

[54] **BUBBLE-TYPE BLOOD OXYGENATOR WITH BAFFLES**

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abandoned.

Foreign Application Priority Data

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261/DIG. 28, 261/123, 128/400, 165/167

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[58] Field of Search..... 23/258.5; 195/1.8;
261/DIG. 28, 123

[56]

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[57]

ABSTRACT

A bubble-type blood oxygenator having an oxygenating chamber within which baffle means are provided substantially in the direction parallel or perpendicular to the axis of said chamber. The baffle means can be used as heat exchange means by passing temperature-controlled liquid through it.

8 Claims, 10 Drawing Figures

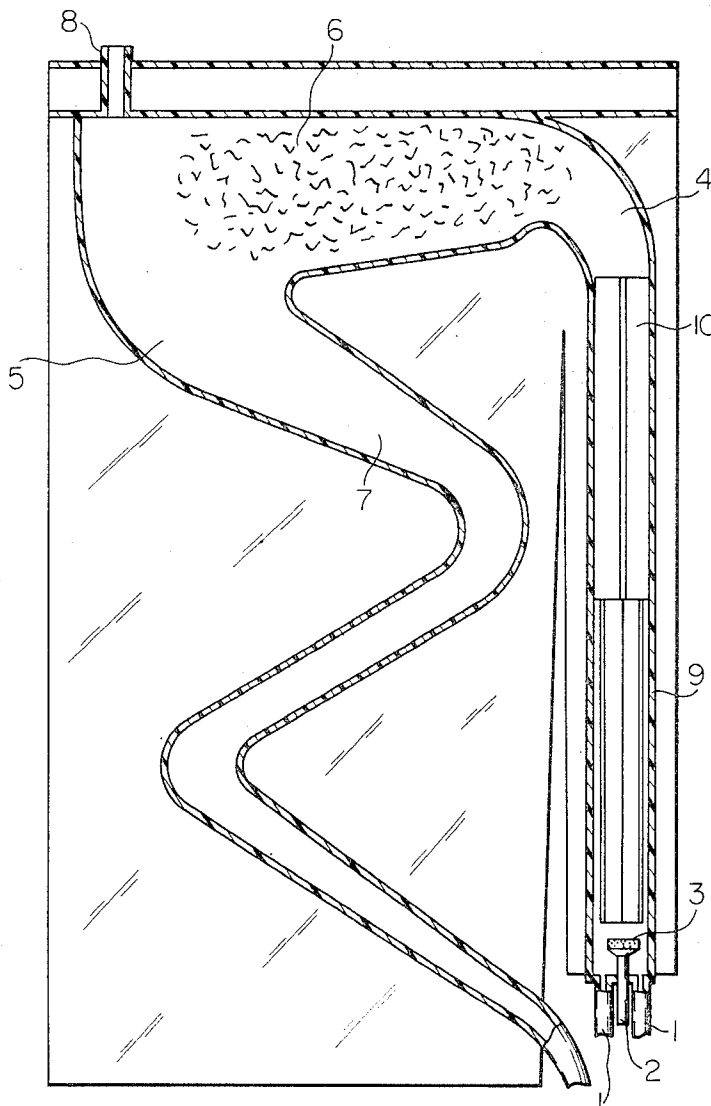
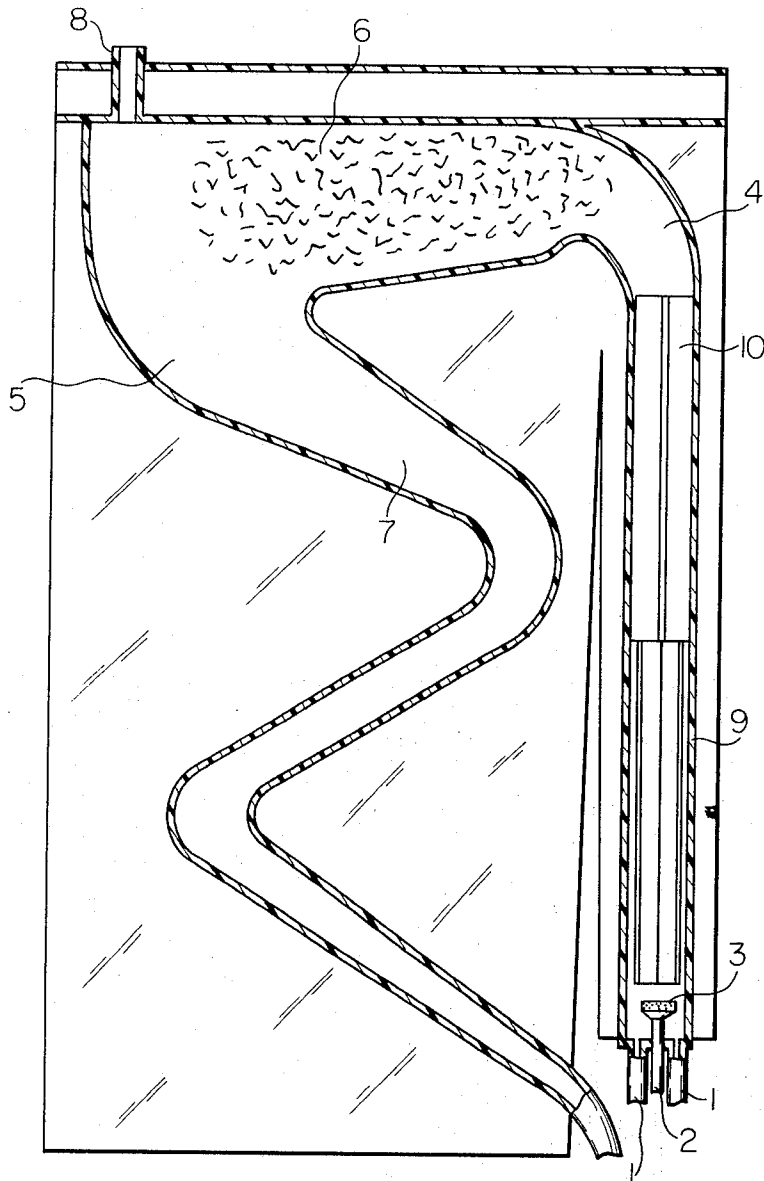


Fig. 1

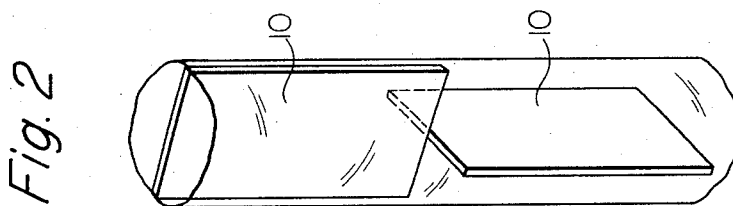
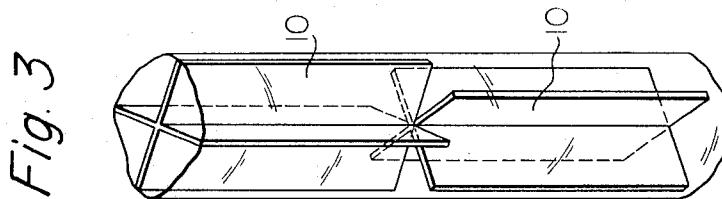
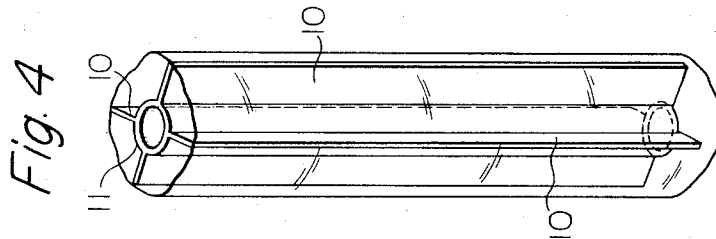


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Fig. 7

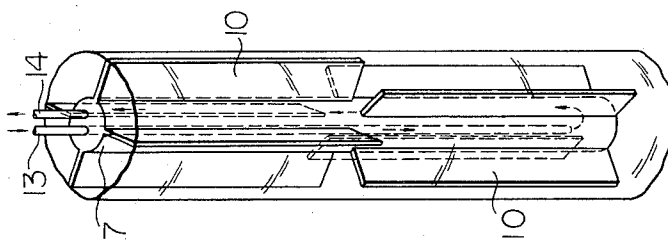


Fig. 6

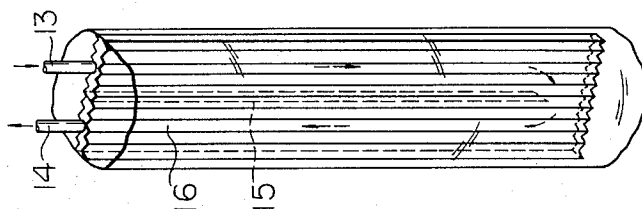
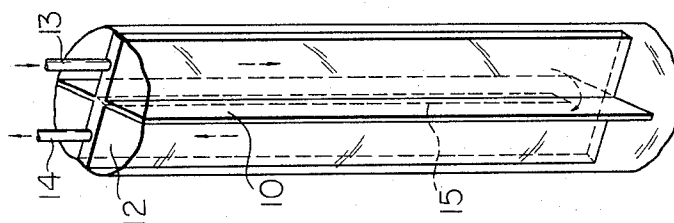


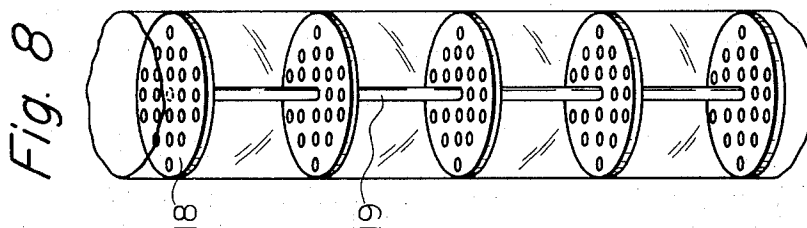
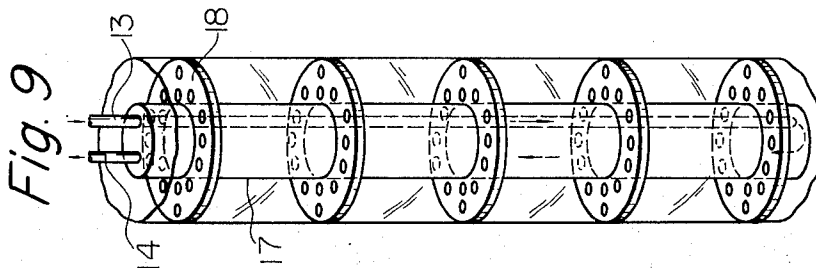
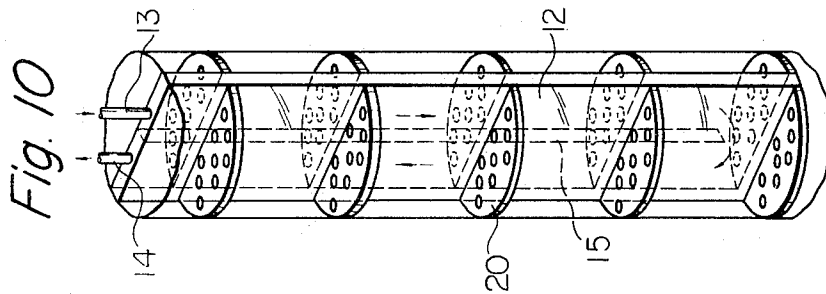
Fig. 5



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BUBBLE-TYPE BLOOD OXYGENATOR WITH BAFFLES

This is a continuation, of application Ser. No. 162,043 filed July 13, 1971 and now abandoned.

This invention relates to a bubble-type blood oxygenator to perform the function of the lung in the heart-lung machine.

The heart-lung machine is used mainly during operation on the heart under direct vision to perform the functions of the natural heart and lungs. The blood oxygenator performs the function of the lung; that is, it oxygenates blood and removes carbon dioxide from blood.

Various types of blood oxygenators are in use. The bubble-type blood oxygenator is economical to manufacture and is usually manufactured as a single-use disposable unit. However, it has disadvantages, the main one being the fact that the rate of hemolysis (that is breaking down of the red blood cells) and other kinds of damage to blood components due to physical effects is higher in this type of blood oxygenator than in the non-disposable-type blood oxygenators, such as the rotating disk-type, which type is troublesome to clean, assemble, and sterilize. Hemolysis and other damage to blood components have bad physiological effects on the human body. For this reason, the use of the bubble-type blood oxygenator has been limited to operations of relatively short duration, say one hour.

The conventional bubble-type blood oxygenator has no baffle means, and there is considerable hemolysis and other damage to blood components because of the violent movement, particularly local downward movement, of blood and gas bubbles caused by circulation of blood and bubbles within the blood oxygenating chamber. The result of such movement is that some portion of the blood is retained longer in the chamber. Also the channelling of gas bubbles, that is the tendency of gas bubbles to rise in certain sections of said blood oxygenating chamber, results in coalescence of bubbles into larger ones, and this increases hemolysis and decreases the efficiency of oxygenation.

In the conventional bubble-type blood oxygenator, the blood temperature is controlled by use of either a non-disposable heat exchanger separate from the blood oxygenator device or a disposable heat exchanger located outside the blood oxygenating chamber.

The primary object of this invention is to provide an improved bubble-type blood oxygenator which causes less hemolysis than prior art devices.

Another object of this invention is to provide a bubble-type blood oxygenator with better oxygenation performance.

Another object of this invention is to provide a heat exchange surface to control the temperature of blood during an operation without the use of a heat exchanger separate from the blood oxygenating chamber.

According to this invention, the flow of blood and gas bubbles is controlled by insertion of one or a plurality of baffle means comprising plate-like bodies, perforated plate-like bodies, or net-like bodies, within the blood oxygenating chamber of the bubble-type blood oxygenator the direction of the baffle means being substantially parallel or substantially perpendicular to the axis of said chamber, thereby reducing greatly hemolysis and other damage to blood components.

Furthermore, by the insertion of baffles, the channelling of gas bubbles is minimized, the dispersion of gas bubbles is improved, and the gas holdup, that is the volume-fraction of gas in the blood-gas mixture, is increased, resulting in better oxygenation performance. This, in turn, makes it possible to reduce the size of the oxygenating chamber, and the amount of blood held in said chamber, which results in still less damage to blood components.

Thus, with the blood oxygenator of this invention, the operation time can be made much longer than with the conventional bubble-type blood oxygenator without baffles without exceeding the allowable limit of hemolysis for human body. Using the blood oxygenator of this invention heart operations lasting more than three hours have been successful. Most of the open heart surgery performed at present with various types of blood oxygenators can be carried out with the blood oxygenator of this invention.

In the blood oxygenator of this invention some types of baffle means can be used as heat exchange means to control the blood temperature. With such baffle means the blood oxygenator device can be made more compact and, further, is more economical to manufacture than the bubble-type blood oxygenator having a separate heat exchanger.

The invention will be better understood from the following description of the preferred embodiments illustrated in the accompanying drawings:

FIG. 1 is a side elevation view of the bubble-type blood oxygenator device having the blood oxygenating chamber 9 provided with the baffle means 10 of the type also shown in detail in FIG. 3. The oxygenating chamber has blood inlets 1, oxygen inlet 2, oxygen disperser 3 through which oxygen gas is dispersed into the blood, and oxygenated blood outlet 4. The defoaming section 5 shown here is of the conventional design comprising a section packed with net (or mesh)-like body 6 impregnated with antifoaming agent, and the gas disengaging section 7 where blood flows slowly, providing residence time and gas-liquid interface sufficient for gas disengagement. 8 is the vent tube. The defoaming section shown in this figure is only an example and defoaming sections of various designs can be used in communication with the oxygenating chamber. The blood oxygenator device can be constructed entirely of either non-metal or metal, or of a combination of non-metal and metal. Any part which comes into contact with blood should be made of blood compatible material. The whole device shown in FIG. 1 can be sterilized after manufacture. The device of FIG. 1 is disposed of after being used once. However, some embodiments of this invention are relatively expensive to manufacture; these can be reused after cleaning and sterilization.

FIG. 2 is a perspective view of the baffle means, comprising two superposed flat plates 10, which should be inserted in the oxygenating chamber in the direction substantially parallel to the axis of said chamber. The two plates are made substantially perpendicular to each other to prevent the channelling of gas bubbles. Three or more plates can be used, one being superposed in a somewhat rotated position with respect to another.

FIG. 3 is a perspective view of another type of baffle means, comprising flat-plate structure 10 having +like cross section, which should be inserted in the oxygenating chamber in the direction of the axis of said chamber. In the embodiment shown in FIG. 3 two super-

posed sets of baffle means with +like cross section are used, one set being in a somewhat rotated position with respect to another to prevent the channelling of gas bubbles. Different numbers of superposed sets of baffle means and different numbers of flat plates for each set may be used.

FIG. 4 is a perspective view of another type of the baffle means, comprising a combination of a hollow cylinder 11 and four radially oriented flat plates 10, which should be inserted in the oxygenating chamber in the direction of the axis of said chamber. A solid cylinder may be used in place of the hollow cylinder. Two or more sets of flat-plate baffle means, one being superposed in a somewhat rotated position with respect to another, and different numbers of radially oriented flat plates for each set may be used.

FIG. 5 is a perspective view of another type of the baffle means comprising flat plates 10 and a hollow flat plate baffle 12, said hollow flat plate baffle having a passage for temperature-controlled liquid which flows in the direction indicated by the arrows. The hollow flat plate baffle is also used as a heat exchange means to control the blood temperature. Appropriate guide means such as shown as 15 is provided within the hollow plate 12 to direct the flow of liquid. 13 is the liquid inlet, and 14 is the liquid outlet. The hollow plate baffle is preferably constructed of metal but can be made of non-metal.

FIG. 6 is a perspective view of another type of the baffle means comprising a hollow plate-like baffle means 16, which is also used as the heat exchange means, the surface of said hollow baffle means having corrugations (wrinkles) to increase the surface area for heat transfer and accordingly heat transfer efficiency. The body is preferably constructed of metal but can be made of non-metal.

FIG. 7 is a perspective view of another type of baffle means, which is also used as heat exchange means, comprising a hollow cylinder 17, which is in the direction of the axis of the oxygenating chamber, and radially oriented flat plates 10 attached to the cylinder like fins. In the embodiment shown in this figure, these flat plates are attached to the upper and lower portions of the cylinder in offset positions for the purpose of preventing the channelling of gas bubbles. Various modifications with respect to the number and positions of the flat plates are possible. Passage for temperature-controlled liquid is provided within the cylinder as indicated by the arrows. 13 is the liquid inlet, extending nearly to the bottom of the cylinder, and 14 is the liquid outlet. The surface of the cylinder, which may have corrugations to increase the heat transfer surface area, acts as the heat transfer surface. The fin-like flat plates mainly function as baffle means but also provide extended surface area for heat transfer. The embodiment shown in this figure is constructed preferably of blood compatible metal, but may also be constructed of non-metal.

FIG. 8 is a perspective view of the baffle means provided within the oxygenating chamber in the direction substantially perpendicular to the axis of said oxygenating chamber, comprising perforated disks 18. A mesh or net-like body can be used instead of perforated plates. Various number of disks may be used depending on the size of the oxygenating chamber. Appropriate distances between the baffles can be kept by use of spacing means of various types. In the embodiment

shown in this figure, the disks are attached to a rod 19 constructed of blood compatible metal or non-metal.

FIG. 9 is a perspective view of another embodiment of this invention, comprising perforated disks 18, substantially perpendicular to the axis of the blood oxygenating chamber, attached to a hollow cylinder 17 substantially at the axis of said oxygenating chamber. Passage for temperature-controlled liquid is provided within the cylinder to control the blood temperature. 13 is the liquid inlet and 14 is the liquid outlet. The cylindrical body functions as the heat exchange means as well as the baffle means. The surface of the cylindrical body may have corrugations to increase the area for heat transfer.

FIG. 10 is a perspective view of another embodiment of this invention, comprising perforated disks (sets of perforated half disks) 20, substantially perpendicular to the axis of the blood oxygenating chamber, attached to a hollow flat plate-like baffle means 12, which is also used as the heat exchange means. Passage for temperature-controlled liquid is provided within the hollow flat plate-like body. 13 is the liquid inlet, and 14 is the liquid outlet. 15 is the guide means to direct the flow of liquid. The surface of the flat plate-like body may have corrugations to increase the surface area for heat transfer.

The foregoing is considered as illustrative only of the principles of the invention. Since numerous modifications and changes will readily occur to those skilled in the art it is not desired to limit the invention to the exact constructions shown and described, and accordingly all suitable modifications and equivalents may fall within the scope of the invention as claimed.

What is claimed is:

1. In a bubble-type blood oxygenator having a blood inlet, an oxygen inlet, an oxygenated-blood outlet disposed for passing oxygenated-blood to a defoaming section and a gas disengaging section, the improvement which consists essentially of an elongated tubular oxygenating chamber having a vertical longitudinal axis, a baffle positioned within said oxygenating chamber, said baffle having superposed flat plates angularly displaced and each extending in a direction substantially parallel to the axis of said oxygenating chamber, said blood and oxygen inlet being at a lower end of the chamber, said oxygen inlet having an oxygen disperser connected thereto, and said outlet for oxygenated blood being at the upper end of the chamber.

2. The bubble-type blood oxygenator of claim 1, wherein two flat plates are superposed one above the other and disposed substantially perpendicular to each other.

3. The bubble-type blood oxygenator of claim 1, wherein two sections of flat plates are superposed one above the other, each section of flat plates having a + configuration in horizontal cross section and being angularly displaced one section relative the other.

4. The bubble-type blood oxygenator of claim 3, wherein a common hollow cylinder joins both superposed sections, said common hollow cylinder having a temperature-controlled liquid inlet channel and a temperature-controlled liquid outlet channel, said common hollow cylinder defining a heat exchange member.

5. The bubble-type blood oxygenator of claim 1, wherein four radially oriented flat plates project about a hollow cylinder, the axis of the hollow cylinder being

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substantially parallel to the axis of said oxygenating chamber.

6. The bubble-type blood oxygenator of claim 1, wherein one of said plates is hollow and includes a temperature-controlled liquid inlet channel and a temperature-controlled liquid outlet channel, said hollow plate defining a heat exchange member.

7. The bubble-type blood oxygenator of claim 5, wherein two radially oriented flat plates project from opposite sides of the said hollow plate, the baffle having a + configuration in horizontal cross section.

8. In a bubble-type blood oxygenator having a blood inlet, an oxygen inlet, an oxygenated-blood outlet disposed for passing oxygenated-blood to a defoaming section and a gas disengaging section, the improvement

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which consists essentially of an elongated tubular oxygenating chamber having a vertical longitudinal axis, a baffle positioned within said oxygenating chamber, said baffle having superposed flat disks joined by an axially positioned hollow cylinder having a temperature-controlled liquid inlet channel and a temperature-controlled liquid outlet channel, said hollow cylinder defining a heat exchange member, said disks each having a plurality of perforations and being horizontally positioned within said chamber, said blood and oxygen inlet being at a lower end of the chamber, said oxygen inlet having an oxygen disperser connected thereto, and said outlet for oxygenated blood being at the upper end of the chamber.

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