

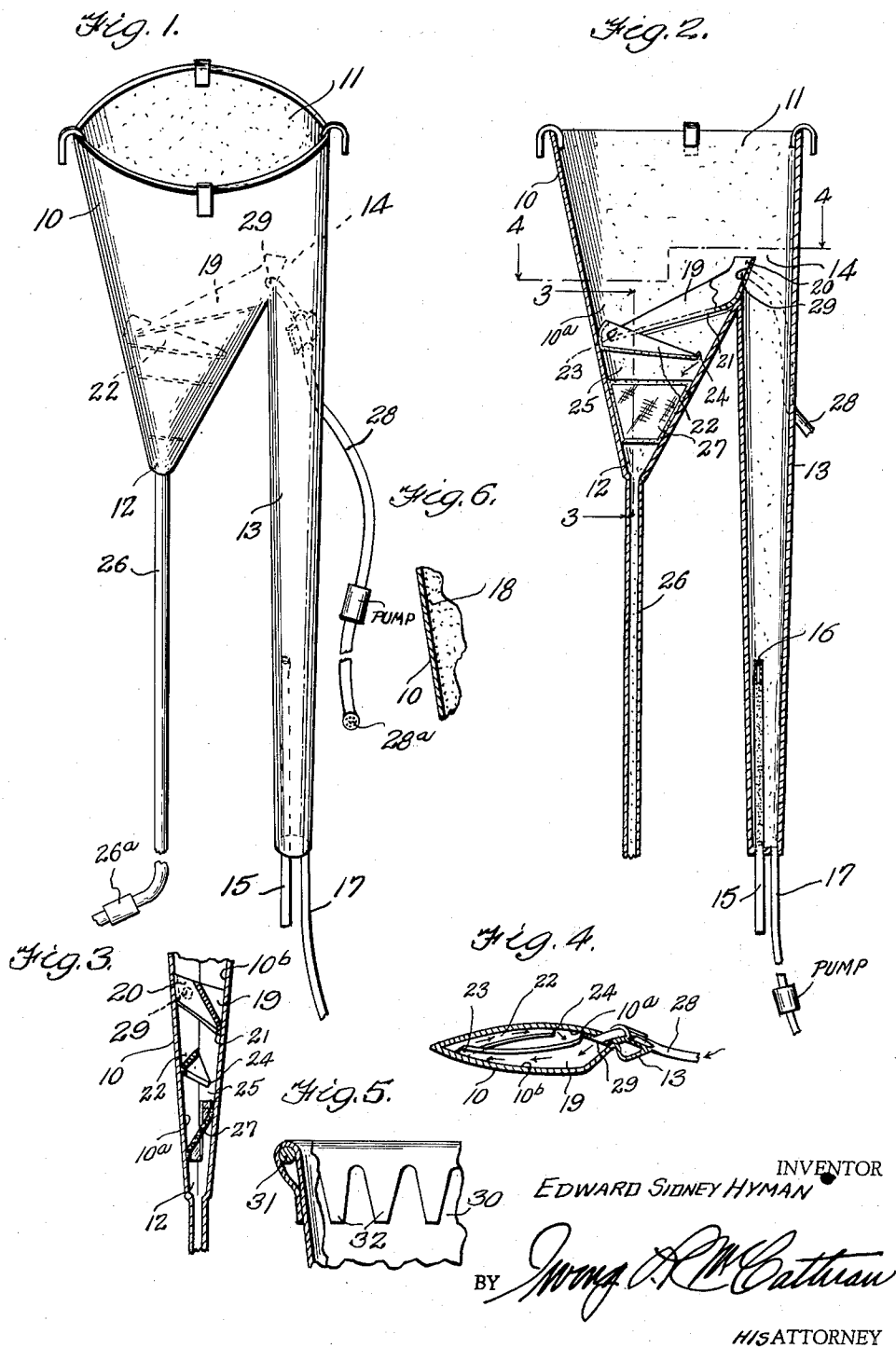
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HEART-LUNG DEVICE

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HEART-LUNG DEVICE

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This invention relates to a heart-lung device, and has for one of its objects the production of a simple and efficient means to by-pass both the heart and lungs in surgical procedure, where it is necessary to make a substitution for the heart or lung, or both, during such surgical procedure.

A further object of this invention is the production of a simple and efficient heart-lung device which is of flexible plastic material, thereby defining an inexpensive device which may be used for long or short surgical procedures, or lengthy medical illness, or may be discarded after one use, and which will minimize the danger of clotting and also eliminate entirely air embolism.

Other objects and advantages of the present invention will appear throughout the following specification and claims.

In the drawing:

FIGURE 1 is a perspective view of the device;

FIGURE 2 is a vertical sectional view thereof;

FIGURE 3 is a vertical sectional view taken on line 3-3 of FIGURE 2;

FIGURE 4 is a transverse sectional view taken on line 4-4 of FIGURE 2;

FIGURE 5 is a fragmentary sectional view through the upper end of the funnel-like body, showing a modified form of supporting structure;

FIGURE 6 is a fragmentary vertical sectional view of the wall of the funnel-like body of the device showing the silicone antifoam non-toxic greasy substance which is rubbed into the inner face of the wall of the plastic material.

By referring to the drawing in detail, it will be seen that 10 designates a body substantially in the nature of an inverted cone defining a funnel-like body tapering from the open upper end 11 toward the bottom end 12. A laterally offset depending mixing inlet tube 13 is carried at one side of the funnel-like body 10 and communicates therewith at the open upper end 14 of the inlet tube 13 in FIGURE 2 and communicating therewith between the top and bottom of the body 10. This mixing inlet tube 13 constitutes a tubular mixing chamber where blood is mixed with oxygen. An oxygen inlet tube 15 enters the bottom of the inlet tube 13, as shown in FIGURES 1 and 2, and extends up into the tube 13 for a suitable distance, about one foot in the present device. The end of the oxygen inlet tube 15 is sealed or closed at 16, and the wall of the tube 15 is perforated with a multitude of tiny apertures preferably formed with a needle, and approximately one thousand in number for the full length of the area of the tube 15 which extends into the tube 13. The tube 15 disperses oxygen inside of the tube 13.

A blood inlet tube 17 communicates with the lower end of the mixing inlet tube 13, as shown in FIGURE 2. Blood from the major veins entering the heart is pumped through this blood inlet tube 17 into the mixing inlet tube 13 of the apparatus or device. The blood inlet tube 17 actually forms a part of the apparatus and is sterilized by simple autoclaving. The pump may be any of several pumps which mechanically compresses the tube from without and milks the blood along. It is not thought necessary to illustrate such a pump, for the reason that such pumps are common to the profession, and the pump constitutes only an attachment to the present device. The pump is the only mechanical force exerted to force the blood into the tube 13, which as stated above constitutes a mixing

chamber, where the blood is mixed with oxygen entering through the perforated oxygen inlet tube 15.

Venous blood is oxygenated in the mixing chamber defined by the tube 13. Carbon dioxide is thereby swept out of the blood by the oxygen and the oxygen bearing carbon dioxide exits through the top open end 11 of the funnel-like body 10. Foaming is minimized by (a) the inverted cone-shape of the body 10 giving an increasingly larger cross section area as the foam should rise and (b) the silicone antifoam 18 shown in detail in FIGURE 6. This silicone antifoam is a non-toxic greasy substance which is rubbed into the inner face of the wall of the plastic material and is shown as in FIGURE 6 merely to indicate the substance. There is no physically free silicone but, as stated above, the silicone is rubbed into the plastic material.

Within the funnel-like body 10 and starting at the junction of the tube 13 with the body 10 and following one inside wall of the body 10, a downwardly inclined strip 19 which together with the wall forms a trough substantially V-shaped in cross section, is secured to the inner face of the body. The upper end 20 is cemented or otherwise fixed to one inner face of the body and the lower opposite marginal longitudinal edge 21 is preferably cemented or otherwise fixed to the opposite inner face of the body. The trough which is defined by the strip 19 and the inner face of the wall 10^b, then follows the transverse contour of the body.

A reverse trough 22 is secured to the inner wall of the body 10 opposite the wall 10^b to which the marginal edge 21 of the trough 19 is secured. This trough 22 is inclined downwardly and transversely of the body 10. The trough 22 by being fixed to the inner face of the body 10, and by having its upper marginal edge flaring inwardly away from the wall 10^a, defines in conjunction with the wall 10^a a substantially V-shaped channel to receive blood which flows down the trough 19. Blood flowing down the trough 19 spills from the lower end 23 thereof into the upper end of the trough 22 since the lower end 23 of the trough 19 overlies the upper end of the trough 22. The blood therefore drips or spills through a zig-zag or spiral-like path down the trough 19, into the trough 22 where it then is discharged from the lower end 24 of the trough 22. The blood starts its descent from the trough 19, initially allowing the smaller bubbles of gas to escape and then causing the descending blood to enter the lower reservoir portion 25 of the body 10 without eddy currents and without streaming toward the exit tube 26 at the bottom of the body 10.

A large downwardly inclined nylon mesh fabric or other filter 27 is fixed at its upper edge to one inner wall surface of the body 10 below the level of the upper end 14 of the mixing tube and at its lower edge to the opposite inner wall surface, the side edges of the filter being also secured to the inner wall to require the blood from the lower reservoir portion 25 to pass through the filter before entering the exit tube 26, and thereby filter out clots of blood. Since the filter 27 slants downwardly from one side of the body 10 to the other side, it serves as an efficient filter with little dissipation of pressure. The reservoir area 25 is simply an inverted cone and serves three functions (a) because of the very slow linear down-flow in this area, the tiniest bubbles may escape upwardly, (b) as a reservoir it serves to naturally synchronize the flow rates and (c) it serves as a reservoir of aerated blood in case of catastrophe.

Blood flows through the bore of the exit or outlet tube 26 by gravity into a major artery, the bore being sufficiently large for efficient operation. By using gravity, a steady arterial pressure may be maintained independent of flow rate within the limits only of the friction resistance of the blood in the tube 26. It should be

noted that normal arterial main pressure in humans, or in fact in dogs, is less than five feet of water in terms of hydrostatic pressure.

An accessory tube 28, for collection of "coronary sinus" blood (that blood which feeds the myocardium itself) is carried by the exterior of the tube 13 and has its upper open end communicating with the upper end of the trough 19. This tube, like the tube 17, is placed in a milking device marked by the legend "PUMP" in FIG. 1. The outer or lower end or tip of the tube 28 is provided with a plurality of openings 28^a so that it cannot be occluded by contact with a heart muscle. Thus it draws in heart blood and air. This mixture simply enters the funnel 19 at the upper end of the funnel. In this way the heart blood is recovered, is aerated, and re-used.

The entire apparatus is wrapped in cloth and autoclaved in the routine fashion. It is then hung or suspended by the funnel-like body 10 in any desired manner several feet above the surgery table. As shown in the modified form in FIGURE 5, the upper end of the body 30 may carry a suspension ring 31 which is retained by the outwardly turned scalloped edge 32. This ring 31 may be attached to any suitable supporting means for suspending the body 30.

If desired, a conventional milking pump 26^a may be attached to the tube 26 to boost pressure when necessary.

It should be noted that the present device is simple, efficient, and inexpensive enough to be discarded after one use. It will minimize the danger of clotting and will eliminate entirely air embolism. Further, it may be used for prolonged periods and it is possible to use the device not only in short surgical procedures, but also in more lengthy medical illnesses.

It should be further understood that certain detail changes in structure may be made so long as these changes fall within the scope of the appended claims.

Having described the invention, what I claim as new is:

1. A device of the class described comprising a body having an exit tube, a mixing inlet tube, an oxygen inlet tube communicating with said mixing inlet tube, a blood inlet tube communicating with said mixing inlet tube for supplying blood thereto from the major vein entering the heart, the upper end of said mixing inlet tube having an open end communicating with said body, the upper end of said body also being open, said body having troughs for conveying blood from the open end of said mixing inlet tube downwardly toward said exit tube, and a filter interposed between said exit tube and said troughs, the exit tube being adapted to convey blood to a selected major artery.

2. A device as defined in claim 1, wherein said troughs include a trough extending from the open upper end of said mixing inlet tube substantially transversely of the body along the inner face of one wall of the body and is inclined downwardly, and wherein a second trough is secured to the inner face of the opposite wall of the body and is inclined downwardly in an opposite direction to the first mentioned trough, the lower end of the first mentioned trough being adapted to empty blood into the upper end of the second mentioned trough, and the lower end of the second mentioned trough being adapted to deliver blood received from the first mentioned trough into the body near said exit tube.

3. A device as defined in claim 1, wherein said troughs comprise a trough extending from the open upper end of said mixing inlet tube substantially transversely of the body along the inner face of one wall of the body and is inclined downwardly, and wherein a second trough is secured to the inner face of the opposite wall of the body and is inclined downwardly in an opposite direction to the first mentioned trough, the lower end of the first mentioned trough being adapted to empty blood into the upper end of the second mentioned trough, the lower end of the second mentioned trough being adapted to deliver blood

received from the first mentioned trough into the body near said exit tube, the said filter being carried in the lower end of said body between said second mentioned trough and said exit tube.

4. A device of the class described comprising a body having an exit tube, a mixing inlet tube, an oxygen inlet tube communicating with said mixing inlet tube, a blood inlet tube communicating with said mixing inlet tube for supplying blood thereto from the major vein entering the heart, the upper end of said mixing inlet tube having an open end communicating with said body, the upper end of said body also being open, said exit tube being connected to the lower end of said body for directing blood therefrom to a selected major artery, and an accessory tube for collecting coronary sinus blood leading from said body directly above said last mentioned means, the end of said accessory tube having a plurality of openings to continuously recover heart blood and facilitate the reuse of said heart blood.

5. An economical disposable heart and lung device adapted to be discarded after once being used, said device comprising a hollow body provided with downwardly inclined upwardly open troughs attached at the inner surface of the body wall and defining a curved descending path from the upper toward the lower end of the body thereby preventing channeling and short circuiting of blood directly through the body, and means carried by the body for simultaneously supplying blood into said body from the major vein entering the heart and returning the blood processed in said body to a selected artery, thereby obviating the dangers of reusing equipment that has contained blood.

6. A device of the class described comprising a unitary structure of flexible plastic material having a hollow body with a large upper portion and a smaller bottom portion, means at the upper end of the device by which it may be suspended with its contents above the level of the patient, said body having an opening at its upper end for the escape of gas, an integral flexible tubing extending from said smaller bottom portion for the gravitational return of processed blood to a selected artery, an integral flexible mixing tube integral with and laterally offset at the side of said hollow body and communicating with said hollow body midway of the height thereof, and a flexible inlet tube integral with the mixing tube and communicating with the lower end thereof, a flexible oxygen inlet tube connected with and sealed to the mixing tube and extending upwardly therein and having along the length of its portion within the mixing tube a multitude of small apertures communicating with the same for the delivery of oxygen bubbles into the blood in the mixing tube, and a flexible accessory tube communicating directly with said body adjacent the communication of said mixing tube therewith and adapted for the delivery of heart blood directly into said body.

7. A device of the class described comprising a unitary structure of flexible plastic material having a hollow body with a large upper portion and a smaller bottom portion, means at the upper end of the device by which it may be suspended with its contents above the level of the patient, said body having an opening at its upper end for the escape of gas, an integral flexible tubing extending from said smaller bottom portion for the gravitational return of processed blood to a selected artery, an integral flexible mixing tube integral with and laterally offset at the side of said hollow body and communicating with said hollow body between the upper and lower ends thereof, a flexible inlet tube integral with the mixing tube and communicating with the lower end thereof, a flexible oxygen inlet tube connected with and sealed to the mixing tube and having along its portion within the mixing tube a multitude of small apertures communicating with the same for the delivery of oxygen bubbles into the blood in the mixing tube, and a filter of flexible material located within the hollow body near the lower end thereof in the path of

oxygenated blood flowing downward in said body, said filter having an upper edge connected to the inner surface at one side of the said hollow body below the level of the said communication of the mixing tube and having a lower edge connected to the inner surface at the other side of said hollow body.

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