

Nov. 20, 1962

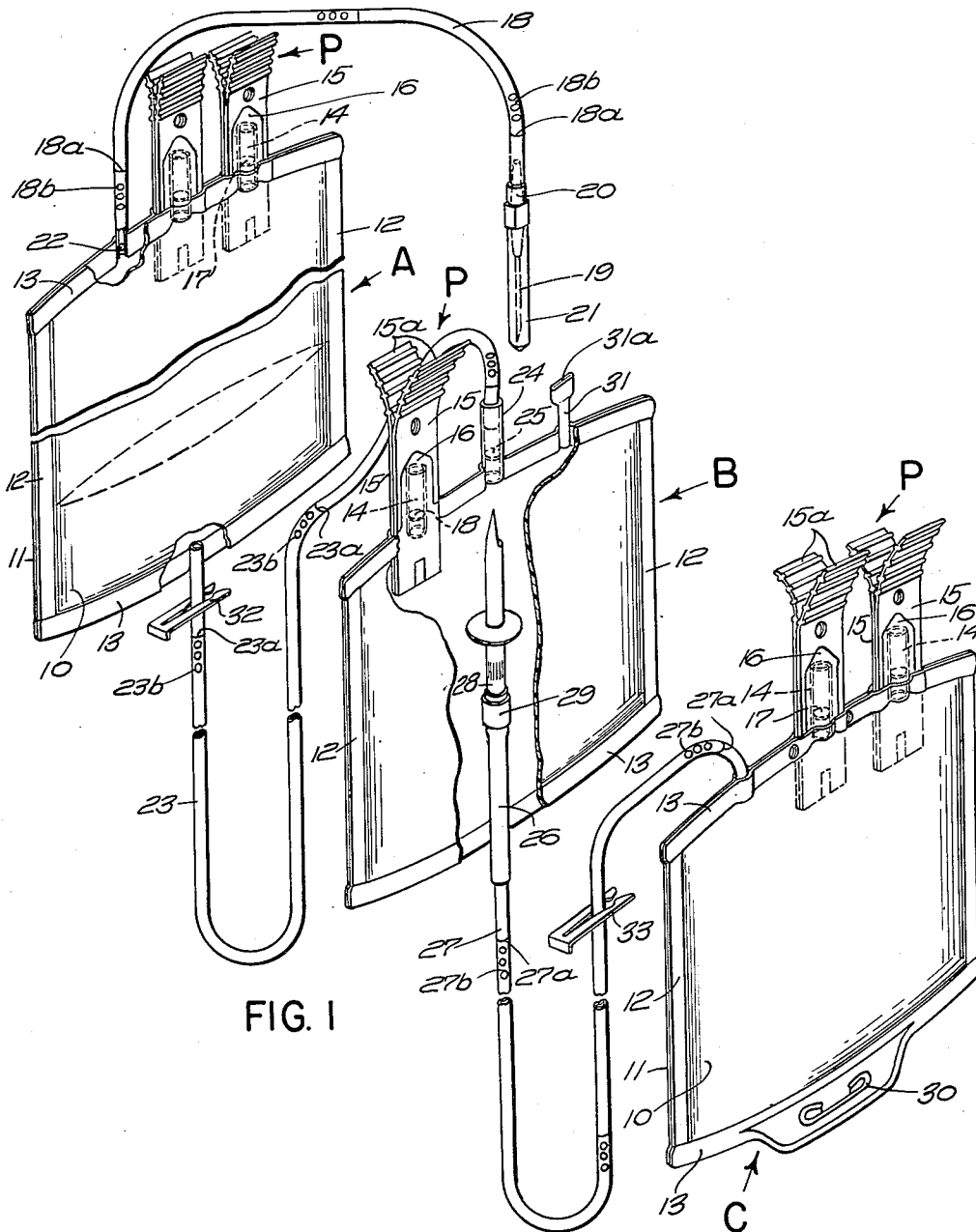
R. P. EARL

3,064,647

BLOOD COMPONENT SEPARATION METHOD AND APPARATUS

Filed June 13, 1957

2 Sheets-Sheet 1



INVENTOR.

ROBERT P. EARL

BY
Emery, Booth, Townsend, Miller, + Weidner

ATTORNEYS

Nov. 20, 1962

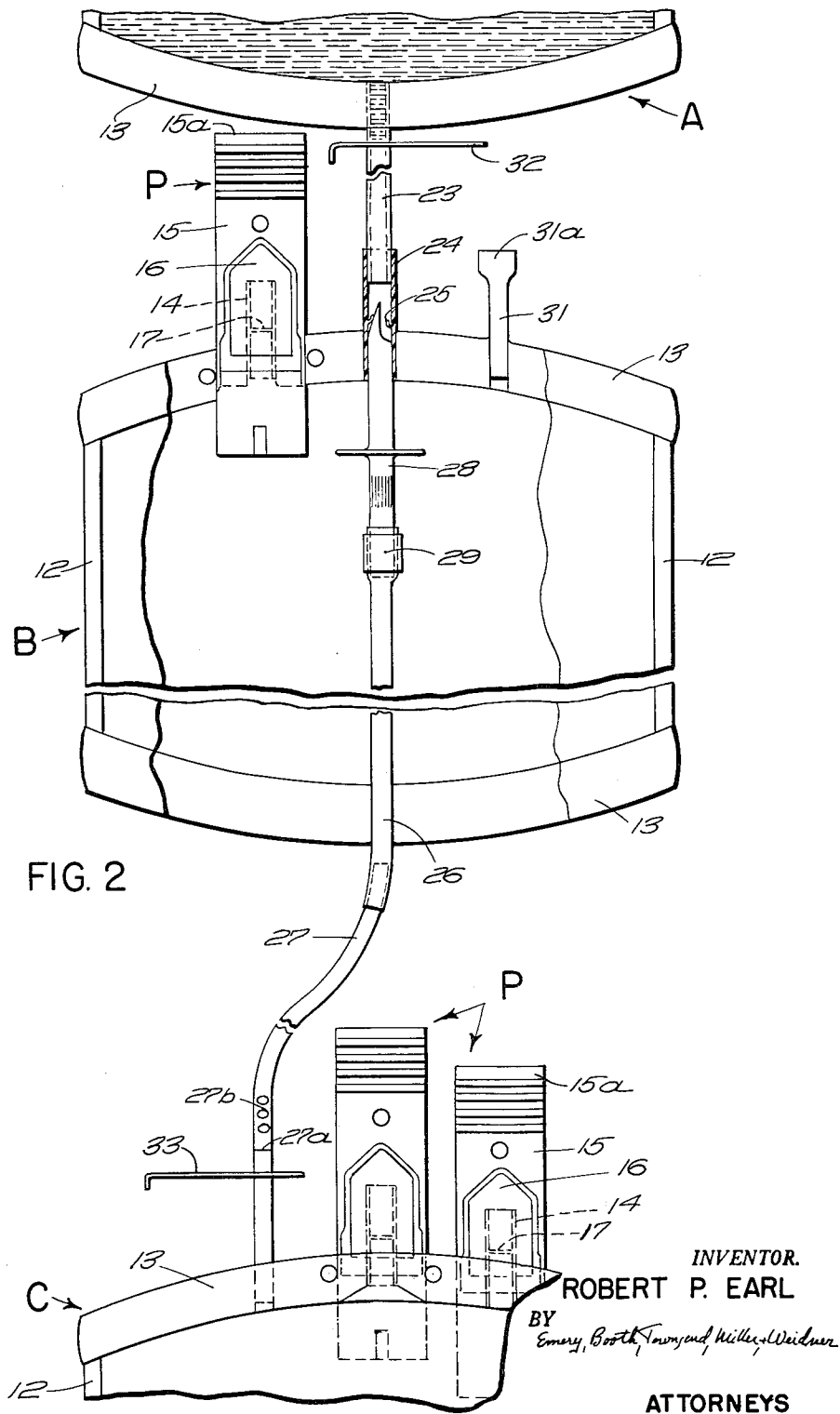
R. P. EARL

3,064,647

BLOOD COMPONENT SEPARATION METHOD AND APPARATUS

Filed June 13, 1957

2 Sheets-Sheet 2



1

3,064,647

BLOOD COMPONENT SEPARATION METHOD AND APPARATUS

Robert P. Earl, Ashland, Mass., assignor, by mesne assignments, to Baxter Laboratories, Inc., Morton Grove, Ill., a corporation of Delaware

Filed June 13, 1957, Ser. No. 665,414

24 Claims. (Cl. 128—214)

This invention relates generally to the handling and treatment of blood, and more particularly to new method and apparatus for preparing or separating from the whole blood its components or derivatives. The invention contemplates the collecting, sampling, concentrating and storing of the blood and its components. It concerns the isolation of the cells, plasma and platelets, and the utilization of each, or separation of one and reconstitution of the remainder of these components. Especially it involves the aseptic preparation of human platelet concentrates without the loss of other blood elements.

The present invention aims at segregating the blood components aseptically, without the risk of contamination and error in identification. The more particular invention object is the provision of a fluid handling system which is integral, closed, sterile sealed, pyrogen free, and essentially air free, and which may be manipulated wholly from without itself, and without venting of the original container. The invention intends also a compact, light weight, economical, and unbreakable blood handling system; a system which presents only hemorepellent surfaces to the blood, which is adapted to gravity or positive pressure flow, and which is otherwise formed and conditioned to promote maximum yields and minimum losses in derivative preparation. The invention seeks further a fluid storing system which may be variously subdivided and manipulated in the component separating and concentrating with assurance of total asepsis, and whose operation is distinguished also by easy availability of blood components as byproducts of the separation of the formed elements.

The invention will be better understood from a consideration of the following specification taken in conjunction with the accompanying drawing in which:

FIG. 1 is an assembly view of one form of the blood component separating apparatus, shown in a pre-use condition; and

FIG. 2 is a fragmentary larger scale elevation of the FIG. 1 apparatus, partly in section, and showing the manipulation of it in a component separation step of the invention.

Whole blood is a complex liquid which has multiple components serving many purposes in the human body. Thus its 45% cellular or formed element part is made up of oxygen-carrying red cells, infection-resisting white cells, and coagulation-aiding platelets. Its 55% liquid or plasma part includes proteins useful for fighting shock and disease. In some cases of sickness or injury, as for example following hemorrhage, transfusion of the whole blood may be needed; but in other cases the indication may be for a particular one of these components, as separated or concentrated from the whole blood.

Thus following burns, crush injuries and other forms of shock not attended by the loss of red cells, the trans-

2

fusion of plasma will restore the diminished blood volume as effectively and more safely than whole blood. In anemia not complicated by circulatory inadequacies, red cells alone will restore the desired red cell level more adequately than whole blood. Again, there may be needed a quantity of platelets whose normal fluid suspension is of excessive volume, so that the platelets must be concentrated to permit the desired restoration to the patient of large quantities of viable platelets in a medium of low fluid volume.

The concentration and use separately of the blood components also avoids the wastage inherent in whole blood transfusion of unneeded elements. Further, the blood elements are susceptible of longer keeping and easier handling, and also of additional uses, when isolated and prepared as derivatives. Thus the platelets, while normally viable for only a day or two, may be preserved as therapeutically effective platelets almost indefinitely by concentrating, and then suspending in a gelatin solution or lyophilizing (freeze drying). Similarly, plasma may be stored at room temperature, or dried, or frozen, when separated as a component in the method and apparatus of the invention.

In medical and hospital practice the blood components and derivatives are now prepared and used as a medicinal formulation or prescription compounded for and tailored to a particular indicated bodily need. This increased and more beneficial and economical application of the blood elements is accomplished with this invention more safely, simply, and easily than heretofore. More particularly, in component concentrating under the invention there are eliminated the dangers, difficulties and disadvantages inherent in the use for the purpose of the prior glass bottle equipment.

Among these disadvantages are the degradation and decreased yield resulting from turbulent flow, as characterizes the vacuum collecting and aspirating technique used with such bottles. There is also the risk of mismatching, or possibility of error such as arises from the physical separation and separate identification of the elements. Use of the prior equipment for the purposes here concerned requires also violation of the rule against re-entry to the primary container (once the blood is collected), and so involves the further risk of contamination. And the glass bottles are heavy and bulky, and also breakable, as in centrifuging.

These several dangers, difficulties and disadvantages are avoided and overcome under the invention by the use of a compact, light weight, disposable plastic type of blood handling equipment, such as shown and described in U.S. Patent No. 2,702,034 granted February 15, 1955, to Carl W. Walter. Most importantly this plastic equipment is safe. That is, its unique design and construction assures aseptic preparation of the blood components. More particularly it is constituted as an integral, closed, sterile sealed, pyrogen free system and it may be subdivided and otherwise manipulated for blood collecting and element isolating without venting of or re-entry to the blood container. The flexible plastic apparatus here concerned is distinguished also by hemorepellence, or anti-coagulative property. It is convenient and economical in that it is low in cost and non-breakable, and affords great savings in weight and space. Its use is accompanied by reduced

3

waste, fewer bloods being rejected, and greater viability being achieved in the bloods collected. The flexible, collapsible blood bag of the invention apparatus is adapted further for fluid expelling by the less turbulent positive pressure method, hence with less injury to the cells. And the infusing is without venting of the sterile closed system, and so without the hazard of air embolism, or of contamination by air-borne bacteria.

Referring now more particularly to FIG. 1, the invention apparatus is there shown generally to comprise a unitary, closed, sealed blood and component collecting, treating and storing system having three main chamber or pack assemblies A, B, C, and arranged and connected also and more particularly for variously separating and reuniting the blood elements. The blood collecting and storing bags or packs A, B, C are herein and commonly constructed of mating juxtaposed plastic sheets 10, 11, which sheets are flatwise sealed, as by dielectric or other heating means, along their side end margins, as at the lines or strips 12 and wider bars 13.

In accordance with the invention, the packs A, B, C and also the associated blood conducting tubing are fashioned of polyvinyl plastic of medical quality, which plastic is transparent, flexible and tough, can be autoclaved, and withstands extremes of heat and cold in storage. The polyvinyl plastic here concerned will be understood also to have a hemorepellent, chemically inert, non-reactive, glossy surface such as delays the coagulation and degradation of the shed blood. In the, say, .10-.20 in. I.D. and .02 in. wall gauge sizes employed for the apparatus tubing the preferred polyvinyl plastic is flexible and elastic, that is, self-restoring; while in the construction of and say .008 in. wall gauge material of the packs it is flexible and collapsible, that is, lay-flat, as shown.

Considering now more particularly the upper or primary pack A the same may be proportioned as herein to receive the standard 500 cc. whole donation, and may in such embodiment have a flatwise length and width of, say, 8 in. x 5 in. The middle or secondary and lower or tertiary packs B, C may be somewhat smaller, say 6 in. x 5 in., as accommodating the smaller volume of the component with which they are to be charged.

The packs A, B, C are seen commonly to be fitted also with one or more port assemblies P such as shown and described in the co-pending application of David Bellamy, Jr., Serial No. 412,549, filed February 25, 1954, now patent No. 2,894,510, issued July 14, 1959, and herein comprising each a short delivery tube 14 and surrounding and overlapping it a pair of juxtaposed strips 15 received and sealed with the tube through the associated upper end seal 12. The strips 15 are in an intermediate portion sealed together around that portion of the tube 14 which projects outwardly of the bag, so as to define a closed chamber or pouch 16 surrounding and sterile-sealing said projecting tube portion. The strips are defined further by separated transversely ribbed terminal portions 15a which may be manipulated or grasped to pull apart said pouch 16 and expose the tube 14, as for coupling to an administering or infusing apparatus, not shown. The port assemblies P are closed also and so double sealed each by a perforative membrane or diaphragm 17 installed transversely of and to close the tube 14 in the region of the bag end seal 13, and which must be punctured, following the pulling apart of the pouch 16, and insertion of the adaptor or coupler of the aforementioned administering apparatus, to effect actual entry to the pack.

Entry to the upper or primary bag or pack is provided also by an integral collecting or donor tube 18 of a convenient, say 30 in. length and having its one end received and sealed through the upper end seal 13. At its other end the donor tube 18 mounts a hypodermic and coupler needle 19 like that of U.S. Patent No. 2,702,037 granted February 15, 1955, to Carl W. Walter.

4

It has a stainless steel cannula which is formed with a tip sharpened and polished to prevent tissue damage and initiation of clotting, and which is formed also with a lumen extending straight through for easy cleaning and flared at its inner end to reduce eddy currents and promote laminar flow, and treated with a medium forming an anti-coagulant or hemorepellent bore lining or film. The needle cannula rigidly mounts at the end distal to its point a surrounding nylon coupling element having a central manipulating body from which projects oppositely axial tapered hubs. The free end of the donor tube 18 is seen as drawn and seized over the inner of these hubs, and there clamped and sealed also by an elastic or rubber band or ferrule 20. A protective rubber sheath 21 is drawn over the projecting stem of the cannula and is removably seized to the other said hub, whereby it closes and seals the needle and also the donor tube 18.

The donor tube 18 may also be divided as by the lateral markings 18a into segments, as may be identified by duplicate or identical numbers or the like indicia 18b, said identical numbers and markings 18a, 18b permanently affixed, as by indelibly imprinting the same. Segmented blood or component samples or aliquots may then be obtained, as for serology, grouping or cross-matching, by sealing or knotting the tube 18 at the markings 18a, upon the initial collection or during a subsequent isolating or reconstituting step. Such integral donor tube segregated samples will be seen to be positively identified to the pack, and obtained without risk of contamination of the residual blood.

The donor tube 18 is initially closed at its inner end and in the region of the pack end seal 13 by an oversized hemorepellent-coated steel ball or bead 22 seized in the tube. The bead 22 will be understood to prevent influx of air when needle sheath 21 is removed.

Fluid outlet at the opposite, normally lower end of the upper pack A is provided by a relatively short, say 8 in. tube 23 sealed and opening through the lower end seal 13, and providing desired integral closed connection to and communication with the middle pack B. The tube 23 is conveniently coupled to the middle pack B by a stiffer, larger diametered adaptor tube 24 of short, say 1 in. length, and sealed and opening through upper end seal 13 of said middle pack B. The free end of outlet tube 23 is inserted and cyclohexanoned or otherwise sealingly and rigidly fixed in the outer end of said adaptor tube 24. This adaptor tube 24 is closed by an internal sheet membrane or perforative diaphragm 25 spanning its lumen in the region of the bag end seal 13.

Referring still to FIG. 1, the middle pack B is seen as integrally joined and connected to lower pack C by a communicating outlet tube 27 of convenient, say 12 in. length, and sealed and opening through the lower and upper end seals 13 of middle and lower packs B, C, respectively. In accordance with the invention, the apparatus may be manipulated entirely from without the packs, and without entering the closed sealed system, for optional connection of lower pack C directly to upper pack A. For this purpose the outlet tube projects part way into middle pack B and there mounts a stiff nylon or the like coupler 28. For convenient connection to the coupler 28 the outlet tube incorporates a stiffer larger diametered adaptor tube 26 of short, say 3 in. length which is telescoped over and cyclohexanoned or otherwise sealingly and rigidly fixed to the end of tube 27 below the pack. The adaptor tube 26 is sealed also through lower end seal 13 and projects part way into middle pack B opposite to and aligned with adaptor tube 24, and has its inner end drawn and seized over the hub of coupler 28, and there clamped as by an elastic or rubber band or ferrule 29. The coupler 28 is seen to extend vertically opposite and with its piercing point spaced, say 1 in. from the inner end of said adaptor tube 24. It will be understood that adaptor tube 24 is

proportioned to fit closely over cannula 28, and is of a length to permit insertion of its point to puncture tube closing diaphragm 25, and so to establish the desired continuity between upper and lower packs A and C.

Returning to lower pack C the same is shown as fitted with a pair of the sterile opening ports P and to be distinguished also and at its lower end seal 13 by a central widened portion cut or apertured as shown to provide a convenient hanging loop 30.

In preparing the apparatus for use, the same is first made pyrogen free, as by rinsing with sterile distilled water. For this purpose there may be provided a special and temporary entry to packs B and C, herein shown as a tube 31 opening through the upper end seal 13 of middle pack B, and which is cut off and sealed, as at 31a, after the rinsing. Pack A is charged with the appropriate, here 75 cc. volume of Acid-Citrate-Dextrose anti-coagulant solution Formula "A" U.S.P. Packs B and C may be supplied with a quantity of nitrogen such as distends and so prevents sticking of their walls, as particularly during sterilization. The apparatus is then sterilized in medically acceptable fashion, as by subjection to steam at least 120° C. continuously for at least 30 min. For preservation in desired sterile, pyrogen free condition the entire apparatus may be stored and sealed after such sterilization in an aluminum foil or like moisture proof package or pouch, not shown.

In the use and operation of the apparatus in accordance with the invention, the whole blood is first collected in upper pack A. In the preferred method, the pack is supported for gravity collection at a level below the donor arm, and the pressure cuff is applied to the arm. A loose overhead knot is made in the donor tube 18 near the needle 19. The site of venipuncture is prepared, as by disinfection and local anesthesia, and the pressure cuff inflated. The needle cover 21 is then removed and phlebotomy accomplished, bead 22 being pushed down into the pack A to permit flow of the blood. The blood in collection is sealed off from packs B and C by diaphragm 25, and it may be excluded also from tube 23 by closing the same, as by clamp 32, just below pack A. Several times during, and also immediately after the collection of the blood the same is mixed with ACD solution by kneading or rocking the pack A. The donor tube knot is then pulled white tight, the tube is severed above the knot, and any desired pilot samples are collected. As heretofore mentioned, the donor tube 18 may also and now or later be segmented below the knot, as by clamping, sealing, or knotting at the markings 18a, and so sealing off the aliquots for cross-matching and the like.

The collection of the blood as described, that is, with minimum turbulence and no foaming and into a sterile closed pyrogen-free system without liquid-gas interface and presenting only hemorepellent surfaces to the blood, achieves the desired prevention or delay of coagulation and degradation of the blood, along with retarding platelet aggregation and chemical change. It results in collection of blood which is qualitatively improved. More particularly, the blood thus collected is substantially free of hemolysis, its plasma yield is increased, and its red cell viability is bettered.

When collection of the 450 to 500 cc. or other desired blood donation is complete, the apparatus is manipulated for separation or isolation of the cells and plasma simply and easily, and without re-entering the system, or blood container. The entire apparatus is placed in the centrifuge cup, with the lower pack C placed at the bottom, as a cushion and filler, and with upper pack A inserted upside down, that is, with the outlet end 13 and tube 23 pointing upwards. Centrifuging at a speed of 1200 r.p.m. and for a period of 20 min. is generally sufficient for the desired sedimenting of the red cells, such as yields also a platelet rich supernatant plasma.

To complete the red cell-plasma separation according

to the invention, and referring now to FIG. 2, the coupler 28 is thrust into the adaptor tube 24 to puncture its diaphragm 25, clamp 32 is released, and upper pack A is manually squeezed to expel the platelet rich plasma, causing it by positive pressure to flow through tubes 23, 27 directly to said lower pack C. The cells and plasma may then be sealed in packs A and C by closing said outlet tubes 23, 27, as by clamps 32, 33.

Further and variously in accordance with the invention, and if it is desired to isolate also the leukocytes, the coupler 26 may, when the white cell interface is reached, be withdrawn from adaptor tube 24, breaking the direct connection between packs A and C. Thus upon continuing the fluid expelling squeezing of the pack A, the buffy coat or white cell cream is directed separately to the middle pack B.

For further treatment or use, or merely for storage of their specialized element content, any of the packs A, B, C may at this or any component storing stage be sealed or clamped off and cut loose from the remainder of the apparatus. Also and incident thereto samples of any component may at any time be acquired as for culturing, and always without violating the rule against re-entry to the container. This is accomplished by sealing or knotting a segment of the appropriate tube 18, 23, 27. The indicated sampling is facilitated and component matching assured by providing outlet tubes 23, 27, similarly as donor tube 18, with segment identifying markings 23a, 27a and numbers 23b, 27b. Again, and for the ultimate administering from the several packs A, B, C there is required only the coupling of an infusing apparatus to the appropriate port assembly P.

The result of the component separating manipulation thus far described will be seen as the sedimenting of a unit of red cells in pack A, the isolating of the white cells in pack B, and the collecting of a unit of platelet rich plasma in pack C.

A further important application of the invention apparatus is to the aseptically prepared of human platelet concentrates, this without loss of the other blood elements, and with such ease and safety as permits the incorporation of such platelet preparation into the routine of blood banking. In this step the apparatus is again placed in a centrifuge. The sedimenting of the platelets requires centrifuging it at a higher or, say 2500 r.p.m. speed and longer or, say 40 min. period. If plasma and packed cells are desired as separate entities, the platelet depleted plasma is expelled, by the same simple squeezing process, from pack C to pack B, the coupler 28 being first or already withdrawn from adaptor tube 24. This leaves a unit of red cells in pack A, a unit of platelet free plasma in pack B, and a unit of platelet concentrate in pack C. The thus concentrated red cells, plasma, and platelets may be sealed in the indicated manner in packs A, B, and C respectively, and they may be stored or otherwise treated in known or preferred manner and for the described or other purposes.

It may alternatively be desired to provide a unit of platelets and a unit of platelet-free whole blood. In such case, the coupler 28 is held in or restored to adaptor tube 24, preserving or re-establishing direct connection between packs A and C, and so that by the mentioned squeezing of pack C its plasma content is expelled to and combined with the cells retained in pack A. Accordingly, and by this further and optional invention step, a unit of platelet concentrate is isolated in pack C, and a unit of reconstituted platelet-free whole blood is established in pack A.

It may here be noted that notwithstanding the loss in separation, and also washing (with saline, before storage), a very high 70-80% recovery of platelets in the concentrates is obtained with the invention apparatus, this by reason of its advantageous construction and operation as herein shown and described.

As a still further invention option following the ini-

tial collection, the content of pack A may be utilized as red cells and plasma, as following gravity separation in storage. In this case the liquid element would be expressed first through one, and the formed element squeezed off last through the other of the pack A ports P.

Those skilled in the art will appreciate that the several blood elements prepared under the invention and as herein shown and described may be variously employed in medical and hospital practice. The platelet concentrates, and also other elements, have extensive clinical and investigative use. The plasma is employed for the treatment of hemophilia as well as for other clinical purposes. The platelet depleted or reconstituted whole blood is used in routine blood transfusions. The invention apparatus is adapted also to low temperature storage of the red cells, white cells, plasma, and platelets.

From the foregoing it will be appreciated that by the method and means of the invention various described blood element or component preparing or separating procedures are carried out aseptically, and also simultaneously, successively or alternatively, in and without entry to an integral closed sterile sealed fluid storing system. Such procedures have been shown to include the preparation of platelet concentrates, the preparation of packed red blood cells, the separation of the buffy coat, and the preparation of cell free plasma. The invention will be understood to afford also the reconstitution of one or more blood elements without risk of mismatching, and further the segregating and removal of aliquots of whole blood, or of blood elements, without risk of contamination of the residue.

The invention has been shown further and importantly to present a practical technique for the aseptic preparation of human platelet concentrates without loss of other blood elements, and to furnish a closed collapsible non-venting apparatus which eliminates the risk of contamination such as inherent in procedures involving and requiring multiple entries into the primary container. The invention has been shown more particularly to provide a truly unitary fluid handling system which is manipulable for element concentrating and divisible for component separating without opening into or separating the apparatus, and so without risk of contamination or mismatching of the cells and plasma.

The invention has been shown still further to present a new and improved method and apparatus which importantly and uniquely affords and insures the clinical use of all blood elements, eliminating the need to discard any portion. And the blood and component collecting and administering under the invention and for every such use is without venting, and otherwise consistent with aseptis.

It will be understood that my invention is not limited to the particular embodiments thereof illustrated and described herein, and I set forth its scope in my following claims.

I claim:

1. Blood component separation apparatus comprising a plurality of flexible collapsible fluid storing chambers, said chambers having connection in an integral closed system, and means within and manipulable from without and without opening said system to alter the connection of a first directly with a second to directly with a third chamber of said system, said chambers and means formed from a hemorepellent material and adapted to be made pyrogen free, sterilized and centrifuged.

2. Blood component separation apparatus comprising a plurality of flexible collapsible fluid storing chambers, said chambers associated in an integral closed system, means within and manipulable from without and without opening said system for variously connecting said chambers, and means associated with said system and manipulable for sealing off said chambers, said chambers and connecting means formed from a hemorepellent material

and adapted to be made pyrogen free, sterilized and centrifuged.

3. Blood component separation apparatus comprising a plurality of flexible collapsible fluid storing chambers, said chambers associated in an integral closed system, means within and manipulable from without and without opening said system for variously connecting said chambers, means manipulable for sealing off said chambers, and fluid storing means communicating with and adapted to be sealed off from said chambers for sampling, said chambers and connecting means formed from a hemorepellent material and adapted to be made pyrogen free, sterilized and centrifuged.

4. Blood component separation apparatus comprising a plurality of flexible collapsible hemorepellent bags integrally connected in a closed sterile pyrogen free fluid storing system, blood collecting means associated with a first bag, and means in and manipulable from without a second bag variously to make and break direct connection between said first and a third bag of said system.

5. Blood component separation apparatus comprising a plurality of flexible collapsible hemorepellent bags integrally connected as a closed sterile sealed pyrogen free fluid storing system, closed collecting means associated with a first bag, means initially closing off said first bag from a second bag, and means in and manipulable from without said second bag to open said closing means and make direct connection between said first and a third bag of said system and subsequently to break said connection for communication between said first and third bags indirectly through said second bag.

6. Blood component separation apparatus comprising a plurality of flexible collapsible, hemorepellent bags, flexible collapsible tubing connecting said bags, said bags and tubing integrally constructed, hermetically sealed, and sterilized, and defining an integral closed sterile sealed fluid system, means associated with said tubing and manipulable to close and open said system between said bags, means associated with and manipulable to open and connect said system for collecting blood into one of said bags, and port means on each of said bags, said port means manipulable for sterile coupling of said bags to component administering means.

7. Blood component separation apparatus comprising a plurality of flexible collapsible hemorepellent bags, blood collecting means associated with one of the bags, flexible collapsible tubes integrally connecting all of the bags, and means in and manipulable from without a middle bag to make and break direct connection between upper and lower bags.

8. Apparatus for separating blood components comprising a plurality of flexible and collapsible bags arranged and connected in an integral closed sterile sealed system, a tube integral with and fitted for collecting blood into one of said bags, means including a tube integrally coupling said one to another of said bags, means initially closing said tube, and means within and manipulable from without said first mentioned means to engage and open said tube closing means.

9. Blood component separation apparatus comprising a plurality of flexible collapsible bags, a tube integral with and fitted for collecting blood into one of said bags, a diaphragm closed outlet tube integral with said one bag, a coupler fitted inlet tube integral with another of said bags, and flexible collapsible fluid storing means sealed about the ends of said outlet and inlet tubes and whereby without entering the apparatus said coupler may be variously inserted through and withdrawn from said diaphragm to make and break direct connection between said bags.

10. Blood component separation apparatus comprising three flexible collapsible bags, a flexible collapsible tube integral with and fitted for collecting blood into the first bag, flexible collapsible tubes integrally connecting the first with the second and the second with the third bag,

said tubes entering oppositely said second bag, one said tube having its end extending within said second bag and adapted to be received in the opposite end of the other said tube, and said second bag manipulable for the telescoping of said tube ends.

11. Blood component separation apparatus comprising a plurality of flexible collapsible bags, a flexible collapsible tube integral with and fitted for collecting blood into the first of said bags, flexible collapsible tubes integrally connecting all of said bags, a perforable diaphragm closing the tube providing inlet to the second of said bags, and a stiff coupler on the tube providing outlet from said second bag, said second bag and stiff coupler manipulable to pierce said diaphragm and make and break direct connection between said first and the third of said bags.

12. Blood component separation apparatus comprising a plurality of flexible collapsible bags, means for collecting the blood into one of said bags, flexible collapsible tubes connecting all said bags in a unitary fluid storing system, said tubes providing inlet and outlet for the intermediate bags of said system, means for releasably closing said tubes and variously subdividing said system, and mean within and manipulable from without one of said intermediate bags releasably to connect its inlet and outlet tubes and so temporarily to close it off from said system.

13. The method of performing blood component separation with a plurality of containers arranged and connected in a unitary, closed, collapsible, sterile sealed, pyrogen free, hemorepellent system which comprises closing between said containers; collecting the blood in one container of said system; effecting a component separation in said one container; opening between said one and another container of said system; and expressing one separated component from said one to said other container.

14. The method of performing blood component separation with a plurality of containers arranged and connected in a unitary, closed, collapsible, sterile sealed, pyrogen free, hemorepellent system which comprises closing the system between the containers; collecting the blood in a first container of said system; effecting a component separation in said first container; opening between said first and a second container of said system; expelling one separated component from said first container to said second container; closing said second container; opening between said first and a third container of said system; and expelling another separated component from said first to said third container.

15. The method of performing blood component separation with a plurality of containers arranged and connected in a unitary, closed, collapsible, sterile sealed, pyrogen free, hemorepellent system which comprises closing between said containers; collecting the blood in a first said container; effecting a component separation in that container; opening between said first and a second said container; expressing one separated component to said second container; and closing and effecting a second component separation in said second container.

16. The method of performing blood component separation with a plurality of containers arranged and connected in a unitary, closed, collapsible, sterile sealed, pyrogen free, hemorepellent system which comprises collecting the blood in a first said container; effecting a component separation in that container; expelling one separated component from said first container to a second said container; closing and effecting a second component separation in said second container; opening said second container and expelling a second-separated component from it to another container of said system; and closing said other container.

17. The method of performing blood component separation with a plurality of containers arranged and connected in a unitary, closed, collapsible, sterile sealed, pyrogen free, hemorepellent system which comprises collecting the blood in a first said container, effecting a com-

ponent separation in that container; making connection directly between said first and a third and through a second said container; expressing one separated component from said first to said third container; breaking said direct connection; and expressing another separated component to said second container of said system.

18. The method of performing blood component separation with a plurality of containers arranged and connected in a unitary, closed, collapsible, sterile sealed, pyrogen free, hemorepellent system which comprises collecting the blood in a first said container; effecting a component separation in that container; making connection directly between said first and a third and through a second said container; expressing one separated component from said first to a third said container; closing and effecting a second component from said third separation in said third container; breaking said direct connection; and expressing a second-separated component, from said third to said second container.

19. The method of separating blood components with three flexible, collapsible bags connected in a unitary closed storing system which comprises collecting the blood in the first bag, centrifuging said first bag, making direct connection between said first and the third bag through the second bag of said system, expressing the blood plasma from said first bag to said third bag, breaking said direct connection and expressing the blood buffy coat from said third bag to said second bag.

20. The method of separating blood components with three flexible, collapsible bags connected in a unitary closed storing system which comprises collecting the blood in the first bag, centrifuging said first bag, making direct connection between said first and the third bag through the second bag of said system, expressing the blood plasma to said third bag, centrifuging said third bag to sediment the blood platelets, breaking said connection, and expressing the platelet depleted plasma to said second bag.

21. The method of performing blood component separation with a plurality of containers arranged and connected in a unitary collapsible pyrogen free hemo-repellent system which comprises closing between one and another container of the system, charging said one container with anticoagulant solution, closing and sterilizing the system, collecting the blood into said one container while mixing it with said solution, effecting a component separation in said one container, opening between that one and said other container of the system, and expressing one separated component to said other container of said system.

22. Blood component separation apparatus comprising a plurality of flexible, collapsible, fluid storing chambers, flexible tubing joining said chambers in a unitary closed system, means initially closing said tubing and thereby individually sealing said chambers, means within and manipulable from without said system to engage and open said initially closing means for establishing communication between said chambers, and means associated with said system and manipulable for reclosing said tubing and thereby individually resealing said chambers.

23. Blood component separation apparatus comprising a plurality of flexible collapsible plastic bags, flexible plastic tubing integrally joined and communicating between said bags, said bags and tubing evacuated, closed, and sterilized to present a unitary, air-free, sterile sealed system for non-deteriorating reception, storage and handling of whole blood and the components thereof, means closing between and manipulable from without said apparatus to open between said bags, port means on and manipulable for outletting from all said bags, a flexible plastic tube inletting to one said bag, a coupler mounted at the free end of said inletting tube, and a sheath sealing said coupler.

24. The apparatus of claim 23 and means closing said

inletting tube to and manipulable from without said apparatus to open the tube to said one bag.

References Cited in the file of this patent

UNITED STATES PATENTS

2,663,298	Rose	Dec. 22, 1953
2,678,159	Ellis	May 11, 1954
2,702,034	Walter	Feb. 15, 1955
2,853,069	Beacham et al.	Sept. 23, 1958

FOREIGN PATENTS

772,636	Great Britain	Apr. 17, 1957
---------	---------------	---------------

1,127,010	France	Aug. 6, 1956
1,082,035	France	June 16, 1954

OTHER REFERENCES

- 5 Gardner et al.: "Platelet Transfusions Utilizing Plastic Equipment" from Journal of Laboratory and Clinical Medicine, volume 43, 1954, pages 196-207. (Copy in Division 55.)
- 10 Surgenor: "Blood," Scientific American, vol. 190, No. 2, February 1954, pages 54-62 (pages 58-62 relied on). (Available in Scientific Library.)