valve under hydrostatic pressure of the cryogen in the Dewar flask.

[0019] Preferably an electrical heating element is positioned on the central feeding conduit in the immediate vicinity of the lower check valve and somewhat above it. This electrical heating element is preferably of low thermal inertia.

[0020] The electrical heating element may optionally be of the resistive and/or electromagnetic inductor types. In the second case, the section of the central feeding conduit, which is surrounded by the electromagnetic inductor, preferably contains elements from ferromagnetic material. In such a way, in the second case, the electrical heating element consists of the inductor and the ferromagnetic tubular section of the central feeding conduit surrounded by the inductor.

[0021] The electric heating element is optionally and preferably thermally insulated from its outside, which is faced outwardly in respect to the central feeding conduit.

[0022] A source of electrical current (AC or DC) is situated outside the Dewar flask and connected with the electric heating element (the resistor or the inductor) by wires. This source can be named as a control-power unit. The control-power unit ensures delivery of electrical current to the electrical heating element in the form of separated pulses. It should be noted, that in the case of AC application, the frequency of the pulses of the electrical current is preferably some orders of magnitude lower than the frequency of the applied AC.

[0023] Delivery of a pulse to the electrical heating element causes the liquid cryogen to boil in the internal space of the central feeding conduit in the section, which is in contact with

the electrical heating element, resulting in sharp elevation of its pressure. As a result, the lower check valve closes; the high pressure portion of the liquid-gaseous cryogen then causes the upper check valve to open. Thereafter, as the result of heat exchange between the central feeding conduit and the liquid cryogen in the Dewar flask, the evaporated portion of the cryogen in the central feeding conduit condenses again while reducing the pressure in the central feeding conduit. The lower check valve then opens and the upper check valve closes.

[0024] The internal surface of the section to be heated by electrical pulses can be provided with internal fins or a porous coating with open porosity, which facilitates boiling process of the liquid cryogen contained in this section.

[0025] The electrical heating element can be provided with outer thermal insulation allowing diminishing heat losses to the liquid cryogen in the Dewar flask and outside the central feeding conduit.

[0026] The upper section of the central feeding conduit, which is adjacent to the section with the electrical heating element, can be provided with means improving heat exchange with the surrounding liquid cryogen. This ensures quick cooling and condensation of the vapors obtained by pulse-wise heating of the lower section, which is in immediate contact with the electrical heating element. These means may optionally be realized as external and/or internal fins.

[0027] The portions of liquid-gaseous cryogen under sufficiently high pressure caused by its partial evaporation by pulses of electrical current can be supplied immediately onto a target area to be cooled via the outer section of the central feeding conduit.

[0028] In another embodiment, the portion of the gaseous-liquid cryogen under high pressure is introduced via the upper check valve into a buffering vessel, which is provided with an evaporation member and an outlet connection with a shut-off valve for supplying the evaporated pressurized cryogen. In addition, the buffering vessel is preferably equipped with required safety and measuring mechanisms (a pressure gauge, safety and relief valves etc), to prevent build up of excessive pressure.

[0029] The parameters of electrical pulses supplied to the electrical heating element can be adjusted by the control-power unit in accordance with the pressure in the buffering vessel.

[0030] Optionally a bellows section may be incorporated in the central feeding conduit; the expansion and contraction of this bellows section dampens any rapid elevation of pressure in the central feeding conduit.

[0031] Optionally and preferably, other safety and relief valves are installed on the outer section of the aforementioned jacket of the pumping unit.

[0032] Preferably, a pressure gauge is installed on the outer section of the jacket which serves for measuring pressure in the Dewar flask.

[0033] The lower edge of the central feeding conduit may optionally be provided with a filter in order to collect mechanical particles contained in the supplied liquid cryogen.

[0034] The lower section of the internal surface of the jacket can be provided with a divider for dividing the upper and lower internal spaces of the Dewar flask, with the divider featuring high hydraulic resistance for passage of the gas through it. This prevents the liquid cryogen in the Dewar flask from being forced up and out in the case of opening the relief

valve of the pumping unit. The divider may optionally comprise an internal threading of the jacket with an internal diameter, which fits the outer diameter of the central feeding conduit. Such an embodiment enables the spiral groove of the threading to present a high hydraulic resistance, which prevents boiling and overflow of the liquid cryogen in the Dewar flask when opening the relief valve.

[0035] In addition, the pumping unit of these embodiments of the present invention can be provided with an inlet port in its jacket for introducing pressurized gas into the Dewar flask in order to establish a required pressure in it.

[0036] The pumping unit of these embodiments of the present invention, which is partially situated in a Dewar flask, is optionally provided with a shut-off valve positioned distally to the upper check valve on the outer section of the upper feeding conduit.

[0037] However, it is possible to obviate application of this shut-off valve because the electrical heating element in combination with the lower and upper check valves may instead optionally fulfill the role of the shut-off valve. In this case, preferably the central feeding conduit includes an external vacuum insulation in the form of a vacuum insulated jacket; the proximal edge of this jacket is preferably sealed with the central feeding conduit above the lower check valve and its distal edge is sealed with the central feeding conduit distally to the upper check valve and externally to the Dewar flask itself.

[0038] The outer sections of the vacuum insulated jacket and the central feeding conduit are preferably implemented as flexible bellows, thereby enabling the use of liquid neon as a cryogen with significant reduction of operation temperature of the geyser pump of the present invention in comparison with application of liquid nitrogen as the cryogen.

[0039] According to some embodiments, the Dewar flask may optionally be used as a fuel tank with LNG (liquid natural gas), for example for installation in a vehicle. For such embodiments preferably the pumping unit is still able to ensure delivery of LNG under different inclination angles of the Dewar flask. Preferably the lower section of the central feeding conduit is divided into a plurality of branches, in which each branch is provided with an independent check valve and an electrical heating unit.

[0040] In addition, a sensing unit supplies to the power-control unit data regarding an angle and direction of inclination of the Dewar flask. For example, two clinometers can play a role of such sensing unit. In such a way, in accordance to the data of the sensing unit, the power-control unit energizes the electrical heating unit, which is related at a certain moment to the branch with its proximal end immersed into liquid cryogen (for example, into LNG). A bellows' section can be incorporated into each branch in order to provide required flexibility to this construction.

BRIEF DESCRIPTION OF THE DRAWINGS

[0041] FIG. 1a and FIG. 1b show an axial cross-sectional view of a Dewar flask with a pumping unit installed in its neck, when an upper check valve is positioned inside of the Dewar flask (FIG. 1a) or outside of the Dewar flask (FIG. 1c).

[0042] FIG. 1c shows an enlarged axial cross- and a sectional view of the upper section of the Dewar flask and the pumping unit.

[0043] FIG. 1d shows an axial cross-sectional view of the lower section of the Dewar flask and the pumping unit.

[0044] FIG. 2 shows an enlarged axial cross-sectional view of the lower section of the Dewar flask and the pumping unit with an inductor used as an electrical heating element.

[0045] FIG. 3 shows an axial cross-sectional view of a pumping unit with a bellows section incorporated into the central feeding conduit.

[0046] FIG. 4 shows an axial cross-sectional view of a Dewar flask with the pumping unit installed in its neck and a buffing vessel equipped with an evaporating member.

[0047] FIG. 5a shows an axial cross-sectional view of a Dewar flask with the pumping unit installed in its neck and a split lower section of the central feeding conduit.

[0048] FIG. 5b shows an axial cross-sectional view of the lower section of a Dewar flask according FIG. 5a.

[0049] FIG. 6 shows an axial cross-sectional view of a Dewar flask according to some embodiments of the present invention, featuring a vacuum insulated jacket that is situated partially in the Dewar flask and partially outside of the Dewar flask

DESCRIPTION OF PREFERRED EMBODIMENTS

[0050] FIG. 1a shows a Dewar flask 101 with neck 102, which is intended to be filled with a liquid cryogen to be supplied by the pumping unit 120. Pumping unit 120 comprises a central feeding conduit 103 for supplying the liquid cryogen to an external location, and jacket 104 surrounding the central feeding conduit 103 with gap 117 formed between them. The central feeding conduit 103 comprises an external section 111. The upper edge of jacket 104 is sealed with the central feeding conduit 103 as shown. An annular rubber ring 105 is installed on jacket 104 and inserted partially into neck 102, for holding pumping unit 120 in Dewar flask 101 and for sealing jacket 104 to the Dewar flask 101. Also, preferably a shut-off valve 108 is installed on the external section 111 of the central feeding conduit 103. The shut-off valve 108 ensures control of the supply of the liquid cryogen.

[0051] In a preferred embodiment, preferably safety and relief valves 109 and 110 are installed on ports of the outer section of jacket 104 for releasing the pressure in the Dewar flask 101. Jacket 104 also preferably features a pressure gauge 114 which is installed on the external section 111 of the central feeding conduit 103 for measuring internal pressure in the Dewar flask 101.

[0052] The lower section of the internal surface of jacket 104 is provided with an internal threading 115 with an internal diameter, which fits the outer diameter of the central feeding conduit 103.

[0053] Two check valves are installed in the internal section of the central feeding conduit: a lower check valve 106 and an upper check valve 119.

[0054] An electrical heating element 107 is positioned onto the central feeding conduit 103 in the immediate vicinity of the lower check valve 106 and somewhat above it. This electrical heating element 107 is preferably of low thermal inertia, but may optionally be of the resistive and/or electromagnetic inductor types. The electric heating element 107 is optionally and preferably thermally insulated from its outside with a thermal insulation 123.

[0055] A control-power unit 116 of electrical current (AC or DC) is situated outside the Dewar flask 101 and connected with the electric heating element 107 by wires 112 and 113.

This control-power unit 116 ensures delivery of electrical current to the electrical heating element 107 in the form of separated pulses.

[0056] FIG. 1b shows the Dewar flask 101 with the pumping unit designed similarly to that shown in FIG. 1a, but the upper check valve 119 is installed in the central feeding conduit outside of the Dewar flask 101.

[0057] FIG. 1c shows an enlarged axial cross- and a sectional view of the upper section of the Dewar flask and the pumping unit 120. Pumping unit 120 comprises a Dewar flask 101 with neck 102, which is intended to be filled with a liquid cryogen to be supplied by the pumping unit 120. The upper section of the pumping unit comprises a central feeding conduit 103 and jacket 104 surrounding the central conduit 103 with gap 117 formed between them. The upper edge of jacket 104 is sealed with the central feeding conduit 103 as shown. Also a seal for sealing jacket 104 to the Dewar flask is provided, along with an annular rubber ring 105 installed on jacket 104 and inserted partially into neck 102, for holding pumping unit 120 in Dewar flask 101. Also, preferably a shut-off valve 108 is installed on the external section 111 of the central feeding conduit 103. The shut-off valve 108 ensures control of the supply of the liquid cryogen.

[0058] In the preferred embodiment, preferably safety and relief valves 109 and 110 are installed on ports 129 and 128, respectively, of the outer section of jacket 104 for establishing and releasing the pressure in the Dewar flask 101. Jacket 104 also preferably features a pressure gauge 114 which is installed on the external section 111 of the central feeding conduit 103 for measuring internal pressure in the Dewar flask.

[0059] The lower section of the internal surface of jacket 104 is provided with an internal threading 115 with an internal diameter, which fits the outer diameter of the central feeding conduit 103.

[0060] An upper check valve 119 is installed in the internal section 122 of the central feeding conduit 103.

[0061] A control-power unit 116 of electrical current (AC or DC) is situated outside the Dewar flask 101 and connected with the electric heating element by wires 112 and 113. Opening 121 and 122 in jacket 104 serve for installation and routing of wires 113.

[0062] FIG. 1d shows an axial cross-sectional view of the lower section of the Dewar flask and the pumping unit. It shows the Dewar flask 101, the central feeding conduit 103, a lower check valve 106 that is installed in the central feeding conduit, and an electrical heating element 107, which is positioned onto or adjacent the central feeding conduit 103 in the immediate vicinity of the lower check valve 106 and somewhat above it. A thermal insulation 123 is optionally and preferably provided on the exterior of electric heating element 107 for thermal insulation; electric heating element 107 is preferably connected with a power-control unit via wires or cables 113.

[0063] Delivery of each pulse to the electrical heating element 107 causes the liquid cryogen to boil in the internal space 122 of the central feeding conduit 103 in the section which is in contact with or adjacent the electrical heating element 107, resulting in sharp elevation of its pressure. As a result, the lower check valve 106 closes; the high pressure portion of the liquid-gaseous cryogen then causes the upper check valve 119 to open. Thereafter, as the result of heat exchange between the central feeding conduit 103 and the liquid cryogen in the Dewar flask, the evaporated portion of

the cryogen in the central feeding conduit 103 condenses again while reducing the pressure in the central feeding conduit 103. The lower check valve 106 then opens and the upper check valve 119 closes.

[0064] FIG. 2 shows an enlarged axial cross-sectional view of the lower section of the Dewar flask and the pumping unit with an inductor used as an electrical heating element. Components having the same or similar function as those shown in FIG. 1 have the same reference numbers.

[0065] An inductor 207 and a ferromagnetic tubular piece 224 are optionally and preferably positioned onto or adjacent the central feeding conduit 103, in this embodiment, in the immediate vicinity of the lower check valve 106 and preferably somewhat above lower check valve 106, for heating through induction. Inductor 207 is optionally and preferably thermally insulated from its outside with a thermal insulation 123 and connected with a power-control unit (not shown) via cables 113.

[0066] FIG. 3 shows an axial cross-sectional view of a pumping unit with a bellows section incorporated into the central feeding conduit. Components having the same or similar function as those shown in FIG. 1 have the same reference numbers.

[0067] A section 328 of the central feeding conduit 103 is preferably situated adjacent to and above the section surrounded by the electrical heating element 107, and preferably features outer longitudinal fins 325 and internal longitudinal fins 326.

[0068] Optionally a bellows' section 327 of the central feeding conduit 103, preferably situated above the finned section 328, is provided for preventing a rapid rise in pressure of the central feeding conduit 103. The bellows section 327 is preferably made of an elastic material.

[0069] FIG. 4 shows an axial cross-sectional view of a Dewar flask with the pumping unit installed in its neck and a buffering vessel equipped with an evaporating member. Components having the same or similar function as those shown in FIG. 1 have the same reference numbers.

[0070] Optionally and preferably a buffering vessel 430 is in fluid communication with the outer section of the central feeding conduit 103, for providing a constant or at least relatively steady supply of the liquid medium. This buffering vessel 430 is equipped with a safety valve 433 and a pressure gauge 432. In addition, an electrical heater 434 is installed in the buffering vessel 430; this electrical heater serves for evaporation the cryogen provided from the Dewar flask 101. The electrical heater 434 is connected with the power-control unit 116 via cables 435. The buffering vessel 430 also preferably comprises an outlet connection 431 with a shut-off valve 436.

[0071] FIG. 5a shows a Dewar flask 501 with neck 502, which is intended to be filled with a liquid cryogen to be supplied by the pumping unit 520. Pumping unit 520 comprises a central feeding conduit 503, this central feeding conduit serves for supply of the liquid cryogen to a target place, and jacket 504 surrounding the central conduit 503 with gap 517 formed between them. The upper edge of jacket 504 is sealed with the central feeding conduit 503 as shown. Also a seal for sealing jacket 504 to the Dewar flask is provided, along with an annular rubber ring 505 installed on jacket 504 and inserted partially into neck 502, for holding pumping unit 520 in Dewar flask 501. Also, preferably a shut-off valve 508 is installed on the outer section of the

central feeding conduit **503**. The shut-off valve **508** ensures control of the supply of the liquid cryogen.

[0072] In the preferred embodiment, preferably safety and relief valves **509** and **510** are installed on ports of the outer section of jacket **504** for establishing and releasing the pressure in the Dewar flask **501**. Jacket **504** also preferably features a pressure gauge **514** which is installed on the outer section of the central feeding conduit **503** for measuring internal pressure in the Dewar flask **501**.

[0073] The lower section of the internal surface of jacket **504** is provided with an internal threading **515** with an internal diameter, which fits the outer diameter of the central feeding conduit **503**.

[0074] Two types of check valves are installed in the internal section the central feeding conduit: lower check valves **506** and an upper check valve **519**.

[0075] Electrical heating elements **507** are positioned onto the lower branches of the central feeding conduit **503** in the immediate vicinity of the lower check valves **506** and somewhat higher than them. These electrical heating elements **507** should preferably be of low thermal inertia.

[0076] The electrical heating elements can be resistors or electromagnetic inductors. The electric heating elements are optionally and preferably thermally insulated with thermal insulations **523**.

[0077] A control-power unit **516** of electrical current (AC or DC) is situated outside the Dewar flask **501** and connected with the electric heating elements **507** by wires **512** and **513**. The control-power unit **516** ensures delivery of electrical current to one of the electrical heating elements **507** in the form of separated pulses and in accordance with data provided from a clinometer **524**, as a non-limiting example of a sensor for sensing angle of declination (tilt). This clinometer **524** measures an inclination angle and orientation of the Dewar flask **501** at a certain moment.

[0078] As shown in FIG. **5b**, the lower branches of the central feeding conduit **503** may also be provided with a bellows section **525**, preferably made of elastic material, to permit the branches to be inserted into Dewar flask **501**.

[0079] FIG. **6** shows an axial cross-sectional view of another embodiment of Dewar flask with a vacuum insulated jacket situated partially in the Dewar flask and partially outside of the Dewar flask. In this embodiment, Dewar flask **101** with neck **102** is filled with a liquid cryogen to be supplied by the pumping unit **620**. Pumping unit **620** comprises central feeding conduit **103** for supplying the liquid cryogen to an external location, and has jacket **104** surrounding the central conduit **103** with gap **117** formed between them. Preferably, pumping unit **620** is held in Dewar flask **101** through some type of device, such as a ring **105** (which may optionally be an annular rubber ring), installed on jacket **104** and inserted partially into neck **102**.

[0080] The central feeding lumen **103** is preferably surrounded by a vacuum insulated jacket **630**, which is sealed with central feeding lumen **103** at the distal and proximal ends and which is located within jacket **104**, for providing a greater degree of thermal insulation. Vacuum insulated jacket **630** preferably comprises an internal jacket section **631** with its proximal end sealed with the central feeding conduit **103** above the lower check valve **106**; and an external jacket section **632**, which is sealed at its distal end with the external section of the central feeding lumen **103**. The central feeding lumen **103** preferably also comprises an external flexible

section **633**, which is optionally and preferably designed as a bellows, to provide flexibility to a hose **634**.

[0081] The operation of dewar flask **101** and pumping unit **620** is substantially similar to that described previously, for example in FIG. **1**; however, the additional thermal insulation provided by vacuum insulated jacket **630** further reduces heating of the cryogenic material. External jacket section **632** is preferably flexible, as is flexible section **633**, so as to provide flexibility to hose **634** during operation, for provision of the cryogenic material through hose **634**. Electrical heating element **107** also replaces the on-off valve of FIG. **1** (element **108** in FIG. **1**); pulses of electrical current switch on the geyser pump due to heating of electrical heating element **107**, and their absence switches off the geyser pump.

[0082] While the invention has been described with respect to a limited number of embodiments, it will be appreciated that many variations, modifications and other applications of the invention may be made.

What is claimed is:

1. A pumping unit for delivering a liquid medium from a vessel in the form of separated pulses; said pumping unit comprising:

- a conduit, which is at least partially contained within said vessel, wherein a proximal end of said conduit is situated in a vicinity of a bottom of said vessel;
- a first check valve installed on a lower section of said conduit;
- an electrical heating element for heating a lower portion of said conduit; and
- a second check valve installed on an upper section of said conduit;

wherein heating of said heating element causes said liquid medium to form vapors in said conduit, said vapors causing said first check valve to close and causing said second check valve to open; and upon condensation of said vapors, said second check valve closes.

2. The pumping unit of claim 1, wherein said liquid medium comprises a cryogen.

3. The pumping unit of claim 2, wherein said electrical heating element has low thermal inertia.

4. The pumping unit of claim 3, wherein said conduit comprises a layer of an outer thermal insulation for reducing heating of the surrounding liquid medium by said electrical heating element.

5. The pumping unit of claim 1, wherein the condensation occurs in a section of the central feeding conduit situated in immediate vicinity of the bottom of the vessel.

6. The pumping unit of claim 1, wherein electrical heating pulses are applied to the heating element, and duration of the electrical heating pulses is significantly less than a time required for floatation of vapor bubbles generated by said electrical heating pulses to the upper section of the central feeding conduit.

7. The pumping unit of claim 1, wherein said second check valve is of a normally open type and wherein said first check valve is of a normally open type.

8. The pumping unit of claim 1, wherein said second check valve is of the normally closed type and wherein said first check valve is of a normally open type.

9. The pumping unit of claim 1, wherein the electrical heating element is of a resistive type.

10. The pumping unit of claim 1, wherein the electrical heating element is of an inductive type.

11. The pumping unit of claim 1, wherein said separate pulses are under high pressure of at least about 1.5 atmospheres.

12. A pumping unit for feeding liquid cryogen from a Dewar flask, comprising:

a central feeding conduit;

seal means for sealing said central feeding conduit to the Dewar flask;

two check valves installed on an upper section and a lower section respectively of said central feeding conduit;

an electrical heating element, situated in immediate contact with or adjacent a section of said central feeding conduit, said section being above and adjacent to said lower check valve;

a power-control unit supplying pulses of electrical current to said electrical heating element; and wherein the liquid cryogen is fed through said central feeding conduit from the Dewar flask.

13. The pumping unit of claim 12, wherein the upper check valve is of a normally closed type.

14. The pumping unit of claim 12, wherein the lower check valve is of a normally open type.

15. The pumping unit of claim 12, wherein the electrical heating element functions as a resistor.

16. The pumping unit of claim 12, wherein the electrical heating element comprises a combination of an inductor and an adjacent section of the central feeding conduit, the adjacent section comprising a ferromagnetic material.

17. The pumping unit of claim 12, further comprising a condensation section of the central feeding conduit, the condensation section including a plurality of outer fins.

18. The pumping unit of claim 12, further comprising a condensation section of the central feeding conduit, the condensation section including a plurality of internal fins.

19. The pumping unit of claim 12, wherein said central feeding conduit further comprises a section constructed as a bellows.

20. The pumping unit of claim 12, further comprising a buffering vessel in fluid communication with an outer section

of the central feeding conduit, said buffering vessel comprising a safety valve and a pressure gauge.

21. The pumping unit of claim 20, wherein said buffering vessel further comprises a heater for evaporating the cryogen provided from said Dewar flask.

22. The pumping unit of claim 21, wherein said buffering vessel further comprises an outlet connection and a shut-off valve.

23. The pumping unit of claim 21, wherein the buffering vessel is equipped with a safety valve and a pressure gauge.

24. The pumping unit of claim 12, wherein the lower section of the central feeding conduit comprises a plurality of branches, each branch being provided with an independent check valve, and an electrical heating unit, the pumping unit further comprising a sensing unit and a power control unit, wherein said sensing unit detects an angle and direction of inclination of said Dewar flask and wherein said power-control unit energizes a selected electrical heating unit according to data communication from said sensing unit, to heat a branch that is immersed with its proximal end into the liquid cryogen in said Dewar flask.

25. The pumping unit of claim 23, further comprising a bellows section incorporated into each branch of the central feeding conduit.

26. The pumping unit of claim 12, wherein the central feeding conduit includes an external vacuum insulation in the form of a vacuum insulated jacket; a proximal edge of said vacuum insulated jacket is sealed with the central feeding conduit above the lower check valve and a distal edge of the jacket is sealed with said central feeding conduit distally to the upper check valve and externally to the Dewar flask.

27. The pumping unit of claim 25, wherein said jacket further comprises an internal threading, such that an internal diameter of said jacket is fitted to an outer diameter of the central feeding conduit.

28. The pumping unit of claim 27, wherein outer sections of said vacuum insulated jacket and said central feeding conduit comprise a flexible bellows.

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