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APPARATUS FOR TREATING A THIN FILM OF LIQUID BY EXPOSURE TO RADIANT ENERGY

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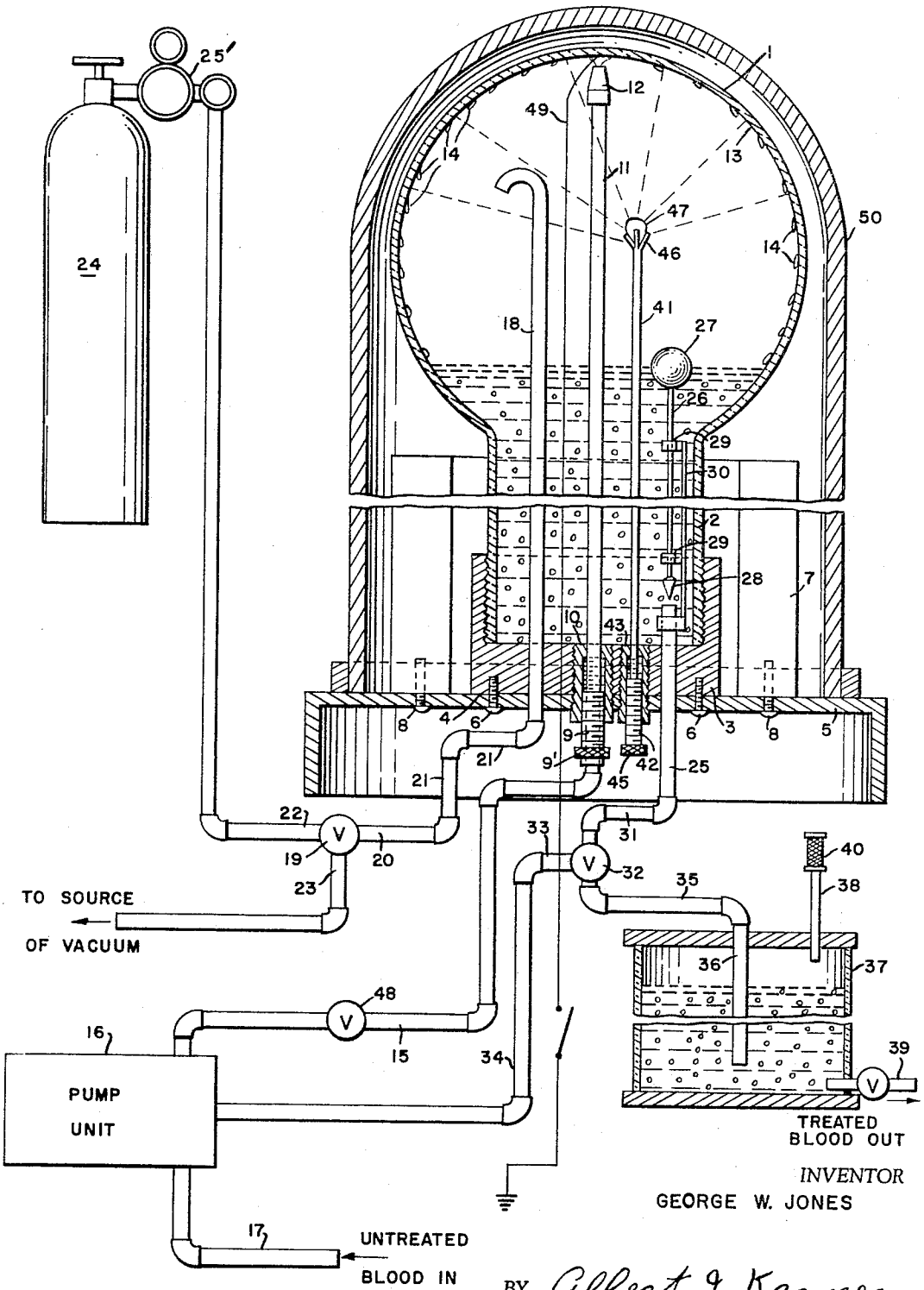


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# APPARATUS FOR TREATING A THIN FILM OF LIQUID BY EXPOSURE TO RADIANT ENERGY

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This invention relates to liquid treatment apparatus and it has special application in the treatment of blood and blood plasma for human and veterinarian therapy.

The invention comprises improvements in apparatus disclosed in my prior Patents Nos. 2,827,901 and 3,046,-903.

One of the objects of the present invention is the provision of improvements in such apparatus which renders them applicable to broader treatment techniques, such as oxygenation under controlled pressured conditions, including hyperbaric and sub-atmospheric pressures, exposure to radiant energy, such as by infra-red and ultra violet light, X-rays, radioactive isotopes, etc.

Another object of the invention is the provision of means for improving the efficiency of contact between the liquid being treated and a gas, such as oxygen, and/or radiant energy with which the liquid is to be treated.

A further object of the invention is the provision of improvements for debubbling treated liquid containing an excess of absorbed gas.

A still further object is the provision of means for forming the liquid to be treated into a continuous thin film in a treatment zone.

A specific object of the invention is the provision of means for treating cancer cells in blood by means of radiation, contact with a treatment gas or gases under selected conditions including hyperbaric pressures.

Another specific object is the provision of means whereby cells of the human body may be treated by extra-corporeal conditioning of the blood which is then returned to the circulatory system of the body.

A further specific object is the provision of means for removing from blood carbon monoxide and/or other injurious gases that have been absorbed thereby, such as from inhalation of combustion gases.

A still further specific object is the provision of apparatus for the purposes indicated which is inexpensive, has relatively few parts. is readily assembled and disassembled, and easily sterilized.

These and still further objects, advantages and features of the invention will appear more fully from the following description considered together with the accompanying drawing, which shows schematically various elements combined and modified in accordance with an embodiment of this invention, some parts being shown in section.

Referring to the drawing with more particularity, the embodiment illustrated comprises a treatment chamber of glass or other suitable material having an upper bulbous part **1** and a lower neck portion **2**.

The lower end of the neck portion **2** is closed with a removable screw cap **3** which has a flat bottom **4** for supporting the chamber on a horizontal surface, such as that of a platform **5**. The cap **3** may be secured to the platform by any suitable means such as screws **6**.

A hollow cylindrical heat exchanger **7** is disposed on the platform **5** about the neck **2** and it is secured to the platform by screws **8**.

A liquid inlet tube **11** passes upwardly through the platform **5** and the cap **3** and, hence, along the longitudinal axis of the chamber. It is held in position by means of a tubular holder **9** threadedly engaging a removable plug **10**. The holder **9** can be adjustably positioned in the plug **10** by means of a knurled knob **9'**.

The upper end of the tube **11** is provided with an outlet nozzle **12** which functions to spread the liquid passing through the tube in a circular spray pattern for impingement against the wall of the chamber immediately thereabove to facilitate its flow downwardly and evenly along an interior surface **13** of the chamber in a thin film **14**. The use of the nozzle may be disposed with in many cases where a satisfactory flow can be obtained with the open tube alone.



Liquid is conducted to the tube **11** through a pipe **15** on the discharge side of a pumping unit **16**. The pumping unit may be of any suitable type but preferably of the type shown and described in my said prior Patent No. 3,046,903. Liquid is fed to the pumping unit **16** through an inlet pipe **17**, the source of which may be the blood of a living organism (not shown) to be treated, or liquid from a mechanical reservoir (not shown) or liquid from any other source of supply.

Alongside the liquid inlet tube **11** there is disposed in the treatment chamber a gas inlet tube **18**, the lower end of which passes out through the cap **3** and the platform **5** to a conventional 3-way valve **19**. The valve **19** has an outlet **20** which is connected to the tube **18** by pipes **21**, a first inlet **22** and a second inlet **23**. The first inlet **22** is connected to a source of gas under pressure, such as a bottle **24** of oxygen or other conventional gas apparatus having conventional pressure and discharge regulating devices **25'**. The second inlet **23** of the valve is connected to a source of vacuum (not shown). By these means, gas pressure conditions within the treatment chamber can be selectively controlled through the valve **19** to provide hyperbaric pressures of different magnitudes or subatmospheric pressures. Also, these opposite pressure conditions can be provided in an alternating or intermittent fashion by simply rotating the conventional actuator (not shown) of the valve **19** between the two positions for communication to the vacuum source on the one hand and to the pressure apparatus on the other.

Liquid treated inside the chamber is discharged through an outlet pipe **25** at the bottom of the neck portion **2** passing through the cap **3**. The upper open end of the pipe **25** is provided with a float valve which comprises a stem **26** connected to a ball float **27** at the top with a plug **28** at the bottom. The stem **26** is slidably mounted on loops **29**, **29** of a bracket **30** to retain the plug **28** in alignment with the open end of the pipe **25**.

The pipe **25** is connected to the inlet **31** of a conventional 3-way valve **32**. One outlet **33** of the valve **32** is connected by a by-pass pipe **34** to the inlet of the pumping unit **16**. The other outlet **35** of the valve **32** is connected by a pipe **36** to a debubbling reservoir **37** which receives the treated liquid. The liquid may be retained in this debubbling reservoir sufficiently long to permit the release of excess gas adsorbed thereby in the treatment chamber. The reservoir is vented to the atmosphere by means of a vent tube **38**. Liquid is withdrawn from the reservoir through a valved discharge tube **39**. The vent tube **38** is provided with an air filter **40** to filter air which may be drawn into the reservoir through displacement when liquid is removed through the discharge tube **39**. By these means the liquid passing out of the treatment apparatus can be controlled by either recirculating it when additional treatment is necessary or alternatively discharged completely from the system.

A support rod **41** is also disposed within the treatment chamber. The lower end is attached to a threaded holder **42** which engages a threaded plug **43** through the bottom of the cap **3**. A knurled head **45** at the bottom of the holder **42** facilitates turning it so as to adjust the elevation of the upper end of the rod. The upper end of the rod is provided with a group of fingers **46** which are arranged to form a cup holder for a pellet **47** of radiant energy, such as radium, radioactive cobalt isotopes, or other con-

ventional sources of radiant energy that is or may be valuable in the treatment of blood or other liquid.

In actual practice, the apparatus may be used in a number of different ways, depending upon the treatment to be achieved. In general, however, the source of liquid to be treated, such as blood, is connected to the inlet tube **17** of the pumping unit **16**. Thus, liquid is forced by the pumping unit continuously or intermittently through the inlet tube **11** of the treatment chamber. It passes through the tube **11** continuously or intermittently to impinge on the interior surface **13** of the bulbous portion **1** and thence flows down over this surface **13** in a thin film **14**. The thickness of the film can be controlled to a degree by controlling the rate at which liquid enters the treatment chamber by means of a valve **48** in pipe **15** or by controlling the action of the pumping unit **16** or both.

Where treatment of the liquid is to be effected by a gas, such as oxygen, the inlet **22** of the valve **19** is connected to a source of gas, such as the gas bottle **24** and the desired rate of flow and/or pressure is regulated by the conventional regulator **25'** connected thereto.

When it is desired to subject the liquid to treatment by sub-atmospheric pressure, the inlet **23** of the valve **19** is connected to a source of vacuum and the valve **19** set to close the tube **18** to communication with the bottle **24** and open it to the source of vacuum. The position of the valve **19** may be changed for or during any particular treatment. It may, for example, be used to subject the liquid being treated first to sub-atmospheric and then to hyperbaric pressures, such as where it is desired to combine treatment by both these facilities.

Alternatively or simultaneously with these treatment facilities, radiant energy may be supplied to the liquid film through pellets **47**, such as that of a radioactive isotope, or other means.

Treated liquid in the treatment chamber collects in the neck portion **2** and it is normally prevented from being discharged by the float valve when the plug **28** is seated on the tube **25**. However, when the level of liquid in the neck portion **2** rises sufficiently high to elevate the ball **27**, the valve is opened and liquid is discharged through the pipe **25** until the level of liquid falls to a point where the valve is again closed by the lowering of the ball **27**.

Liquid normally passes from the tube **25** into the debubbling reservoir **37** where excess gas adsorbed by the liquid can be removed. The liquid can be withdrawn from the reservoir through the outlet tube **39** for use as needed.

Where liquid passing out of the treatment chamber through the tube **25** requires additional treatment in the treatment chamber, it may be returned to the system through the by-pass **34** by resetting the valve **32**.

To remove static electrical charges which may accumulate on the surface of the liquid as it passes through the system, particularly on the film surface, an electrical ground conductor **49** is disposed in the treatment chamber in contact with the liquid, as shown.



A bell-shaped radiation shield **50** is also provided for removable disposition about the treatment chamber when radioactive treatment is being effected.

Having thus described my invention, I claim:

Apparatus for variously treating a liquid comprising a treatment chamber having a confined space delineated by an outer wall, said wall having a downwardly extending arcuate portion, an inlet tube for carrying liquid to be treated into the space, a nozzle on the inner end of the inlet tube for subdividing a stream of the liquid directed to an uppermost area of the arcuate portion, whereby the liquid spray in continuously contacting said area collects in the form of a thin film and flows by gravity along the inner surface of the arcuate portion, the shape of the film conforming to the shape of the arcuate portion, a source of treatment gas under superatmospheric pressure and a source of vacuum, means for selectively communicating the space within the chamber adjacent the film with either of the said sources while the film is in a state of flow so as to permit subjecting the film continuously to the effects of the gas and the vacuum alternatively, means for collecting the film in a pool at the bottom of the chamber, an outlet for the discharge of liquid from the pool, a float valve for controlling the flow of liquid from the pool to the outlet as a function of the level of the liquid in the pool, a debubbling reservoir connected to the outlet, means for selectively recycling liquid in the pool through the inlet tube, said chamber comprising a lower neck portion, an annular heat exchanger surrounding the lower neck portion, a source of radiant energy supported in the chamber adjacent the wall, and a radiation shield removably disposed about the chamber and the source of radiant energy.


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