

[72] Inventors **Ryoichi Naito;**
Osamu Yamaji, Osaka, Japan
 [21] Appl. No. **795,934**
 [22] Filed **Feb. 3, 1969**
 [45] Patented **Feb. 2, 1971**
 [73] Assignee **The Green Cross Corporation**
Osaka, Japan
a corporation of Japan
 [32] Priority **Oct. 3, 1968**
 [33] **Japan**
 [31] **43/86264**

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Primary Examiner—William I. Price
 Attorney—Christen, Sabol

[54] **APPARATUS FOR BLOOD PLASMA SEPARATION**
1 Claim, 14 Drawing Figs.

[52] U.S. Cl..... 233/26

[51] Int. Cl..... B04b 1/00,
 B04b 9/14

[50] Field of Search..... 233/1, 26,
 17, 27, 28

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ABSTRACT: An apparatus for centrifugally separating blood plasma from red blood cells, said apparatus being adapted for use with a blood bag set composed of a pair of mother bags and a daughter bag communicating therewith, said apparatus comprising a blood bag receiving box of generally inverted V-shape cross section having a pair of bottom plates hinged for upward movements, rotary drum, flywheel of larger inertia than that of the drum and a mechanism operable, after completion of blood plasma separation within said mother bags and after switching off of the power source of the apparatus, to upwardly urge the bottom plates of the blood bag box against the cover thereof by virtue of the difference in inertial rotation between the drum and the flywheel to thereby automatically squeeze the separated fluid of blood plasma out of the mother bags into the daughter bag.

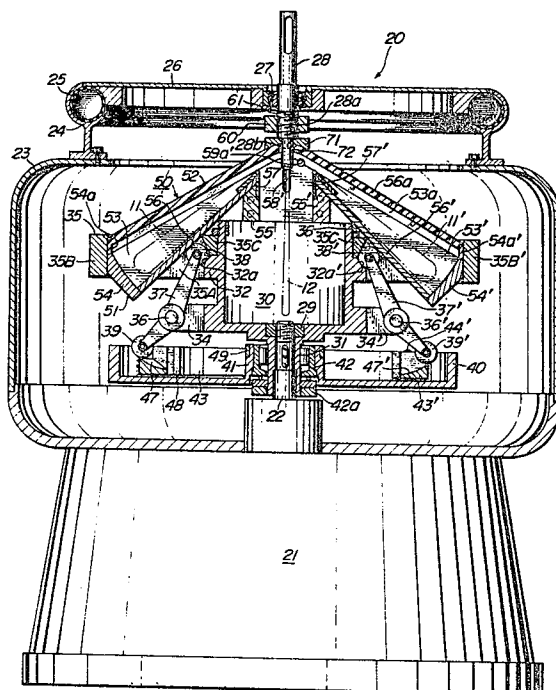


FIG. 1 PRIOR ART

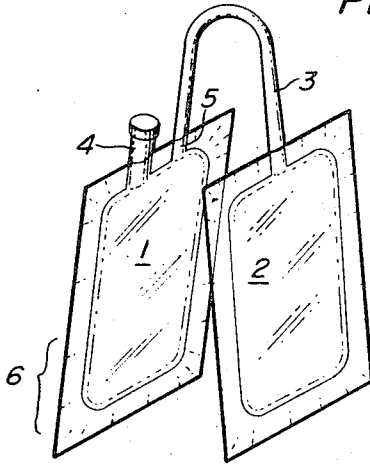


FIG. 2

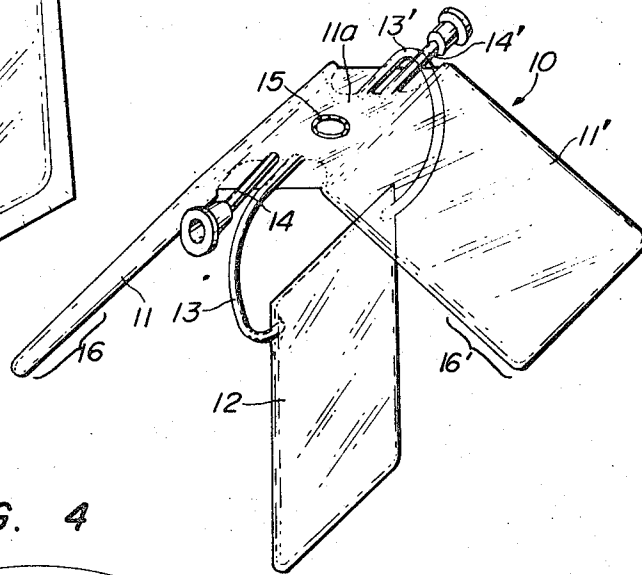


FIG. 4

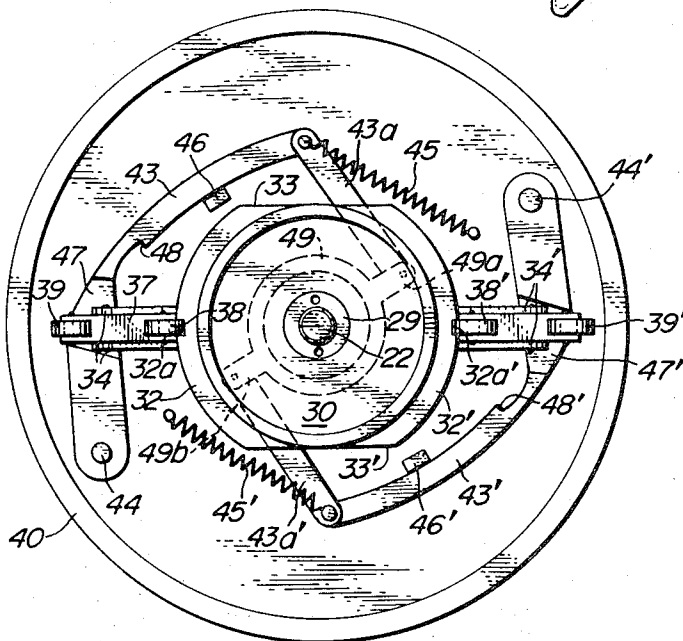
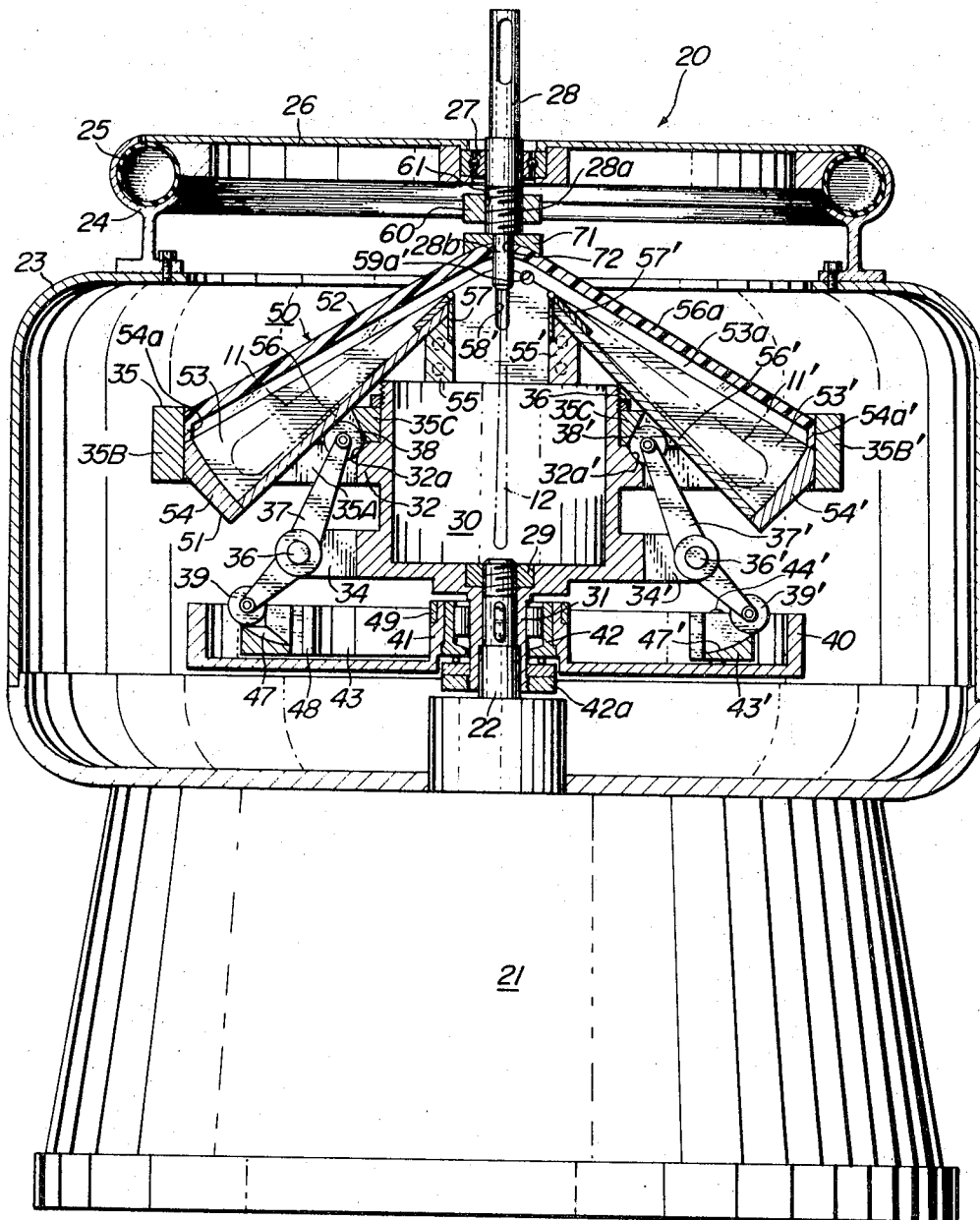


FIG. 3



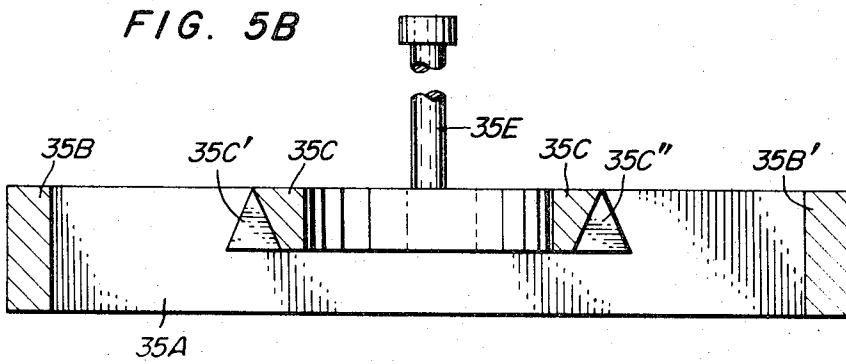
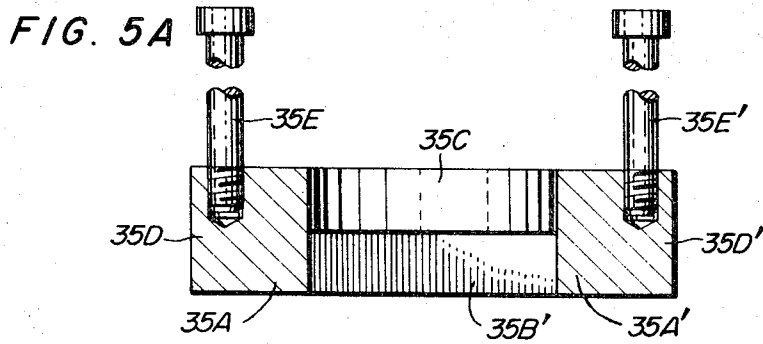
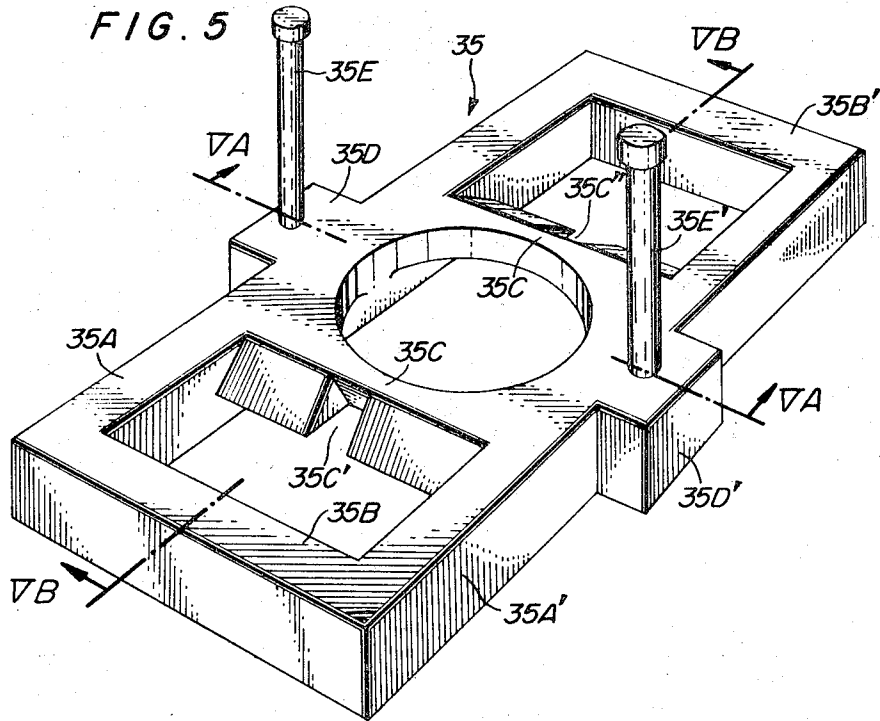


FIG. 6

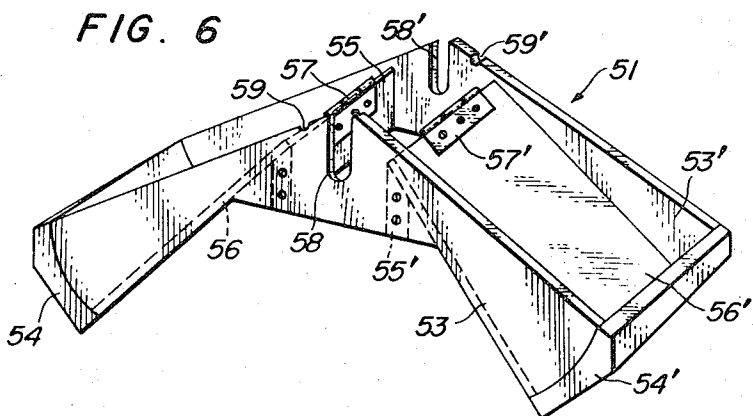


FIG. 7

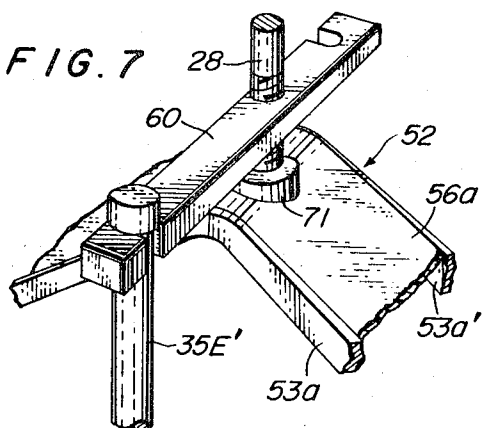


FIG. 8

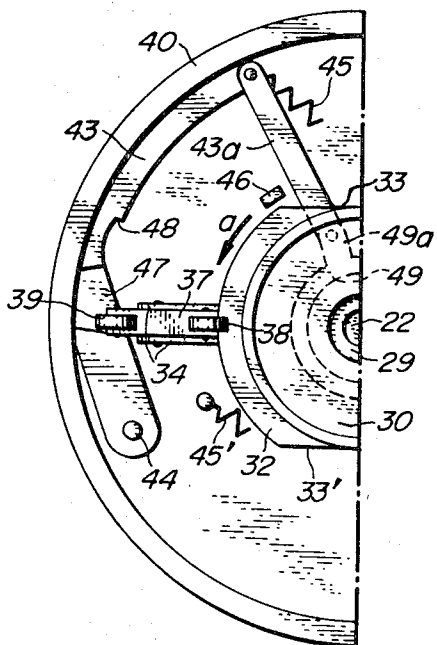


FIG. 9

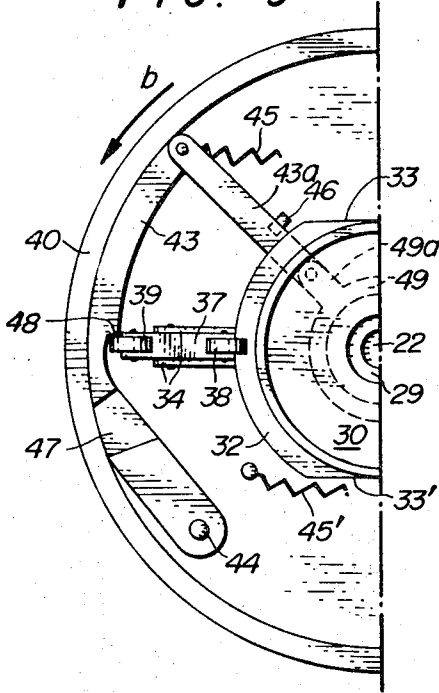


FIG. 11

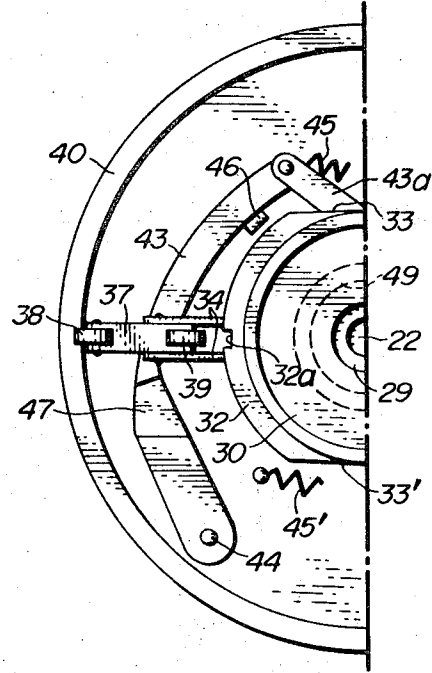


FIG. 10

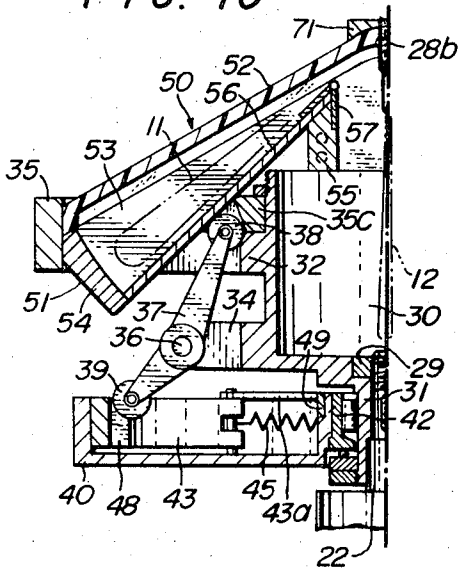
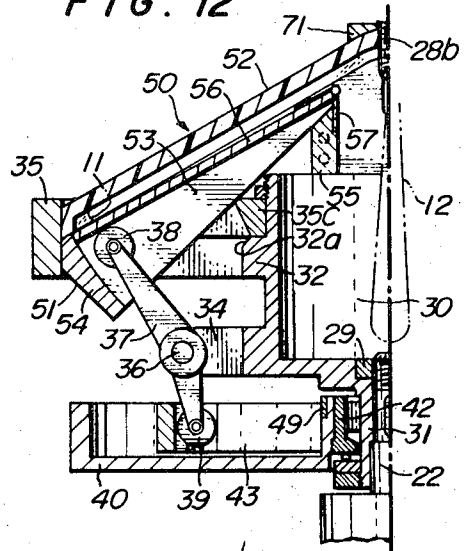


FIG. 12



APPARATUS FOR BLOOD PLASMA SEPARATION

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to an apparatus for blood plasma separation, and more particularly, to an apparatus for centrifugally separating blood into red blood cells and fluid of plasma.

Blood comprises corpuscles mostly of red blood cells and fluid of plasma rich in proteins. Once blood is taken out from the body, red blood cells hardly survive long, whereas plasma can be preserved for a long period of time and can further be fractionated and purified into several useful preparations according to the respective specific properties of each protein fraction. It is a well-known fact in physiology that plasma proteins are replenished in the body within a short time after blood donation but red blood cells require a rather long time for their reconstitution. From the viewpoint of donor's health, therefore, it is advisable that red blood cells be separated from liquid of plasma and returned back into the circulation of the donor.

The series of procedures; collection of blood from vein of a donor into a container with anticoagulant, separation of plasma, resuspension of red blood cells and giving back of the suspension into the vein of the donor, are called as "plasmapheresis" in this field and becoming commoner in practice.

For this reason, a variety of methods have already been developed for separation of blood plasma. They are roughly classified into following two categories:

1. A method using glass bottle; and
2. A method using flexible and soft blood bag.

1. Glass bottle method

A glass bottle of 500 ml. capacity and containing 10 percent aqueous sodium citrate solution is sterilized and used as a blood container for bleeding, into which blood is collected from the vein of a donor. After separation of red blood cells and plasma by means of centrifugal separator, the supernate is taken out through a fine tubing, leaving the packed red blood cells at the lower part of the bottle. Normal saline or other equivalent solution is added to suspend the red blood cells and return the suspension to the vein of the donor.

2. Flexible blood bag method

A blood bag such as one shown in FIG. 1 is usually used. The blood bag is made of polyvinyl chloride or other qualitatively equivalent material for flexibility of the bag. The bag is composed of a mother bag 1, a daughter bag 2 and a tubing 3 interconnecting them. The mother bag is added with an anticoagulant solution such as sodium citrate solution and is sterilized. Venous blood is collected in the mother bag through a short tubing 4 connecting a venous needle and the mother bag. The bag is then mounted on a centrifuge and rotated thereby with the tubing 3 collapsibly closed and with an outlet 5 disposed close to the rotatory shaft whereby most of the red blood cells are gathered at the bottom 6 of the mother bag. After the centrifugation and stop of the centrifuge, the mother bag is placed between and pressed with two hinged transparent boards for squeezing the plasma out of the mother bag through the outlet 5 and the tubing 3 into the daughter bag 2. The tubing is cut to separate the daughter bag containing the plasma from the mother bag. The latter is supplied with normal saline to suspend the packed red blood cells and reinfuse to the donor's vein. It is generally accepted that, as compared with the glass bottle method, this blood bag method maintains better sterility during the procedures in addition to its causing less damages to the red blood cells because of flexibility of bags and connection of a mother bag and a daughter bag through tubing.

Whichever method may be employed, 20 to 30 minutes are required for the procedures in which the blood collected from a donor is subjected to centrifugal separation of plasma by use of a centrifuge which has operative acceleration and deceleration

stages in rotational speed. Thus, the donor suffers from a mental pain in having a long wait and from a physical pain in holding a bleeding needle in the vein for a long time.

SUMMARY OF THE INVENTION

It is, therefore, a primary object of the present invention to provide an improved blood plasma separation apparatus which is designed to be used with a flexible blood bag set consisting of mother and daughter bags and containing blood collected from donors and which is operable to centrifugally separate the blood into red blood cells and fluid of plasma and, after switch-off of the power source of the apparatus, automatically press the mother bags for squeezing out the separated fluid of plasma therefrom during inertial rotation of the apparatus thereby to greatly shorten the time required for transfer of plasma.

According to the present invention, there is provided an apparatus for separating fluid of blood plasma from red blood cells, said apparatus being adapted for use with a blood bag set composed of a pair of mother bags and a daughter bag communicated therewith, said apparatus comprising a box of substantially inverted V-shape for receiving said blood bag set in such a manner that said mother bags extend outwardly downwardly in diametrically opposite directions and said daughter bag hangs down, said box having bottom plates hinged for upward movement, a main rotary body on which said box is mounted, a flywheel of larger inertia rotatably mounted onto said rotary body for free rotation within a predetermined range, substantially vertical levers pivotably connected to said rotary body and having their upper ends in contact with said bottom plates of said blood bag box, horizontal levers pivotably mounted at one ends onto said flywheel and having recesses therein, said vertical levers having their lower ends received in said recesses in said horizontal levers, respectively, tension springs connected to the other end of said horizontal levers for biasing same inwardly toward said rotary body, said horizontal levers having shoulders in the inner faces thereof next to said recesses toward said the other ends whereby, upon outward displacement of said horizontal levers due to centrifugal force, said lower ends of said vertical levers are brought into engagement with said shoulders of said horizontal levers.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and features of the present invention will be made apparent from the following description in conjunction with the accompanying drawings, and in which:

FIG. 1 schematically illustrates, in perspective view, a commonly used prior art blood bag set;

FIG. 2 is a view similar to FIG. 1 but illustrating a blood bag set according to the present invention;

FIG. 3 is a vertical sectional view of an embodiment of the blood plasma separation apparatus according to the present invention;

FIG. 4 is a plan view of a rotary section of the apparatus shown in FIG. 1 with a part removed away;

FIG. 5 is a perspective view of a frame for holding a blood bag receiving box;

FIG. 5A is a cross-sectional view taken along line VA-VA in FIG. 5;

FIG. 5B is a cross-sectional view taken along line VB-VB in FIG. 5;

FIG. 6 is a perspective view of the blood bag receiving box;

FIG. 7 is a fragmentary perspective view showing a cover of the blood bag receiving box in FIG. 6 and means for fastening the cover, with parts removed and cut away;

FIG. 8 illustrates in plan view engagement between vertical and horizontal levers;

FIG. 9 is a view similar to FIG. 8 but illustrating the levers in slightly different position;

FIG. 10 illustrates in vertical section the levers in the position shown in FIG. 9;

FIG. 11 is a view similar to FIG. 9 but illustrating the levers in further different position; and

FIG. 12 illustrates in vertical section the levers in the position shown in FIG. 11.

DESCRIPTION OF PREFERRED EMBODIMENT

Referring now to FIG. 2, the blood bag set according to the present invention is indicated generally at 10 and comprises a pair of mother bags 11, 11' communicating with each other through an intermediate or bridge portion 11a interconnecting the mother bags at their tops, a small daughter bag 12 disposed between the mother bags and a pair of tubings 13, 13' connecting the daughter bag 12 to the bridge portion 11a for communicating the interiors of the mother bags with that of the daughter bag. The mother bags 11, 11' are connected with short tubings 14, 14' adapted to be connected with bleeding needles through appropriate tubings, respectively. Formed centrally of the bridge portion 11a are openings in the top and the bottom walls of the bridge portion. The peripheral edges of the openings are heat-sealed together. A ring 15 is fitted to the sealed edge of the opening. The blood bag set 10 is made of polyvinyl chloride or the like material. Preferably, the material is transparent or semitransparent for enabling one to observe the interiors of the bags from the outside thereof. Also, the material is required to withstand a steam pressure sterilization at 121° C. for 30 minutes. The whole bag set is subjected to a heat sterilization after putting of an anticoagulant solution, such as aqueous solution of sodium citrate or heparin, of proper concentration into the mother bags. For collection of blood, all bags of a set are placed in a closed container, whose inner pressure is then reduced. A negative atmospheric pressure sucks the blood from the vein of a donor through a bleeding needle and one of the short tubings 14, 14' into the mother bags. During the bleeding, the tubings 13, 13' are pressed and closed with a clamp to prevent the blood from flowing into the daughter bag 12. The blood collected in the mother bags 11, 11' is well mixed with the anticoagulant solution and is divided equally into two masses to balance the mother bags.

A description will next be made, with reference to FIGS. 3 to 7, of a centrifugal machine according to the present invention and adapted to be used with the blood bag set 10 shown in FIG. 2. Referring first to FIG. 3, there is shown an embodiment of the centrifugal machine generally designated at 20. The machine includes a base 21 housing therein an electric motor (not shown) having its shaft 22 projecting upwardly. Onto the top of the base 21 is secured a generally cylindrical casing 23 having an open top. An annular fitting 24 is mounted by means of bolts and nuts on the casing 23 around the opening in the top thereof. Fitted to the annular fitting 24 is an annular shock-absorbing air-tube 25 over which is detachably mounted a cover 26 having a bearing 27 mounted in a central aperture in the cover. The bearing 27 is adapted for rotatably receiving therein a shaft 28 for the purpose which will be described later.

Within the casing 23 is disposed a bottomed drum 30 having a boss 31 extending downwardly from the bottom through which the motor shaft 22 extends upwardly into the interior of the drum. The latter is fastened to the motor shaft by means of a nut 29. The drum 30 has, at the intermediate portion of the height, a radially outwardly projecting annular flange which is cut at diametrically opposite sides to form two substantially arcuate flanges 32, 32' and two straight and parallel surface 33, 33' as shown in FIG. 4. The distance from the center of the drum 30 to each of the surfaces 33, 33' is the same as the outer radius of the drum as measured at the portion just above the flanges 32, 32'. The drum 30 is also provided with two pairs of radial projections 34 and 34'. The arcuate flanges are respectively formed, at central portions, with notches 32a, 32'a having their bottoms extending outwardly downwardly, the center of the notch in each of the flanges 32, 32' being in vertical alignment with the center of each pair of the radial projections.

A substantially rectangular frame 35 is secured to the drum 30 by means of a ring 36 threadably engaging the upper portion of the drum. More specifically, the frame 35 includes two longitudinal bars 35A, 35A', lateral bars 35B, 35B' interconnecting the bars 35A, 35A' at the opposite ends thereof and a lateral bridge 35C interconnecting the longitudinal bars at the central portion of the frame 35 as best seen in FIG. 5. The bridge 35C is coplanar at the top surface, with the top surfaces of the bars 35A, 35A', 35B, 35B' but is substantially one half in thickness the bars, as shown in FIGS. 5-A and 5-B. The bridge 35C is formed therein with an annular opening whose diameter is the same as the distance between the inner surfaces of the longitudinal bars 35A, 35A', which distance is, in turn, the same as or slightly larger than the diameter of the drum 30 as measured at the portion just above the flanges 32, 32'. It will, thus, be apparent that, when the frame 35 is mounted over the drum 30, the annular opening in the bridge 35C of the frame 35 snugly receives the upper portion of the drum with the bottom surface of the bridge in contact with the upper shoulders of the arcuate flanges 32, 32' and with the inner surfaces of the frame bars 35A, 35A' at longitudinally intermediate portions of the surfaces tightly contacting the opposite parallel surfaces 33, 33' of the drum 30. When the ring 36 is fastened downwardly on the drum 30, therefore, the frame 35 is rigidly connected to the drum for rotation therewith.

The frame 35 further includes a pair of ears 35D, 35D' connected to the outer surfaces of the longitudinal bars 35A, 35A' centrally thereof. Studs 35E, 35E' having enlarged heads are rigidly planted in the ears 35D, 35D' for the purpose described later. In addition, the bridge 35C of the frame 35 has downwardly outwardly inclined outer surfaces and is also provided with a pair of notches 35C', 35C'' in the inclined outer surfaces centrally thereof, respectively. The bottom surfaces of the notches 35C', 35C'' incline downwardly inwardly, as best seen in FIG. 5-B. Thus, it will be appreciated that, when the frame 35 is mounted in position on the drum 30, one of the notches in the arcuate flanges 32, 32' and one of the notches 35C', 35C'' in the frame bridge 35C are in vertical alignment and the inclined bottom surfaces of the vertically aligned notches cooperate to define two recesses in the combined drum 30 and frame 35 for the purpose described hereinafter.

The pairs of projections 34, 34' have pins 36, 36', respectively, on which two-armed generally vertical levers 37, 37' are pivotably mounted at substantially intermediate points of their lengths. The levers 37, 37' are respectively provided with rollers 38, 38' at their upper ends. The length of each of the lever 37, 37' between its pivotal axis and the upper end is dimensioned such that the upper roller 38 or 38' is received by and rests in the recess defined by the inclined bottom surfaces of the notches in the arcuate flange 32 or 32' and in the bridge 35C of the frame 35.

A flywheel 40 is mounted around the boss 31 of the drum 30. Specifically, the wheel 40 has a central boss 41 which extends upwardly from the bottom of the wheel 40 and which surrounds a unit of rotary and thrust bearing 42 disposed around the drum boss 31. A nut 42a is disposed around the drum boss 31 under the bearing unit 42 for rotatably supporting the flywheel assembly on the drum 30.

A pair of elongated arcuate horizontal levers 43, 43' are disposed radially outwardly of the vertical levers 37, 37', respectively, and have their one ends pivotally connected by means of pins 44, 44' on the bottom of the flywheel 40 adjacent the upstanding peripheral wall thereof. The other end of each horizontal lever is connected with a tension spring 45 or 45' anchored on the flywheel bottom on the point substantially diametrically opposite to the pivotal axis of the horizontal lever so as to pivotally move the free end thereof inwardly toward the drum 30 about the pin 44, 44'. Stops 46, 46' are provided on the flywheel bottom adjacent the free or forward ends of the horizontal levers 43, 43' for preventing the free ends of the horizontal levers beyond a predetermined range. The horizontal levers are formed with recesses 47, 47' of sub-

stantial width and having inwardly downwardly inclined bottom surfaces for receiving lower rollers 39, 39' of the vertical levers 37, 37'. Each of the horizontal levers is thinned at the portion next to the recess 47 or 47' and then widened or enlarged to form a step or shoulder 48 or 48' with which the lower roller 39 or 39' of corresponding vertical lever is brought into engagement when the horizontal levers are moved outwardly against the tension springs 45, 45' by centrifugal force. It will thus be noted that the horizontal levers rotate with the flywheel about the rotational axis thereof relative to the vertical levers as will be described in detail hereinafter. Rotatably mounted around the flywheel boss 41 is a ring 49 having diametrically opposing projections 49a, 49b which are linked to the free ends of the horizontal levers 43, 43', respectively, by means of link rods 50, 50' whereby the pairs of horizontal levers are controlled to have equalized movements.

Disposed over the drum 30 is a blood bag receiving box or container generally designated at 50 in FIG. 3. The box 50 has generally rooflike or inverted V-shape cross section and is composed of a body 51 and a cover 52. As will be seen in FIG. 6, the body 51 of the blood bag box 50 has opposite side plates or walls 53, 53' of generally inverted V-shape and generally rectangular opposite end walls 54, 54' interconnecting the opposite sidewalls at their opposite ends. Disposed between the opposite sidewalls 53, 53' are spaced intermediate plates 55, 55' of substantial thickness for interconnecting the sidewalls at their intermediate portions. The intermediate plates have outwardly downwardly inclined upper surfaces and horizontal bottom surfaces. A pair of bottom plates 56, 56' are connected to the intermediate plates 55, 55' respectively by means of hinge means 57, 57' for upward swinging movements. The inner surfaces of the end plates 54, 54' are arcuate for this purpose. The sidewalls 53, 53' are formed with larger notches 58, 58' at the top apices and small notches 59, 59' adjacent the notches 58, 58', respectively, for the purpose which will become apparent later. The sidewalls have their horizontal bottom edges in the plane in which the bottom surfaces of the intermediate plates 55, 55' extend. The horizontal bottom edges of the sidewalls 53, 53' have the dimension the same as or slightly larger than the outer diameter of the drum 30 as measured on the top thereof. Furthermore, each of the end walls 54, 54' is partly cut so as to form a vertical plane, the distance between the vertical planes in the opposite end plates 54, 54' being the same as or slightly smaller than the distance between the inner surfaces of the lateral bars 35B, 35B' in the frame 35. It will, thus, be appreciated that, when the blood bag box body 51 is disposed over the drum 30, the bottom surfaces of the intermediate plates 55, 55' are supported by the top of the drum 30 and the vertical planes in the end plates 54, 54' of the box body 51 tightly contact the inner surfaces of the lateral bars 35B, 35B' of the frame 35, with the bottom plates 56, 56' of the box 50 being in contact with and supported by the inclined surfaces of the bridge 35C of the frame 35 and the upper roller 38, 38' of the vertical levers 37, 37'. The side plates 53, 53' of the body 51 of the box 50 are shaped such that, vertical planes in the end plates 54, 54' engage the inner surfaces of the lateral bars 35B, 35B' in the lower halves thereof.

The cover 52 of apparent blood bag container 50 is dimensioned and shaped to match the size and configuration of the body portion 51 of the container and has a pair of parallel side plates 53a, 53a' as seen in FIG. 7, a pair of vertical end walls 54a, 54a' as seen in FIG. 3 and a top plate 56a of a single piece structure. In the illustrated embodiment, the end walls 54a, 54a' and the top plate 56a are formed integrally, but they may be formed separately. A disc 71 is rigidly secured to the top plate 56a on the apex and centrally thereof. A hole 72 is formed through the plate 71 and the top plate 56a. Each of the side plates 53a, 53a' is formed with a semicircular notch 59a, 59a' (only the notch 59a' is shown in FIG. 3) at a location corresponding to that of the notch 59 or 59' in each of the side plates 53, 53' of the body 51. It will, therefore, be apparent

that, when the cover 52 is mounted over the body 51 in the machine 20, the side plates 53a, 53a' and end walls 54a, 54a' of the cover snugly ride on the corresponding parts in the container body 51 with the outer surfaces of the end walls and a part of the outer surfaces of the side plates in close contact with the inner surfaces of the lateral bars 35B, 35B' of the frame 35 in the remaining upper halves of the bar surfaces. It will also be apparent that, in this position of the box 50, the two pairs of notches 59 and 59a: 59' and 59a' define two annular openings, one of which is seen in FIG. 3.

A rod 60, having notches in the opposite sides adjacent the opposite ends thereof, spans the studs 35E, 35E' above the cover 52 of the blood bag 50 with said notches receiving therein the shanks of the studs 35E, 35E', as will be seen in FIG. 7. As will be seen in FIG. 3, the rod 60 is formed, at the intermediate portion, with a threaded hole 61 with which the above-mentioned shaft 28 engages at its threaded portion 28a. The shaft 28 further has a reduced lower portion 28b extending downwardly from the threaded portion 28a into the interior of the blood bag box 50 through a hole 72 in the disc 71 on the top plate 56a of the cover 52. Thus, it will be noted that the shaft 28 has a downwardly facing annular shoulder which engages the top surface of the disc 71. It will be further noted that, when the shaft 28 is rotated in one of the directions, it is moved down relative to the rod 60 to press the disc 71 downwardly for rigidly holding the cover 52 of the box 50 against upward separation from the body portion 51 of the box. In this state, the upper surface of the rod 60 is urged against the under surfaces of the enlarged heads of the studs 35E, 35E'.

A description will be made hereunder of the operation of the above-described centrifugal machine.

When it is desired to place the blood bag set 10 in the centrifugal machine 20, the shaft 28 is loosened to disengage the rod 60 from the studs 35E, 35E' and to remove the rod 60 together with the cover 26 from the machine. Then, the cover 52 of the blood bag box 50 is lifted away from the body 51 of the box and from the supporting frame 35. Then, the above-described blood bag set 10 is placed in the box 50 in such a manner that the mother bags 11, 11' extends downwardly and outwardly along the bottom plates 56, 56' of the box body 51, respectively, with the short tubings 14, 14' received in the notches 59, 59' in the box side plates 53, 53' and extending therethrough into the exterior of the box 50, respectively, and that the daughter bag 12 extends downwardly into the interior of the drum 30, with the curved portions of the connecting tubes 13, 13' received in the notches 58, 58' in the side plates 53, 53'. In this position of the blood bags, the clips on the connecting tubings 13, 13' are removed so as to provide communication between the interiors of the mother and daughter bags. The cover 52 is then placed over the box body 51 and is fastened by means of the shaft 28, the rod 60 and the pair of studs 35E, 35E' in the manner as described in the above. It will be noted that, when the shaft 28 is screwed down, the reduced diameter lower end 28b of the shaft 28 extends through the ring 15 on the blood bag set 10 contained in the box 50.

Upon completion of the above preparation, the motor of the machine is switched on to rotate its shaft 22 and thus the drum 30 connected thereto. The rotation of the drum is transmitted by the frame 32 mounted thereon to the blood bag box 50 and thus to the blood bag set 10 contained in the box with the mother bags 11, 11' held in inclined state. The machine is operated at 2,000 to 3,000 r.p.m. The blood in the mother bags is, thus, subjected to centrifugal force by which the red blood cells are gradually moved down and collected in the bottom portions 16, 16' of the mother bags 11, 11' whereas the fluid of the blood plasma is gathered in the upper portions of the bags due to the difference in specific gravity between the red blood cell and the plasma.

At the start of the operation of the centrifugal machine, each of the horizontal levers 43, 43' are in their innermost positions in which they are held in contact with the stops 46,

46' by the tension springs 45, 45', respectively, and in which the lower rollers 39, 39' of the vertical levers 37, 37' are positioned on the radially outer edges of the recesses 47, 47' in the levers 43, 43', respectively, as seen in FIG. 4. The rotation of the drum 30 indicated by an arrow *a* in FIG. 8 causes the vertical levers to urge, at the lower ends, the horizontal levers in counterclockwise direction, which in turn rotates the flywheel 40 in the same direction. As the rotational speed of the drum 30 increases, the horizontal levers 43, 43' are moved outwardly against the springs 45, 45' by the centrifugal force, whereas the lower rollers 39, 39' remain engaging the recesses 47, 47' even at high speed rotation (FIG. 8).

After a predetermined period of time known from experience as being sufficient for the red blood cells to be completely separated out from the liquid of blood plasma, the motor is switched off. The machine continues rotating due to inertia in such a manner that the rotational speed is gradually reduced by the resistances of air and friction generated between mechanical elements. However, the flywheel 40 has a greater inertia and, thus, has a smaller deceleration as compared with those of the rotary drum 30. This produces a relative rotation between the flywheel and the drum. Namely, the rotary drum becomes to have a lower speed than that of the flywheel, so that the rollers 39, 39' are disengaged from their recesses 47, 47' in the horizontal levers 43, 43' down into inside of the latter and are brought into engagement with the shoulders 48, 48' of the levers as shown in FIGS. 9 and 10. Thereafter, the inertial rotation of the flywheel as indicated by an arrow *b* in FIG. 9 is transmitted through the horizontal and vertical levers 43, 43'; 37, 37' to the drum 30 for rotating the latter together with the flywheel.

The speed of the flywheel is slowed down in a while and the centrifugal force in the horizontal levers are reduced so that the springs 45, 45' bias the free ends of the levers inwardly. These inward movements of the horizontal levers urge the lower rollers 39, 39' of the vertical levers 37, 37' inwardly to cause them to rotate about their pivotal axes or pins 36, 36' whereupon the upper rollers 38, 38' of the vertical levers upwardly urge the bottom plates 56, 56' of the blood bag box 50 to press the mother bags 11, 11' between the bottom plates and the top plate 56a of the box 50. Thus, the fluid of blood plasma is squeezed out of the mother bags 11, 11' through tubings 13, 13' into the daughter bag 12. The arrangement of the above structural elements is such that, when the horizontal levers 43, 43' are moved to their innermost positions in which they contact their stops 46, 46' almost all of the liquid of blood plasma are removed from the mother bags 11, 11' into the daughter bag 12 leaving the red blood cells with the mother bags.

At about a time the blood plasma separation is completed, the flywheel stops its rotation. Then, the cover 52 of the blood bag box 50 is removed in the above-described manner to

replace the blood bag set 10 from the machine. The lower rollers 39, 39' of the vertical levers 37, 37' are manually shifted from the shoulders 48, 48' of the horizontal levers 43, 43' into the recesses 47, 47' therein for the next operation.

Thus, it will be appreciated that, with the apparatus of the present invention, blood plasma separation is completed during the period from the time the motor of the centrifugal machine is switched off to the time the rotation of the machine stops.

The present invention has been described with reference to a preferred embodiment. It is to be understood that the embodiment above described is only for illustrative purpose and the present invention may have various modifications and changes within the scope and spirit of the invention which is defined by the appended claims. For example, the set of blood bag 10 in FIG. 1 may be provided with a pair of additional tubings each interconnecting the mother bags 11 and 11' at their lower ends for balancing the quantities of the blood contained therein during initial stage of centrifugal operation. In addition, the casing 23 in FIG. 3 may be provided around the cylindrical wall thereof with a circular jacket through which cooling liquid, such as ethyleneglycol, of a temperature ranging from 2 to -3° C. may be circulated for maintaining the temperature in the casing and thus of the blood in the blood bags in the casing lower than about 10° C. during centrifugal separation of the blood.

We claim:

1. An apparatus for separating fluid of blood plasma from red blood cells, said apparatus being adapted for use with a blood bag set composed of a pair of mother bags and a daughter bag communicated therewith, said apparatus comprising a box of substantially inverted V-shape for receiving said blood bag set in such a manner that said mother bags extend outwardly downwardly in diametrically opposite directions and said daughter bag hangs down, said box having bottom plates hinged for upward movement, a main rotary body on which said box is mounted, a flywheel of larger inertia rotatably mounted onto said rotary body for free rotation within a predetermined range, substantially vertical levers pivotably connected to said rotary body and having their upper ends in contact with said bottom plates of said blood bag box horizontal levers pivotably mounted at one ends onto said flywheel and having recesses therein, said vertical levers having their lower ends received in said recesses in said horizontal levers, respectively, tension springs connected to the other end of said horizontal levers for biasing same inwardly toward said rotary body, said horizontal levers having shoulders in the inner faces thereof next to said recesses toward said the other ends whereby, upon outward displacements of said horizontal levers due to centrifugal force, said lower ends of said vertical levers are brought into engagements with said shoulders of said horizontal levers.

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