United States Patent [19]

Kush

[11] **3,742,988**

[45] **July 3, 1973**

[54] **APPARATUS AND METHOD FOR DISSOLVING SOLUBLE GAS IN A LIQUID**

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[22] Filed: **Nov. 3, 1969**

[21] Appl. No.: **873,201**

[52] **U.S. Cl.** .... **141/2,** 23/259, 128/1.1, 128/272, 141/25, 141/105, 250/106 R, 261/121

[51] **Int. Cl.** **B01l 5/00**

[58] **Field of Search** .... 23/259; 128/1.1, 128/272; 141/1, 2, 4, 5, 9, 18, 21, 25–27, 37, 11, 69, 100, 105, 107, 114; 169/6–8, 32; 222/80; 250/106 R, 106 T; 261/1, 121

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[57] **ABSTRACT**

A container having a sealable access opening, an inlet conduit and an outlet conduit with a valve therein and a plunger threadedly engaged through the housing for breaking a glass ampule containing a soluble gas within the housing from the exterior thereof. The housing is flushed and filled with a desired fluid, the ampule is broken and the solution of fluid and soluble gas is drawn from the housing as desired.

6 Claims, 4 Drawing Figures

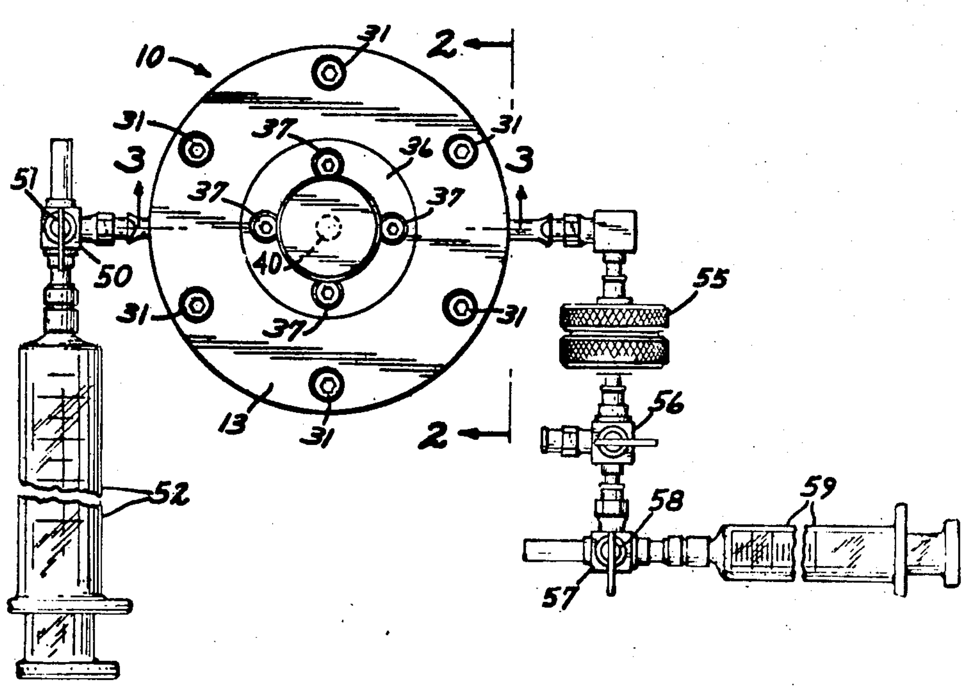


FIG. 1

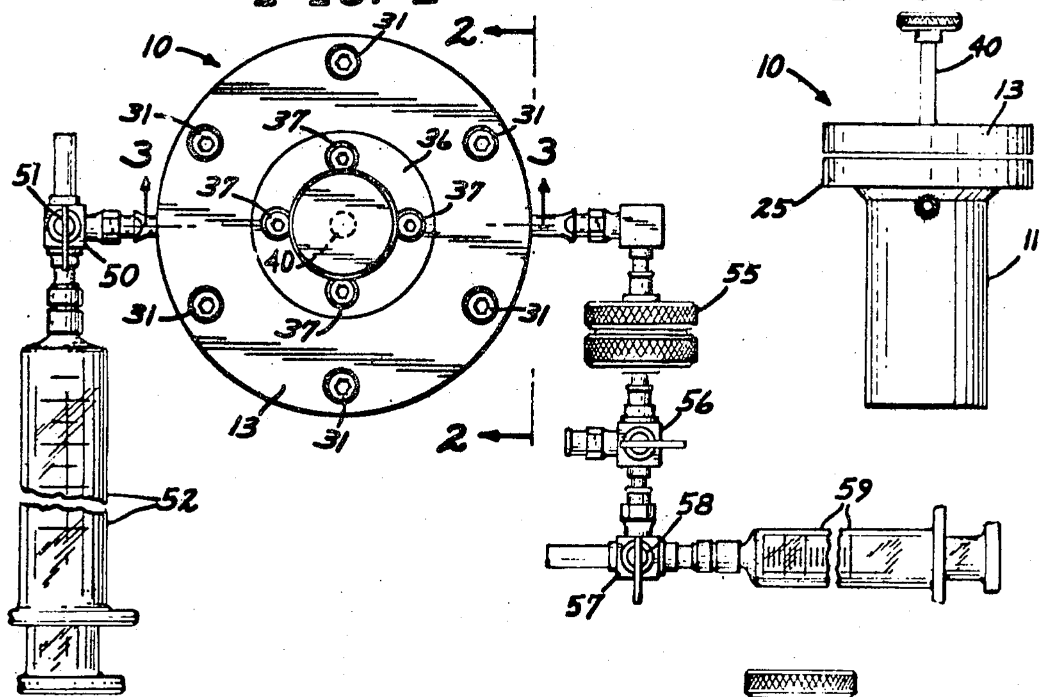


FIG. 4

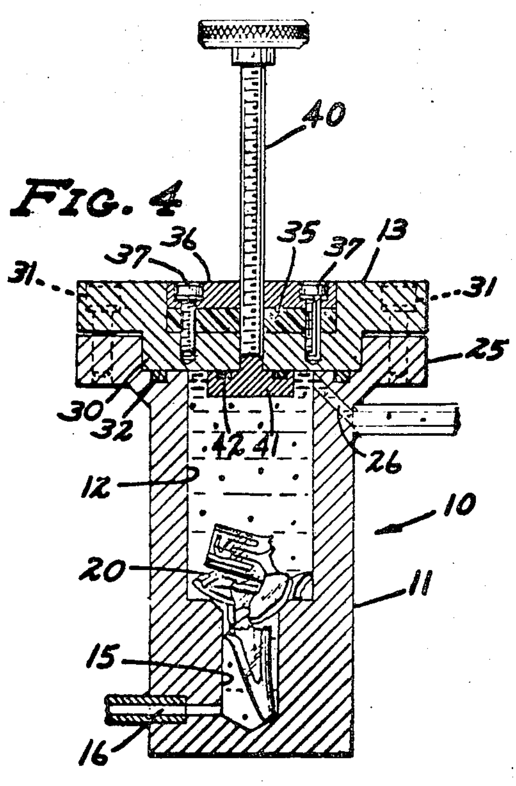
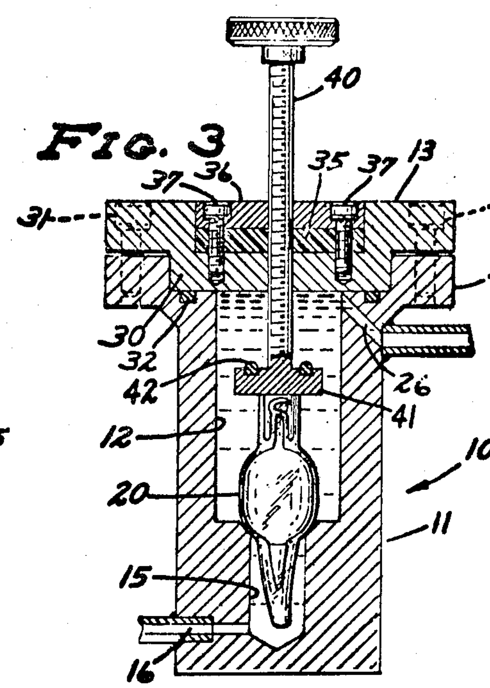


FIG. 3



APPARATUS AND METHOD FOR DISSOLVING SOLUBLE GAS IN A LIQUID

BACKGROUND OF THE INVENTION

1. Field of the Invention

In some fields it is necessary to dissolve a soluble gas in a liquid without allowing any substantial quantities of the gas to escape and, in some instances, without allowing the gas or the ultimate solution to come into contact with any foreign objects or material, such as the operator, the atmosphere, etc. This is especially true in the medical field.

The present apparatus and method were developed to dissolve the radioisotope ^{133} xenon, which is purchased in the gaseous state, in a sterile saline solution. In this particular instance it is imperative that the gas is isolated from the individual performing the task, because of the radiations from the radioisotope, and that the ultimate solution is isolated from the atmosphere, because it must be maintained sterile. ^{133}xenon is obtained in glass ampules containing a volume of about 5 cc of gas at a pressure of approximately 10 mm of mercury. The ampule is wrapped in a lead foil to minimize radiation exposure to personnel handling the ampule.

2. Description of the Prior Art

A prior art method of dissolving ^{133}xenon in a saline solution is described in the following two publications:

Loken, M. K. and Westgate, H. D.: Evaluation of pulmonary function using xenon-133 and the scintillation camera. *Am. J. Roentgen., Rad. Ther. and Nuclear Med.* 100:835, 1967.

Loken, M. K. and Westgate, H. D.: Using xenon-133 and a scintillation camera to evaluate pulmonary function. *J. of Nuclear Med.* 5:45, 1968. Unfortunately, this prior art method is only approximately 35 percent efficient, is difficult to set up and requires that the transfer apparatus be kept in a laboratory exhaust hood because of the finite chance of loss of the radioactive gas.

SUMMARY OF THE INVENTION

The present invention pertains to apparatus for dissolving a substantially soluble gas contained in a sealed breakable ampule in a liquid including a container having a liquid inlet and outlet with valve means therein, a sealable access opening and a member movable from the exterior of the container to engage and break the ampule when the container is filled with the desired liquid.

It is an object of the present invention to provide improved apparatus for dissolving a substantially soluble gas contained in a sealed breakable ampule in a liquid.

It is a further object of the present invention to provide apparatus for dissolving soluble gas in a liquid, which apparatus is sealed to prevent leakage of undissolved gases.

It is a further object of the present invention to provide apparatus for dissolving a soluble gas in a liquid, which apparatus is relatively efficient, inexpensive to manufacture and simple to operate.

It is a further object of the present invention to provide an improved method of dissolving a soluble gas in a liquid while maintaining the liquid sterile and the operator free from exposure to the gas.

These and other objects of the present invention will become apparent to those skilled in the art upon consideration of the accompanying specification, claims and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring to the drawings, wherein like characters indicate like parts throughout the figures:

FIG. 1 is a view in top plan of the present apparatus with syringes connected to the inlet and outlet;

FIG. 2 is a view, somewhat diminished in size, as seen generally from the line 2—2 in FIG. 1;

FIG. 3 is a sectional view as seen from the line 3—3 in FIG. 1; and

FIG. 4 is a view similar to FIG. 3 with the movable parts in a different position.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring more specifically to the drawings the numeral **10** generally designates a container including a generally cylindrical housing **11** having a cylindrical cavity **12** therein, opening axially outwardly at one end of the housing **11**, and a cover **13** sealingly engaged with the housing **11** to close the cavity **12**. The container **10** is adapted to be positioned with the cavity **12** opening upwardly and a generally coaxial well **15**, having a substantially smaller diameter than the cavity **12**, is formed in the lower end of the cavity **12**. An inlet passageway **16** is formed in the side of the housing **11** so as to communicate with the lower end of the well **15**. It should be understood that the inlet passageway **16** might communicate with the well **15** at a different position but the illustrated position was chosen because it insures a complete flushing of the cavity **12** when fluid is injected through the passageway **16**, as will become apparent presently. The well **15** is designed to receive a pointed end of an ampule **20** therein with the ampule extending into the cavity **12** above the well **15**, as illustrated in FIG. **3**. Further, the ampule **20** fits into the well **15** so that liquid from the inlet passageway **16** can flow freely therearound and the ampule **20** is maintained in the upright position.

Adjacent the upper end of the housing **11** a radially outwardly extending step is formed in the wall of the cavity **12** around the entire periphery thereof. Further, a radially outwardly extending flange **25** is formed as an integral part of the housing **11** at the upper end thereof adjacent the radially outwardly extending step in the cavity **12**. An outlet passageway **26** extends through the housing **11** and into communication with the cavity **12** adjacent the radially outwardly extending step therein. As will become apparent presently, the outlet passageway **26** is adjacent the inner surface of the cover **13** so that all air and other foreign material can be flushed from the cavity **12** by injecting fluid into the inlet passageway **16** and allowing the foreign materials and fluid to pass out through the outlet passageway **26**.

The cover **13** is formed in a generally disk shape with the radius thereof being approximately equal to the radius of the flange **25**. The bottom surface of the cover **13** is formed with a generally axially outwardly extending step **30** therein generally circular and coaxial with the cover **13** and housing **11**. The radius of the step **30** is slightly smaller than the radius of the radially outwardly extending step in the cavity **12** and mates therewith so that the cover **13** engages the upwardly directed surfaces of the housing **11** and forms an upper wall for the cavity **12** at the radially outwardly directed step therein. A plurality of internally threaded, upwardly opening holes are provided in the flange 25 and screws 31 are threadedly engaged therein through axially extending holes in the cover 13 to hold the cover 13 firmly in place. A circumferentially extending upwardly opening groove is formed in the upper surface of the radially outwardly extending step in the cavity 12 and a resilient O-ring 32 is positioned therein to form a seal between the housing 11 and the cover 13. As previously described, the outlet passageway 26 communicates with the cavity 12 at the downwardly directed surface of the step 30 in the cover 13.

A circular well is formed coaxially in the upper surface of the cover 13, which well extends axially downwardly into the cover 13. A pressure disk 35 having a radius slightly smaller than the radius of the well in the cover 13 and an axial width substantially smaller than the axial depth of the well, is positioned in the well adjacent the bottom thereof. A second disk 36, similar in shape to the pressure disk 35, is positioned within the well in overlying relationship to the disk 35. A plurality of holes are provided through the disks 35 and 36 and axially aligned internally threaded holes are formed in the cover 13 so that screws 37 inserted through the holes in the disks 35 and 36 engaged into the cover 13, maintain the disks 35 and 36 in tight overlying relationship. An axially aligned opening is formed through the disk 36, pressure disk 35 and cover 13 and the hole is internally threaded for reasons which will become apparent presently.

An externally threaded elongated shaft 40 is threadedly engaged in the hole through the disks 35 and 36 and the cover 13 so that one end thereof extends into the cavity 12 and the other end is accessible external of the container 10. The internal end of the shaft 40 has a disk 41 generally coaxially affixed thereto for axial movements within the cavity 12 in response to rotation of the shaft 40. The upper surface of the disk 41, or the surface adjacent the lower surface of the cover 13, has a peripheral groove therein with a resilient O-ring 42 engaged therein. The O-ring 42 provides a seal between the disk 41 and the cover 13 when the shaft 40 is rotated outwardly as far as it can be. The O-ring 42 prevents the egress of any fluid or gas from the container 10 between the shaft 40 and the cover 13. The pressure disk 35 is formed of some material which is slightly compressible, such as some of the tetrafluoroethylene fluorocarbon resins sold under the trademark "Teflon" and the like, so that a seal is provided between the cover 13 and the shaft 40 when the disk 36 is engaged tightly against the pressure disk 35 by the screws 37. Thus, with the cover 13 sealingly engaged on the housing 11 the container 10 is substantially sealed and the shaft 40 is movable from the exterior of the container 10 to a position where the disk 41 within the cavity 12 engages and breaks the ampule 20.

Referring to FIG. 1, the inlet passageway 16 has an adapter 50 affixed thereto with a lock 51 associated therewith for receiving the needle of a syringe 52 therein and sealingly engaging the end of the syringe 52. In this embodiment the relatively large syringe 52 is utilized as a supply of a desired liquid but it should be understood that other devices might be utilized as a supply. The adapter 50 provides communication between the syringe 52 and the cavity 12 and prevents contact of the fluid in the needle with the atmosphere.

The outlet passageway 26 has a microporous filter element 55 connected in communication therewith, the outlet of which goes to a valve 56. The microporous filter element 55 may be any type of element which will filter various foreign material, such as glass particles, bacteria, etc., from the solution passing through the outlet passageway 26. Typical microporous filter disks are sold under the trademark "Millipore" and have a 25 mm diameter with 0.45 micron pores therethrough. The valve 56 has an adapter 57 and lock 58 associated therewith for receiving a syringe 59 therein similar to the adapter 50 and lock 51. The syringe 59 is utilized to draw a desired amount of solution from the container 10 with the valve 56 open.

In the operation of the present apparatus, the container 10 and the inlet and outlet passageways 16 and 26 with the adapters 50, 57 and valve 56, all of which are formed of some suitable material such as stainless steel, are sterilized by autoclaving or the like. An ampule 20 containing ^{133}xenon is then sterilized by some convenient method, such as immersing it in an aqueous zepharin chloride solution 1.750 for approximately 60 minutes. After the ampule 20 is properly sterilized it is placed in the cavity 12 with the pointed end thereof engaged in the well 15 to hold the ampule 20 in an upright position. The cover 13 is then sealingly engaged on the housing 11 and the large syringe 52 filled with a sterile saline solution is affixed in the adapter 50. The valve 56 is opened and saline solution is forced from the syringe 52 into the cavity 12 to flush all air and other foreign materials therefrom. With all air removed from the cavity 12 the valve 56 is closed and the shaft 40 is rotated until the disk 41 engages and breaks the ampule 20. The shaft 40 is then immediately rotated in a reverse direction until the O-ring 42 in the upper surface of the disk 41 engages the cover 13 to insure a good seal between the cover 13 and the shaft 40.

With the ampule 20 broken the soluble gas therein dissolves in the saline solution within the cavity 12. The smaller syringe 59 is then engaged in the adapter 57 and the valve 56 is opened to allow solution to be withdrawn from the container 10 as required. As solution is withdrawn from the container 10 by the syringe 59 new sterile saline solution is automatically injected by the syringe 52. In the present embodiment, with the size of ampule described, the inside dimensions of the cavity 12 are approximately a 4 cm diameter and a 5 cm height. Assuming complete mixing of the replacement saline solution, the concentration of the xenon-saline solution in the cavity 12 decreases according to the following formula:

$$C_v = C_o e - (Q/V)$$

where C_v = residual concentration in the container 10 after the removal of the dose, measured in millicuries per milliliter (mC_i/ml)

C_o = the original concentration correct for decay (mC_i/ml).

Q = total volume of saline solution removed to date (ml)

V = volume of the container 10 (ml).

In general, C_o is approximately equal to 15 mC_i/ml at the time the gas is dissolved in the saline solution. It should be understood that gases other than ^{133}xenon might be used in the present apparatus and, depending upon the amount of gas utilized and the type, the size and material utilized for the container **10** and the concentrations may vary considerably.

Thus, apparatus is disclosed wherein a soluble gas can be dissolved in a liquid with little or no danger of the gas escaping or of contaminating the ultimate solution. Further, the apparatus is relatively inexpensive to manufacture, simple to operate and requires no additional elaborate equipment because of its inherent safety features.

What is claimed is:

1. Apparatus for dissolving a substantially soluble gas contained in a sealed, breakable ampule in a liquid comprising:

a. a housing having a cavity therein with an access opening and a removable cover sealingly engaged over the opening;
b. means mounted within the cavity of said housing and operable from the exterior of said housing to break an ampule positioned within the cavity;
c. inlet and outlet means communicating with the cavity in said housing for introducing liquid into the cavity and removing liquid and dissolved gas from the cavity, respectively; and
d. filter means mounted in the outlet for removing foreign material from the liquid and dissolved gas as it is removed from the cavity.

2. Apparatus as set forth in claim **1** wherein the outlet means includes a fitting for receiving a syringe in sealed engagement therewith and in communication with the cavity in the housing through the outlet means.

3. Apparatus as set forth in claim **1** wherein the filter means includes a microporous filter element.

4. Apparatus for dissolving a substantially soluble gas contained in a sealed, breakable ampule in a liquid comprising:

a. a housing having a cavity therein with an access opening and a removable cover sealingly engaged over the opening;
b. a portion of the cavity in said housing being designed for receiving an unbroken, gas filled ampule therein and maintaining the ampule in a desired orientation;
c. a member threadedly engaged in said housing with a portion thereof external of said housing and a portion extending within the cavity, said member being movable between a first position in which the ampule is not engaged and a second position in which the ampule is engaged and broken;
d. inlet means communicating with the cavity in said housing for introducing liquid into the cavity;
e. outlet means communicating with the cavity adjacent the uppermost portion of the cavity for removing a solution of liquid and dissolved gas from the cavity;
f. microporous filter means mounted in the outlet means for removing foreign material from the solution as it is removed from the cavity; and
g. valve means in the outlet means adjustable to allow and prevent the flow of liquid therethrough.

5. Apparatus as set forth in claim **4** wherein the portion of the threadedly engaged member extending within the cavity includes a surface parallel with and in juxtaposition to the inner surface of the cavity having sealing means thereon, said parallel surface sealingly engaging the inner surface of the cavity with the threadedly engaged member in the first position for preventing the escape of gas between the housing and the threadedly engaged member.

6. A method of dissolving a substantially soluble gas contained in a sealed, breakable ampule in a liquid comprising the steps of:

a. placing the ampule in a sealed container having a liquid inlet and an outlet for the solution of liquid and gas, which outlet has valve means therein adjustable between open and closed positions, said container further having a member movable from the exterior of the container to engage and break the ampule;
b. applying a source of the desired liquid to the inlet of the container and opening the outlet valve to fill the container with the desired liquid and flush all undesirable material from the container;
c. maintaining the source of the desired liquid in communication with the inlet and closing the outlet valve;
d. moving the member to break the ampule within the liquid filled container; and
e. applying a syringe to the outlet, opening the outlet valve and drawing out a desired amount of the solution.

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