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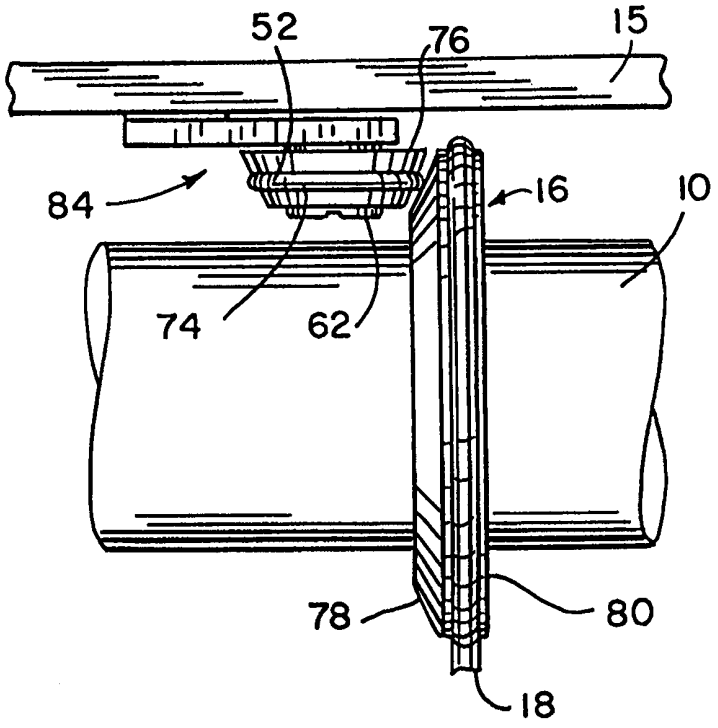
(54) Title: APPARATUS FOR SUPPORTING AND DRIVING A ROTATING CYLINDER

(57) Abstract

An irradiator includes a support structure (15) for supporting and rotating a cylinder (10) of the type used for treating fluids. The cylinder (10) is hollow and is mounted for rotation about an inclined axis for permitting fluids such as blood constituents to flow by gravity downward along the internal peripheral wall of the cylinder. The cylinder (10) is mounted on roller bearings (52) having a resilient bearing surface (74) for isolating potential external vibration. A removable resilient ring (74) is placed on the outer surface of the bearing to provide the isolating bearing surface. The resilient bearing configuration may also be used to support the cylinder on the selected angle of inclination.



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APPARATUS FOR SUPPORTING AND DRIVING A ROTATING CYLINDER

BACKGROUND OF INVENTION

Field of Invention

This invention is generally related to a rotating cylinder for treatment of materials and is specifically related to an apparatus for supporting and driving a rotating cylinder such as a cylindrical ultraviolet irradiator for the treatment of fluids.

Description of the Prior Art

It is well know to support a hollow cylinder with the axis inclined to permit a loose material or fluid to run through the cylinder along its inner peripheral wall while rotating the cylinder to spread the material over the inner surface in order to create a film. A known example of such an apparatus is an irradiator used for the ultraviolet treatment of blood. An example of a rotating cylindrical irradiator was manufactured by the J. J. Drill Company, Kalamazoo, Michigan in the 1950's. In the irradiator there described, blood components are introduced into the upper end of an inclined rotating cylinder and allowed to gravity feed along the inner wall of the cylinder as it is rotated in order to allow the blood to form a thin film on the inner wall as it flows toward the lower discharge end. As the blood moves through the cylinder, it is subjected to an axially mounted ultraviolet lamp for irradiating the fluid flowing through the cylinder.

It has been found that by controlling the exposure of blood constituents to ultraviolet light that various foreign microorganisms in the blood supply can be altered or immobilized. For example, various strains of virus can be inactivated and thereafter used to develop a vaccine which may be injected into the blood supply of an animal in order to create a natural immunity to the virus. Such a method has been used to create influenza and rabies vaccines for a number of years.

Currently, the most prevalent use of irradiators for ultraviolet treatment of blood components is for generating serums from the blood of mammals. In a typical example, mammal of human blood is removed from a subject and the platelets are then centrifuged out of the plasma. The remaining serum or basically non-solid clear component of the blood is irradiated to inactivate any virus that happens to be present. This will also typically kill or immobilize any other microorganisms that may happen to be present int he sample. If the plasma is further fractionated, that is, divided into different fractions, such as, by way of example, fibrinogen, different globulin, and literally hundreds of subcomponents which can be segregated by any of the well known methods of separating plasma, each of the fractions can then also be treated using the same irradiating method.

Prior to the development of a practical method for treating large quantities of blood through cylindrical irradiation, a small sample was placed on a flat plate, such as a specimen slide or a microscope slide, and then exposed to ultraviolet light, or a small portion was allowed to flow through a small diameter, clear quartz tube that had an ultraviolet light on the outside of that tube. This method has been successfully used in a laboratory environment for research screening to verify the response of the various fractions to specific exposures to ultraviolet light.

Prior to the nineteen fifties, and prior to the development of the early mass quantity irradiator, it was impractical to treat blood through irradiation even though many of the benefits were well documented. During World War II, transfusions of blood plasma became commonplace. It was at this time that it became clear through the large scale of available documentation that transfusion of plasma from one person to another caused the spread of certain viral diseases among patients drawing from a common pooled blood plasma source. At this time, it became apparent that large scale irradiation to kill or immobilize these various microorganisms was essential to creating a safe blood plasma supply, with the irradiator as disclosed in the aforementioned patent being the first successful system for irradiating blood plasma on a commercial scale. This was a successful effort greatly increasing the availability of safe blood plasma supplies in the nineteen fifties.

Unfortunately, during the Korean war it appeared that the irradiation treatment was not successful for killing or immobilizing various strains of hepatitis and by 1960 commercial irradiation for human blood plasma pools basically ceased. In 1964, the World Health Organization published a statement that all pooled plasma from blood banks, plasma banks, and producers of plasma, could not be distributed for human transfusion. The commercial use of irradiators diminished to near zero. While certain applications remained viable, particularly for bovine blood plasma, the extremely reduced demand for commercial irradiators resulted in halting the continuing development of the technology.

More recently, irradiation has been found to be particularly successful in the inactivation of rabies virus for the manufacture of rabies vaccine. Of the less than 25 known commercial irradiators still in existence in the world the vast majority are used for producing rabies vaccine. On a lesser scale, the irradiators are also effective against and used for influenza virus, and at least one company in Italy and one in Japan, use the irradiator of the aforementioned reference to manufacture influenza vaccine.

Over the last several years, it has been determined that blood fractions irradiation may be a valuable treatment for immobilizing certain viruses and potentially placing the patient so infected in long term remission.

With the renewed interests in ultraviolet treatment of blood constituents, there is a pressing need for an improved, high volume irradiator apparatus. Moreover, the currently available technology, while very successful for its intended purpose over thirty-five years ago, relied very heavily on trial and error and the steady monitoring by experienced technicians. There remains a need for a commercial irradiator which is reliable independently of the high level of skill generally required with past machinery in order to assure that the promising new irradiation treatments can be duplicated on a commercial level.

SUMMARY OF THE INVENTION

The subject invention is directed to a device for supporting and rotating a cylinder of the type used for treating fluids. In the preferred embodiment, the cylinder is hollow and is mounted for rotation about an inclined axis for permitting fluids such as blood constituents

to flow by gravity downward along the internal peripheral wall of the cylinder. It is an important aspect of the invention that the angle of inclination, the drive speed and the thickness of the fluid film on the wall of the cylinder are controlled and variable in order to achieve consistent and predictable results during various treatment processes. The various monitoring features are very critical in controlling the precise exposure of the fluid to the lamp. A matrix made up of input fluid flow rate, lamp intensity, film thickness, rotational speed and inclination angle determines the actual exposure process. Accurate information of all variables is essential to a reliable and predictable process.

It is another important feature of the invention that both the drive system and the mounting system are designed to isolate the cylinder from external vibrations and to minimize non-uniformity of the fluid film. In the preferred embodiment of the invention, integral monitoring systems are provided for monitoring and controlling the inclination angle and the rotational speed of the cylinder as well as for monitoring the thickness of the fluid film in order to assure uniform exposure to the light source. A sensor may also be provided to monitor the intensity of the light source.

In one embodiment of the invention, the cylinder is mounted on roller bearings having a resilient bearing surface for isolating potential external vibration. In the preferred form, a removable resilient ring is placed on the outer surface of the bearing rolling to provide the isolating surface. The resilient roller bearing configuration may also be used to support the cylinder on the selected angle of inclination. To further isolate the cylinder against vibration, the drive mechanism is mounted on a floating mount with a resilient, sound deadening drive o-ring extending around the outer perimeter of the cylinder.

The base is mounted on unique levelers permitting independent leveling of each of the three or four legs without a tendency of the structure to walk. This is accomplished by utilizing a unique leveling leg assembly having an internal shaft with an outer spin ring. The spin ring is axially adjustable against a stop provided on the base for permitting the base to move relative to the shaft reducing any tendency of the leg to walk by maintaining it stationary against the support surface.

The lamp mounting system has also been modified from prior art models to provide more accurate placement of the lamp along the axis of the cylinder while at the same time providing means for isolating the lamp assembly from the interior of the cylinder. A unique collection cup is provided at the discharge end of the cylinder for receiving the discharged, treated fluid and the collection cup is designed to receive the sea one end of the lamp assembly. In the preferred embodiment of the invention, the collection cup is mounted in a stationary position in axial alignment with the discharge end of the cylinder. The collection cup comprises an outer cylindrical sleeve with a diametric base. An inner sleeve is provided along the axis and passes through the base for added strength. The collection cup sits in a C-shaped bracket mounted on the cylinder support plate and adapted to swing radially to remove the cup from the assembly for maintenance. The C-clamp is designed to substantially surround and engage the extended inner sleeve of the cup to hold it in axial position relative to the cylinder. The lamp supports assembly includes a tapered mounting cap which is adapted to be received in the inner open end of the inner cup sleeve. The taper on the mounting cap permits the lamp assembly to be self seating.

While in the preferred embodiment the cylinder is fully supported by the resilient bearing surfaces, inlet and discharge end caps are provided to isolate the interior of the cylinder and to provide mounting surfaces for supporting the collection cup, the lamp assembly and fluid input conduits. In the preferred embodiment, the open end of the collection cup is received in an annular channel of the discharge end cap and a resilient seal may be provided to seal the end cap. Where desired, a fluid or non-contact seal may be provided between both end caps to hermetically seal the interior of the cylinder. A sensor may be positioned on the inlet end cap to monitor the intensity of the lamp.

Where desired, the base of the support structure may be provided with a splash guard to assure that any spillage is not introduced into the interior of the structure, greatly reducing maintenance and clean up in the event of an accidental spill. Also, the control unit is positioned at a remote location, assuring that the cylinder assembly is isolated to the fullest extent possible. The lamp assembly includes an outer sleeve for completely isolating the

lamp from the interior of the cylinder, again facilitating cleanup in the event a shut down results in fluid dripping from the inner cylinder wall onto the axially positioned lamp.

In an alternative embodiment, various other lamp sources may be substituted for providing other types of treatment procedures. For example, a laser lamp may be utilized in the assembly with a minimum of structural modification.

Typically, a stainless steel cylinder is used. However, other materials may be substituted. For example, a quartz cylinder may be used and since quartz transmits ultraviolet light, this permits placement of the light source outside of the cylinder. Also, the use of a quartz cylinder permits the placement of a sensor in the cylinder wall to precisely monitor the thickness of the film in combination with the light intensity.

The inlet tube conduit includes a unique tube pincher to assure prompt stoppage of flow in the event of a shut down due to power failure. The system is designed to be fail safe and is a particularly important feature when the cost of blood specimens is considered. Power is required to permit fluid flow and any loss of power automatically shuts down the flow through the conduit.

The subject invention provides an improved cylinder fluid treatment device that is reliable, substantially fail safe and provides accurate and predictable results. It is particularly useful in the irradiation treatment of blood constituents but is readily adaptable to other rotating cylinder treatment procedures.

In one method of treatment in accordance with the teachings of the subject invention, it has been found that irradiation therapy is successful in impeding the progression of the AIDS virus, potentially placing HIV-positive subjects in long term remission. In experimental tests, it has been found that a psoralen derivative drug attaches itself to white blood cells that have been identified as HIV receptors. By ingesting the psoralen drug, which has a natural biochemical dye, the specific HIV-recepitve platelets can be identified. Thereafter, a specimen of the treated blood is removed from the body and fractionated in the normal manner. The plasma and white blood cells are then treated by irradiation and exposed to ultraviolet light. With proper exposure, psoralen dye absorbs the ultraviolet light without damaging or altering the unaffected cells. This damages or alters the HIV-receptor

cells without altering the remainder of the blood supply. The blood fractions are then recombined and replaced in the subject's blood supply. Experimental results have indicated that as the blood comes back into the subject's blood stream, the body recognizes that there is a foreign substance, which is the altered receptor cells, and develops an antibody is active against all HIV receptor-type cells, not just the specimens which have been altered by ultraviolet treatment. Basically, the end result is that the antibody starts destroying all the receptor white blood cells to which the HIV virus would attach. These blood cells are rendered immobile and it appears the HIV virus cannot multiply without the presence of viable receptor cells. While this does not eliminate the presence of the HIV virus in the subject, it shows promising indications of an ability to place the subject in long term remission. Further, it appears that upon recurrence of the receptor cells in the body, the process can be repeated with similar results. While experiments have been promising, at the present time the various potential side effects have not been determined and large scale clinical testing will be necessary. Similar tests are underway for treatment of certain cancers and various other blood related diseases.

The various features and aspects of the invention are more clearly described in the accompanying drawings and detailed description of the preferred embodiments which follow.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view of the irradiator assembly of the subject invention.

Fig. 2 is a fragmentary cross-sectional view along the axis of the cylinder, showing the detail of the assembly of Fig. 1.

Fig. 3 is a cross-sectional view taken along the line of 3-3 of Fig. 2 and through the axis of the cylinder, showing the bearing mounting supports for supporting the cylinder for rotation.

Fig. 4 is a cross-sectional view taken generally along the line 4-4 of Fig. 3.

Fig. 5 is a view looking generally along the line 5-5 of Fig. 2.

Fig. 6 is a view looking generally along the line 6-6 of Fig. 2.

Fig. 7 is a cross-sectional view taken generally along the line 7-7 of Fig. 3.

Fig. 8 is a cross-sectional view looking generally along the line 8-8 of Fig. 3, and diagonally showing the location and detail of the sensors and the tube pincher of the irradiator of Fig. 1.

Fig 8a is a cross-sectional view of the sensor assembly.

Fig. 9 is a detailed top view of the tube pincher with the cover removed in the shut-down mode.

Fig. 10 is a side view of the tube pincher shown in Fig. 9, with the cover removed.

Fig. 11 is an enlarged view, partially in section, showing the leveler assembly of the subject invention.

Fig. 12 is a perspective view of an alternative embodiment of the lamp assembly.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

As best shown in Figs. 1 and 2, the irradiator of the preferred embodiment consists of an inclined cylinder 10 mounted for rotation on a pair of support members or brackets 12 or 14, which are mounted on and extended outwardly from a support plate 15. The support plate 14 is mounted on a support column 17, and may be indexed relative thereto to change the angle of inclination of the support plate and the rotating cylinder 10. A drive ring 16 circumscribes the cylinder 10, and a drive belt 18 is in position in the drive channel in the ring

16. The drive belt is driven by a motor 20 to rotate the cylinder about its axis and relative to the support brackets 12 and 14. Bearings 22, 23, 24 and 25 (see Fig. 2) are provided in the brackets 12 and 14, respectively, for supporting the cylinder to permit it to rotate freely in response to the motor 20.

In the preferred embodiment, the support column 17 is secured to a base 27, which includes a plurality of leveler legs 29, whereby the entire assembly may be leveled for proper orientation. The leveler legs of the preferred embodiment are better illustrated in Fig. 10 and are described in detail herein. A remote power supply/control panel assembly 31 is cabled to the irradiator unit via cable 33, for supplying power to the unit and for monitoring the various parameters controlling the process.

The irradiator is used to expose selected constituents of human blood to various stimuli such as ultraviolet light, laser treatment, or the like. To that end, a supply tube 26 is provided at the upper end plate 33 of the support plate 15, and is attached to a supply of blood. The blood flows through the tube 26 and is introduced onto the interior peripheral surface 11 (Fig. 3) of the cylinder 10. As the cylinder slowly rotates, the blood forms a liquid film over the entire surface of the cylinder.

In the preferred embodiment, and as better seen in Figs. 2 and 3, ultraviolet lamp assembling 28 is positioned along the axis of the cylinder and is operable to expose the blood in the cylinder to ultraviolet rays for treatment purposes.

The blood is released into a collection cup 30 at the opposite end of the cylinder and is released through an exit nipple 32 at orifice 37. In the preferred embodiment, the collection cup 30 has an open mouth 39 (Fig. 2) which is received in a recessed channel 34 provided in the lower end plate 35 attached to the support plate 15. The recessed channel 34 forms an annulus around the through hole 38. The lower or exit end 36 of the cylinder 10 passes through the through hole 38 and into the open mouth of the cup, but does not come in contact with the cup at any point.

The lamp assembly 28 is supported by the upper end plate 33 attached to the main support plate 15 and by the collection cup which is mounted in the recess in the lower end plate 35. While the lamp extends the length of the cylinder, it is not in contact with it at any point, and the cylinder is free to rotate relative to the lamp.

In the preferred embodiment, the lower end 40 of the ultraviolet lamp assembly is axially supported by a reduced cylindrical member 41 of the collection cup 30 (see Figs. 2 and 7). As best seen in Fig. 2, the cup 30 is preferably a glass cup with an open mouth 39 and a closed bottom 44. The reduced cylindrical portion 41 extends outwardly from the bottom 44 and has a hollow cylindrical interior which is large enough to accommodate the outer perimeter of the lamp 28. In the preferred embodiment a mounting block 43, with a tapered bore or receptive socket 45 is positioned in the closed end 46 of the reduced collection cup. The conically tapered lower end cap 40 of the lamp assembly is received in the bore or socket, whereby the lamp is self-centering in the collection cup assembly.

In the preferred embodiment of the invention, the support plate 15, and thus the cylinder, lamp and collection cup assembly, may be tilted relative to the column 17 to alter the inclined angle of the cylinder and thereby control the rate of gravity feed of the blood film along the cylinder, controlling the time duration of exposure to the lamp. The thickness of the film is controlled by the rotational speed of the cylinder as driven by the motor 20. The control module 31 includes a face control panel 49 for controlling the various parameters of the entire system.

In the preferred embodiment of the invention the control module 31 is remote from the base 27 and the irradiator assembly. This permits the irradiator to be completely isolated from human contact during operation.

The drive ring 16, supports bearings 22, 23, 24, and 25 and the drive bearing 52 (Figs. 2 and 5) have been significantly modified over the prior art to provide for smoother rotation of the cylinder to assure uniform thickness of the film in the cylinder and to assure uniform feed in order to optimize the exposure of the blood to the lamp in a controlled process.

The improved bearing assembly is best shown in Figs. 3, 4 and 5. Specifically, Fig. 4 shows a sectional view of the bearing 22 mounted on support bracket 12 for supporting the cylinder 10 (Fig. 3). The bearing assembly 22, and each of the remaining bearing assemblies 23, 24, 25 and 52, are mounted on bearing shaft or stud 54 directly on the respective support bracket. The bearing shaft has a reduced, threaded outer end 56 adapted to be received in a threaded or tapped hole 58 in the support bracket. An enlarged shoulder

defines a bearing race 60 which is in axial alignment with the threaded end 56, and an enlarged slotted head 62 is provided outboard of the bearing race to secure the bearing assembly on the bearing race. Typically, and in the manner well known to those skilled in the art, the bearing assembly is positioned on the race externally of a plurality of ball-bearing elements to provide smooth rotation of the roller bearing relative to the roller race. Typically, the ball-bearing elements of the type encased in a circular carrier or cage 64 are position ed directly on the bearing race. The roller 68 is then mounted directly on the bearing cage for rotation therewith, with the internal ring 70 positioned against the relief face of the bearing cage 64 to hold the roller 68 in position and keep it out of contact with the internal face of the slotted head 62. An annular groove 72 is provided around the outer periphery of the roller 68. A resilient, replaceable O-ring 74 is placed in the groove. This assures that the only contact of the cylinder 10 is with the resilient O-ring 74, providing a good dampening between the cylinder and the rest of the assembly (see Figs. 3 and 5). A spacer washer 75 is provided to assure clearance between the support bracket and the bearing race.

The thrust bearing assembly 52 for engaging the drive ring 16 is essentially the same as that just described with the exception that the outer surface 76 of the bearing roller is tapered, as best shown in Fig. 5. This ensures proper clearance between the tapered face 78 of the drive ring 16 and the roller bearing assembly 52.

The drive train including the improved drive ring 16 and thrust bearing assembly 52 is best shown in Fig. 5. The drive ring 16 is mounted in a manner to circumscribe the cylinder 10. The drive ring of the preferred embodiment includes two important features which may be used independently or in combination with additional features of the invention. The bearing face 78 of the drive ring 16 is at an oblique angle relative to the axis of the cylinder. This permits the support bearing 52 to bear directly against the drive ring. This is important since in the preferred embodiment this bearing is the only element utilized to keep the cylinder from sliding along its axis when the cylinder is at an inclined angle to permit gravity feed of fluids. Specifically, by providing a drive ring adapted for receiving a bearing support, it permits the cylinder to be floating only on the roller bearings 22, 23, 24,

25 and 52, providing for the smooth operation essential to maintaining a uniform film thickness for predictable and controlled exposure conditions.

The drive ring 16 also includes an annular channel 80, which in the preferred embodiment is a concave arcuate groove adapted for receiving a drive belt 18 in Fig. 1 of circular cross-section such as by way of example, an O-ring. This provides a smooth drive system assuring uniform rotational speed of the cylinder 10.

The thrust bearing support bracket assembly 84 is essentially "L"-shaped and is pivotal about the center of the "L" at pivot point 86 (Fig. 2). The bracket is secured directly to the support plate 15 via a fastener such as the adjustment bolt 88. The bracket can be pivoted about point 86 in order to precisely align the drive ring 16 with the drive pulley 90 of the drive motor 20, and then locked in position in a manner well known to those who are skilled in the art. The triangle motor assembly 20 is mounted on a mounting bracket 92 which is secured directly to the support plate 15.

As shown in Fig. 1, the support column 17 is inserted in a receptive opening 94 in the base 27 and a protective ring flange 96 is provided around the support column to assure that material does not fall down into the base in case of a leak or spillage. In addition, it will be noted that the preferred embodiment of the base includes a cover 98 with tapered or angled sides to assure that any spillage runs away from the column rather than toward it and into the opening 96.

The collection cup 31 is generally shown in Figs. 1, 2, 6 and 7. In the preferred embodiment, the collection cup is made of blown clear glass or other suitable material and includes and outer cup 102 and an integral inner cup 104. While the preferred embodiment of the cup is of an integral construction, this is not necessary to meet the objectives of the invention. The integral inner cup 104 is primarily used for supporting the lower end 40 of the lamp assembly. The circular or C-shaped cup support 106 is adapted to engage the inner cup 104 to support the cup in the assembly. Specifically, a recessed channel 108 (Fig. 2) may be provided to receive and seat the support 106. In the preferred embodiment, the C-shaped support 106 is pivotally mounted on a rod 116 which is secured to the end plate 35 of the support 15 (see Fig. 2). In order to place the cup in the assembly, the support 106 is swung out of the way and the open mouth of the cup 31 is placed in the receptive channel

34 in the end plate 35. After the cup is properly positioned, the support 106 is pivoted into support position, engaging the receptive channel 108 in the inner cup 104 of the cup 31. This assembly permits quick release of the cup for cleaning and maintenance purposes. Where desired, a resilient gasket 118 may be provided between the lip of the open end of the cup and the plate 35 to seal the interior of the cup relative to external elements. The exit nipple 32 is provided for releasing collected fluids from the irradiator assembly. Typically, the exit nipple is attached to a flexible tube or conduit 112 in the well known manner.

The remote control module 31 and control panel 49 are also shown in Fig. 1. All controls for the irradiator operation are housed in this module. The control panel includes a readout module such as an LED readout 98 or the like to provide visual monitoring of the light intensity, speed of rotation of the cylinder, flow rate of the fluids and other parameters controlling the irradiator assembly via cable 33 which enters the rear of the support base 27.

Fig. 11 illustrates an enlarged view of one of the leveler legs 29 for the support base 27 and, where desired, the control module 31. As there shown, each leveler leg includes a threaded stud 120 which is received in a complementary tapped hole 121 in the bottom wall 122 of the base or module. A jam nut 124 is threadable received on the shaft and is positioned beneath the wall 122. The stud terminates at its lower end 126 in and adjustment wheel 128. In the preferred embodiment, the adjustment wheel is permanently secured to the shaft in order to ensure that the wheel and shaft always move together. The wheel is rotatably mounted on a base 130, as by threaded pin 132. The shaft 120 and wheel 128 are thus rotable relative to the base 130. In the preferred embodiment, the wheel 128 includes a circumferential apron to conceal the base 130 for aesthetic purposes.

In operation, rotation of the wheel and shaft will change the relative position of the wall 122 and the base 130. However, the base will not rotate or creep but will stay in a fixed position. Once the wall 122 is properly positioned, the jam nut 124 is tightened against the wall to lock the assembly in place. In the preferred embodiment, a teflon graphite washer 136 may be positioned between the base 130 and the wheel 128 to reduce friction. Preferably, the base is made of a high density rubber or polyurethane. This configuration provides a leveler assembly which allows leveling of the various elements without rotating the base of the leveler, assuring that it is non-skid and nonmarring.

The irradiator of the present invention also includes an improved and novel tube pincher 150, as specifically shown in Figs. 8, 8a, 9 and 10. With specific reference to Fig. 8, the tube pincher is communication with the inlet tube 26 and is designed to pinch the tube in the event there is a power failure or shut-down of the system. As shown in Figs.2 and 8, the tube pincher can be mounted on the support plate of the assembly, and within the U-shaped cover 152 (Fig. 1). Also, note that the upper inlet end 154 of the cylinder 10 is within the cover 152 and that the upper end 156 of the lamp assembly 28 extends through the cover 152 and is secured on the upper end support plate 33. The power supply for the lamp is remote and connected via cable.

The tube pincher, as shown diagramically in Fig. 8, and in detail in Figs. 9 and 10, includes a channel 160 in which the tube 26 is placed and secured. A plunger mechanism 162 is in communication with the channel and is designed to advance in the direction of arrow A (Fig. 9) and into engagement with the tube in response to a control signal. The control mechanism for operating the pincher is housed in the housing or module l64. In the preferred embodiment, the tube pincher is designed to be in the open position, as drawn, whenever the irradiator is operable. In the event of a shut-down or a power failure present at module 165, and a loss of power signal is present at the pincher control mechanism, the spring closes the plunger in the direction of arrow A to shut off the flow in tube 26. In the preferred embodiment, the tube pincher includes a plunger 162 which is normally closed against the tube 26 by a biasing element such as the spring 180. In its preferred form, the spring is a linear tension spring adapted for exerting a constant force on the plunger regardless of its position. The plunger is mounted on a solenoid actuator 182 which is controlled by a micro switch 84. Whenever the irradiator system is in an operative mode, the solenoid is actuated to act against the spring 180 and retract the plunger, for opening the tube 26 and allowing flow therethrough. Thus, the unique tube pincher of the subject invention is operative to close the supply tube 26 whenever the system is shut down for any reason.

An alternative lamp assembly is shown in Fig.12. This configuration includes a sealed lamp unit 228 having a tapered tip end 240 which is adapted to be received in the receptive socket 45 of the collection cup 30 (see Fig. 2). The opposite end 256 is adapted

to be inserted through the upper end plate 33 of the support assembly (see Fig. 2), with the power cable or fiber optic light guide 258 being coupled to a remote power supply 260. In the preferred embodiment, the lamp 228 may include a slotted cover 262 having a plurality of elongated through slits 266 through which the light passes. This configuration is articularly useful for laser processing techniques.

One of the important features of the irradiator system of the present invention is the provision of sensors 300, 302 in the system, see Fig. 8, to determine the intensity of the ultraviolet light and the thickness of the film to monitor actual exposure of blood sample to the irradiating light source. The sensors for sensing the intensity of the ultraviolet light are placed in the upper end of the cylinder 10 and are mounted on the stationary upper end bracket 152, extending into the cylinder between the outer peripheral wall of the cylinder and its axis, with the sensor mechanism aimed in the cylinder toward the light source 28. A similar sensor may be provided in the opposite direction for monitoring reflective light in order to determine the thickness of the film.

In addition, an alternative embodiment for the sensor should be provided showing the sensor on the external surface of the cylinder. This is particularly useful when the cylinder is made of an ultraviolet transmitting material such as quartz, where the intensity of the light source can be measured at the first mentioned sensor and the relative of the intensity of the light source can be measured at the external sensor, to thereby determine the thickness of the film.

In operation, the cylinder 10 is mounted for rotation about an inclined axis or permitting fluids such as blood constituents to flow from tube 26 onto the inner wall 11 of the cylinder and by gravity downward along the internal peripheral wall of the cylinder and into the collection cup 30, where it is collected and discharged through the orifice 37 of nipple 32 and into the collection tubing 112. The lamp is energized to expose the film of fluid throughout the length of the cylinder. It is an important aspect of the intention that the angle of inclination, the drive speed and the thickness of the fluid film on the wall of the cylinder are controlled and variable in order to achieve consistent and predictable results during various treatment processes. The various monitoring features are very critical in controlling the precise exposure of the fluid to the lamp. A matrix made up of input fluid

flow rate, lamp intensity, film thickness, rotational speed and inclination angle determines the actual exposure process. Accurate information of all variables is essential to a reliable and predictable process.

In one such process, it has been found that ultraviolet exposure may have an important and positive effect in impeding the growth of the HIV virus in human subjects. In experimental tests, it has been found that a psoralen derivative drug attaches itself to white blood cells that have been identified as HIV receptors. By ingesting the psoralen drug, which has a natural biochemical dye, the specific HIV-receptive platelets can be identified. Thereafter, a specimen of the treated blood is removed from the body and fractionated in the normal manner. The plasma and white blood cells are then treated by irradiation and exposed to ultraviolet light. With proper exposure, psoralen dye absorbs the ultraviolet light without damaging or altering the unaffected cells. This damages or alters the HIV-receptor cells without altering the remainder of the blood supply. The blood fractions are then recombined and replaced in the subject's blood supply. Experimental results have indicated that as the blood comes back into the subject's blood stream, the body recognizes that there is a foreign substance, which is the altered receptor cells, and develops an antibody to attack these cells. It has been found that the antibody is active against all HIV receptor-specific cells, not just the specimens which have been altered by ultraviolet treatment. Basically, the end result is that the antibody starts destroying all the receptor white blood cells to which the HIV virus would attach. These blood cells are rendered immobile and it appears the HIV virus cannot multiply without the presence of viable receptor cells. While this does not eliminate the presence of the HIV virus in the subject, it shows promising indications of an ability to place the subject in long term remission. Further, it appears that upon recurrence of the receptor cells in the body, the process can be repeated with similar results. While experiments have been promising, at the present time the various potential side effects have not been determined and large scale clinical testing will be necessary. Similar tests are underway for treatment of certain cancers and various other blood related diseases.

Typically, a stainless steel cylinder is used. However, other materials may be substituted. For example, a quartz cylinder may be used and since quartz transmits ultraviolet light, this permits placement of the light source outside of the cylinder. Also, the use of a

quartz cylinder permits the placement of a sensor in the cylinder wall to precisely monitor the thickness of the film in combination with the light intensity.

While certain features and embodiments have been described in detail herein, it will be understood that the present invention encompasses all of the enhancements and modifications within the scope of the following claims.

CLAIMS

What is claimed is:

1. An apparatus for rotating a hollow cylinder having an outer peripheral wall, an inner peripheral wall and an axis at an inclined angle, the cylinder further including an upper end for receiving material to be processed and a lower discharge end, the apparatus comprising:

a. a plurality of bearing elements in engagement with the outer peripheral wall of the cylinder and adapted for supporting the cylinder on a selected inclined angle, the bearing elements having a resilient bearing surface in direct contact with the outer peripheral wall of the cylinder;

b. a radial ring mounted on the cylinder and projecting radially outwardly therefrom, one of said bearing elements in engagement with the ring for securing the cylinder against axial movement; and

c. a drive belt circumscribing the outer wall of the cylinder and in communication with a drive means for rotating the cylinder about its axis.

2. The apparatus of claim 1, wherein said radial ring includes an outer annular groove and wherein said drive belt is seated in said groove.

3. The apparatus of claim 1, wherein each of said bearing elements further comprises:

a. a central shaft;

b. a cylindrical roller having an outer annular wall and a center hole and mounted for rotation on the central shaft, the cylindrical roller including a recessed circumferential channel in the annular wall; and

c. a resilient element seated in the recessed channel and having an outer bearing surface protruding beyond the outer annular wall of the roller to assure that the cylinder comes in contact only with the resilient element.

4. The apparatus of claim 3, wherein:

a. the shaft includes and enlarged head on one end and a bearing race surface adjacent the head; and

b. the center hole of the cylindrical roller is smaller than the enlarged head as includes a circumferential wall adapted to be seated on the bearing race surface of the shaft.

5. The apparatus of claim 4, wherein:

a. the bearing race surface is larger than the end of the shaft which is opposite the head for forming a shoulder between said end and said bearing race surface; and

b. the cylindrical roller includes a radial stop surface projecting into the center hole for engaging the shoulder for controlling axial movement of the roller relative to the shaft.

6. The apparatus of claim 1, wherein the radial ring includes a bearing surface on the discharge end side of the ring for engaging the bearing element, said bearing surface at an angle forming a truncated cone intersecting the diameter of the ring and cylinder at an angle of between 25 and 45 degrees.

7. The apparatus of claim 1, further including:

a. a base;

b. an upstanding support mounted in and supported by the base;

c. a cylinder support assembly mounted on the base, wherein the bearing elements are mounted for rotation directly on the support assembly.

8. The apparatus of claim 7, wherein the support assembly is pivotally mounted on the upstanding support for controlling the angular axis of the cylinder.

9. The apparatus of claim 8, further including a level sensor mounted on the upstanding support.

10. The apparatus of claim 7, the base including a splash cover circumscribing the upstanding support and adapted for directing any fluid away from the upstanding support.

11. A roller bearing having a resilient bearing surface, the roller bearing comprising:

a. a central shaft;

b. a cylindrical roller having an outer annular wall and a center hole and mounted for rotation on the central shaft, the cylindrical roller including a recessed circumferential channel in the annular wall; and

c. a resilient element seated in the recessed channel and having an outer bearing surface protruding beyond the outer annular wall of the roller to assure that the cylinder comes in contact only with the resilient element.

12. The roller bearing of claim 11, wherein:

a. the shaft includes and enlarged head on one end and a bearing race surface adjacent the head; and

b. the center hole of the cylindrical roller is smaller than the enlarged head as includes a circumferential wall adapted to be seated on the bearing race surface of the shaft.

13. The roller bearing of claim 12, wherein:

a. the bearing race surface is larger than the end of the shaft which is opposite the head for forming a shoulder between said end and said bearing race surface; and

b. the cylindrical roller includes a radial stop surface projecting into the center hole for engaging the shoulder for controlling axial movement of the roller relative to the shaft.

14. An apparatus for rotating a hollow cylinder having an outer peripheral wall, an inner peripheral wall and an axis at an inclined angle, the cylinder further including an

upper inlet end for receiving material to be processed and a lower discharge end, the apparatus comprising:

a. an upper end plate mounted in non-contacting relationship with the upper end of the cylinder and in axial alignment therewith;

b. a lower end plate mounted in non-contacting relationship with the lower discharge end of the cylinder and in axial alignment therewith, the lower end plate having an axial through hole larger than the cylinder and adapted for receiving the lower discharge end thereof;

c. a circumferential channel in the end plate and surrounding the through hole thereof;

d. a collection cup seated in the circumferential channel of the lower end plate, the collection cup comprising an outer cylindrical sleeve having an open end and an opposite closed end, the open end adapted to be seated in the circumferential channel of the lower end plate; and

e. the collection cup including an inner sleeve coaxial with the outer sleeve and having one end extending through the closed end of the cup to form an extension and an opposite open end in communication with the cylinder.

15. The apparatus of claim 14, further including a support for holding the collection cup in place relative to the cylinder, the support adapted for surrounding the extension for positioning the cup relative to the axis of the cylinder.

16. The apparatus of claim 15, wherein the collection cup is mounted on the axis of the cylinder.

17. The apparatus of claim 15, wherein the cylinder is mounted for rotation independently of the collection cup.

18. The apparatus of claim 15, wherein the collection cup support further includes a substantially C-shaped bracket pivotally mounted such that the C swings into and out of circumscribing relationship with the extension.

19. The apparatus of claim 15, wherein the end cap is tapered in the form of a truncated cone and is self seating in the open end of the inner sleeve.

20. The apparatus of claim 15, wherein the lamp assembly is elongated and when mounted extends along the axis of the cylinder, the lamp assembly having an upper end member adapted to be received in the upper end plate.

21. The apparatus of claim 14, further including a lamp assembly having an end cap which is adapted to be placed in the open end of the inner sleeve of the collection cup for mounting the lamp assembly in the cylinder.

22. The apparatus of claim 14, wherein:

a. the end plate includes a recessed opening for receiving the open end of the collection cup; and

b. the open end of the collection cup is shaped to be snugly received in the recessed opening.

23. The apparatus of claim 22, further including a resilient gasket between the open end of the collection cup and the recessed opening in the end plate.

24. An apparatus for rotating a hollow cylinder having an outer peripheral wall, an inner peripheral wall and an axis at an inclined angle, the cylinder further including an upper inlet end for receiving material to be processed and a lower discharge end, the apparatus comprising:

a. a speed sensor in communication with the outer peripheral wall for monitoring the speed of rotation of the cylinder;

b. a process sensor in communication with the interior of the cylinder for monitoring the process.

25. The apparatus of claim 24, further including an ultraviolet lamp in the interior of the cylinder, and wherein the process sensor monitors the intensity of the ultraviolet light.

26. A fluid treatment apparatus for treating liquid by exposure to light, the apparatus of the type having a hollow cylinder with an outer peripheral wall, an inner peripheral wall and an axis at an inclined angle, the cylinder further including an upper end for receiving the liquid to be processed and a lower discharge end, drive means for rotating the cylinder about its axis and a source of light for exposing the liquid within the cylinder, the apparatus comprising:

a. a plurality of bearing elements in engagement with the outer peripheral wall of the cylinder and adapted for supporting the cylinder on a selected inclined angle, the bearing elements having a resilient bearing surface in direct contact with the outer peripheral wall of the cylinder;

b. a radial ring mounted on the cylinder and projecting radially outwardly therefrom, one of said bearing elements in engagement with the ring for securing the cylinder against axial movement; and

c. a drive belt circumscribing the outer wall of the cylinder and in communication with a drive means for rotating the cylinder about its axis;

d. an upper end plate mounted in non-contacting relationship with the upper end of the cylinder and in axial alignment therewith;

e. a lower end plate mounted in non-contacting relationship with the lower discharge end of the cylinder and in axial alignment therewith, the lower end plate having an axial through hole larger than the cylinder and adapted for receiving the lower discharge end thereof;

f. a circumferential channel in the end plate and surrounding the through hole thereof;

g. a collection cup seated in the circumferential channel of the lower end plate, the collection cup comprising an outer cylindrical sleeve having an open end and an opposite closed end, the open end adapted to be seated in the circumferential channel of the lower end plate; and

h. the collection cup including an inner sleeve coaxial with the outer sleeve and having one end extending through the closed end of the cup to form an extension and an opposite open end in communication with the cylinder.

27. The apparatus of claim 26, further including a lamp assembly in the hollow cylinder and mounted on the axis thereof, the lamp assembly including:

a. an upper end member adapted to be received in the upper end plate; and

b. a lower end cap which is adapted to be placed in the open end of the inner sleeve of the collection cup for mounting the lamp assembly in the cylinder.

28. The apparatus of claim 27, the lamp assembly further including:

a. a light source located along the axis of the cylinder and mounted such that the cylinder rotates independently of the light source; and

b. a shield for shielding the light source from the liquid in the cylinder.

29. The apparatus of claim 26, wherein the liquid is a blood constituent and the source of light is ultraviolet for irradiating the exposed blood constituent.

30. The apparatus of claim 26, wherein the light source is a laser lamp locate within the cylinder.

31. The apparatus of claim 30 wherein the lamp assembly is a self-contained, sealed it positioned within the cylinder.

32. The apparatus of claim 26, further including:

a. a speed sensor in communication with the outer peripheral wall for monitoring the speed of rotation of the cylinder;

b. a process sensor in communication with the interior of the cylinder, for monitoring the process.

33. The apparatus of claim 32, wherein the cylinder is of a quartz material adapted for transmitting ultraviolet light herethrough.

34. The apparatus of claim 24, including a lamp assembly positioned outside and adjacent the outer peripheral wall of the cylinder.

35. An irradiator apparatus for treating blood constituents by exposure to ultraviolet light, the irradiator of the type having a hollow cylinder with an outer peripheral wall, an inner peripheral wall and an axis at an inclined angle, the cylinder further including an upper end for receiving the blood constituent to be processed and a lower discharge end, drive means for rotating the cylinder about its axis and a source of light for exposing the blood constituent within the cylinder, the apparatus comprising:

a. a plurality of bearing elements in engagement with the outer peripheral wall of the cylinder and adapted for supporting the cylinder on a selected inclined angle, the bearing elements having a resilient bearing surface in direct contact with the outer peripheral wall of the cylinder;

b. a radial ring mounted on the cylinder and projecting radially outwardly therefrom, one of said bearing elements in engagement with the ring for securing the cylinder against axial movement;

c. a drive belt circumscribing the outer wall of the cylinder and in communication with a drive means for rotating the cylinder about its axis; and

d. a control module positioned at a location remote from the irradiator cylinder, with cables for interfacing the control module with the drive means.

36. An apparatus as called for in claim 35, further including:

a. an upper end plate mounted in non-contacting relationship with the upper end of the cylinder and in axial alignment therewith;

b. a lower end plate mounted in non-contacting relationship with the lower discharge end of the cylinder and in axial alignment therewith, the lower end plate having an axial through hole larger than the cylinder and adapted for receiving the lower discharge end thereof;

c. a circumferential channel in the end plate and surrounding the through hole thereof;

d. a collection cup seated in the circumferential channel of the lower end plate, the collection cup comprising an outer cylindrical sleeve having an open end and an opposite closed end, the open end adapted to be seated in the circumferential channel of the lower end plate; and

e. the collection cup including an inner sleeve coaxial with the outer sleeve and having one end extending through the closed end of the cup to form an extension and an opposite open end in communication with the cylinder.

37. The apparatus of claim 35, the control module further including a plurality of adjustable support legs depending from the module, each support leg comprising:

a. a central, externally threaded shaft having a lower end and an upper end, the upper end in communication with the control module;

b. a base at the lower end of the shaft for defining a support surface;

c. an adjusting ring having an internal threaded hole mated with the threaded shaft, the adjusting ring threadably carried on said shaft, the adjusting ring adapted for movement along the shaft and adapted for selective engagement with the control module, whereby the control module is moved relative to the axis of the shaft depending upon the position of the adjusting ring.

38. The apparatus of claim 37, wherein the adjusting ring is of a generally truncated cone configuration, with a hollow core sufficient to circumscribe the base when the adjusting ring is in its lowermost position.

39. The apparatus of claim 38, wherein the base is of a greater diameter than the shaft.

40. An adjusting leg for adjusting the height of a object, the leg comprising:

a. a central, externally threaded shaft having a lower end and an upper end, the upper end in communication with the object, the object movable relative to the axis of the shaft;

b. a base at the lower end of the shaft for defining a support surface;

c. an adjusting ring having an internal threaded hole mated with the threaded shaft, the adjusting ring threadably carried on said shaft, the adjusting ring adapted for movement along the shaft and adapted for selective engagement with the object, whereby the object is moved relative to the axis of the shaft and its position is dependent upon the position of the adjusting ring.

41. The apparatus of claim 40, wherein the adjusting ring is of a generally truncated cone configuration, with a hollow core sufficient to circumscribe the base when the adjusting ring is in its lowermost position.

42. The apparatus of claim 41, wherein the base is of a greater diameter than the shaft.

43. A fail safe device for selectively opening and closing a flow passage, wherein the device is normally closed to restrict flow and is open to flow only during operation of a peripheral apparatus, the fail safe apparatus automatically responsive to any shut down of the peripheral to restrict flow through the flow passage, the fail safe device comprising:

a. a gate movable between a flow restricting position and an open flow position;

b. a gate control mechanism adapted for normally maintaining the gate in the flow restricting position and further adapted to be selectively activated for moving the gate and for maintaining the gate in the open flow position only when activated; and

c. an activator associated with the gate control mechanism and responsive to an applied stimulus corresponding to operation of the peripheral apparatus for activating the gate and moving it to the open flow position.

44. The fail safe device of claim 43, wherein the flow passage is a resilient tube having a hollow interior flow passageway and where the gate is a non-invasive pinching mechanism adapted for pinching the tube and thereby closing the flow passageway when in the normal condition and for releasing the tube and thereby opening the flow passageway when in the activated position.

45. The fail safe device of claim 43, wherein the gate control mechanism further comprises a mechanical biasing means for normally biasing and urging the gate into the flow restricting position and the activator is adapted for overcoming the biasing means and moving the gate to the open flow position.

46. The fail safe-device of claim 45, wherein the mechanical biasing means is a coil spring in direct communication with the gate.

47. The fail safe device of claim 45, wherein the activator is a solenoid responsive to an electrical signal which is present whenever the peripheral apparatus is operative.

48. The fail safe device of claim 44, further including a housing, the gate control mechanism and the activator being carried in the housing, the housing further including an aperture, the gate axially movable into and out of the housing through the aperture, the housing including a tube holding means in direct communication with the aperture.

49. The fail safe device of claim 48, the tube holding device further comprising an elongated channel extending transversely relative to the movement axis of the gate and adapted for positioning a resilient tube relative to the gate, wherein the gate moves into the channel for pinching the tube and out of the channel for releasing the tube.

50. A flow control device for an irradiator of the type adapted for treating blood or constituents thereof by exposure to ultraviolet light, the irradiator of the type having a hollow cylinder with an outer peripheral wall, an inner peripheral wall and an axis at an inclined angle, the cylinder further including an upper end for receiving the blood to be processed and a low discharge end, drive means for rotating the cylinder about its axis and a source of light for exposing the blood constituents within the cylinder, a resilient tube having an open end at the upper end of the cylinder, the flow control apparatus adapted for controlling flow of blood in the resilient tube, the flow control apparatus being normally closed to restrict flow and being open to flow only during operation of the irradiator, the flow control apparatus comprising:

a. a gate movable between a normal flow restricting position and activated open flow position, the gate adapted for pinching the tube and thereby closing the flow passageway when in the normal condition and for releasing the tube and thereby opening the flow passageway when in the activated position;

b. a gate control mechanism adapted for normally maintaining the gate in the flow restricting position and further adapted to be selectively activated for moving the gate and for maintaining the gate in the open flow position only when activated; and

c. an activator associated with the gate control mechanism and responsive to an applied stimulus corresponding to operation of the peripheral apparatus for activating the gate and moving it to the open flow position.

51. The fail safe device of claim 50, wherein the gate control mechanism further comprises a mechanical biasing means for normally biasing and urging the gate into the flow restricting position and the activator is adapted for overcoming the biasing means and moving the gate to the open flow position.

52. A method for irradiating selected constituents of blood by exposing it to ultraviolet light, the method comprising the steps of:

a. introducing a volume of the selected blood constituents onto the interior surface of a hollow, open ended inclined cylinder, whereby the blood gravity feeds along the interior surface of the cylinder and forms a thin, uniform and continuous film thereon;

b. exposing the film to an ultraviolet light as it progresses along the cylinder; and

c. continuously monitoring the thickness of the film and the intensity of the light to assure proper exposure as the blood progresses along the cylinder.

53. The method of claim 52, wherein the speed of rotation of the cylinder may be altered to adjust the thickness of the film.

54. The method of claim 52, wherein the angle of inclination of the cylinder may be altered to adjust the thickness of the film.

55. The method of claim 52, wherein the intensity of the ultraviolet light may be adjusted to alter the exposure of the blood.

56. The method of claim 52, wherein the volume of blood may be altered to adjust the thickness of the film.

57. The method of claim 52, wherein any combination of the following parameters may be utilized to adjust the exposure of the blood to the ultraviolet light:

a. the speed of rotation of the cylinder may be altered to adjust the thickness of the film;

b. the angle of inclination of the cylinder may be altered to adjust the thickness of the film;

c. the intensity of the ultraviolet light may be adjusted to alter the exposure of the blood; and

d. the volume of blood may be altered to adjust the thickness of the film.

58. A method of treating a blood supply contaminated with an HIV-virus, the method including the steps of deriving a blood sample from an HIV-infected subject, ingesting a psoralen derivative drug in the blood supply of an HIV-infected subject for identifying the HIV-receptor platelets in the blood supply, thereafter deriving a blood sample from the subject, and thereafter:

a. fractionating the blood to separate the plasma and platelets from the remaining constituents;

b. exposing the plasma and platelets to ultraviolet light;

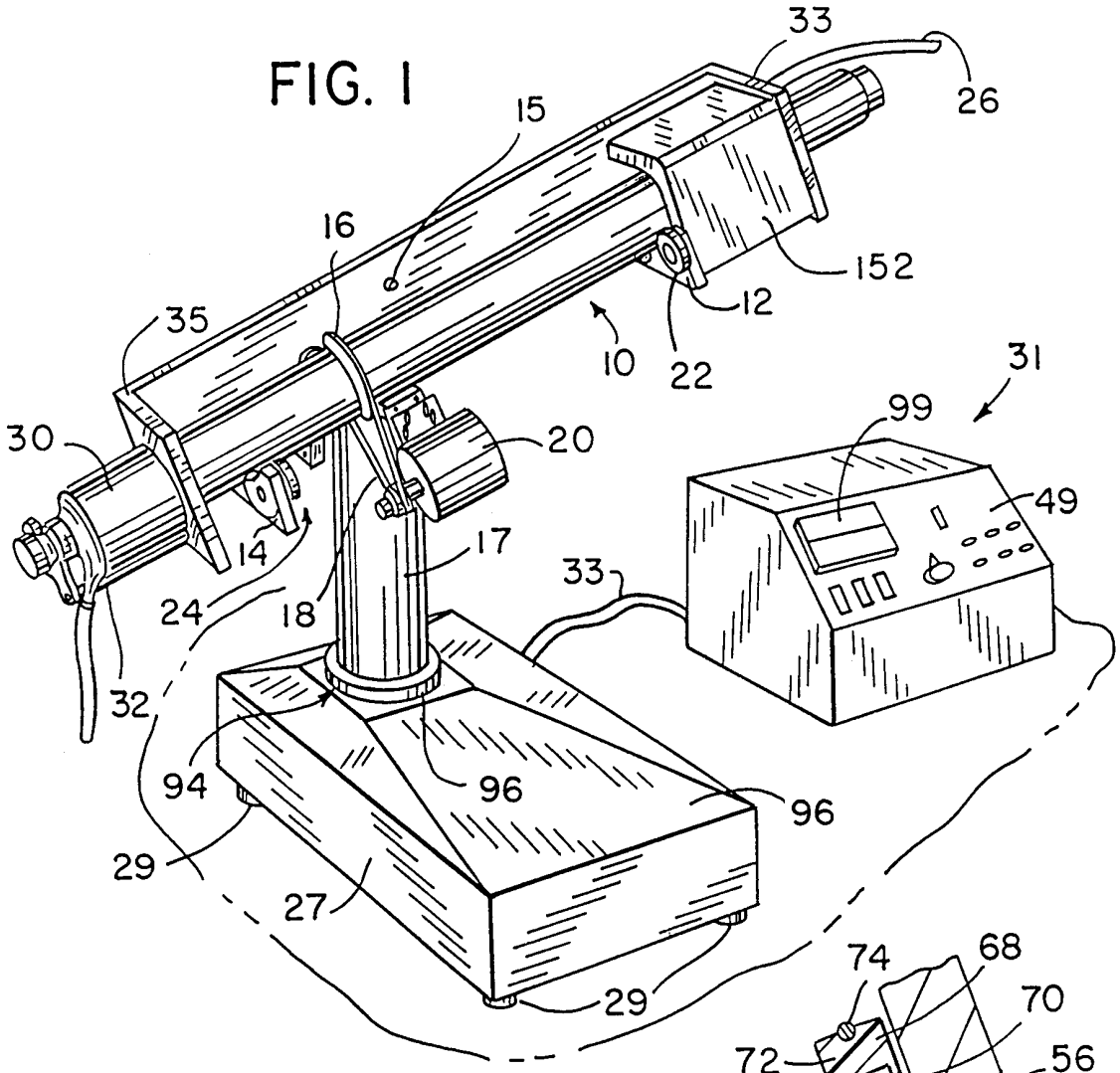
c. altering the platelets responsive to the psoralen derivative drug;

d. reconstituting the constituents of the blood;

e. replacing the reconstituted blood sample in the HIV-infected subject, whereby the natural antibodies of the subject attack the ultraviolet treated platelets and all like platelets in the blood supply for impeding the progress of the HIV infection.

59. The method of claim 58, wherein steps "a" through "e" are repeated as necessary.

FIG. 1



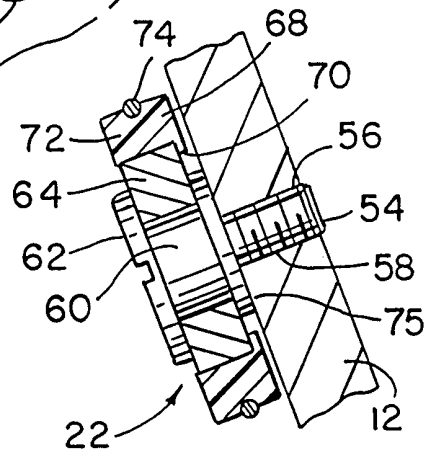


FIG. 4

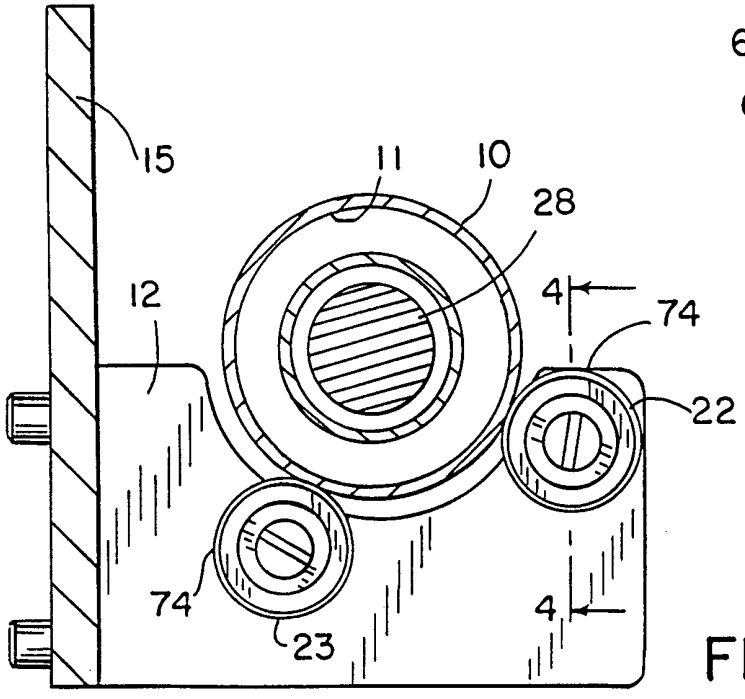


FIG. 3

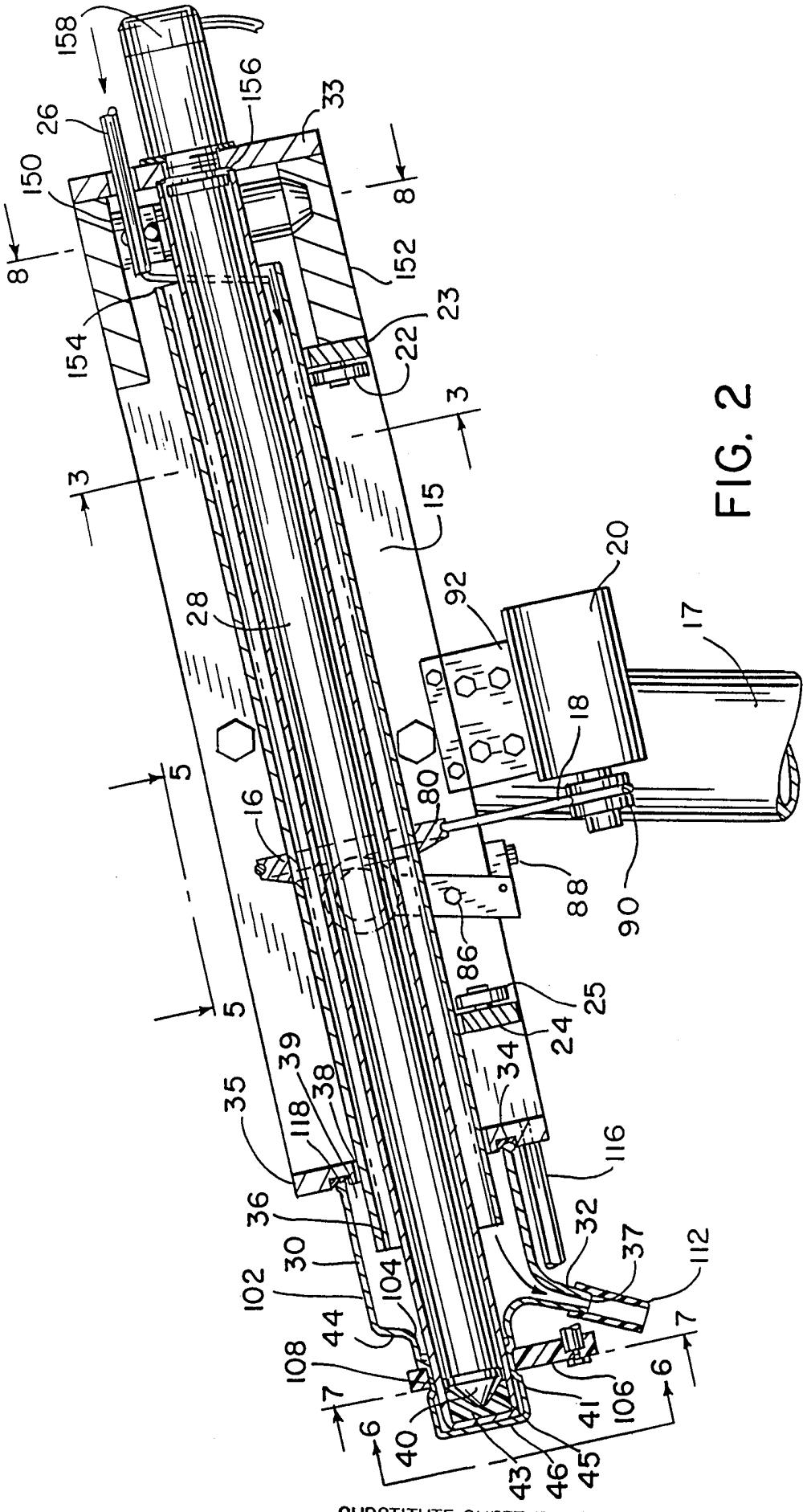

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FIG. 2

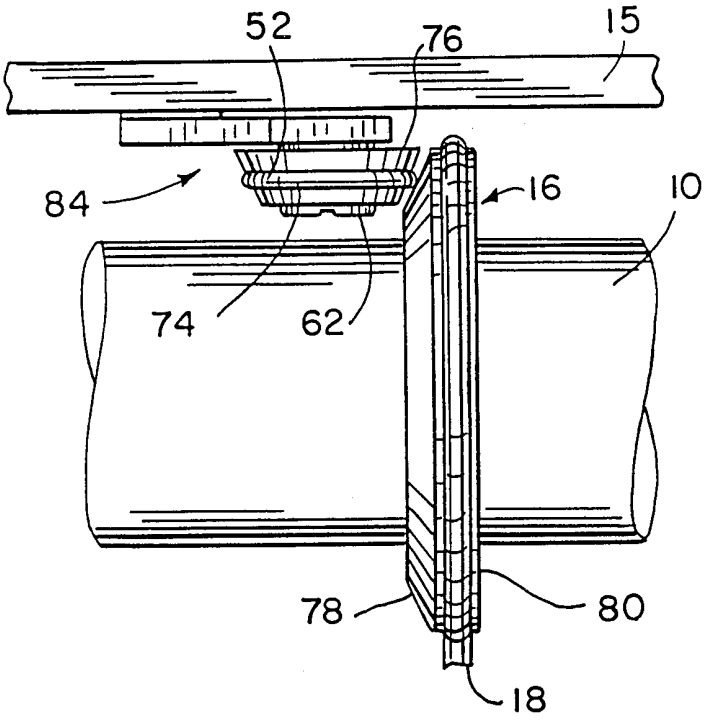


FIG. 5

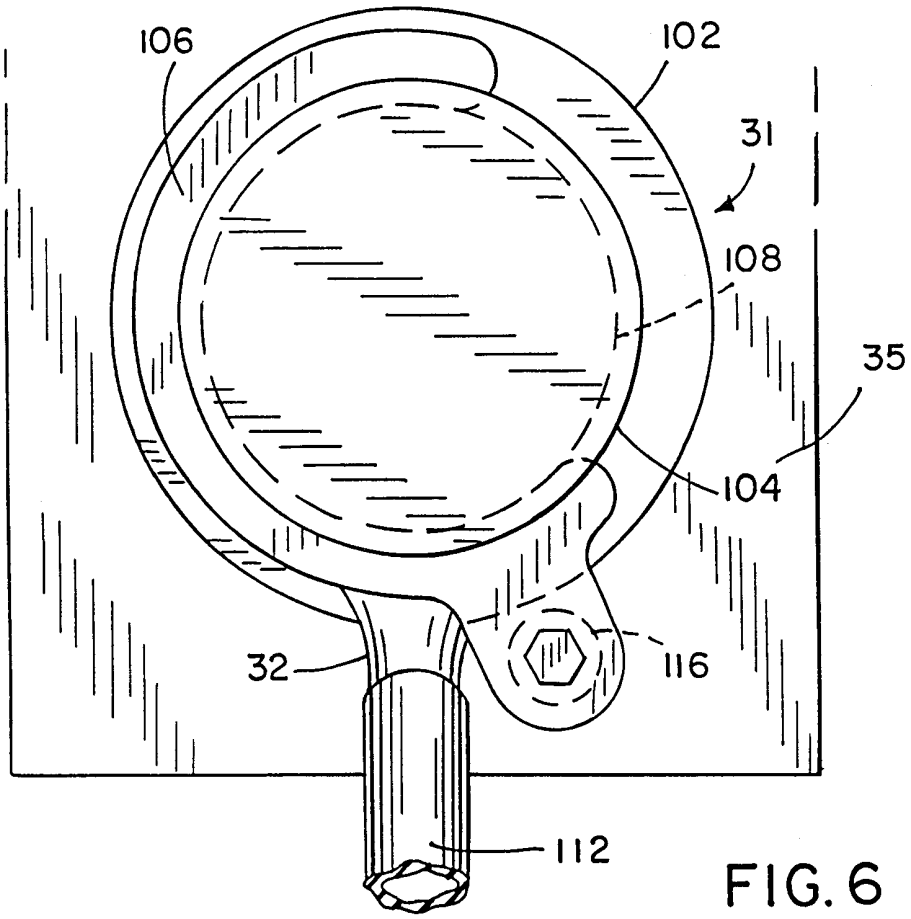


FIG. 6

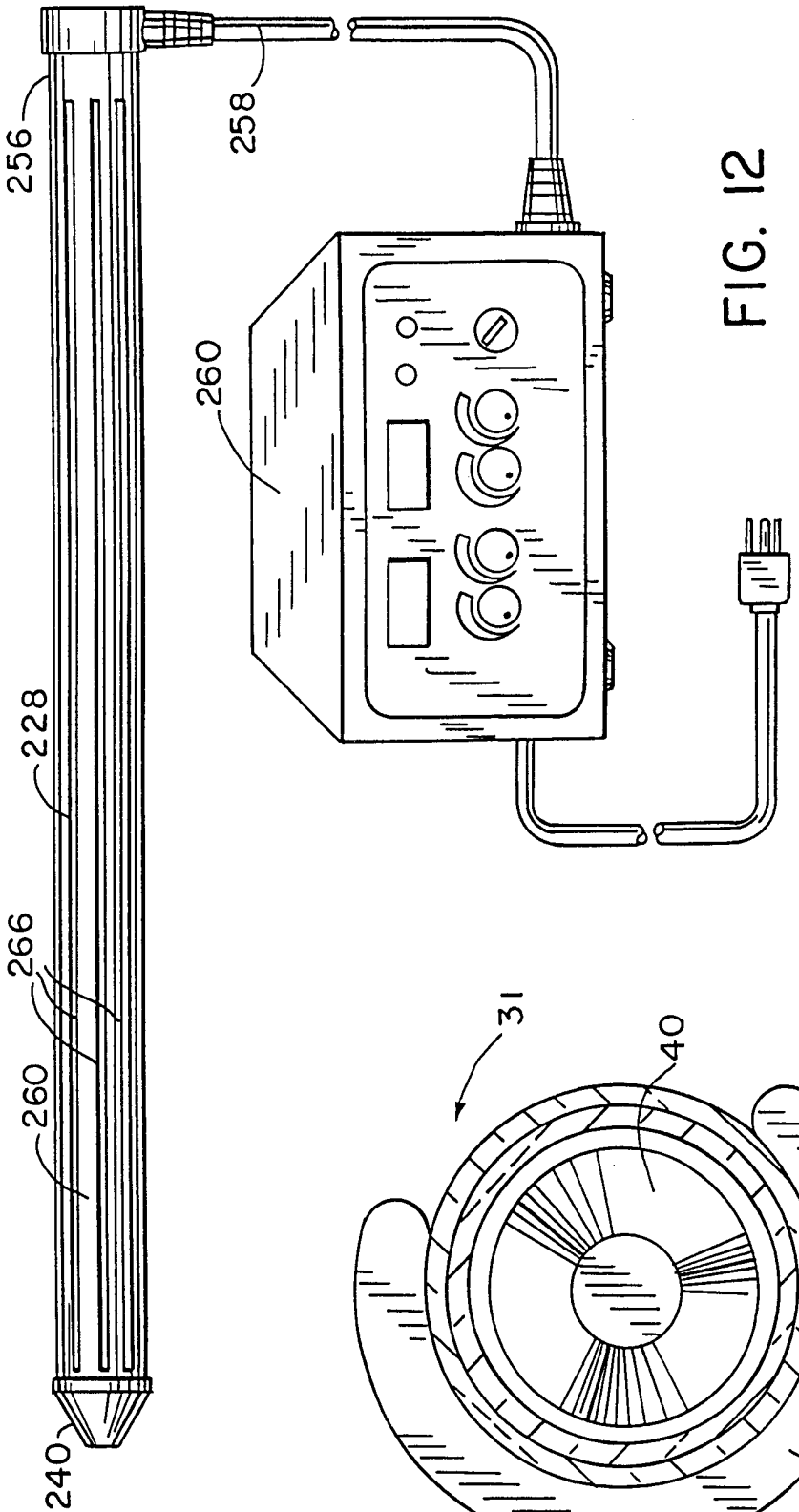


FIG. 12

FIG. 7

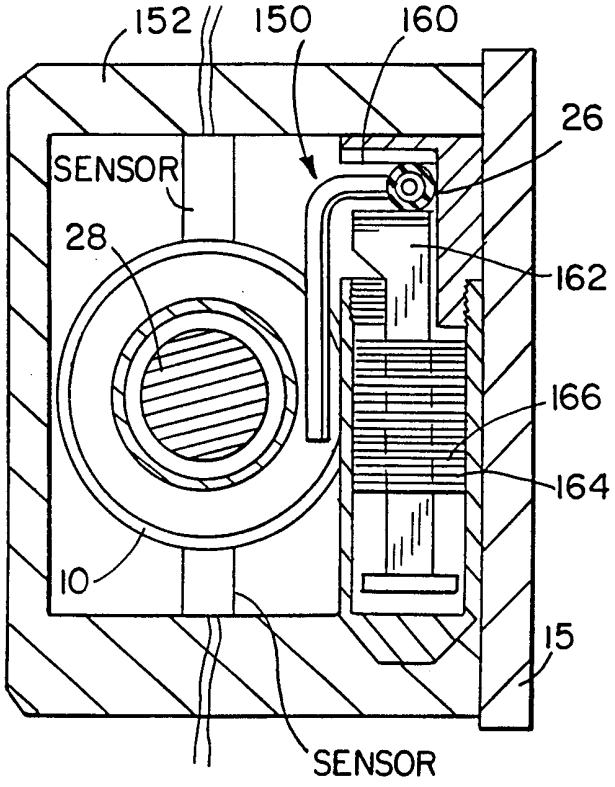
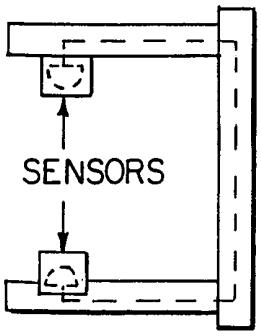


FIG. 8

FIG. 8a



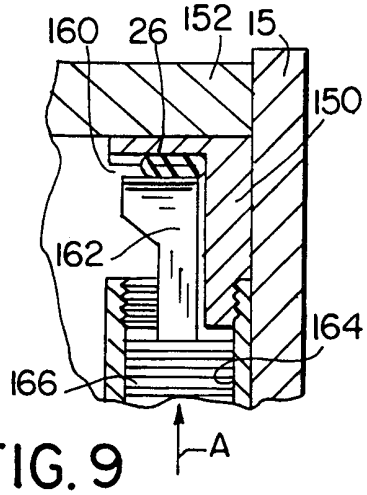


FIG. 9

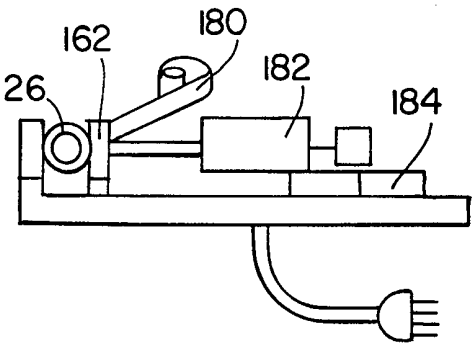


FIG. 10

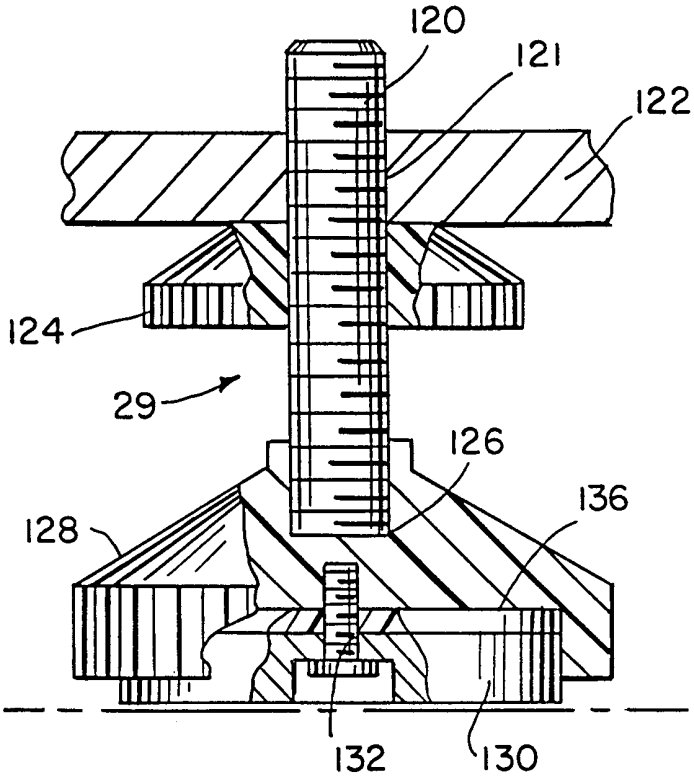


FIG. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/13691

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :C12M 1/10
US CL :435/283.1

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : Please See Extra Sheet.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,567,616 A (DILL, II) 22 October 1996 (22.10.96), see entire document.	1-10, 26-39
Y	US 1,925,875 A (MCLAUGHLIN ET AL.) 05 September 1933 (05.09.33), see entire document.	1-10, 35, 37-39
Y	GB 810,791 A (GALLARD) 25 March 1959 (25.03.59), see entire document.	1-10, 35, 37-39
Y	US 4,904,874 A (ELLNER) 27 February 1990 (27.02.90), see entire document.	1-10, 34, 35, 37-39
Y	US 4,780,178 A (YOSHIDA ET AL.) 25 October 1988 (25.10.88), see entire document.	34
Y	US 5,154,896 A (MOCHIDA ET AL.) 13 October 1992 (13.10.92), see entire document.	34

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
13 NOVEMBER 1997	02 DEC 1997
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer WILLIAM H. BEISNER Telephone No. (703) 308-0651

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/13691

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	DE 37 39 966 A (KATADYN PRODUKTE AG) 08 June 1989 (08.06.89), see entire document.	34
Y	US 3,592,423 A (MUI) 13 July 1971 (13.07.71), see entire document.	37-39
A	US 5,133,932 A (GUNN ET AL.) 28 July 1992 (28.07.92), see entire document.	1-10, 26-39
A	US 3,485,576 A (MCRAE ET AL.) 23 December 1969 (23.12.69), see entire document.	1-10, 26-39

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/13691

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-10 and 26-39

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/13691

B. FIELDS SEARCHED
Minimum documentation searched
Classification System: U.S.

435/2, 173.1, 283.1, 286.1, 286.2, 286.4, 286.5, 292.1, 808; 422/24, 209; 366/220, 233; 250/435, 432R, 436, 438; 384/549, 565; 604/4

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I, claims 1-10 and 26-39, drawn to a device for rotating a hollow cylinder which includes bearing means.

Group II, claims 14-23 and 26-34, drawn to a device for rotating a hollow cylinder which includes supporting plates and collection cups.

Group III, claims 11-13, drawn to a roller bearing.

Group IV, claims 24-25, drawn to a device for rotating a hollow cylinder which includes a speed control system.

Group V, claims 40-42, drawn to an adjustable leg device.

Group VI, claims 43-51, drawn to a system for rotating a hollow cylinder which includes a failsafe gate device.

Group VII, claims 52-57, drawn to a method of exposing blood to ultraviolet light.

Group VIII, claims 58-59, drawn to a method of treating HIV-infected blood.

The inventions listed as Groups I and II do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature of group I is the bearing means for supporting the rotating hollow cylinder while the special technical feature of Group II are the end plates and collection cups for flowing liquid into and out of the rotating hollow cylinder. Since the special technical feature of Group I is not present in the Group II invention and the special technical feature of the Group II invention is not present in the Group I invention, unity of invention is lacking.

The inventions listed as Groups I and III do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature of group I is the bearing means for supporting the rotating hollow cylinder while the special technical feature of Group III is a roller bearing with a central shaft, a cylindrical roller and a resilient element which can be used to support rotating structures other than a hollow cylinder. Since the special technical feature of Group I is not present in the Group III invention and the special technical feature of the Group III invention is not present in the Group I invention, unity of invention is lacking.

The inventions listed as Groups I and IV do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature of group I is the bearing means for supporting the rotating hollow cylinder while the special technical feature of Group IV is a speed sensor and processor for a device for rotating a hollow cylinder. Since the special technical feature of Group I is not present in the Group IV invention and the special technical feature of the Group IV invention is not present in the Group I invention, unity of invention is lacking.

The inventions listed as Groups I and V do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature of group I is the bearing means for supporting the rotating hollow cylinder while the special technical feature of Group V is an adjustable leg structure. Since the special technical feature of Group I is not present in the Group V invention and the special technical feature of the Group V invention is not present in the Group I invention, unity of invention is lacking.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/13691

The inventions listed as Groups I and VI do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature of group I is the bearing means for supporting the rotating hollow cylinder while the special technical feature of Group VI is a fail safe valve mechanism. Since the special technical feature of Group I is not present in the Group VI invention and the special technical feature of the Group VI invention is not present in the Group I invention, unity of invention is lacking.

The inventions listed as Groups I and VII do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature of group I is the bearing means for supporting the rotating hollow cylinder while the special technical feature of Group VII is a method for irradiating blood with ultraviolet light which does not require the use of a device with the special technical feature of the invention of Group I. Since the special technical feature of Group I is not present in the Group VII invention and the special technical feature of the Group VII invention is not present in the Group I invention, unity of invention is lacking.

The inventions listed as Groups I and VIII do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature of group I is the bearing means for supporting the rotating hollow cylinder while the special technical feature of Group VIII is a method treating HIV-infected blood which includes several method steps which cannot be performed by the device of Group I. Since the special technical feature of Group I is not present in the Group VIII invention and the special technical feature of the Group VIII invention is not present in the Group I invention, unity of invention is lacking.

The inventions listed as Groups II and III do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature of group II are the end plates and collection cups for flowing liquid into and out of the rotating hollow cylinder while the special technical feature of Group III is a roller bearing with a central shaft, a cylindrical roller and a resilient element which can be used to support rotating structures other than a hollow cylinder. Since the special technical feature of Group II is not present in the Group III invention and the special technical feature of the Group III invention is not present in the Group II invention, unity of invention is lacking.

The inventions listed as Groups II and IV do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature of group II are the end plates and collection cups for flowing liquid into and out of the rotating hollow cylinder while the special technical feature of Group IV is a speed sensor and processor for a device for rotating a hollow cylinder. Since the special technical feature of Group II is not present in the Group IV invention and the special technical feature of the Group IV invention is not present in the Group II invention, unity of invention is lacking.

The inventions listed as Groups II and V do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature of group II are the end plates and collection cups for flowing liquid into and out of the rotating hollow cylinder while the special technical feature of Group V is an adjustable leg structure. Since the special technical feature of Group II is not present in the Group V invention and the special technical feature of the Group V invention is not present in the Group II invention, unity of invention is lacking.

The inventions listed as Groups II and VI do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature of group II are the end plates and collection cups for flowing liquid into and out of the rotating hollow cylinder while the special technical feature of Group VI is a fail safe valve mechanism. Since the special technical feature of Group II is not present in the Group VI invention and the special technical feature of the Group VI invention is not present in the Group II invention, unity of invention is lacking.

The inventions listed as Groups II and VII do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature of group II are the end plates and collection cups for flowing liquid into and out of the rotating hollow cylinder while the special technical feature of Group VII is a method for irradiating blood with ultraviolet light which does not require the use of a device with the special technical feature of the invention of Group II. Since the special technical feature of Group II is not present in the Group VII invention and the special technical feature of the Group VII invention is not present in the Group II invention, unity of invention is lacking.

The inventions listed as Groups II and VIII do not relate to a single inventive concept under PCT Rule 13.1 because,

under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature of group II are the end plates and collection cups for flowing liquid into and out of the rotating hollow cylinder while the special technical feature of Group VIII is a method treating HIV-infected blood which includes several method steps which cannot be performed by the device of Group II. Since the special technical feature of Group II is not present in the Group VIII invention and the special technical feature of the Group VIII invention is not present in the Group II invention, unity of invention is lacking.

The inventions listed as Groups III and IV do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature of group III is a roller bearing with a central shaft, a cylindrical roller and a resilient element which can be used to support rotating structures other than a hollow cylinder while the special technical feature of Group IV is a speed sensor and processor for a device for rotating a hollow cylinder. Since the special technical feature of Group III is not present in the Group IV invention and the special technical feature of the Group IV invention is not present in the Group III invention, unity of invention is lacking.

The inventions listed as Groups III and V do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature of group III is a roller bearing with a central shaft, a cylindrical roller and a resilient element which can be used to support rotating structures other than a hollow cylinder while the special technical feature of Group V is an adjustable leg structure. Since the special technical feature of Group III is not present in the Group V invention and the special technical feature of the Group V invention is not present in the Group III invention, unity of invention is lacking.

The inventions listed as Groups III and VI do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature of group III is a roller bearing with a central shaft, a cylindrical roller and a resilient element which can be used to support rotating structures other than a hollow cylinder while the special technical feature of Group VI is a fail safe valve mechanism. Since the special technical feature of Group III is not present in the Group VI invention and the special technical feature of the Group VI invention is not present in the Group III invention, unity of invention is lacking.

The inventions listed as Groups III and VII do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature of group III is a roller bearing with a central shaft, a cylindrical roller and a resilient element which can be used to support rotating structures other than a hollow cylinder while the special technical feature of Group VII is a method for irradiating blood with ultraviolet light which does not require the use of a device with the special technical feature of the invention of Group III. Since the special technical feature of Group III is not present in the Group VII invention and the special technical feature of the Group VII invention is not present in the Group III invention, unity of invention is lacking.

The inventions listed as Groups III and VIII do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature of group III is a roller bearing with a central shaft, a cylindrical roller and a resilient element which can be used to support rotating structures other than a hollow cylinder while the special technical feature of Group VIII is a method treating HIV-infected blood which includes several method steps which cannot be performed by the device of Group III. Since the special technical feature of Group III is not present in the Group VIII invention and the special technical feature of the Group VIII invention is not present in the Group III invention, unity of invention is lacking.

The inventions listed as Groups IV and V do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature of group IV is a speed sensor and processor for a device for rotating a hollow cylinder while the special technical feature of Group V is an adjustable leg structure. Since the special technical feature of Group IV is not present in the Group V invention and the special technical feature of the Group V invention is not present in the Group IV invention, unity of invention is lacking.

The inventions listed as Groups IV and VI do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature of group IV is a speed sensor and processor for a device for rotating a hollow cylinder while the special technical feature of Group VI is a fail safe valve mechanism. Since the special technical feature of Group IV is not present in the Group VI invention and the special technical feature of the Group VI invention is not present in the

Group IV invention, unity of invention is lacking.

The inventions listed as Groups IV and VII do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature of group IV is a speed sensor and processor for a device for rotating a hollow cylinder while the special technical feature of Group VII is a method for irradiating blood with ultraviolet light which does not require the use of a device with the special technical feature of the invention of Group IV. Since the special technical feature of Group IV is not present in the Group VII invention and the special technical feature of the Group VII invention is not present in the Group IV invention, unity of invention is lacking.

The inventions listed as Groups IV and VIII do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature of group IV is a speed sensor and processor for a device for rotating a hollow cylinder while the special technical feature of Group VIII is a method treating HIV-infected blood which includes several method steps which cannot be performed by the device of Group IV. Since the special technical feature of Group IV is not present in the Group VIII invention and the special technical feature of the Group VIII invention is not present in the Group IV invention, unity of invention is lacking.

The inventions listed as Groups V and VI do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature of group V is an adjustable leg structure while the special technical feature of Group VI is a fail safe valve mechanism. Since the special technical feature of Group V is not present in the Group VI invention and the special technical feature of the Group VI invention is not present in the Group V invention, unity of invention is lacking.

The inventions listed as Groups V and VII do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature of group V is an adjustable leg structure while the special technical feature of Group VII is a method for irradiating blood with ultraviolet light which does not require the use of a device with the special technical feature of the invention of Group V. Since the special technical feature of Group V is not present in the Group VII invention and the special technical feature of the Group VII invention is not present in the Group V invention, unity of invention is lacking.

The inventions listed as Groups V and VIII do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature of group V is an adjustable leg structure while the special technical feature of Group VIII is a method treating HIV-infected blood which includes several method steps which cannot be performed by the device of Group V. Since the special technical feature of Group V is not present in the Group VIII invention and the special technical feature of the Group VIII invention is not present in the Group V invention, unity of invention is lacking.

The inventions listed as Groups VI and VII do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature of group VI is a fail safe valve mechanism while the special technical feature of Group VII is a method for irradiating blood with ultraviolet light which does not require the use of a device with the special technical feature of the invention of Group VI. Since the special technical feature of Group VI is not present in the Group VII invention and the special technical feature of the Group VII invention is not present in the Group VI invention, unity of invention is lacking.

The inventions listed as Groups VI and VIII do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature of group VI is a fail safe valve mechanism while the special technical feature of Group VIII is a method treating HIV-infected blood which includes several method steps which cannot be performed by the device of Group Vi. Since the special technical feature of Group VI is not present in the Group VIII invention and the special technical feature of the Group VIII invention is not present in the Group VI invention, unity of invention is lacking.

The inventions listed as Groups VII and VIII do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: The special technical feature of group VII is a method of treating blood with ultraviolet light which requires a thin film formed on a hollow cylinder which is exposed to ultraviolet light while the special technical feature of group VIII is a method of treating HIV infected blood which includes several blood manipulation steps which includes exposing plasma to ultraviolet light but is not specific to the use of a thin film and/or a hollow cylinder. Since the special technical feature of Group VII is not present in the Group VIII invention and the special technical feature of the Group VIII

invention is not in the Group VII invention, unity of invention is lacking.