

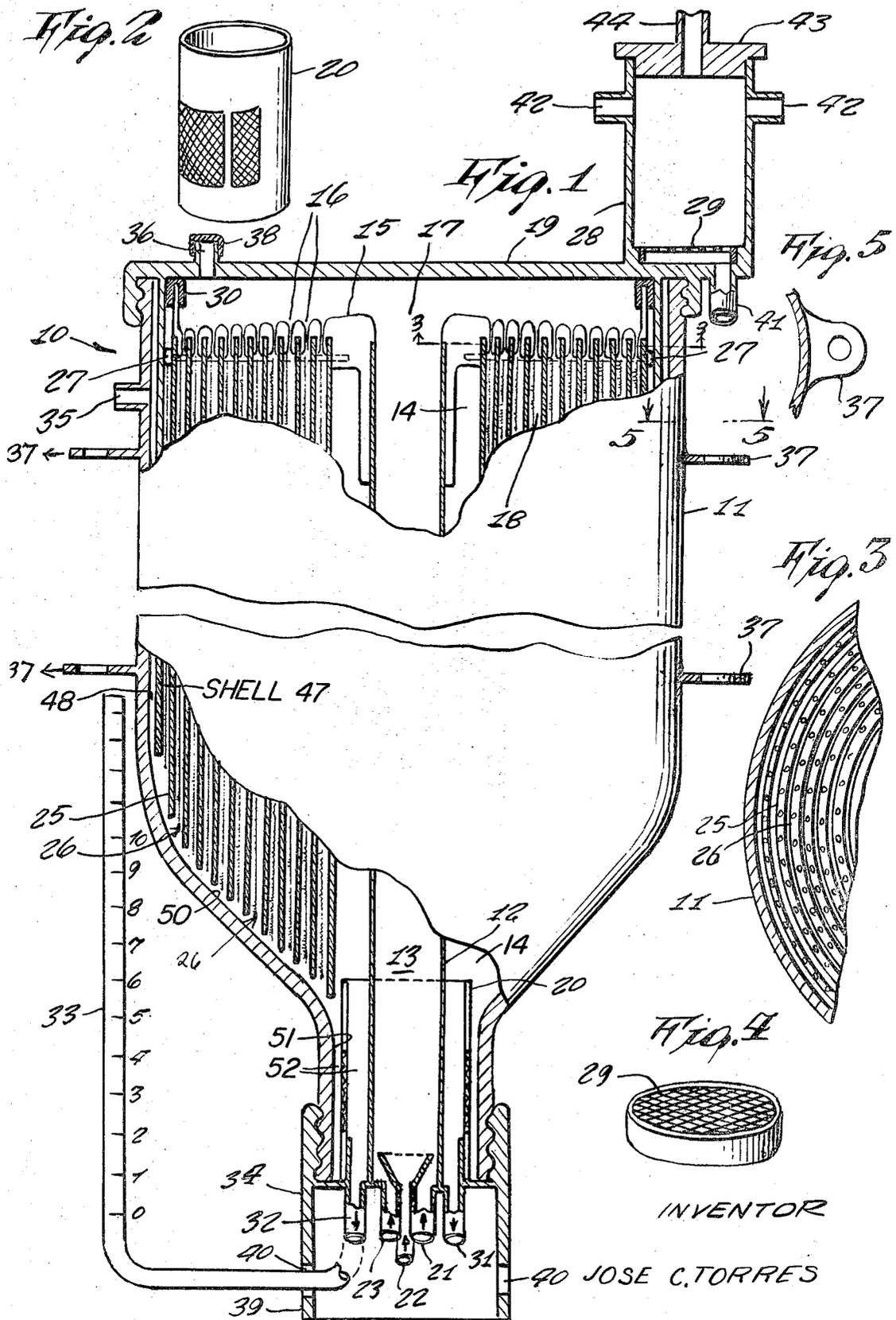
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BUBBLE FILM OXYGENATOR

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**BUBBLE FILM OXYGENATOR**  
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8 Claims

## ABSTRACT OF THE DISCLOSURE

An oxygenator within an upright casing having a centrally disposed hollow stem, an intermediate surrounding shell and an outer casing wall providing three annular upright concentric chambers, namely, a stem chamber, a surrounding chamber and an outer chamber wherein blood and oxygen flow upwardly through the stem chamber to overflow therefrom and spread annularly outward over a perforated head which directs the flow downwardly through and distributes it over a filming apparatus in the surrounding chamber, at the bottom of which the gas separates from the liquid and turns upwardly to flow through the outer chamber to a gas outlet while the liquid is drained downwardly inward toward the lower end portion of the stem and into a small stem-surrounding sump from which it is discharged through a filter and a bottom liquid outlet.

This invention relates to a respiratory gas-exchange device for oxygenating human and other animal bloods.

A principal object of the present invention is to provide an oxygenator which uses the bubbling and filming oxygenation properties, increasing the oxygenating capacity and lowering the total priming of the heart lung machine substantially to 1.3 to 1.6 liters.

Another object of the present invention is to provide a bubble film oxygenator which can be used with any other type of pump machine and is intended to be auto-claved.

Another object of the present invention is to provide a bubble film oxygenator which is made of treated heat resistant plexi-glass and stainless steel.

Other objects of the present invention are to provide a bubble film oxygenator which is simple in design, inexpensive to manufacture, rugged in construction, easy to use and efficient in operation.

These and other objects will be readily evident upon a study of the following specification and the accompanying drawing wherein:

FIG. 1 is a side elevational view of one embodiment of the invention shown partly in cross-section;

FIG. 2 is a perspective view of one of the parts thereof;

FIG. 3 is a fragmentary cross-sectional view taken on the lines 3—3 of FIG. 1;

FIG. 4 is a perspective view of another part thereof; and

FIG. 5 is a fragmentary view corresponding to one taken along line 5—5 of FIG. 1.

Referring now to the drawing in detail, the reference numeral 10 represents a bubble film oxygenator according to the present invention wherein there is an external bottle 11 containing an internal straight stainless hollow stem or tube 12 which divides the interior of 11 into a centrally-disposed bubbling oxygenator chamber 13 and an external chamber 14. A distribution platform or head 15 contains multiple openings 16 and connects the superior or head chamber 17 with the film oxygenating space 18. This platform or head 15 is made of plastic material. A plastic upper cover 19 with a vertical cylinder 20 serves as a cover for the head chamber 17. A filter 28 in the arterialized blood reservoir or sump 52 surrounding the lower end portion of the stem 12 is provided and is made

of stainless steel. The bubbling chamber 13 is connected at the bottom with three inlets one of which comprises the venous return 21, another the oxygen inlet 22, and another the coronary suction inlet 23. The upper part of the chamber 13 connects with the superior or head chamber 17.

The exterior chamber 14 provides a reservoir 52 of arterialized blood surrounding the lower end portion of the stem 12 and a blood filming chamber section 18, which contains a series of narrowly spaced concentric plastic tubes 25 and a circular stainless steel screen mesh tube or cylinder 26 between each pair of plastic tubes 25. The tubes 25 and mesh cylinders 26 are attached to the distributing platform with two pins 27.

There are eleven filming tubes 25 and 10 stainless steel screen mesh filming tubes or cylinders 26, one of which is placed between each pair of the tubes 25.

A coronary suction reservoir 28 is made of plastic and contains a fine stainless steel filter 29. A rubber seal 30 covers the upper rim of the distribution platform 15 and makes the head chamber 17 airtight.

The oxygen inlet 22 within chamber 13 or tubular stem 12 contains a stainless steel perforated diaphragm with fine multiple openings so to reduce the size of the bubbles. An arterial tube outlet 31 is provided for conducting oxygenated and filtered blood to an unshown pump machine, which returns it to the body of the patient, while another arterial tube outlet 32 is provided to the manometer 33. The manometer is graduated in centimeters, as shown.

The lower cover 34 of the oxygenator is made of stainless steel and serves as a base for the upright tubular stem 12, and depending inlets 21—23 and outlets 31—32.

Additionally it provides a round or cylindrical rim for receiving the lower end of cylinder 20 which contains a stainless steel mesh filter. An outlet 35 from the upper part of the external bottle-shaped tube 11 is provided for venting excess carbon dioxide and oxygen. A vent 36 from the superior head chamber 17 is provided to release pressure in the head chamber as necessary.

Ears 37 are provided so as to be secured to the support of the machine. A rubber stop cock 38 is fitted over the vent 36 for closing the same. It is to be noted that the filter 29 of the coronary suction reservoir shall be at the lower end thereof, as shown in FIG. 1 of the drawing. A downward extension of the cover 34 provides a base 39 for the support of the oxygenator. This base is provided with lateral openings 40 as shown, to accommodate the inlets 21—23 and outlets 31—32 extending therethrough.

The coronary suction reservoir 28 or top cover 19 is provided with an outlet 41 located below the filter 29. In use, outlet 41 is connected to inlet 23. Two inlets 42 connect with the coronary suction reservoir and comprise coronary suckers. A cover 43 for the coronary suction reservoir includes an inlet pipe 44 for fluid or blood.

In operative use, the venous blood will be drained from the right atrium of the heart, by gravity through the inlet 21 to empty at the bottom of the bubble oxygenator chamber 13. In this chamber the blood will mix with oxygen and progress to the superior head chamber 17 and through the openings of the distributing head or platform 15 will enter the filming oxygenation section 18 of the chamber 14, which surrounds the stem 12, and by gravity progress down to the arterialized sump 52 at the bottom of chamber 14. Since there will be no escape of oxygen in this upper part or the superior chamber, oxygenation will be maximal. Then the excess of oxygen and carbon dioxide will go out through the outlet 35. The arterialized blood passes through the arterial outlet 31 to the pump machine and on to the patient. The sump 52 at the bottom of chamber 14 will contain a vertical

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cylinder 20 having a filter made of a fine screen stainless steel and fine screen mesh. The outlet 32 will connect by way of a plastic tube to a measuring device which will measure the amount of arterialized blood in the sump 52. Two coronary suction tubes will empty into the coronary reservoir 28 through inlets 42. From coronary reservoir 28 blood passes through outlet 41 to inlet 23. The connection between outlet 41 and inlet 23 will be a plastic tube which will be clamped and opened in order to deposit blood as needed. The inlet pipe 44 will be used to add blood or solution to the coronary reservoir and allow air to escape from the coronary suction. The entire oxygenator system will be placed below the cardiac level so that drainage from the heart will be by gravity and this will be graduated by using a clamp in the system.

The lower end portion of the inverted bottle-shaped casing 11 has the characteristic shoulder and neck sections of a bottle. The inner wall 50 of the shoulder section and the inner wall 51 of the neck section cooperatively form a funnel-shaped drainage concentrating means composed of a collecting surface 50, corresponding to said inner shoulder wall 50, and a sump-forming wall 51, corresponding to said inner neck wall 51, and providing a relatively small stem-surrounding sump 52. By "relatively small," I mean that sump 52 is of a small diameter and height in relation to the diameter and height of the filming section 18 of the chamber 14.

The collecting surface 50 functions to receive the distributing liquid films discharging from the liquid filming apparatus 25, 26 and to direct those films downwardly inward toward the stem 12. The relatively small sump 52 functions to receive and concentrate the incoming liquids in a relatively small space located at the bottom of chamber 14 around the lower end of the stem 12. The sump 52 is divided by the cylindrical filter 20 into a pair of concentric sections comprising an outer cylindrical section having a top inlet and an inner cylindrical section having said bottom outlet connections 31, 32.

In summary, I have provided a respiratory gas-exchange device 10 for oxygenating a liquid such as animal blood, comprising: (A) an upright outer casing 11 (1) closed at its top and bottom ends; (B) wall means 12, 47 dividing the interior of the casing 11 into three vertical chambers comprising (1) a bubble chamber 13 having its bottom closed at the lower end portion of the casing and its top open within the upper portion of the casing, (2) an adjacent chamber 14 having sections, at the top, bottom and mid-portion of the casing, comprising (a) an upper head section 17 in open communication with the upper opening of the bubble chamber, (b) an upwardly-open bottom drainage section having a liquid outlet 31 at its bottom, and (c) an interposed liquid-filming section 18 openly communicating with the underlying drainage section for liquid drainage purposes, said liquid filming section 18 having a cross-sectional area much larger than the cross-sectional area of said bubble chamber 13, and (3) a gas chamber 48 having its top closed, its lower end portion in open lateral communication with the lower open end of the liquid-filming section and a gas outlet 35 in its upper end portion; (C) a distributing head 15 covering the top of the filming section 18 and provided with perforations 16 by which liquid and gas from the overlying head section 17 are fed into and distributed over the filming section 18; (D) a liquid-filming apparatus 25, 26 arranged within the liquid-filming section to receive distributed liquid and gas from said distributing head 15, (1) said apparatus being operative to cause the liquid to film downwardly through the filming section; (E) drainage means in said drainage section comprising (1) a sump 52 having an upper open end and a lower end containing said bottom liquid outlet 31, and (2) a liquid-collecting surface 50 positioned below but adjacent to the lower end of the filming apparatus and arranged to receive the liquid draining from that ap-

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paratus and drain it into the open end of said sump 52; (F) means providing a liquid inlet 21 or 23 in the bottom of said bubble chamber 13 for flowing a liquid stream successively through the bubble chamber 13, the head section 17, the filming section 18 and the drainage section to said bottom liquid outlet, (1) said liquid stream forming a column which rises within the bubble chamber and overflows into the head chamber to spread over the distributing head by which it is distributed over the liquid filming apparatus through which it films downwardly; and (G) means providing an oxygen inlet 23 in the bottom of said bubble chamber for flowing an oxygen stream successively through the bubble chamber, the head section, the filming section and the gas chamber to said gas outlet, (1) said oxygen bubbling upwardly through the liquid column in said bubble chamber for oxygenation purposes and then flowing downwardly in contact with the surface of the liquid films in the filming section for additional oxygenation purposes. In the preferred form shown, the stem 12, the filming apparatus 25, 26, the shell 47 and the sump 52 are all concentrically arranged about the vertical axis of the device 10.

While various changes may be made in the detailed construction, it is understood that such changes will be within the spirit and scope of the present invention as is defined by the appended claims.

I claim:

1. A respiratory gas exchange device for oxygenating blood, comprising:

- (A) an upright outer casing
  - (1) closed at its top and bottom ends;
- (B) wall means dividing the interior of the casing into three vertical chambers comprising
  - (1) a bubble chamber having its bottom closed at the lower end portion of the casing and its top open within the upper portion of the casing,
  - (2) an adjacent chamber having sections, at the top, bottom and mid-portion of the casing, comprising
    - (a) an upper head section in open communication with the upper opening of the bubble chamber,
    - (b) an upwardly-open bottom drainage section having a blood outlet at its bottom, and
    - (c) an interposed blood-filming section openly communicating with the underlying drainage section for blood drainage purposes, said blood filming section having a cross-sectional area much larger than the cross-sectional area of said bubble chamber, and
  - (3) a gas chamber having its top closed, its lower end portion in open lateral communication with the lower open end of the blood-filming section and a gas outlet in its upper end portion;
- (C) a distributing head covering the top of the filming section and provided with perforations by which blood and gas from the overlying head section are fed into and distributed over the filming section;
- (D) a blood-filming apparatus arranged within the blood-filming section to receive distributed blood and gas from said distributing head,
  - (1) said apparatus being operative to cause the blood to film downwardly through the filming section;
- (E) means providing a blood inlet in the bottom of said bubble chamber for flowing a blood stream successively through the bubble chamber, the head section, the filming section and the drainage section to said bottom blood outlet,
  - (1) said blood stream forming a column which rises within the bubble chamber and overflows into the head chamber to spread over the distributing head by which it is distributed over

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the blood filming apparatus through which it films downwardly; and

(F) means providing an oxygen inlet in the bottom of said bubble chamber for flowing an oxygen stream successively through the bubble chamber, the head section, the filming section and the gas chamber to said gas outlet,

(1) said oxygen bubbling upwardly through the blood column in said bubble chamber for oxygenation purposes and then flowing downwardly in contact with the surface of the blood films in the filming section for additional oxygenation purposes.

2. The device of claim 1 including:

(A) drainage means in said drainage section comprising

(1) a sump having an upper open end and a lower end containing said bottom blood outlet, and  
 (2) a blood-collecting surface positioned below but adjacent to the lower end of the filming apparatus and arranged to receive the blood draining from that apparatus and drain it into the open end of said sump.

3. The device of claim 1 wherein:

(A) said casing is tubular;

(B) said wall means includes

(1) an upright tubular stem centrally disposed in said casing to provide said bubble chamber, and  
 (2) an upright cylindrical shell concentrically disposed about said stem with its top closed at the upper end of the casing and its bottom open at the lower end of said mid-portion of the casing,  
 (a) said shell providing the outer wall of said head and filming sections and the inner wall of said gas chamber.

4. The device of claim 3 wherein:

(A) said blood filming apparatus comprises

(1) a series of narrowly spaced concentric tubes, and  
 (2) a screen mesh cylinder between each pair of tubes

5. The device of claim 3 including:

(A) drainage means in the drainage section comprising

(1) an annular collecting surface extending around the lower end portion of the stem adjacent the lower end of the filming apparatus to receive distributed blood from that apparatus

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and direct said blood downwardly inward toward the stem, and

(2) a relatively small stem-surrounding sump having its upper end open to receive blood draining from said collecting surface with its lower end discharging said blood through said bottom blood outlet.

6. The device of claim 5 wherein:

(A) said drainage means is in the form of the shoulder and neck sections of an inverted bottle,

(1) the inner surface of the shoulder section providing said collecting surface, and  
 (2) the neck section providing said sump.

7. The device of claim 6 wherein:

(A) said blood filming apparatus comprises

(1) a series of narrowly spaced concentric tubes, and  
 (2) a screen mesh cylinder between each pair of tubes.

8. The device of claim 7 including:

(A) normally closed means in the upper end of the casing for venting said head chamber at the will of the operator; and

(B) filtering means located within said sump to filter sump blood flowing to said bottom blood outlet.

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