(19) DANMARK

(10) **DK 180554 B1**

(12) PATENTSKRIFT

Patent- og
Varemærkestyrelsen

(51) Int.Cl.: ***G01N 15/06 (2006.01)*** ***G01N 7/00 (2006.01)*** ***G01N 21/17 (2006.01)*** ***G01N 33/18 (2006.01)***

(21) Ansøgningsnummer: **PA 2020 00483**

(22) Indleveringsdato: **2020-04-24**

(24) Løbedag: **2020-04-24**

(41) Alm. tilgængelig: **2021-06-17**

(45) Patentets meddelelse bkg. og publiceret den: **2021-06-17**

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(54) Titel: **ASSAY ROBOT FOR MEASURING SUSPENDED PARTICLES IN HIGH PARTICLE AQUEOUS SOLUTIONS**

(56) Fremdragne publikationer:
**JP S5388792 A**
**US 3680962 A**
**WO 2007/071825 A1**
**WO 92/01738 A1**
**US 6450006 B1**

(57) Sammendrag:
**An assay robot (100) for measuring the turbidity value and the amount of unresolved gases relative to the liquid is disclosed. The robot (100) comprises a housing (104) for supporting multiple components. The components include valve 1, cylinders (2 and 3), a pressure chamber 6, a pneumatic cylinder 7, and a sensor 8. The valve (1) are securely disposed in the housing (104) for distributing a sample liquid/product and water into the cylinders (2 and 3). The robot (100) could homogenize, dilute, and exhaust the liquid using a homogenizer (4) and a holding cell (5). The pneumatic cylinder (7) further comprises a piston, which is configured to move to and fro within the pressure chamber (6), thereby measuring the turbidity value and the unresolved gases relative to the liquid based on the volume displaced by the piston in the pressure chamber (6) using the sensor (8).**

**Fortsættes...**

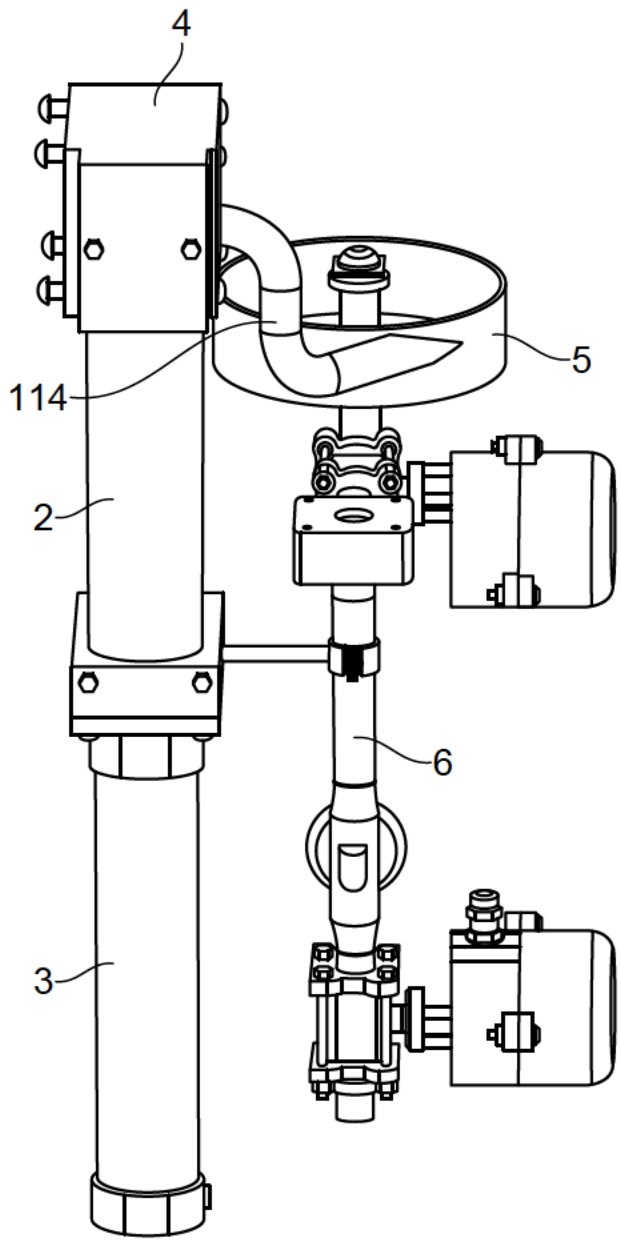


FIG. 3

# ASSAY ROBOT FOR MEASURING SUSPENDED PARTICLES IN HIGH PARTICLE AQUEOUS SOLUTIONS

## TECHNICAL FIELD OF THE INVENTION

The invention disclosed herein generally relates to a device for measuring unresolved gases in liquids. More particularly, the present invention relates to an assay robot for efficiently measuring turbidity value i.e., suspended particles and the amount of residual unresolved gas relative to the liquid in real-time using a sensor and treating a suspension of particles/solid contents in the carrier liquid.

## BACKGROUND

Solid particles of small dimensions contained in liquids, especially when they float or are suspended therein, are generally surrounded in or encased by numerous minute air bubbles. The adhesion of the air bubbles to the particles makes it difficult to remove them and sometimes impossible by the ordinary methods. The smaller the bubbles, the greater the difficulty. This is particularly the case in handling washing waters from mines, white waters from paper mills and generally all effluents in which solids are contained or suspended in a finely divided state.

Numerous methods and pieces of equipment have been devised to separate liquids from each other and to separate any gas that may be entrapped in the liquids. Such apparatus and methods have wide application in many industries. In addition, the measurement of the concentrations of unresolved gases and volatile components in liquids is very helpful for process control and to indicate and prevent process instabilities in many chemical and biotechnological plants.

A prior art, JPS5388792 of *NISHIHARA KANKIYOU EISEI KENKI*, discloses an assay robot for measuring turbidity value, wherein said measuring turbidity comprises condensing air bubbles in the liquid, and wherein said condensing air bubbles comprises providing an assay robot comprising valves securely disposed in the housing for distributing a sample liquid/product and water into a cylinder. Further, the assay robot comprises a pressure chamber, configured to increase the pressure of the liquid above the equilibrium level, thereby condensing air bubbles in the liquid. However, above-mentioned prior art fails to provide solution on providing a contained assay robot combining a measurement of unresolved gases relative to the liquid with the turbidity measurement.

However, the prior devices and methods suffer from certain disadvantages such as being limited in measuring the amount of residual unresolved gas relative to the liquid in real-time and they cannot satisfactorily separate the liquid from the particles. Further, the development of a precise and efficient measuring system is very challenging because air bubbles are dynamic and unstable relative to time and space in a moving liquid, thus hindering an accurate validation of the measuring system. Further, the air bubbles may remain in the liquid, causing an inaccurate or variable reading.

In the light of above-mentioned problems, there is a need for an assay robot for measuring bubbling liquid with particles or high solid contents by comminuting and homogenizing the particles in the liquid to optimize the repeatability of the measurement result. Further, there is a need for an assay robot that prepares the fluid for online analysis, using a standard optical sensor, for example, a turbidity sensor.

## SUMMARY OF THE INVENTION

This summary is provided to introduce a selection of concepts in a simplified form that is further disclosed in the detailed description of the invention. This summary is not intended to identify key or essential inventive concepts of the claimed subject matter, nor is it intended for determining the scope of the claimed subject matter.

The present invention discloses a device for measuring unresolved gases in liquids. More particularly, the present invention relates to an assay robot for efficiently measuring turbidity value i.e., suspended particles and the amount of residual unresolved gas relative to the liquid in real-time using a sensor and treating a suspension of particles/solid contents in the carrier liquid.

In one embodiment, the robot is configured to measure the turbidity value i.e., the amount of particles presented in the liquid and the unresolved gases relative to the liquid. In one embodiment, the robot comprises a housing for supporting components of the robot. In one embodiment, the housing is securely mounted on one or more supports from a ground level. In another embodiment, the housing is rotatably mounted on one or more supports from a ground level. The one or more supports are securely anchored to the ground using an anchor. In one embodiment, a pair of handles are securely affixed to both sides of the housing. In one embodiment, a screen is securely mounted on a front portion of the housing for displaying the measured value of the unresolved gases relative to the liquid.

In one embodiment, the components of the robot are securely and operatively disposed within the housing. In one embodiment, the components include, but not limited to, one or more valve, one or more cylinders, a homogenizer, a holding cell, a pressure chamber, a pneumatic cylinder, and a sensor. In one embodiment, the valve are securely disposed in the housing for distributing a sample liquid/product and water into one or more cylinders. The homogenizer is securely and fluidly connected to the cylinders and is

configured to receive and homogenize the sample liquid and water and at the same time, the liquid is diluted in a mixing ratio determined by the stroke length of the cylinders.

In one embodiment, the holding cell is securely connected to the homogenizer via a hose. The holding cell is configured to exhaust the liquid for removing large bubbles. In one embodiment, the holding cell comprises a spiral, which is configured to skim the liquid before running down to the sensor. In one embodiment, the holding cell further comprises a needle valve, which is configured to regulate holding time for exhausting the liquid. In one embodiment, the pressure chamber is connected to the holding cell and is configured to increase the pressure of the liquid above the equilibrium level, thereby condensing air bubbles in the liquid. In one embodiment, the pneumatic cylinder is operatively connected to the pressure chamber. In one embodiment, the pneumatic cylinder further comprises a piston, which is configured to move to and fro within the pressure chamber, thereby measuring the unresolved gases relative to the liquid based on the volume displaced by the piston in the pressure chamber.

In one embodiment, the sensor is securely and fluidly connected to a bottom portion of the pressure chamber, configured to detect the volume displaced by the piston in the pressure chamber and log or record the unresolved gases relative to the liquid. In one embodiment, the logged unresolved gases relative to the liquid could be displayed on the screen, which is mounted on the housing. In one embodiment, the sensor could be, but not limited to, an optical sensor and a magnetic inductive sensor.

In one embodiment, the surface tension of the liquid squeezes the air bubbles with a radius of a few hundred nanometers so hard that the pressure in the air bubble could withstand a pressure difference of about 15 bar. Therefore, the robot raises the pressure to a difference of more than 35 bar for 10 seconds before logging the measurement value. The robot comminutes and homogenizes the particles in the liquid to optimize the repeatability of the measurement result. Liquid with uniform particles gives the highest data quality.

Other objects, features and advantages of the present invention will become apparent from the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing summary, as well as the following detailed description of the invention, is better understood when read in conjunction with the appended drawings. For illustrating the invention, exemplary constructions of the invention are shown in the drawings. However, the invention is not limited to the specific methods and structures disclosed herein. The description of a method step or a structure referenced by a numeral in a drawing is applicable to the description of that method step or structure shown by that same numeral in any subsequent drawing herein.

FIG. **1** exemplarily illustrates a front view of an assay robot securely and rotatably mounted on one or more supports in an embodiment of the present invention.

FIG. **2** exemplarily illustrates a side view of the assay robot securely and rotatably mounted on one or more supports in one embodiment of the present invention.

FIG. **3** exemplarily illustrates a rear perspective view of components of the assay robot in one embodiment of the present invention.

FIG. **4** exemplarily illustrates a front perspective view of the components of the assay robot in one embodiment of the present invention.

FIG. **5** exemplarily illustrates a rear perspective view a water heater securely disposed in the housing in one embodiment of the present invention.

FIG. **6** exemplarily illustrates a front perspective view the water heater securely disposed in the housing in one embodiment of the present invention.

FIG. **7** exemplarily illustrates a top perspective view of valves and hose connections in one embodiment of the present invention.

FIG. **8** exemplarily illustrates a side perspective view of the valves and hose connections in one embodiment of the present invention.

FIG. **9** exemplarily illustrates an exploded view of a rotor rotatably securing to a shaft of a motor in one embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIGs. **1-2**, an assay robot **100** for measuring unresolved gases in a liquid or high particle aqueous solution is disclosed. In one embodiment, the robot **100** is configured to measure the turbidity value i.e., the amount of suspended particles presented in the liquid and the amount of unresolved gases relative to the liquid. In one embodiment, the robot **100** comprises a housing **104** for supporting multiple components of the robot **100**. In one embodiment, the housing **104** is securely mounted on one or more supports **110** from a ground level. In another embodiment, the housing **104** is rotatably mounted on one or more supports **110** from a ground level as shown in FIG. **2**. The one or more supports **110** are securely anchored to the ground using an anchor **112**. In one embodiment, a pair of handles **106** are securely affixed to both sides of the housing **104**. In one embodiment, a screen **108** is securely mounted on a front portion of the housing **104** for displaying the measured value of the unresolved gases relative to the liquid. In an exemplary embodiment, the robot **100** is configured to measure the turbidity value i.e., the amount of suspended particles presented in the liquid in the feed pipe for rotten tanks at biogas plants.

Referring to FIGs. **3-4**, the components of the robot **100** are disclosed. In one embodiment, the components of the robot **100** are securely and operatively disposed within the housing **104** (shown in FIG. **1**). In one embodiment, the components include, but not limited to, one or more valve **1**, one or more cylinders (**2** and **3**), a homogenizer **4**, a holding cell **5**, a pressure chamber **6**, a pneumatic cylinder **7**, and a sensor **8**. In one embodiment, the valve **1** are securely disposed in the housing **104** for distributing a sample liquid/product and water into one or more cylinders (**2** and **3**). The homogenizer **4** is securely and fluidly connected to the cylinders **3** and is configured to receive and homogenize the sample liquid and at the same time, the liquid is diluted in a mixing ratio determined by the stroke length of the cylinders **3**.

In one embodiment, the holding cell **5** is securely connected to the homogenizer **4** via a hose **114**. The holding cell **5** is configured to exhaust the liquid for removing large bubbles. In one embodiment, the holding cell **5** comprises a spiral **116**, which is configured to skim the liquid before running down to the sensor **8**. In one embodiment, the holding cell **5** further comprises a needle valve **118**, which is configured to regulate holding time for exhausting the liquid. In one embodiment, the pressure chamber **6** is connected to the holding cell **5** and is configured to increase the pressure of the liquid above the equilibrium level, thereby condensing air bubbles in the liquid. In one embodiment, the pneumatic cylinder **7** is operatively connected to the pressure chamber **6**. In one embodiment, the pneumatic cylinder **7** further comprises a piston, which is configured to move to and fro within the pressure chamber **6**, thereby measuring the unresolved gases relative to the liquid based on the volume displaced by the piston in the pressure chamber **6**. In an exemplary embodiment, a magnetic inductive sensor is disposed on the cylinder which drives the piston. The piston runs past the sensor if there are many bubbles in the liquid. The current measurement cycle is interrupted and a new cycle will be initiated.

In one embodiment, the sensor **8** is securely and fluidly connected to a bottom portion of the pressure chamber **6**, configured to detect the volume displaced by the piston in the pressure chamber **6** and log or record the unresolved gases relative to the liquid. In one embodiment, the logged unresolved gases relative to the liquid could be displayed on the screen **108** (shown in FIG. **1**), which is mounted on the housing **104**. In one embodiment, the sensor **8** could be, but not limited to, an optical sensor and a magnetic inductive sensor. Analysis data is collected electronically and forms the basis for monitoring and adjustments in the process and adjustments may be made fully automatic without human interventions. In one embodiment, the robot **100** could measure fluorescence in the liquid. When measuring the fluorescence, the apparatus can regulate the liquid to a predetermined temperature. For example, the particles present in the liquid with fluorescent properties will change wavelength with temperature changes. Liquid refractive index/density also varies with temperature.

In one embodiment, the surface tension of the liquid squeezes the air bubbles with a radius of a few hundred nanometers so hard that the pressure in the air bubble could withstand a pressure difference of about 15 bar. Therefore, the robot **100** raises the pressure to a difference of more than 35 bar for 10 seconds before logging the measurement value. The robot **100** comminutes and homogenizes the particles in the liquid to optimize the repeatability of the measurement result. Liquid with uniform particles gives the highest data quality. The robot **100** is designed for fully automatic, liquid sample preparation, primarily for optical analysis and ensures optimal repeatability and human error is excluded. After analysis, the liquid can be returned to the process. All functions are controlled by a computer.

Referring to FIGs. **5-6**, a water heater **97** securely disposed in the housing **104** of the robot **100** is disclosed. In one embodiment, the robot **100** further comprises a water heater **97**, which is securely disposed in the housing **104**. The water heater **97** is configured to heat the water and distribute within the robot **100** via one or more hoses for cleaning i.e. with known turbidity. Then the measurement is logged on the flushing water, and if the turbidity is increasing it means that the turbidity meter's optics are contaminated and that hot flushing water must be used. In one embodiment, the robot **100** is configured to measure the turbidity value i.e., the amount of suspended particles presented in the liquid in the feed pipe for rotten tanks at biogas plants. Turbidity is proportional to the number of particles presented in the liquid. The sampled liquid is diluted in a 1:1 ration to obtain half the measurement result. The robot multiplies the result by 2 before it is presented on the display. In one embodiment, the water heater **97** is powered via a power supply with 230 V. In one embodiment, a control unit **107** is disposed in the top portion of the housing **104** for controlling a drive unit or motor. In one embodiment, the robot **100** further comprises a manifold **103** with compressed air from a bulkhead passage **98**. In one embodiment, one or more hoses run from the manifold **103** to one or more pilot valves (**99**, **101**, and **102**) for speed control. In one embodiment, a holding bracket **109** is provided for the manifold **103**. In one embodiment, the manifold **103** could be an air manifold.

Referring to FIGs. **7-8**, the valves (**91** and **92**) and hose connections of the robot **100** is disclosed. In one embodiment, one or more hoses are used for distributing cold and hot water, and compressed air within the robot **100**. In one embodiment, the hoses are securely connected to the plurality of valves (**91** and **92**) and the hose connections. In one embodiment, the valves (**91** and **92**) could be, but not limited to, 3-way valves. In one embodiment, transparent hoses are used to distribute liquids within the robot **100**. In one embodiment, a hose with an inlet runs from the water heater **97** and is securely fitted onto the member/nipple **90** over the safety valve **122**, and feeds cold water. In one embodiment, another hose runs from the member/nipple **89** over the safety valve **122** to a hose connection **83** at the bottom of the valve **92**. In one embodiment, another hose runs from the water heater **97** and is fixed or screwed onto the hose connection **75** with a 1/8" wrap.

In one embodiment, another hose **123** runs from a hose connection **87** to a tee member **88** for distributing hot water via the valve **91**. In one embodiment, another hose runs from the tee member **88** down to a hose connection **79** (shown in FIG. **6**) of a ball valve **65** (shown in FIG. **6**). In one embodiment, another hose runs from a bulkhead entry **95** to a hose connection **82** at the bottom of the valve **91**. In one embodiment, another hose is a sewer pipe, which runs from the ball valve **65** to a bulkhead insertion item **96**.

Referring to FIG. **9**, a rotor **26** rotatably secured to a shaft **124** of a motor **80** is disclosed. In one embodiment, the motor **80** is securely disposed within the housing **104** of the robot **100**. In one embodiment, the rotor **26** is securely and rotatably connected to the shaft **124** of the motor **80** via a bearing **81** using a mounting plate **23**. In one embodiment, the motor **80** is configured to whip the liquids to ensure good and uniform mixing of a viscous product and water for dilution.

The advantages of the present invention include the robot **100** effectively measuring the amount of residual unresolved gas relative to the liquid by eliminating the air bubbles in the liquid and displaying results in real-time via the screen **108**. The robot **100** comminutes and homogenizes the particles in the liquid to optimize the repeatability of the measurement result. Liquid with uniform particles gives the highest data quality.

The foregoing examples have been provided merely for the purpose of explanation and are in no way to be construed as limiting of the present concept disclosed herein. While the concept has been described with reference to various embodiments, it is understood that the words, which have been used herein, are words of description and illustration, rather than words of limitation. Further, although the concept has been described herein with reference to particular means, materials, and embodiments, the concept is not intended to be limited to the particulars disclosed herein; rather, the concept extends to all functionally equivalent structures, methods and uses, such as are within the scope of the appended claims.

KRAV

En analyserobot (**100**) til måling af uklarhedsværdi og uløste gasser i en væske, hvori nævnte måling af uklarhed omfatter kondensering af luftbobler i væsken, og hvor der er kondenserende luftbobler og måling af en mængde uløste gasser i en væske. Analyserobotten omfatter:

en eller flere ventiler **(1)** sikkert installeret i et hus **(104)** til distribution af en prøvevæske / produkt og vand ind i en eller flere cylindre **(2 og 3)**, og en trykbeholder **(6)** konfigureret til at øge væsketrykket over ligevægtsniveauet og derved kondensere luftbobler i væsken, Kendetegnet ved:

en homogenisator **(4)** sikkert og flydende forbundet med cylindrene **(3)**, konfigureret til at modtage og homogenisere produktet og vandet, og på samme tid fortynde produktet i et blandingsforhold bestemt af slaglængden på cylindrene **(3)**;

en holdecelle (**5**) tilsluttet sikkert til homogenisatoren (**4**) via slange (**114**), hvor holdecellen (**5**) er konfigureret til at udtømme væsken til fjernelse af store bobler; hvor trykbeholderen (**6**) er forbundet til holdecellen (**5**),

en pneumatisk cylinder (**7**) operativt forbundet til trykbeholderen (**6**), hvor den pneumatiske cylinder (**7**) omfatter et stempel, der er konfigureret til at bevæge sig til og fra inde i trykbeholderen (**6**), derved kondenserer luftbobler i væsken og tillade måling af de opløste gasser i forhold til væske, baseret på det volumen, der er fortrængt af stemplet i trykbeholderen (**6**), og

en sensor (**8**) sikkert og flydende forbundet med en bunddel af trykbeholderen (**6**), konfigureret til at måle det volume, der er forskudt af stemplet i trykbeholderen (**6**) og registrere de opløste gasser i forhold til væsken.

2. Analyserobotten **(100)** ifølge krav 1, yderligere omfattende en skærm (108), sikkert monteret på huset **(104)**, hvor skærmen **(108)** er konfigureret til at vise måleværdien af de opløste gasser i forhold til væsken.

3. Analyserobotten (**100**) ifølge krav 1, hvor holdecellen (**5**) omfatter en spiral (**116**), hvor spiralen (**116**) er konfigureret til at skumme væsken, før den løber ned til sensoren (**8**).

4. Analyserobotten (**100**) ifølge krav 1, hvor holdecellen (**5**) yderligere omfatter en nåleventil (**118**), konfigureret til at regulere holdetid for udtømning af væsken.

5. Analyserobotten (**100**) ifølge krav 1, hvor sensoren (**8**) er enten en optisk sensor eller en magnetisk induktiv sensor.

6. Analyserobotten (**100**) ifølge krav 1, yderligere omfattende en vandvarmer (**97**), forsvarligt anbragt i huset (**2**), hvor vandvarmeren (**97**) er forbundet til en eller flere slanger konfigureret til at distribuere varmt vand indeni analyserobotten (**100**).

7. Analyserobotten (**100**) ifølge krav 1, hvor huset (**104)** er sikkert og drejeligt monteret på en eller flere støtter (**110**) fra jordoverfladen, hvor den ene eller flere støtter (**110**) er sikkert forankret til jorden ved hjælp af et beslag (**112**).

8. Analyserobotten (**100**) ifølge krav 1, yderligere omfattende et par håndtag (**106**), fastgjort på hver side af huset (**104**).

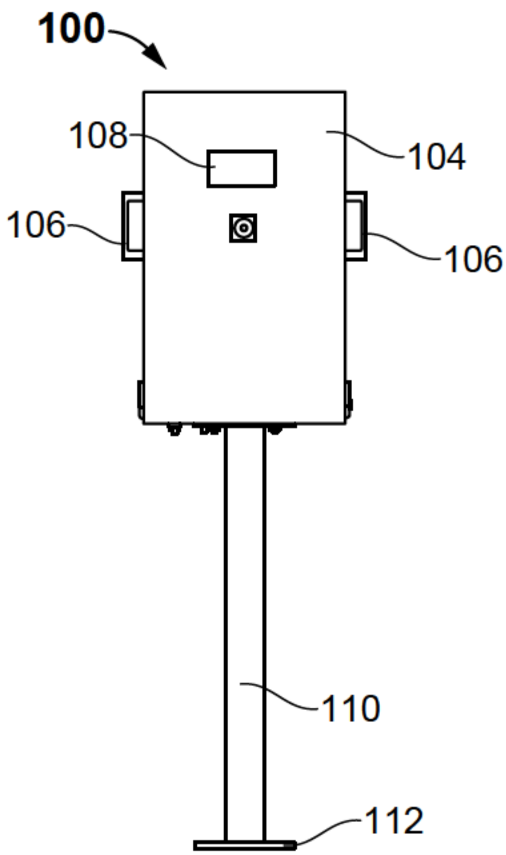


FIG. 1

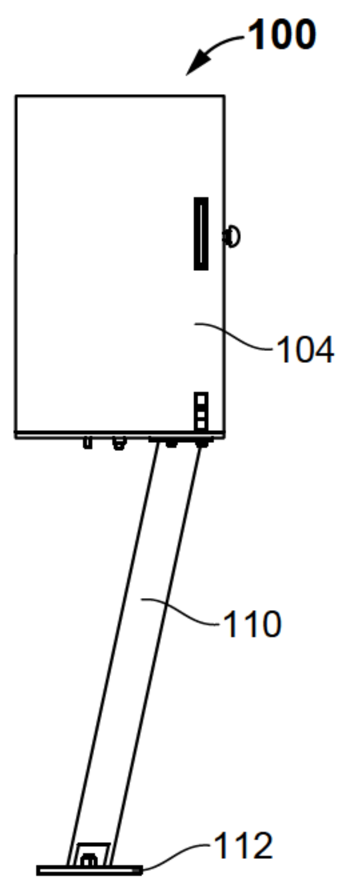


FIG. 2

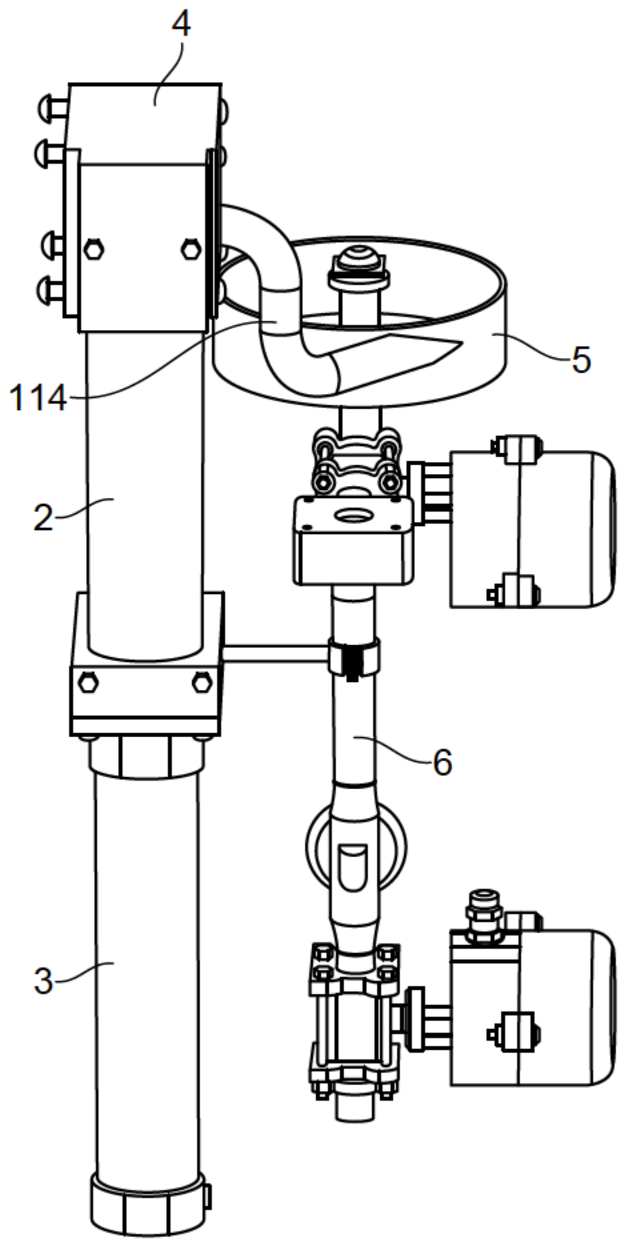


FIG. 3

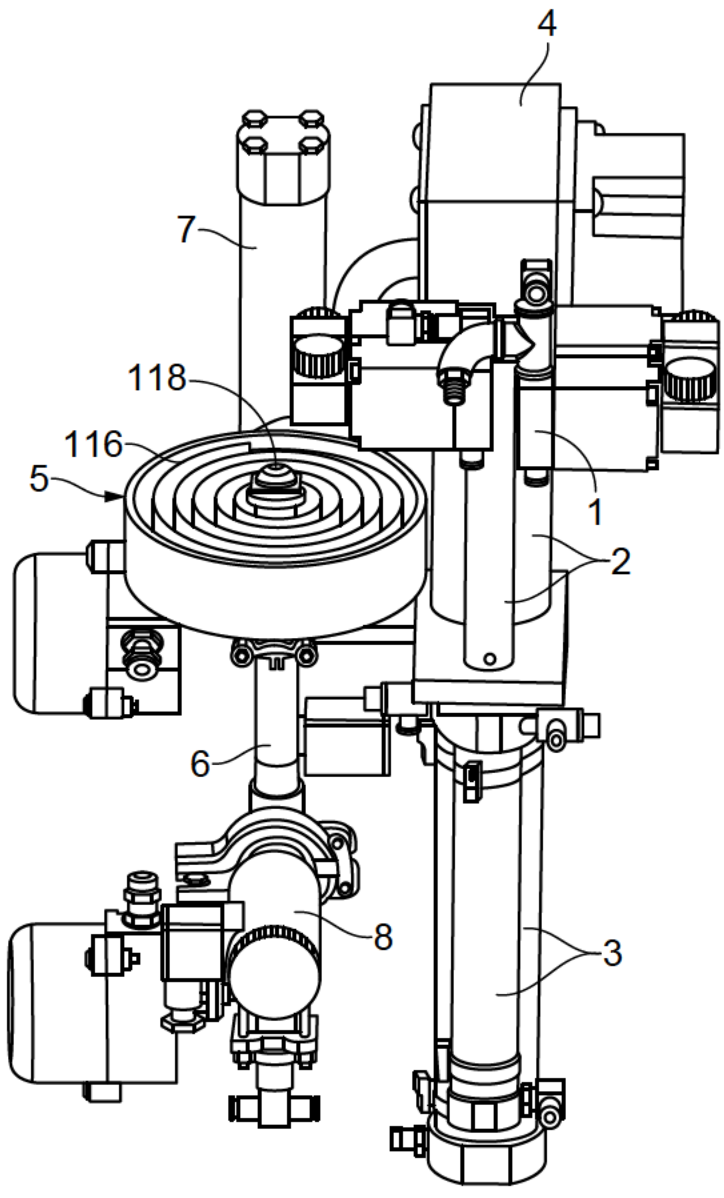


FIG. 4

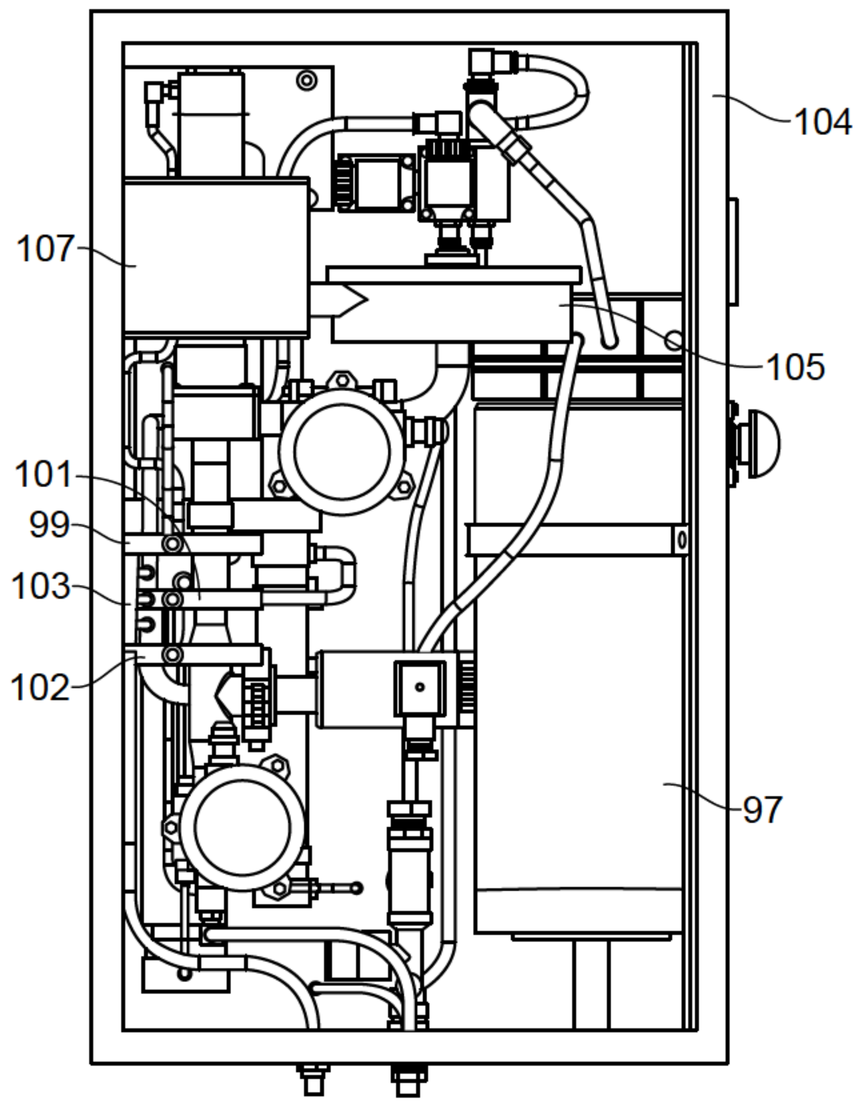


FIG. 5

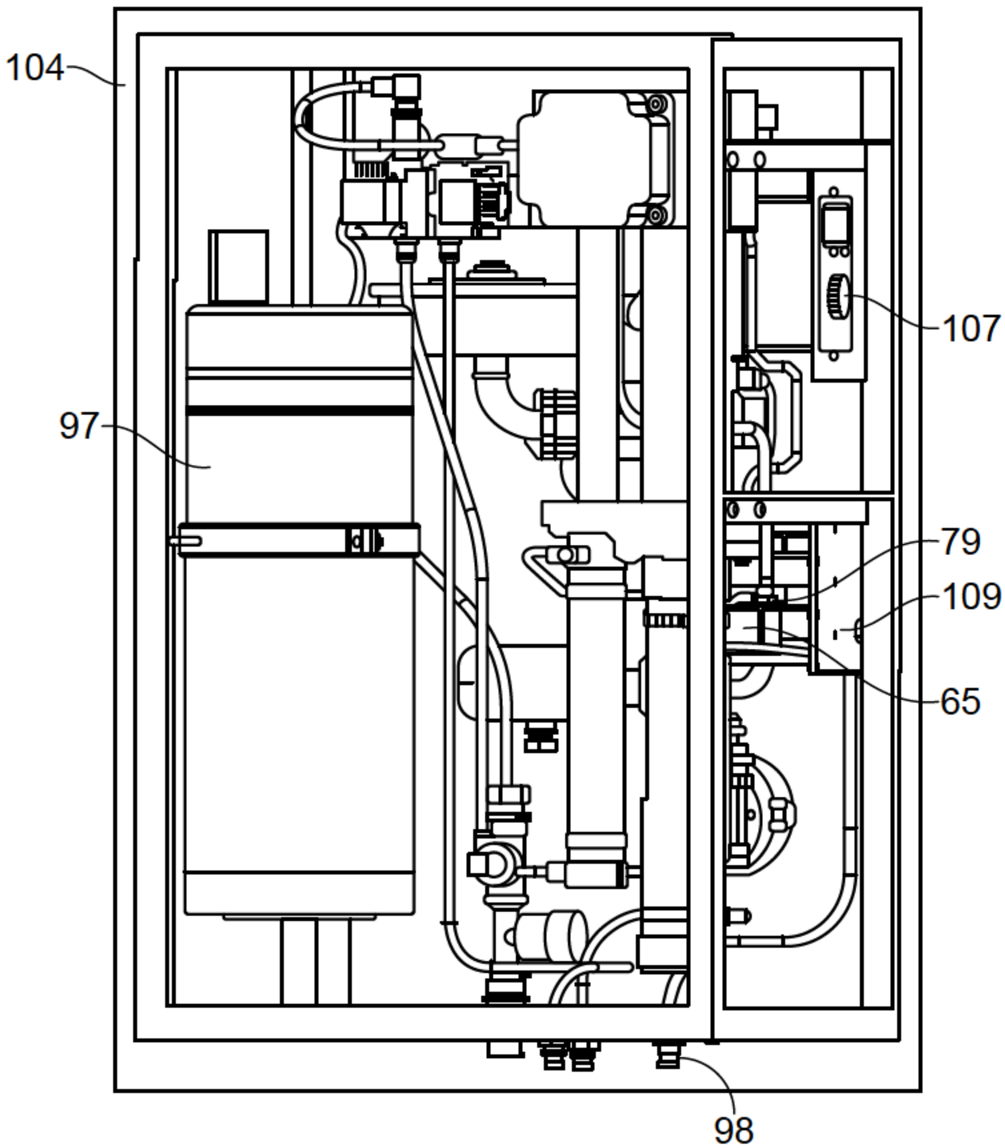


FIG. 6

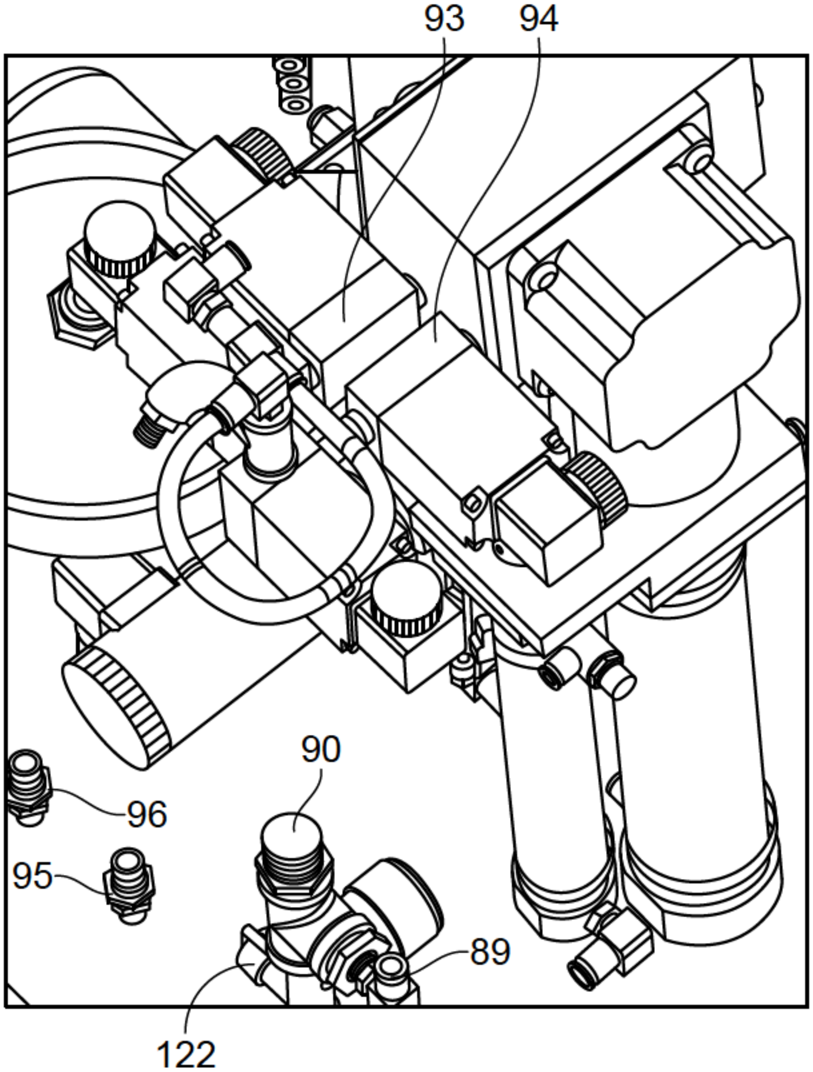


FIG. 7

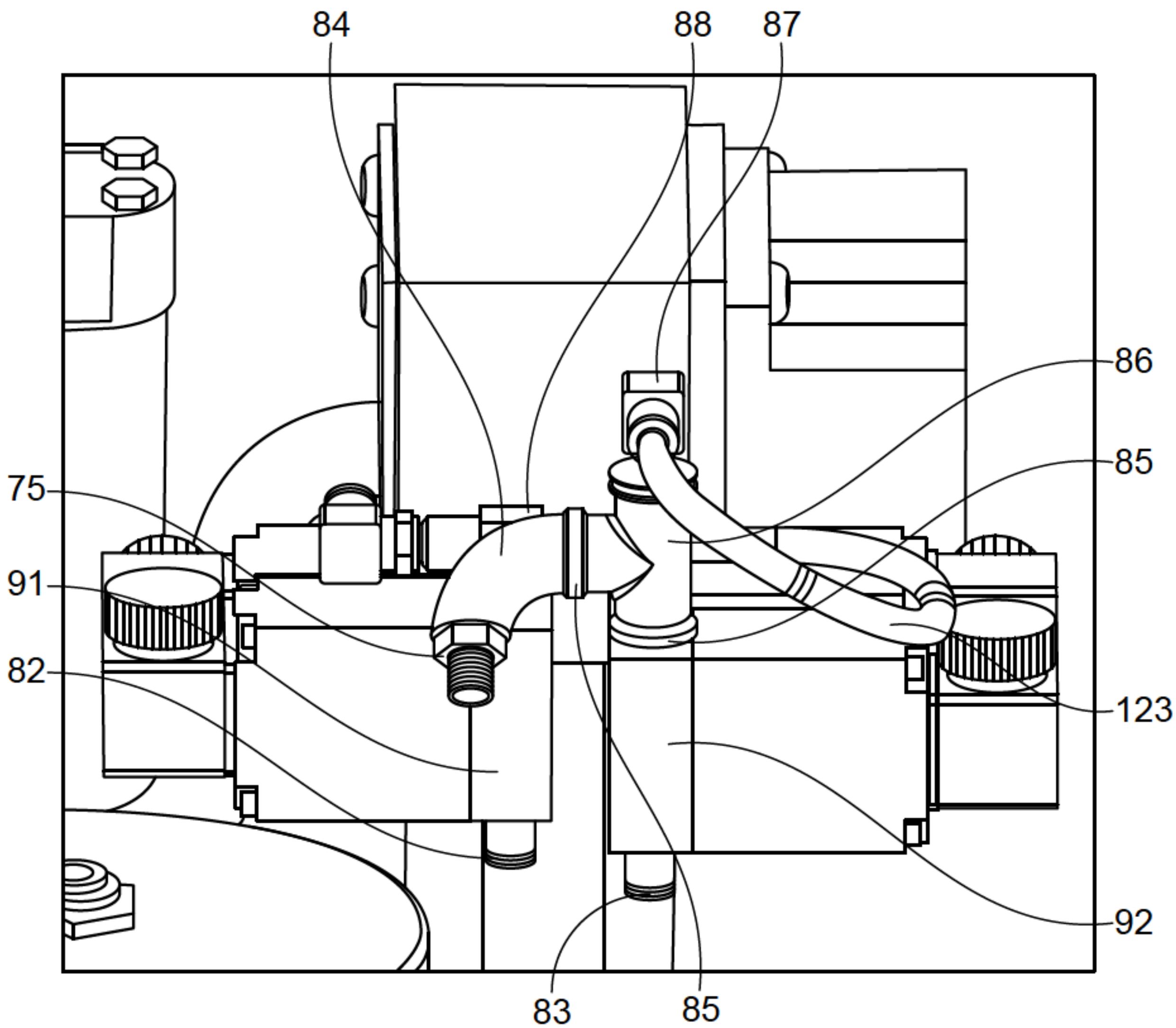


FIG. 8

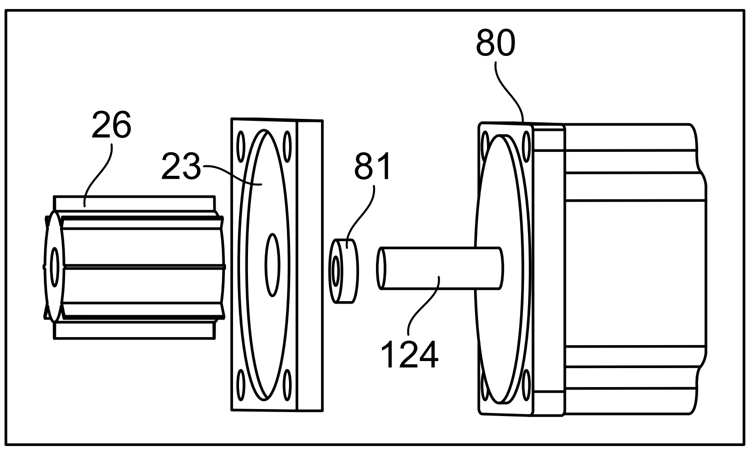


FIG. 9