Oct. 29, 1968 V. G. LUCAS 3,407,812

METHOD FOR PERFORMING PLASMAPHERESIS IN SITU

Filed Nov. 9, 1965 2 Sheets-Sheet 1

FIG. 1

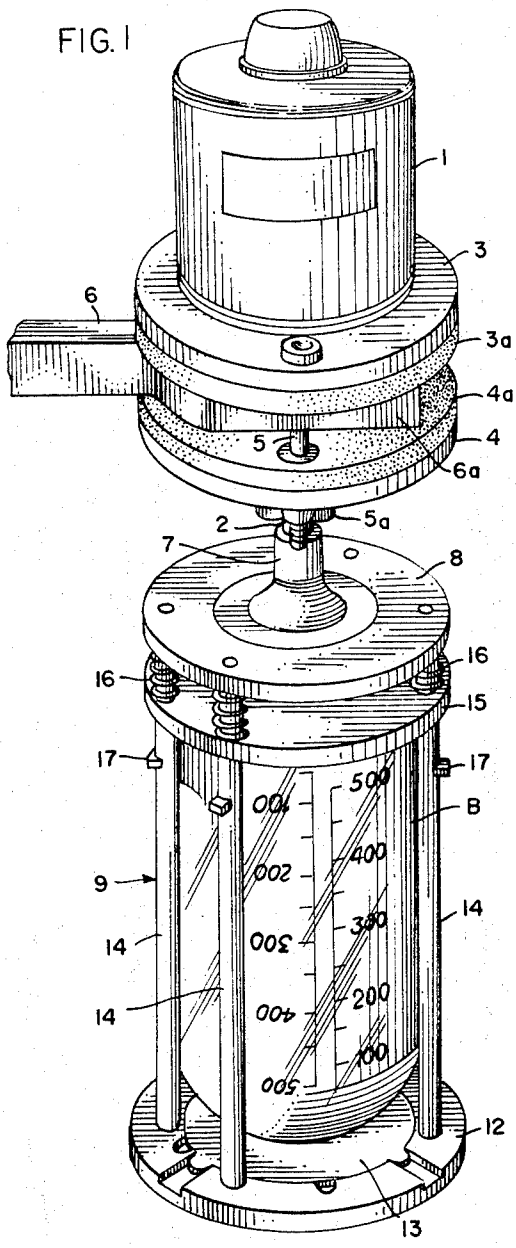


FIG. 2

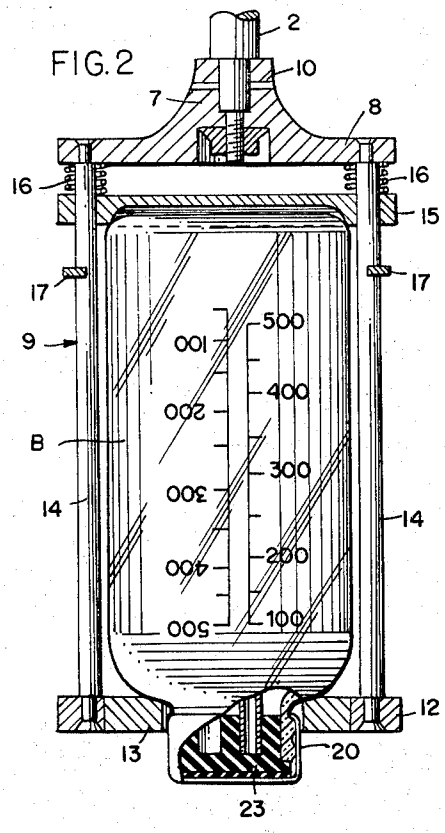


FIG. 6

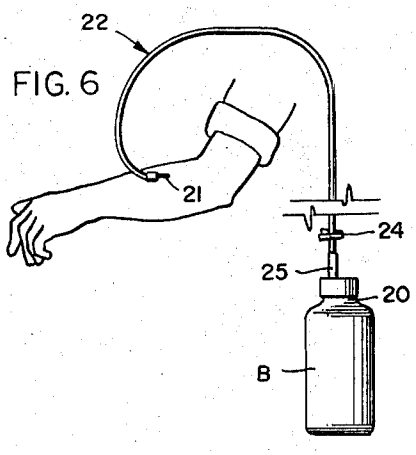


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FIG. 7

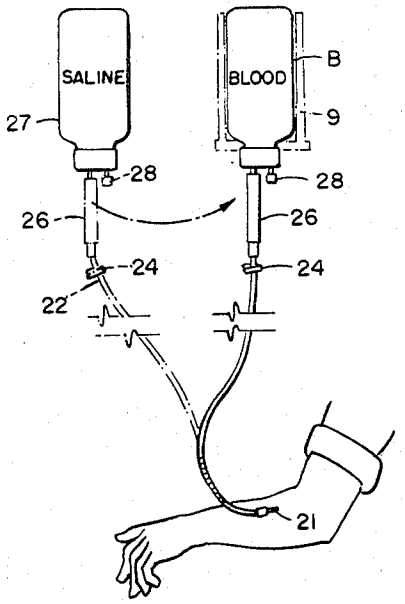



FIG. 3

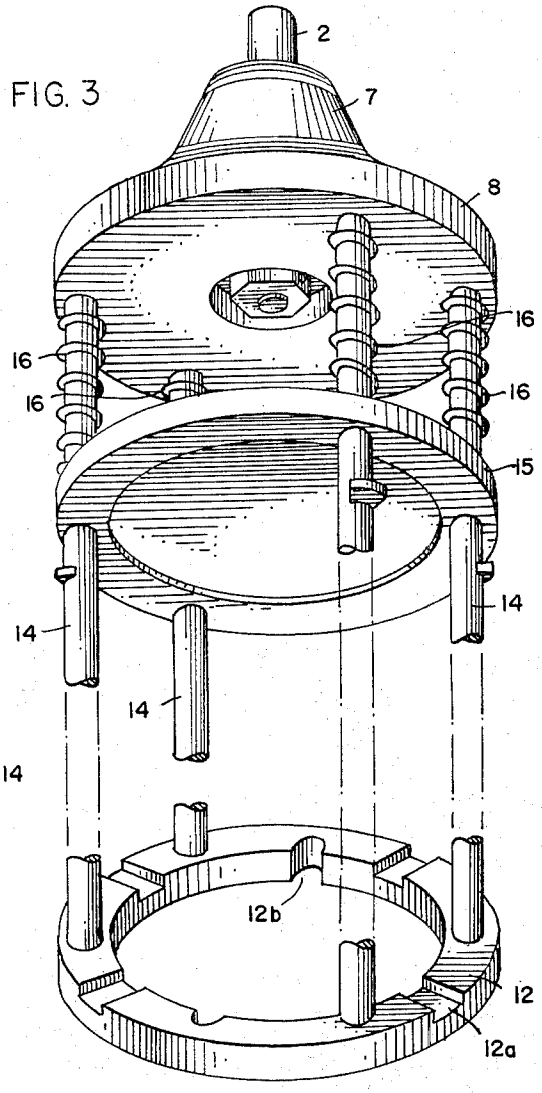



FIG. 4

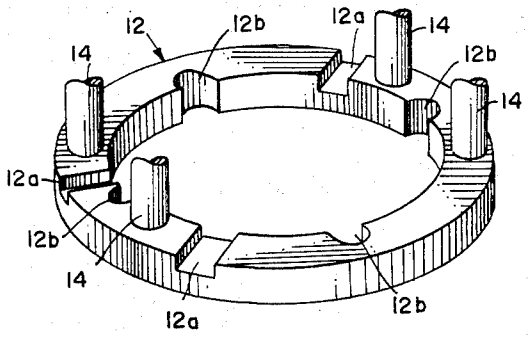
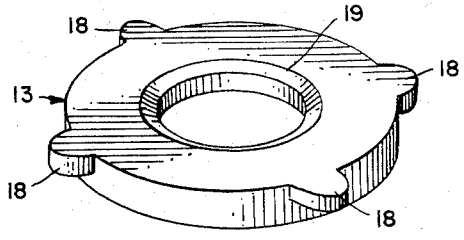



FIG. 5

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# METHOD FOR PERFORMING PLASMAPHERESIS IN SITU

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7 Claims. (Cl. 128—214)

## ABSTRACT OF THE DISCLOSURE

A method and apparatus for practicing plasmapheresis in situ, in which a donor's vein is first punctured with the needle of a conventional blood collection set and a predetermined quantity of the donor's blood is collected in the chamber of a container, such as a standard blood bottle, which has a tapered neck zone. The set is then detached from the bottle without withdrawing the needle from the donor's vein and the collected blood is immediately centrifuged in the same chamber, with the neck zone thereof facing downwardly, until the red cells migrate peripherally and displace the plasma towards the center of the chamber. The centrifugation is then gradually discontinued and the bottle is maintained in inverted stationary position until the peripherally-migrated red cells have settled into the neck zone of the chamber. Finally, with the stationary bottle still in inverted position, the original blood collection set, the needle of which still communicates with the donor's vein, is connected to the bottle at the neck zone to draw off the red cells collected in the lower portion of the chamber and to return them to the donor through the same needle, thereby retaining the separated plasma in the chamber of the bottle.

This invention relates to plasmapheresis, and more specifically, to a method for performing plasmapheresis in situ.

In the past, whenever it has been desired to obtain human plasma by plasmapheresis, blood has first been withdrawn from the donor and has then been transmitted to a laboratory where it has been centrifuged to obtain separation of plasma from the red cells. Such a procedure has been characterized by the following disadvantages:

(1) The donor must suffer venipuncture twice; first for withdrawal of blood, and second, for reinjection of the red cells separated from his own blood, the re-injection of such cells serving to speed the process of recuperation so that more frequent donations may be feasible.

(2) Centrifugation of blood in the laboratory requires a detailed control in order to avoid mistakes that may produce shock in the donor if red cells from another person are administered to him.

(3) Repeated handling of the blood and its passage from one container to another, as well as recuperation of the red cells for re-injection, amount to a series of operations which require considerable time and increase the danger of infections and mistakes.

Accordingly, it is an object of the present invention to provide a method for performing plasmapheresis in situ, thereby overcoming many of the important disadvantages and dangers in plasmapheresis as it is now practiced. Specifically, it is an object to provide a method for practicing plasmapheresis in situ, thereby achieving important advantages in safety, asepsis and speed, to insure success with the least possible inconvenience and danger to the donor.

Another object is to provide a method in which withdrawal of blood, and the centrifugation of such blood, are both carried out in the same container. In this connection, it is a specific object to provide a method in which centrifugation is achieved by rotating the collection bottle on its own axis. A further object is to provide a method in which a blood collection bottle is not only utilized directly in the centrifugation process, but is supported in such a way that re-injection of the red blood cells is greatly facilitated.



Other objects and advantages will be apparent from the specification and drawings, in which:

FIGURE 1 is a perspective view of the complete apparatus embodying the present invention, such apparatus including an electric motor elastically suspended, and a carriage stand mounted for rotation by the motor and adapted to contain a collection bottle in inverted position.

FIGURE 2 is a longitudinal sectional view of the carriage stand.

FIGURE 3 is an exploded perspective view illustrating structural details of the stand.

FIGURE 4 is a broken perspective view of the lower portion of the bottle retainer showing the lower retaining ring.

FIGURE 5 is a perspective view of a disk adapted to be mounted in the retainer's lower retaining ring.

FIGURE 6 is a view in reduced scale illustrating a first step in practicing the method of the present invention.

FIGURE 7 is another view in reduced scale illustrating subsequent steps in practicing such method.

Referring specifically to the drawings, I will now describe in detail the construction and functional characteristics of the apparatus, and the steps of the method, which permit practicing human plasmapheresis in the same place where blood is collected and which also allows immediate re-injection to the donor of his own red cells.

The apparatus shown in FIGURE 1 comprises an electric motor **1** disposed vertically with its shaft **2** projecting downwardly. At the lower end of the motor housing is a horizontal plate or clamping member **3** which is provided along its underside with a resilient pad or cushion **3***a*. A second clamping member **4**, provided along its upper surface with a similar pad or cushion **4***a*, is spaced beneath member **3** and is detachably connected thereto by vertical bolts **5** or by any other suitable connecting means. By rotating wing nuts **5***a*, the distance between plates **3** and **4** may be reduced or increased to either clamp or release a supporting arm **6** having a Y-shaped end portion **6***a* disposed between the plates. The opposite end of the arm is firmly secured to a standard (not shown) or other appropriate stationary support means.

Motor shaft **2** extends downwardly through apertures in both clamping plates and is connected at its lower end to an adaptation neck **7** which constitutes a union between the shaft and the upper plate **8** of a bottle retainer or support **9**. A pin **10** (FIGURE 2) extends through the lowermost end of the shaft and securely anchors the motor shaft and plate **8** for simultaneous rotation.

A collection bottle B, into which blood withdrawn from a donor is collected and in which centrifugation is thereafter immediately performed, is disposed in inverted position within the cage-like retainer **9**. As shown in the drawings, retainer **9** comprises the upper disk **8**, lower retaining ring **12** and disk **13**, and parallel columns **14** extending between the upper disk **8** and the lower ring-disk assembly **12–13**. The four columns are arranged in uniformly and circumferentially spaced relation. On the columns, another disk or plate **15** is slidably mounted and bears against the bottom of inverted bottle B. Disk **15** is urged downwardly by helicoidal expansion springs **16** concentrically mounted on the columns and interposed between upper plate **8** and disk **15**. The extent of spring expansion is limited by lugs **17** connected to the respective columns. Lugs **17** therefore serve as stops to

limit the extent of downward movement of disk **15** under the influence of springs **16**.

Lower ring **12** is provided on its upper surface with a plurality of uniformly and circumferentially spaced notches or recesses **12***a*. In addition, the inner surface of the ring is provided with a like number of recesses or openings **12***b*, such recesses being uniformly spaced from each other and preferably being disposed substantially equal distances circumferentially between notches **12***a*. Disk **13** is adapted to fit within the large central opening of ring **12** and, as shown clearly in FIGURE 5, has a plurality of uniformly and circumferentially spaced ears **18**. The ears project outwardly and are of semi-circular shape, as are the recesses or openings **12***b* of ring **12**, and the two parts (disk **13** and ring **12**) are so mated that the disk may be moved upwardly into the large central opening of the ring with its ears **18** slidably received within openings or recesses **12***b*. Disk **13** is also provided with a central opening **19** for receiving the neck **20** of bottle B.

It is to be noted that the diameter of the large central opening of ring **12** is greater than the diameter of bottle B. Therefore, the bottle may be introduced into the cage-like retainer by inserting it upwardly in inverted position until its base engages the undersurface of spring-loaded plate **15**. Disk **13** is fitted onto the inverted neck of the bottle, and the plate and bottle are then urged upwardly to compress springs **16** and to permit the ears **18** of the disk to pass upwardly through openings **12***b*. Thereafter, disk **13** is rotated until ears **18** seat within notches or recesses **12***a*. The weight of the bottle B, combined with the downward force exerted by springs **16**, hold the ears **18** in position within recesses **12***a* during the centrifugation step.

It will be observed that when the apparatus is assembled as shown in FIGURE 1, stationary arm **6** supports the unit at a point or zone between motor **1** and bottle retainer **9**. This arrangement, coupled with the cushioning effect of padded clamping members **3** and **4**, substantially eliminates or dampens vibrations which might otherwise occur during centrifugation. As will be brought out later, it is important that vibrations which might produce turbulence of blood during centrifugation, and during the gradual reduction in rotational speed of the retainer following a period of centrifugation, be avoided.

Preferably, the motor is constructed to rotate shaft **2** and retainer **9** at a speed of between 1500 to 3000 revolutions per minute. It is imperative that the motor be constructed and arranged, or controlled in its operation, so that deceleration of the retainer **9** and the blood-containing bottle B, following a period of centrifugation, occur gradually over an interval in excess of 3 minutes. Such gradual deceleration is necessary to prevent turbulence in the blood and to permit a substantially complete separation of plasma and red cells. The gradual and uniform deceleration may be easily achieved by constructing the rotating parts to spin with minimum friction and also to possess, by virtue of their mass, sufficient momentum to spin for a period in excess of 3 minutes and preferably for a period in excess of 4 minutes, after the electric motor has been deenergized. In practice, a deceleration period in the range of 4 to 10 minutes, with an optimum period of approximately 7 to 8 minutes, has been found particularly effective. Periods in excess of 10 minutes are not desirable because they unduly extend the plasmapheresis procedure without any appreciable increase in the degree of red cell and plasma separation.

While gradual deceleration may be achieved as described above, it is to be understood that similar results may be obtained with rotating parts having greater friction and less mass by simply gradually reducing the electric power supplied to the motor over an interval in excess of 3 minutes and, preferably, in excess of 4 minutes.

To practice plasmapheresis in situ, using the apparatus just described, venipuncture is first performed with the needle **21** of a conventional blood collection set **22**, and then collecting the blood in a sterile, partially-evacuated bottle B (FIGURE 6). Bottle B is a standard blood-collection bottle, having its neck **20** closed with a self-sealing rubber stopper **23**. Blood flows through the collection set into the bottle and, after a predetermined amount of blood (normally 500 cc.) has been collected, standard clamp **24** is manipulated to close the blood-collection tube and the filling needle **25** is withdrawn from the self-sealing stopper **23** and, as indicated in broken lines in FIGURE 7, is inserted into the drip tube assembly **26** connected to a suspended bottle **27** containing sterile physiological saline. The sterile saline is allowed to flow along the tube **22** which connects to the donor's vein. This allows (1) some degree of replenishment of the total fluid lost by the donor during the withdrawal of blood and (2) the maintenance of patency of the needle which was previously inserted into the donor's vein and which has not been removed therefrom. Failure to maintain a slow flow of physiologically compatible liquid through this needle would result in the formation of a clot within the needle.

Blood bottle B is entirely conventional and contains standard amounts of an approved anti-coagulant substance such as, for example, citrate, heparin, or EDTA.

After the filling needle **25** has been removed from the self-sealing stopper of the blood bottle, the substantially filled bottle is placed within retainer **9**, in the position shown in FIGURES 1 and 2, and motor **1** is energized to centrifuge the collected blood for a period of 15 to 20 minutes, including deceleration time. Centrifugation causes the red cells to migrate outwardly against the inside wall surface of the bottle, thereby separating the cells from the plasma which remains in the bottle's axial zone. Following centrifugation, the bottle is allowed to remain undisturbed in the stationary retainer **9** for a further period of 1 to 3 minutes, at which time the red cells which have been driven to the wall of the bottle during centrifugation slide downwardly and occupy the lower portion of the inverted bottle.

As indicated by the solid lines in FIGURE 7, a typical airway needle **28** is then inserted into self-sealing stopper **23** and into communication with the air tube (not shown) within the blood bottle. Thereafter, drip tube assembly **26** is withdrawn from the stopper of the saline bottle **27** and the needle of that assembly is inserted into the stopper of the inverted blood bottle. The contents of the bottle are allowed to flow through the tube system **22** into the donor's vein until exactly half the contents of the blood bottle (approximately 250 cc.) have been so administered. The administration procedure is then discontinued by closing clamp **24**, and needle **21** is withdrawn from the donor's vein.

The residual contents of the blood bottle will consist of plasma contaminated by a certain small proportion of red cells. In practice, this contamination amounts to between 2 to 5% of the 250 cc. residual volume. The contaminating red cells are subsequently removed from the plasma by the use of a conventional centrifuge. This degree of red cell loss is quite insignificant and is considered to be small enough to permit a healthy individual to be subjected to the plasmapheresis procedure disclosed herein several times in a week.

It will be noted that throughout the plasmapheresis procedure, needle **21** remains in position in the donor's vein. Only a single venipuncture occurs and, since the entire procedure is conducted at the donor's bedside, there is no danger that the red cells returned to the donor may have been taken from someone else. The entire procedure is performed safely and relatively quickly, in 25 minutes or less, with no discomfort to the donor except possibly for that occasioned by the single venipuncture.

While in the foregoing I have disclosed the method of the invention in considerable detail for purposes of

illustration, it will be understood that many of these details may be varied without departing from the spirit and scope of the invention.

I claim:

1. In a method for practicing plasmapheresis in situ, the steps of puncturing a donor's vein with the needle of a blood collection set and collecting a predetermined quantity of the donor's blood in a blood bottle having a tapered neck zone, then detaching the set from said blood bottle without withdrawing said needle from the donor and immediately centrifuging the collected blood by rotating the same bottle in inverted position about its axis until the red blood cells migrate peripherally and displace the plasma towards the center of the bottle, then gradually reducing the rotational speed of the bottle and permitting downward migration of the red cells under the influence of gravity into the neck zone of the inverted bottle without turbulence, and then, with the stationary bottle still in inverted position, reconnecting said set to said bottle at said neck zone to draw off the red cells collected in the lower portion of the bottle and return them to the donor through the same needle, retaining the separated plasma in the blood bottle.

2. The method of claim 1 in which the step of gradually reducing the rotational speed of the bottle is performed over a period in excess of 3 minutes.

3. The method of claim 1 in which the bottle is rotated at a speed within the range of approximately 1500 to 3000 revolutions per minute, the speed of the bottle being thereafter gradually reduced to zero over a speed-reducing interval of between approximately 4 to 10 minutes.

4. In a method for practicing plasmapheresis in situ, the steps comprising: puncturing a donor's vein with the needle of a blood collection set and collecting a predetermined quantity of the donor's blood in a partially-evacuated blood bottle having a tapered neck zone and containing a standard anti-coagulant; then detaching the set from said bottle without withdrawing the needle from the donor's vein; then immediately centrifuging the collected blood by rotating the same bottle in inverted position in the immediate vicinity of the donor until the red cells have migrated peripherally and have displaced the plasma toward the center of the bottle; then gradually and uniformly reducing the rotational speed of the bottle over a deceleration interval in excess of 3 minutes; then maintaining the bottle in stationary inverted position until the peripherally-migrated red cells settle into the neck zone of the bottle; and then, with the stationary bottle still in inverted position, reconnecting said set to said bottle to draw off the red cells collected in the lower portion of the bottle and return them to the donor through the same needle, retaining the separated plasma in the bottle.

5. The method of claim 4 in which there is the additional step of attaching the needle of said set to a saline administration bottle to administer physiological saline to the donor while the collected blood in being centrifuged.

6. The method of claim 4 in which the blood bottle and its contents are centrifuged at a rotational speed falling within the range of approximately 1500 to 3000 revolutions per minute, said centrifuging and decelerating steps occurring over an interval within the range of approximately 15 to 20 minutes.

7. In a method for practicing plasmapheresis in situ, the steps of drawing a quantity of blood through a venipuncture in a donor and collecting said blood in a chamber having a tapered end zone, then rotating said chamber about a vertical axis extending through said end zone and while said chamber is oriented with said end zone facing downwardly until the red blood cells migrate peripherally and displace the plasma towards the axis of rotation, then gradually reducing the rotational speed and permitting downward migration without turbulence of the red cells into said end zone under the influence of gravity, and then, without altering the orientation of said chamber, and immediately upon discontinuance of rotational movement, drawing off the red cells from said tapered end zone and directly returning them to the donor through said venipuncture.

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