Description

This invention relates to systems for separating and irradiating multicomponent fluids and, in particular, to the use of such systems in the field of treating cells with photoactivatable compounds by radiation, which activates the compounds to effect cellular change.

Numerous human disease states of the blood respond favorably to the treatment of selected blood components by visible or ultraviolet light irradiation. Such treatment may be effective to eliminate immunogenicity in cells, inactivate or kill selected cells, inactivate viruses or bacteria, or activate desirable immune responses. Certain forms of treatment with light irradiation may be effective without the introduction of outside agents or compounds, while others may involve the introduction of specific agents or catalysts. Among the latter treatment techniques is the use of photoactivatable agents to regulate the population of leukocytes. It is well-known that a number of human disease states may be characterized by the overproduction of certain types of leukocytes, including lymphocytes, in comparison to other populations of cells which normally comprise whole blood. Excessive or abnormal lymphocyte populations result in numerous adverse effects in patients including the functional impairment of bodily organs, leukocyte mediated autoimmune diseases and leukemia related disorders many of which often ultimately result in fatality.

U.S. Patent Nos. 4,321,919; 4,398,906; 4,428,744; and 4,464,166 to Edelson describe methods for treating blood whereby the operation or viability of certain cellular populations may be moderated thereby providing relief for these patients. In general, the methods comprise treating the blood with a dissolved photoactivatable drug, such as psoralen, which is capable of forming photoadducts with DNA in the presence of ultraviolet (U.V.) radiation. It is believed that covalent bonding results between the psoralen and the lymphocyte nucleic acid thereby effecting metabolic inhibition of the treated cells. Following extracorporeal irradiation, the cells are returned to the patient where they are thought to be cleared by natural processes but at an accelerated pace believed attributable to disruption of membrane integrity, alteration of DNA within the cell, or like conditions often associated with substantial loss of cellular effectiveness or viability.

Although a number of photoactivatable compounds in the psoralen class are known, 8-methoxy psoralen is presently the compound of choice. An effective radiation for this compound, and many psoralens in general, is the ultraviolet spectrum in the range of approximately 320 to 400 nanometers, alternatively referred to as the U.V.A. spectrum. As the development of photoactivatable compounds proceeds, it may be expected that changes in the preferred activation radiation spectrum may occur. For instance, it may be preferable to treat some disease states with light in the ultraviolet spectrum of 280 to 320 nanometers, referred to as the U.V.B. spectrum. Suitable selection of radiation sources may be expected to increase treatment efficiency and is contemplated as an obvious optimization procedure for use with the invention disclosed herein.

In initial implementations of the Edelson methods whole blood was treated in vitro using devices such as flasks, filtration columns, spectrophotometer cuvettes, and petri dishes. The blood sample to be irradiated was added to the containers and the containers placed adjacent to the radiation source. Such systems were characterized by difficulty in providing the necessary safeguards intrinsically necessary where patient bodily fluids are concerned, particularly since these fluids must be returned to the patient, thereby necessitating strict avoidance of contamination. Further, such methods tend to be volume limited, are characterized by many mechanical manipulations and are generally unacceptable from a clinical and regulatory viewpoint.

United States patent no. 4,573,960 describes an advance made in these initial implementation techniques by Taylor. Taylor describes a practical device for coupling the radiation provided by commercially available light sources, such as so-called "black-light" fluorescent tubes, to cells for treatment by Edelson's photoactivated drug methods. In summary, the disposable cassette described by Taylor comprises a plurality of fluorescent tube-like light sources such as the U.V.A. emitting Sylvania F8T5/BLB bulb, which are individually, coaxially mounted in tubes of larger diameter which are, in turn, coaxially mounted in sealing arrangement within second outer tubes of even larger diameter, thereby forming a structure having two generally elongated, cylindrical cavities about each radiation source. The inner cavity preferably communicates with the atmosphere thereby facilitating cooling of the radiation source. The second tube forming the outer cavity further comprises inlet and outlet means for receiving and discharging, respectively, the cells to be irradiated. A plurality of these structures are serially interconnected between inlets and outlets of adjacent members to provide for serpentine flow of cells through each outer cavity. Thus, continuous flow of the cells through the plurality of cavities surrounding the centrally disposed radiation sources facilitates thorough treatment of the cells.

To be fully practical, however, the Taylor device requires a clinically acceptable instrument to house the device and to provide the cells to be treated in an appropriate form. Such an instrument and a method for its use are described in the aforementioned U.S. Patent 4,573,960. The method there described for extracorporeally photoactivating a photoactivatable reagent in contact with blood cells comprises the steps of collecting and separating on a continuous basis blood from a patient while the patient is connected to the instrument, returning undesired blood portions obtained during separation, and disconnecting the patient from the treatment system while the desired portion is photoactivatably treated, whereafter the treated cells are returned to the patient. Thus, the instrument and method of this patent broadly maximizes a patient's safety and optimizes the various aspects of such photoactivation treatment by breaking the entire procedure down into three phases or modes. In the first mode the instrument collects and separates blood on a continuous basis as it is withdrawn from the patient and returns unwanted portions to the patient, all of which are accomplished while the patient remains connected to the apparatus. Thereafter, prior to energizing the irradiation sources for photoactivating the photoactivatable reagent in contact with the desired blood portion, the patient may be disconnected from the instrument while irradiation and photoactivation are performed on the separated component of the blood during the second mode. Following photoactivation the treated cells may then be facilely returned to the patient during a third mode, utilizing a variety of techniques, the preferred being a simple drip chamber gravity feed infusion line.

While the foregoing instrument and method provide a system which has met clinical and regulatory standards, it is desirable to provide the system with even greater clinical and operational efficiency. It would be desirable, for instance, to combine the first and second modes of the prior method, whereby the desired blood component is photoactivatably treated during separation of the blood components. While improving efficiency and reducing system complexity, such an improvement would also eliminate the blood tubing set, valves, container, and tubular or flat plate cassettes required for the separate irradiation mode of operation in the prior apparatus described in the aforementioned U.S. Patent 4,573,960 and in U.S. Patent 4,737,140 (Lee et al.). In such an improved arrangement, the dynamic operating variables of the separation process could be used to controllably irradiate the desired blood component while minimizing unnecessary irradiation of other components of the blood.

Furthermore, the necessary remixing of the separated blood components may be performed at the conclusion of the irradiation treatment by the same apparatus that initially separates the blood components, thereby obviating the intervening step of returning only unwanted components to the patient.

DE-A-2745041 describes and illustrates a plasmaphoresis device according to the preamble of claim 1. The device uses centrifugal forces for separating patient whole blood into various layers containing red blood cells or plasma or lymphocytes. After separation the plasma layer is removed and the remaining parts are returned to the patient.

FR-A-1233327 describes and illustrates a device for extracorporeal enrichment of blood with a mixture of oxygen. Ozone used by this device is produced in situ by irradiation of oxygen in the same device. The wall of the irradiation chamber surrounding the source of radiation may be transmissive at least for particular wavelengths. Unspecific simultaneous irradiation of all blood components can occur to amend blood quality.

In accordance with the principles of the present invention, a multicomponent fluid separation and irradiation apparatus is provided which may be advantageously utilized to separate and irradiate desired components of blood. The apparatus includes a housing;

a rotatable member located within said housing;

a disposable separation/irradiation chamber adapted to be mounted in said rotatable member and including a vertical cylindrical outer compartment in fluid communication with an inner compartment extending between said outer compartment and the center of said chamber, and a first passageway accessing said inner compartment; and

a dynamic seal having a rotatable member and a stationary member, said rotatable member being connected to said inner compartment of said chamber, and said first passageway passing through said dynamic seal; and characterised by

a source of radiant energy of a given wavelength connected to said housing and located radially within said separation/irradiation chamber so as to oppose the inner wall of said outer compartment, wherein said inner wall of said outer compartment is transmissive of radiant energy of said given wavelength.

In the drawings:

FIGURE 1 illustrates in a partially cross-sectional view a first embodiment of a multicomponent fluid separation and irradiation system constructed in accordance with the principles of the present invention;

FIGURE 2 is a plan cross-sectional view of the system of FIGURE 1;

FIGURE 3 is an alternate embodiment of the system of FIGURE 1 utilizing a circular tube light source;

FIGURE 4 illustrates a cross-sectional view of a second multicomponent fluid separation and irradiation system constructed in accordance with the principles of the present invention;

FIGURE 5 is an elevational view of the fluid separation compartment of the embodiment of FIGURE 4;

FIGURE 6 is an enlarged cross-sectional view of the fluid separation compartment of the embodiment of FIGURE 4;

FIGURE 7 is an enlarged cross-sectional view of an alternate embodiment of the fluid separation compartment of the embodiment of FIGURE 4; and

FIGURE 8 is a cross-sectional view of a fluid separation compartment which is filled with a predetermined quantity of blood.

Referring first to FIGURE 1, a whole blood separation and irradiation device constructed in accordance with the principles of the present invention is shown. The device comprises a stationary housing 1 and cover 3 which encloses a rotatable separation/irradiation chamber 14. Depending from the stationary centrifuge cover is a light source in the form of five U-shaped U.V. bulbs 2. The bulbs are arranged in a generally circular configuration around the inside of the separation/irradiation chamber of the device as shown in the plan cross-sectional view of FIGURE 2. The bulbs are shielded about their outer perimeter by a protective bulb cover 21, which also is attached to the cover 3.

The stationary and rotatable sections of the device are joined by a rotary seal 60 at the axial center of the device. The rotary seal 60 includes an upper, nonrotating disk-shaped component 7 and a lower, rotating disk-shaped component 6. The nonrotating component 7 is attached to a central shaft 9 of the device by an elastic member 8. The central shaft in turn passes through and is attached to the cover 3 by a clamp 31. The elastic member 8 urges the nonrotating component 7 downward so that the annular contacting surface of the component 7 is in contact with the upper surface of the rotating component 6 of the seal, thereby establishing a dynamic seal as the rotatable section of the device is rotated. The rotary seal is of the type described in U.S. Patent 4,300,717.

Extending through the shaft 9 from above the cover 3 to the bottom of the separation/irradiation chamber is a feed tube 13. Axially extending from the shaft 9 is an air outlet port 11, the distal end of which is sealed with a microbial filter 12. Alternatively, the distal end of the air outlet port may be connected to a sterile empty bag. As the separation/irradiation chamber 14 is filled with whole blood, displaced air passes through the passageway between the feed tube 13 and the inner wall of the shaft 9. The air is then vented out through the filter 12 or into the empty bag. The distal end 10 of the feed tube 13 may be fitted with a connection to connect the tube to a blood supply line (not shown).

The rotatable section of the device includes a continuously sealed separation/irradiation chamber 14 having a cylindrical outer compartment 62. The outer compartment 62 has an outer wall 17 and an inner wall 16 which opposes the light source 2. The inner wall 16 is made of a material transparent to a wavelength of the light source. For example, acrylic plastics, polyethylene, polypropylene, polyvinylchloride, pyrex glass, and silica are transparent to ultraviolet and visible light. The separation/irradiation chamber 14 is seated inside a chuck 19, and is sealed therein by an O-ring 20. The chuck 19 is connected by a coupling 40 to the shaft 39 of a motor 22 in the bottom of the housing that rotates the chuck at the desired speed. Centrifugal forces will thus be developed in the separation/irradiation chamber 14 and its outer compartment 62 as the chamber is rotated about the light source 2. The chamber 14 remains sealed during rotation by the rotary seal 60. A drain tube 30 allows drainage of cleaning and other fluids from the chuck 19 by opening a stopcock on the drain tube.

The cover 3 is connected to the housing 1 by a hinge 18. The hinge desirably articulates so that when the clamp 31 is unclamped and opened about the shaft 9 the cover can be lifted and will clear the shaft 9 and the air outlet port 11 without interference.

In operation, the motor is energized to rotate the separation/irradiation chamber 14 for the generation of centrifugal forces within the chamber. A desirable range of the centrifugal speed is 1000-6000 RPM. A blood supply line is connected to the distal end 10 of the feed tube 13 and whole blood treated with a photoactivatable compound and preferably an anticoagulant is supplied to the tube by a blood pump or gravity feed. As the blood enters the system the air displaced by the volume of blood is vented out through the air outlet port 11 and microbial filter 12 or into a sterile empty bag. The whole blood passes down the tube to the recessed blood collection well 15 at the bottom of the separation/irradiation chamber 14. The centrifugal forces of the rotating chamber push the blood out of the well 15 and up the sloped bottom 26 of the chamber to the outer compartment 62 of the chamber. A step 27 is formed at the junction of the bottom of the chamber and the outer compartment

62 whereby substantially all of the blood will be elevated above the bottom of the chamber and into the compartment 62 without contacting the inner wall 16 of the chamber. The rotating chamber forces the blood against the outer wall 17 of the separation/irradiation chamber where cell separation occurs in accordance with the sedimentation rates of individual blood components. This centrifugal separation will result in the development of a layer 25 of red blood cells in contact with the outer wall 17 of the chamber. The innermost separated layer comprises a plasma layer 23, and between the red blood cell layer and the plasma layer is a thin lymphocyte enriched layer 24, referred to herein as a buffy coat layer. Thus the red blood cells, which would otherwise act to shield other blood components from U.V. light, are located outside the lymphocyte enriched buffy coat layer. The composition of whole blood, and hence the relative thicknesses of the separated layers, is approximately 45% red blood cells, 55% plasma, and 0.1% buffy coat.

The sedimentation rate of lymphocytes is lower than that of other white blood cells in the buffy coat 24. Thus, the lymphocytes are highly concentrated in the side of the buffy coat which opposes the plasma layer 23. U.V. light from the light source 2 will therefore pass through the protective bulb cover 21, the inner wall 16 of the separation/irradiation chamber, and the plasma layer 23 to irradiate the lymphocytes in the buffy coat 24, a sequence shown in the view of FIGURE 2. Since the rotational forces in the chamber 14 will establish buffy coat and plasma layers of uniform thickness by reason of the vertical wall 17 of the chamber, the lymphocytes will be uniformly irradiated by the light source. By measuring the ratios of the components of the whole blood and the volume of blood supplied to the separation/irradiation chamber, the intensity and duration of irradiation exposure can be regulated to result in a controlled reaction of the lymphocytes to irradiation in combination with a photoactivatable compound.

At the end of the desired period of irradiation the motor 22 is turned off to stop the rotation of the separation/irradiation chamber 14. The separated blood components flow down from the outer compartment 62 of the chamber and down the sloped bottom 26 of the chamber, where they are remixed as they collect in the blood collection well 15. The blood is pumped out of the collection well through the feed tube 13 for return to the patient. The disposable components of the system which have come into contact with body fluids are removed and disposed of, including the separation/irradiation chamber 14, the dynamic seal, and the shaft 9 and attached components 10-13, which are unclamped from the cover 3.

A constructed embodiment as described in FIGURE 1 has been built and tested using 250 ml. of whole blood and a rotational speed of 1650 RPM. It was found that, at a rotational speed of as low as 200 RPM, blood had begun to migrate up the outer wall of the separation/irradiation chamber under the influence of centrifugal force. After the separation and irradiation process was completed, it was found that the separated blood consitiuents remixed at the bottom of the chamber due to angular deceleration and pumping as the centrifuge slowed down and came to a stop.

FIGURE 3 illustrates a modified form of the embodiment of FIGURE 1, differing in that circular U.V. bulbs 2' are used in place of the U-shaped bulbs of FIGURE 1. Like the embodiment of FIGURE 1, the circular bulbs 2' are suitably attached to the underside of the cover 3, and are protected by the surrounding bulb cover 21 which is transparent to U.V. light.

Referring now to FIGURE 4, a second embodiment of a whole blood separation and irradiation device constructed in accordance with the principles of the present invention is shown. In this embodiment the stationary section of the device is substantially the same as described above, including the cover 3, the housing 1, the feed tube 13 affixed through the cover clamp 31, and the stationary component 7 of the seal with its elastic member 8. Unlike the previous embodiment, the rotatable component 6 of the rotary seal is clamped so as to enter a rotating fluid entry compartment 28 at the upper portion of the device. The feed tube 13 extends through the cover 3 to a point near the bottom of the fluid entry compartment. A support member 35 is attached between the fluid entry compartment 28 and an outer centrifuge drum 36 of the rotatable section of the device. The centrifuge drum 36 is seated in a rotating chuck 70. A groove 74 for a drive belt 38 is formed around the lower extension of the chuck 70. The drive belt 38 is located around the groove 74 and pulley 37 of the drive motor 22. The rotating chuck 70 rotates with respect to the housing by bearings 72 located between the chuck and the housing.

Located inside the centrifuge drum 36 is an array of five U-shaped U.V. bulbs 47. The bulbs 47 are mounted on a bulb mount 49 at the bottom of the device. The bulbs are surrounded by a protective bulb cover 48 which is transparent to U.V. light. The bulbs 47 are energized by a power source 76 located inside the housing.

Blood is conducted from the fluid entry compartment 28 to a separation/irradiation chamber 29 by a radial feed tube 32. The feed tube 32 is continued downward through a passageway 33 of the separation/irradiation chamber 29 and terminates at a port 42 at the bottom of the chamber.

While only a single radial feed tube is shown in the embodiment of FIGURE 4, it may be appreciated that a number of such tubes may radiate from the fluid entry compartment, or that blood may be conducted from the fluid entry compartment by a hollow disk-shaped member radiating outward from the fluid entry compartment. In such alternatives an array of vertical passageways would be used to conduct the blood to the bottom of the chamber 29.

Located inside the centrifuge drum 36 is a cylindrical separation/irradiation chamber 29, shown in an enlarged cross-section in FIGURE 6 and in FIGURE 5. In the latter FIGURE the cylindrical chamber has been "unrolled" to a flat shape for clarity of illustration. The chamber 29 is connected to a rigid plastic or metal support plate 46 as its outer member. Around the periphery of the support plate are a number of locating pins 45. When the chamber 29 is mounted inside the centrifuge drum 36, locating holes 44 of the chamber fit over the matching locating pins 45. The support plate 46 includes a passageway or passageways for passage of the vertical section 33 of the feed tube 32.

The disposable chamber 29 is formed of two flexible polymeric sheets 51, 53 which are transparent to U.V. light and are heat or adhesively sealed about the periphery of sheet 51 as indicated at 43 to form a bag-like compartment. As shown in FIGURE 5, blood is supplied to the chamber at the inlet port 42 where the feed tube section 33 enters the chamber. The locating holes 44 are spaced around the periphery of the outer polymeric sheet 53. When the flexible chamber is mounted in the centrifuge, it is covered around its inner surface by a cylindrical supporting wall 41, which is transparent to light at the critical wavelength and contains holes which align with the locating pins 45. The supporting wall 41 prevents the development of bulging at the bottom of the flexible chamber as the centrifuge slows down and blood accumulates at the bottom of the flexible compartment.

In operation the separation/irradiation chamber 29 and the supporting wall 41 are mounted inside the centrifuge drum 36 against the support plate 46 and the radial feed tube or tubes 32 are connected to the fluid entry compartment 28. The centrifuge drum and chuck are then rotated by the motor and its belt and pulley drive arrangement. The separation/irradiation chamber 29 is primed by pumping heparanized saline solution into the chamber as it rotates. After the chamber has been thoroughly primed with the solution the centrifuge is slowed to a rotational speed below 100 RPM (e.g., about 20 RPM) and the supply pump is reversed to pump the saline solution out of the separation/irradiation chamber. As the solution is pumped out the flexible chamber 29 collapses to its initial empty condition.

Following the priming procedure the centrifuge is accelerated to its separation speed, e.g., on the order of 1000-6000 RPM, depending upon the diameter of the chamber. Whole blood is then pumped into the separation/irradiation chamber through the feed tube 13 leading to the fluid entry compartment 28. The centrifugal forces of the rotating fluid entry compartment push the blood outward through the radial feed tube 32 where it flows down the vertical tube portion at 33 and through the port 42 to the separation/irradiation chamber 29. The chamber 29 is initially collapsed as the flexible chamber is pressed against the support plate 46 due to centrifugal force, but the flow of blood will expand the flexible chamber toward the supporting wall 41 as blood fills the chamber. The whole blood then becomes distributed in layers, as described above, against the outer wall of the rotating separation/irradiation chamber 29. U.V. light from the light source 47 will pass through the protective bulb cover 48, the supporting wall 41, the inner chamber sheet 51, and the inner plasma layer 23 to reach the lymphocytes in the buffy coat layer 24, shown most clearly in FIGURE 6.

When the desired irradiation period has ended, the rotating centrifuge drum is slowed down, preferably to a speed below 50 RPM. The separated blood begins to flow downward in the chamber under the influence of gravity and the flexible sheets of the chamber collapse as blood is pumped out of the chamber through the port 42 and tubes 13, 32 and 33. When the chamber has been emptied the flexible chamber is collapsed back to its initial position against the outer wall of the chamber. By reason of this collapsible and expandible bag-like chamber there is no need to vent air from the chamber during the filling procedure. The disposable components are removed and disposed of after use, including the separation/irradiation chamber 29, tubes 13, 32, and 33, the compartment 28, and the dynamic seal.

FIGURE 7 shows an alternate embodiment of the chamber 29 of FIGURES 4-6, in which the inner cylindrical surface of the chamber 29 is formed of a sheet 51 of flexible film which is sealed about its periphery 58 to a rigid support component 57, the latter functioning as both the outer wall of the separation/irradiation chamber and the support plate 46. In this embodiment the need for a separate support plate distinct from the separation/irradiation chamber is eliminated. Overlying the flexible film inner surface of the chamber in this embodiment is the inner cylindrical supporting wall 41 which is mounted on locating pins extending from the periphery of the inner surface of the chamber. Some of the polymeric material suitable for use as the support component 57, the supporting wall 41, and the flexible film 51 include poly-

propylene, polyethylene, ethylvinyl acetate, polyvinylchloride, and acrylic materials.

A further embodiment of a separation/irradiation chamber 14' suitable for use in the device of FIGURE 1 is shown in FIGURE 8. It has been found that occasional bubbling of the whole blood can cause small deposits of red blood cells to strike and adhere to the inner wall 16 of the separation/irradiation chamber 14 of FIGURE 1. These small deposits of red cells can retard the transmission of light from the bulbs 2 to the separated buffy coat layer 24. The separation/irradiation chamber 14' of FIGURE 8 alleviates this condition by providing a volume between the chamber walls which is substantially entirely filled with a predetermined volume of blood. The separation/irradiation chamber 14' of FIGURE 8 is approximately 4 inches in height and has a controlled spacing between the inner wall 16' and the outer wall 17' which can be filled as shown in FIGURE 8 by 250 ml. of blood. The space between the walls at the top of the chamber is approximately 2 mm, and at the center of the wall height the space is approximately 6 mm wide. This spacing is achieved by employing a vertical outer wall 17' and an inwardly tapering inner wall 16', which tapers away from the outer wall at an angle of approximately 2°-3°. The angular taper allows air in the chamber to be replaced by blood by migrating down the inner tapered wall and to the center of the chamber, where it is vented out through the shaft 9 and the air outlet port 11. As the separating blood fills the volume of the separation/irradiation chamber 14', the plasma layer will continually wash the inner wall 16', causing any red blood cells at the inner wall surface to detach and migrate to the outer wall under the influence of centrifugal force. Thus, there is no air gap between the inner wall 16' and the plasma layer 23, which eliminates irradiation losses due to the passage of light through the air gap and reflective losses at the surface of the plasma layer. As the separation/irradiation chamber of FIGURE 8 is slowed down after the separation and irradiation procedure, the inner wall of the chamber is again washed by the angular deceleration of the plasma layer as the separation/irradiation chamber comes to a stop.

Claims

1. Apparatus for separating and irradiating blood comprising:

a housing (1);

a rotatable member (19; 70) located within said housing (1);

a disposable separation/irradiation chamber (14; 29, 40) adapted to be mounted in said rotatable member (19; 70) and including a vertical cylindrical outer compartment (62; 29) in fluid communication with an inner compartment extending between said outer compartment (62; 29) and the center of said chamber (14; 29, 40), and a first passageway (13) accessing said inner compartment; and

a dynamic seal (60) having a rotatable member (6) and a stationary member (7), said rotatable member (6) being connected to said inner compartment of said chamber (14; 29, 40), and said first passageway (13) passing through said dynamic seal (60); and characterised by

a source (2, 21; 47) of radiant energy of a given wavelength connected to said housing (1) and located radially within said separation/irradiation chamber (14; 29, 40) so as to oppose the inner wall (16; 51) of said outer compartment (62; 29), wherein said inner wall (16; 51) of said outer compartment (62; 29) is transmissive of radiant energy of said given wavelength.

2. The apparatus of claim 1, wherein said inner compartment of said separation/irradiation chamber (14) extends inwardly from the bottom of said outer compartment and said first passageway (13) is connected at the center of said inner compartment.

3. The apparatus of claim 2, wherein said separation/irradiation chamber (14) further includes a central compartment extending upward and in fluid communication with said inner compartment, said dynamic seal (60) is connected to said central compartment, and said source (2, 21) of radiant energy is located between said central compartment and said inner wall (16) of said outer compartment (62).

4. The apparatus of claim 3, wherein said first passageway (13) extends through said central compartment to a point near the bottom of said inner compartment.

5. The apparatus of claim 4, further comprising a second passageway (11) accessing said separation/irradiation chamber (14) and extending through said dynamic seal (60) for the passage of air out of said separation/irradiation chamber (14).

6. The apparatus of claim 5, wherein said first (13) and second (11) passageways pass concentrically through said dynamic seal (60).

7. The apparatus of claim 2, wherein said separation/irradiation chamber (14) further includes a

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propylene, polyethylene, ethylvinyl acetate, polyvinylchloride, and acrylic materials.

A further embodiment of a separation/irradiation chamber 14' suitable for use in the device of FIGURE 1 is shown in FIGURE 8. It has been found that occasional bubbling of the whole blood can cause small deposits of red blood cells to strike and adhere to the inner wall 16 of the separation/irradiation chamber 14 of FIGURE 1. These small deposits of red cells can retard the transmission of light from the bulbs 2 to the separated buffy coat layer 24. The separation/irradiation chamber 14' of FIGURE 8 alleviates this condition by providing a volume between the chamber walls which is substantially entirely filled with a predetermined volume of blood. The separation/irradiation chamber 14' of FIGURE 8 is approximately 4 inches in height and has a controlled spacing between the inner wall 16' and the outer wall 17' which can be filled as shown in FIGURE 8 by 250 ml. of blood. The space between the walls at the top of the chamber is approximately 2 mm, and at the center of the wall height the space is approximately 6 mm wide. This spacing is achieved by employing a vertical outer wall 17' and an inwardly tapering inner wall 16', which tapers away from the outer wall at an angle of approximately 2°-3°. The angular taper allows air in the chamber to be replaced by blood by migrating down the inner tapered wall and to the center of the chamber, where it is vented out through the shaft 9 and the air outlet port 11. As the separating blood fills the volume of the separation/irradiation chamber 14', the plasma layer will continually wash the inner wall 16', causing any red blood cells at the inner wall surface to detach and migrate to the outer wall under the influence of centrifugal force. Thus, there is no air gap between the inner wall 16' and the plasma layer 23, which eliminates irradiation losses due to the passage of light through the air gap and reflective losses at the surface of the plasma layer. As the separation/irradiation chamber of FIGURE 8 is slowed down after the separation and irradiation procedure, the inner wall of the chamber is again washed by the angular deceleration of the plasma layer as the separation/irradiation chamber comes to a stop.

Claims

1. Apparatus for separating and irradiating blood comprising:

a housing (1);

a rotatable member (19; 70) located within said housing (1);

a disposable separation/irradiation chamber (14; 29, 40) adapted to be mounted in said rotatable member (19; 70) and including a vertical cylindrical outer compartment (62; 29) in fluid communication with an inner compartment extending between said outer compartment (62; 29) and the center of said chamber (14; 29, 40), and a first passageway (13) accessing said inner compartment; and

a dynamic seal (60) having a rotatable member (6) and a stationary member (7), said rotatable member (6) being connected to said inner compartment of said chamber (14; 29, 40), and said first passageway (13) passing through said dynamic seal (60); and characterised by

a source (2, 21; 47) of radiant energy of a given wavelength connected to said housing (1) and located radially within said separation/irradiation chamber (14; 29, 40) so as to oppose the inner wall (16; 51) of said outer compartment (62; 29), wherein said inner wall (16; 51) of said outer compartment (62; 29) is transmissive of radiant energy of said given wavelength.

2. The apparatus of claim 1, wherein said inner compartment of said separation/irradiation chamber (14) extends inwardly from the bottom of said outer compartment and said first passageway (13) is connected at the center of said inner compartment.

3. The apparatus of claim 2, wherein said separation/irradiation chamber (14) further includes a central compartment extending upward and in fluid communication with said inner compartment, said dynamic seal (60) is connected to said central compartment, and said source (2, 21) of radiant energy is located between said central compartment and said inner wall (16) of said outer compartment (62).

4. The apparatus of claim 3, wherein said first passageway (13) extends through said central compartment to a point near the bottom of said inner compartment.

5. The apparatus of claim 4, further comprising a second passageway (11) accessing said separation/irradiation chamber (14) and extending through said dynamic seal (60) for the passage of air out of said separation/irradiation chamber (14).

6. The apparatus of claim 5, wherein said first (13) and second (11) passageways pass concentrically through said dynamic seal (60).

7. The apparatus of claim 2, wherein said separation/irradiation chamber (14) further includes a

radial step (27) located at the lower junction of said inner and outer compartment surfaces.

8. The apparatus of claim 2, wherein said inner compartment includes a bottom floor (26) which is sloped toward the center of said chamber.

9. The apparatus of claim 8, wherein said inner compartment further includes a collection well (15) located at the center of said floor (26), said collection well (15) being accessed by said first passageway (13).

10. The apparatus of claim 2, wherein said radiant energy source (21) comprises a plurality of circular shaped bulbs (21) arranged in a vertical pattern in opposition to the inner wall (16) of said outer compartment (62).

11. The apparatus of claim 1, wherein said inner compartment comprises:

a fluid entry compartment (40) attached to said rotatable member (6); and

conduit means (32) for fluidly connecting said fluid entry compartment (40) and said outer compartment (29).

12. The apparatus of claim 11, wherein said outer compartment (29) is collapsible.

13. The apparatus of claim 11, wherein said fluid entry compartment (40) is located at the top of said separation/irradiation chamber (29, 40).

14. The apparatus of claim 13, wherein said conduit means (32) is connected between said fluid entry compartment (40) and a point (42) near the bottom of said outer compartment (29).

15. The apparatus of claim 12, further comprising a rigid cylindrical member (41) adapted to be mounted inside said rotatable member (70) to retain said collapsible outer compartment (29) between said rotatable member (70) and said rigid cylindrical member (41).

16. The apparatus of claim 5 or 11, wherein said housing (1) includes an aperture passing therethrough, and further including:

means (31) for attaching said first passageway (13) and said stationary member (7) of said dynamic seal (60) to said housing (1), whereby said passageway (13) passes through said aperture.

17. The apparatus of claim 16, wherein said housing (1) includes a housing cover (3) containing said aperture and means (31) for detachably affixing said passageway (13) in said aperture.

18. The apparatus of claim 3 or 17, further including a shield (21; 48) attached to said housing (1) which is transmissive of radiant energy at said given wavelength and is located between said source (2, 21; 47) and said outer compartment (62; 29)

19. The apparatus of claim 2 or 18, wherein said radiant energy source (2; 47) comprises a plurality of U-shaped bulbs (2; 47) arranged in a circular pattern in opposition to the inner wall (16; 51) of said outer compartment (62; 29).

20. Apparatus according to claim 12, wherein said separation/irradiation chamber (40, 29) comprises first (51) and second (53) flexible sheets, at least one (51) of which is transparent to said radiant energy, said sheets (51, 53) being bonded together to form an interior compartment (29), said interior compartment (29) being connected to said first passageway (13), and including means for mounting said compartment-forming sheets (51, 53) within said rotatable member (70) with said transparent sheet (51) opposing said energy source.

21. Apparatus according to claim 12, wherein said separation/irradiation chamber (40, 29) comprises:

a rigid outer cylindrical member (46); and

a sheet of flexible material (51) which is transparent to said radiant energy, said sheet being peripherally bonded inside said outer cylindrical member (46) to form a compartment (29) with a flexible inner wall.

22. The apparatus of claim 20 or 21, further including a rigid cylindrical member (41) mounted within said rotatable member (70) for retaining said separation/irradiation chamber (40, 29) between said rotatable member (70) and said rigid cylindrical member (41), wherein said rigid cylindrical member (41) is transmissive of said radiant energy.

23. The apparatus of claim 20 or 22, including a fluid entry passageway (32) connected near the bottom of said compartment (29).

24. The apparatus of claim 23, wherein said passageway (32) accesses said compartment (29) through said outer cylindrical member (46).

25. The apparatus of claim 22, comprising a plurality of pins (45) located about the periphery of said rotatable member (70), a plurality of holes located about the periphery of said interior compartment (29) which align with said pins, and wherein said rigid cylindrical member (41) includes a plurality of holes located about its periphery which align with said pins.

- Patentansprüche

1. Vorrichtung zur Trennung und Bestrahlung von Blut aufweisend:
ein Gehäuse (1);
ein drehbares Teil (19; 70), das im Gehäuse (1) angeordnet ist;
eine disponible Trennungs/Bestrahlungs-Kammer (14; 29, 40), die so gestaltet ist, daß sie im drehbaren Teil (19, 70) befestigbar ist, und ein vertikales, zylindrisches Außenabteil (62, 29) in Fluidverbindung mit einem Innenabteil aufweist, das sich zwischen dem Außenabteil (62; 29) und dem Zentrum der Kammer (14; 29, 40) erstreckt, und einen ersten Durchgang (13), der in das Innenabteil eintritt; und
eine dynamische Dichtung (60) mit einem drehbaren Teil (6) und einem stationären Teil (7), wobei das drehbare Teil (6) mit dem Innenabteil der Kammer (14; 29, 40) verbunden ist, und der erste Durchgang (13) durch die dynamische Dichtung (60) hindurchführt; und gekennzeichnet durch
eine Strahlungsenergiequelle (2, 21; 47) mit einer gegebenen Wellenlänge, die mit dem Gehäuse (1) verbunden ist, und radial innerhalb der Trennungs/Bestrahlungs-Kammer (14; 29, 40) angeordnet ist, um der Innenwand (15; 51) des Außenabteils (62; 29) gegenüberzuliegen, wobei die Innenwand (16; 51) des Außenabteils (62; 29) durchlässig für eine Strahlungsenergie der gegebenen Wellenlänge ist.

2. Vorrichtung nach Anspruch 1, bei der das Innenabteil der Trennungs/Bestrahlungs-Kammer (14) sich vom Boden des Außenabteils nach innen erstreckt, und der erste Durchgang (13) im Zentrum des Innenabteils angeschlossen ist.

3. Vorrichtung nach Anspruch 2, bei der die Trennungs/Bestrahlungs-Kammer (14) weiterhin aufweist ein zentrales Abteil, das sich nach oben erstreckt und in Fluidverbindung mit dem Innenabteil ist, wobei die dynamische Dichtung (60) mit dem zentralen Abteil verbunden ist, und die Strahlungsenergiequelle (2, 21) zwischen dem zentralen Abteil und der Innenwand (16) des Außenabteils (62) angeordnet ist.

4. Vorrichtung nach Anspruch 3, bei der der erste Durchgang (13) sich durch das zentrale Abteil bis zu einer Stelle nahe dem Boden des Innenabteils erstreckt.

5. Vorrichtung nach Anspruch 4, weiterhin aufweisend einen zweiten Durchgang (11), der in die Trennungs/Bestrahlungs-Kammer (14) eintritt und sich durch die dynamische Dichtung (60) für den Durchgang von Luft aus der Trennungs/Bestrahlungs-Kammer (14) heraus erstreckt.

6. Vorrichtung nach Anspruch 5, bei der der erste Durchgang (13) und der zweite Durchgang (11) konzentrisch durch die dynamische Dichtung (60) hindurchführen.

7. Vorrichtung nach Anspruch 2, bei der die Trennungs/Bestrahlungs-Kammer (14) weiterhin aufweist eine radiale Stufe (27), die bei der unteren Verbindung der Oberflächen des Innenabteils und des Außenabteils angeordnet ist.

8. Vorrichtung nach Anspruch 2, bei der das Innenabteil einen Bodengrund (26) aufweist, der zum Zentrum der Kammer hin abfällt.

9. Vorrichtung nach Anspruch 8, bei der das Innenabteil weiterhin aufweist einen Sammelschacht (15), der im Zentrum des Bodens (26) angeordnet ist, wobei der Sammelschacht (15) über den ersten Durchgang (13) zugänglich ist.

10. Vorrichtung nach Anspruch 2, bei der die Strahlungsenergiequelle (21) eine Vielzahl von kreisförmigen Küvetten (2) aufweist, die in einem vertikalen Muster gegenüberliegend der Innenwand (16) des Außenabteils (62) angeordnet sind.

11. Vorrichtung nach Anspruch 1, bei der das Innenabteil aufweist:
ein Fluideintrittsabteil (40), das am drehbaren Teil (6) befestigt ist; und
eine Kanaleinrichtung (32) zur Fluidverbindung des Fluideintrittsabteils (40) und des Außenabteils (29).

12. Vorrichtung nach Anspruch 11, bei der das Außenabteil (29) zusammendrückbar ist.

13. Vorrichtung nach Anspruch 11, bei der das Fluideintrittsabteil (40) am oberen Ende der Trennungs/Bestrahlungs-Kammer (29, 40) angeordnet ist.

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14. Vorrichtung nach Anspruch 13, bei der die Kanaleinrichtung (32) zwischen dem Fluideintrittsabteil (40) und einer Stelle (42) nahe dem Boden des Außenabteils (29) angeschlossen ist.

15. Vorrichtung nach Anspruch 12, weiterhin aufweisend ein starres, zylindrisches Teil (41), das so gestaltet ist, daß es im Innern des drehbaren Teils (70) befestigt werden kann, um das zusammendrückbare Außenabteil (29) zwischen dem drehbaren Teil (70) und dem starren, zylindrischen Teil (41) zurückzuhalten.

16. Vorrichtung nach Anspruch 5 oder 11, bei der das Gehäuse (1) eine Öffnung aufweist, die dahindurchgeht, und weiterhin aufweist:
eine Einrichtung (31) zur Befestigung des ersten Durchgangs (13) und des stationären Teils (7) der dynamischen Dichtung (60) am Gehäuse (1), wobei der Durchgang (13) durch die Öffnung hindurchführt.

17. Vorrichtung nach Anspruch 16, bei der das Gehäuse (1) einen Gehäusedeckel (3) aufweist, der die Öffnung und die Einrichtung (31) zur lösbaren Befestigung des Durchgangs (13) in der Öffnung aufweist.

18. Vorrichtung nach Anspruch 3 oder 17, weiterhin aufweisend eine Abschirmung (21; 48), die am Gehäuse (1) befestigt ist, welche für Strahlungsenergie mit der gegebenen Wellenlänge durchlässig ist, und zwischen der Quelle (2, 21; 47) und dem Außenabteil (62; 29) angeordnet ist.

19. Vorrichtung nach Anspruch 2 oder 18, bei der die Strahlungsenergiequelle (2, 47) eine Vielzahl von U-förmigen Küvetten (2, 47) umfaßt, die in einem kreisförmigen Muster gegenüberliegend der Innenwand (16; 51) des Außenabteils (62; 29) angeordnet sind.

20. Vorrichtung nach Anspruch 12, bei der die Trennungs/Bestrahlungs-Kammer (40, 29) eine erste (51) und eine zweite (53) flexible Lage umfaßt, von denen zumindest eine (51) transparent für die Strahlungsenergie ist, wobei die Lagen (51, 53) miteinander verbunden sind, um ein inneres Abteil (29) zu bilden, wobei das innere Abteil (29) mit dem ersten Durchgang (13) verbunden ist, und eine Einrichtung zur Befestigung der Abteilbildungs-Lagen (51, 53) innerhalb des drehbaren Teils (70) aufweist, wobei die transparente Lage (51) der Energiequelle gegenüberliegt.

21. Vorrichtung nach Anspruch 12, bei der die Trennungs/Bestrahlungs-Kammer (40, 29) aufweist:
ein starres Außenzylinderteil (46); und
eine flexible Materiallage (51), die für die Strahlungsenergie transparent ist, wobei die Lage peripher innerhalb des Außenzylinderteils (46) verbunden ist, um ein Abteil (29) mit einer flexiblen Innenwand zu bilden.

22. Vorrichtung nach Anspruch 20 oder 21, weiterhin umfassend ein starres, zylindrisches Teil (41), das innerhalb des drehbaren Teils (70) befestigt ist zum Zurückhalten der Trennungs/Bestrahlungs-Kammer (40, 29) zwischen dem drehbaren Teil (70) und dem starren, zylindrischen Teil (41), bei der das starre, zylindrische Teil (41) für die Strahlungsenergie durchlässig ist.

23. Vorrichtung nach Anspruch 20 oder 22, aufweisend einen Fluideintrittsdurchgang (32), der nahe dem Boden des Abteils (29) angeschlossen ist.

24. Vorrichtung nach Anspruch 23, bei der der Durchgang (32) in das Abteil (29) durch das äußere, zylindrische Teil (46) eintritt.

25. Vorrichtung nach Anspruch 22, aufweisend eine Vielzahl von Stiften (45), die um die Peripherie des drehbaren Teils (70) herum angeordnet sind, eine Vielzahl von Löchern, die um die Peripherie des Innenabteils (29) angeordnet sind, welche mit den Stiften ausgerichtet sind, und bei der das starre, zylindrische Teil (41) eine Vielzahl von Löchern aufweist, die um seine Perpherie herum angeordnet sind, welche mit den Stiften ausgerichtet sind.

Revendications

1. Appareil de séparation et d'irradiation du sang, comprenant :
un carter (1);
un organe rotatif (19; 70), monté à l'intérieur dudit carter (1);
une chambre de séparation/irradiation (14; 29, 40) jetable, adaptée pour être montée dans ledit organe rotatif (19; 70) et comprenant un compartiment extérieur (62; 29) cylindrique vertical, en communication hydraulique avec un compartiment intérieur s'étendant entre ledit compartiment extérieur (62; 29) et le centre de ladite chambre (14; 29, 40), et une première voie de massage (13) permettant l'accès audit compartiment intérieur; et
un joint d'étanchéité dynamique (60) équi-

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pé d'un organe rotatif (6) et d'un organe stationnaire (7), ledit organe rotatif (6) étant relié audit compartiment intérieur de ladite chambre (14; 29, 40), et ladite première voie de passage (13) passant à travers ledit joint d'étanchéité dynamique (60); et caractérisé par

une source d'énergie radiante (2, 21; 47) à longueur d'onde déterminée, reliée audit carter (1) et placée radialement à l'intérieur de ladite chambre de séparation/irradiation (14; 29, 40), de manière à être à l'opposé de la paroi intérieure (16; 51) dudit compartiment extérieur (62; 29), appareil dans lequel ladite paroi intérieure (16; 51) dudit compartiment extérieur (62; 29) est susceptible de transmettre de l'énergie radiante d'une longueur d'onde prédéterminée.

2. Appareil selon la revendication 1, dans lequel ledit compartiment intérieur de ladite chambre de séparation/irradiation s'étend vers l'intérieur, en partant du fond dudit compartiment extérieur et ladite première voie de passage (13) étant reliée au centre dudit compartiment intérieur.

3. Appareil selon la revendication 2, dans lequel ladite chambre de séparation/irradiation (14) comprend en outre un compartiment central s'étendant vers le haut et en communication hydraulique avec ledit compartiment intérieur, ledit joint d'étanchéité dynamique (60) étant relié audit compartiment central, et ladite source d'énergie radiante (2, 21) étant située entre ledit compartiment central et ladite paroi intérieure (16) dudit compartiment (62).

4. Appareil selon la revendication 3, dans lequel ladite première voie de passage (13) s'étend à travers ledit compartiment central, vers un point proche du fond dudit compartiment intérieur.

5. Appareil selon la revendication 4, comprenant en outre une seconde voie de passage (11), donnant accès à ladite chambre de séparation/irradiation (14) et s'étendant à travers ledit joint d'étanchéité dynamique (60), pour donner passage à l'air s'échappant de ladite chambre de séparation/irradiation (14).

6. Appareil selon la revendication 5, dans lequel lesdites première (13) et deuxième (11) voies de passage passent concentriquement à travers ledit joint d'étanchéité dynamique (60).

7. Appareil selon la revendication 2, dans lequel ladite chambre de séparation/irradiation (14) comprend en outre un étagement radial (27), situé à la jonction inférieure entre les surfaces desdits compartiments intérieur et extérieur.

8. Appareil selon la revendication 2, dans lequel ledit compartiment intérieur comprend un sol de fond (26), incliné en descendant en direction du centre de ladite chambre.

9. Appareil selon la revendication 8, dans lequel ledit compartiment intérieur comprend en outre un puits collecteur (15), situé au centre dedit sol (26), ledit puits collecteur (15) étant accessible à l'aide de ladite première voie de passage (13).

10. Appareil selon la revendication 2, dans lequel ladite source d'énergie radiante (21) comprend une pluralité de bulbes (21) de forme circulaire, disposés suivant un motif vertical, en opposition à la paroi intérieure (16) dudit compartiment extérieur (62).

11. Appareil selon la revendication 1, dans lequel ledit compartiment intérieur comprend :

un compartiment d'entrée de fluide (40), fixé audit organe rotatif (6); et

un moyen de conduite (32) , pour assurer une liaison hydraulique entre ledit compartiment d'entrée de fluide (40) et ledit compartiment extérieur (29).

12. Appareil selon la revendication 11, dans lequel ledit compartiment extérieur (29) est rétrécissable.

13. Appareil selon la revendication 11, dans lequel ledit compartiment d'entrée de fluide (40) est situé en partie haute de ladite chambre de séparation/irradiation (29, 40).

14. Appareil selon la revendication 13, dans lequel ledit moyen de conduite (32) est raccordé entre ledit compartiment d'entrée de fluide (40) et un point (52) situé près du fond dudit compartiment extérieur (29).

15. Appareil selon la revendication 12, comprenant en outre un organe cylindrique (41) rigide, adapté pour être monté à l'intérieur dudit organe rotatif (70), en vue de retenir ledit compartiment extérieur (29) rétrécissable entre ledit organe rotatif (70) et ledit organe cylindrique (41) rigide.

16. Appareil selon la revendication 5 ou 11, dans lequel ledit carter (1) comprend une ouverture le traversant, et comprenant en outre :

un moyen (31) pour fixer ladite première voie de passage (13) et ledit organe stationnaire (7) dudit joint d'étanchéité (60) dynamique audit carter (1), de manière à faire passer ladite voie de passage (13) à travers ladite ouverture.

17. Appareil selon la revendication 16, dans lequel ledit carter (1) comprend un couvercle de carter (3), contenant ladite ouverture et le moyen (31) destiné à fixer amovible ladite voie de passage (13) dans ladite ouverture.

18. Appareil selon la revendication 3 ou 17, comprenant en outre un écran (21;48) fixé audit carter (1), qui transmet de l'énergie radiante à ladite longueur d'onde déterminée et qui est situé entre ladite source (2, 21 ; 47) et ledit compartiment extérieur (62 ; 29).

19. Appareil selon la revendication 2 ou 18, dans lequel ladite source d'énergie radiante (2; 47) comprend une pluralité de bulbes (2; 47) en forme de U, disposés suivant un motif circulaire, en opposition à la paroi intérieure (16; 51) dudit compartiment extérieur (62; 29).

20. Appareil selon la revendication 12, dans lequel ladite chambre de séparation/irradiation (40, 29) comprend des première (51) et deuxième (53) feuilles flexibles, au moins l'une (51) d'entre elles étant transparente à ladite énergie radiante, lesdites feuilles (51, 53) étant liées l'une à l'autre pour former un compartiment intérieur (29), ledit compartiment intérieur (29) étant relié à ladite première voie de passage (13), et comprenant un moyen pour le montage desdites feuilles formant compartiment (51, 53) à l'intérieur dudit organe rotatif (70) , ladite feuille transparente (51) étant située à l'opposé de ladite source d'énergie.

21. Appareil selon la revendication 12, dans lequel ladite chambre de séparation/irradiation (40, 29) comprend :

un organe cylindrique extérieur (46) rigide; et

une feuille en matériau flexible (51), transparente a ladite énergie radiante, ladite feuille étant liée en périphérie à l'intérieur dudit organe cylindrique (46) extérieur, en vue de former un compartiment (29) ayant une paroi intérieure flexible.

22. Appareil selon la revendication 20 ou 21, comprenant en outre un organe cylindrique (41) rigide, monté à l'intérieur dudit organe rotatif (70), en vue de retenir ladite chambre de séparation/irradiation (40, 29) entre ledit organe rotatif (70) et ledit organe cylindrique (41) rigide, dans lequel ledit organe cylindrique (41) rigide est transparent à ladite énergie radiante.

23. Appareil selon la revendication 20 ou 22, comprenant une voie de passage d'entrée de fluide (32) raccordée près du fond dudit compartiment (29).

24. Appareil selon la revendication 23, dans lequel ladite voie de passage (32) donne accès audit compartiment (29), en passant à travers ledit organe cylindrique (46) extérieur.

25. Appareil selon la revendication 22, comprenant une pluralité de picots (45), placés autour de la périphérie dudit organe rotatif (70), une pluralité de trous, situés autour de la périphérie dudit compartiment intérieur (29), alignés par rapport auxdits picots, et dans lequel ledit organe cylindrique (41) rigide comprend une pluralité de trous situés autour de sa périphérie, alignés par rapport auxdits picots.