The present invention relates to centrifugal separators and, in particular, to centrifuges for separating certain blood constituents from each other.

A primary object of this invention is to provide a centrifuge which is capable of completely separating one blood constituent, for example, the red cells, from another blood constituent, for example the plasma, of a given quantity of blood.

It is well known to those skilled in the art, that plasma may be infused into a donor without regard to differences in blood types but that it is extremely dangerous to infuse red cells into a donor if his blood type does not match that of the donor. This serious danger is eliminated by the present invention.

Another object is to facilitate the return of the red cells of a blood donation to the donor.

A further object is to provide apparatus which can be easily cleaned and sterilized.

Another object is generally to provide an improved blood centrifuge.

The above and other objects, features and advantages of the present invention will be more fully understood from the following description considered in connection with the accompanying illustrative drawings.

In the drawings:

Fig. 1 is a view of apparatus embodying the present invention, the centrifuge vessel being shown in vertical section;

Fig. 2 is a fragmentary sectional view, on a larger scale, taken on the line 2--2 of Fig. 1;

Fig. 3 is a top plan view of the apparatus, on a smaller scale;

Fig. 4 is a vertical section, on a larger scale, of a portion of the centrifuge and illustrates a modification in the securement of the bottom wall to the side wall of the vessel; and

Fig. 5 illustrates on a smaller scale, the retaining ring utilized in the modification shown in Fig. 4.

Referring now to Figs. 1 through 3 of the drawings, which illustrate the best mode now contemplated by us for practicing the invention, the apparatus comprises a centrifuge vessel 10 which, as here shown, is preferably in the form of a froto-conical bowl which is provided with a dished bottom. Said vessel is removably secured to a flanged collar 12 which is keyed to the shaft 14 of a motor M for rotation thereby about a vertical axis.

The vessel 10 comprises a conical side wall member 16 which is in fluid-tight relation with a bottom wall member 18 which is provided with the central dished portion or well 20. The outer surface 22 of the bottom wall extends downwardly and is inclined outwardly from the perimeter 23 of the well and terminates in a circular flange 24. Said flange is seated in a complementary shoulder 26 defined in the bottom rim 28 of the member 16, being secured thereto in fluid-tight relation, as by the screws 30. It will be noticed from Fig. 1, that the outer surface 22 of the bottom wall and the confronting inner surface 25 of the wall member 16 define a circular trough 32 which encompasses the well 20 and which converges upwardly at an angle of 45° toward the vertical axis about which the centrifuge vessel rotates. Wall member 16 has an inner flange 27 which abuts a step 29 defined in the circular flange 24 of the bottom wall member 18 to form the bottom of the trough 32. The screws 30 secure the flange 27 and the underlying portion of the bottom wall in fluid-tight relation. It will also be noted that the trough is open at the upper end thereof, at the perimeter 23 of the dished portion 20. A plurality of equally spaced fins or vanes 34 are carried by the wall member 16 and extend into the trough 32 and also have a portion 36 which extends into the well 20, as best illustrated in Fig. 1. It will be noted that the fins 34 are spaced from the bottom wall surface 22 so that the chambers in the trough 32, which are defined by said fins, are in fluid communication with each other through said spaces. Wall member 16 converges toward the vertical axis of rotation and is provided with an upper rim 38 for receiving a suitable cover (not shown), which may be releasably secured thereto. It will be observed that the inner wall of trough 32 forms a dam between the two compartments.

In order to removably mount the vessel 10 for rotation about a vertical axis by the motor shaft 14, the bottom wall member 18 is provided with a central recess 40 for receiving an apertured hub member 42. The hub is provided with a circular flange 44 and a plurality of bolts 46 extend through the flange into the bottom wall to secure the latter together. The hub 42 is provided also with a pair of locating pins 48 for insertion into the bottom wall member 18 to effect correct alignment of said parts. The tapered collar 12 is keyed to the motor shaft 14 by the cross pin 50. The collar is provided with a circular flange 52 and with the pair of upstanding locating pins 54. A locking nut 56 seats under the collar flange 52, as best illustrated in Fig. 1, and is internally threaded for threaded engagement with the hub 42, the latter being provided with apertures 58 for receiving the locating pins 54. From the foregoing, it will be readily apparent that said bottom wall 18, 16, and with the collar 12 keyed to the motor shaft 14, the apparatus may be readily assembled for rotation by the motor M, by seating the hub on the shaft collar with the locating pins 54 on the collar extending into the apertures 58 in the hub. Thereafter, the locking nut 56 locks the hub to the shaft collar. The vessel 10 may be readily removed from the motor M by merely retracting the locking nut out of engagement with the hub, whereby the vessel may be conveniently removed, with the hub thereon, from the motor.

Referring now to the modification illustrated by Figs. 5 and 6, the previously mentioned securing screws 30 are eliminated and in place thereof a fluid-tight engagement between overlying portions of side wall 16A and bottom wall 18A of the vessel is obtained by means of the resilient snap ring 60. It will be noted that the ring 60 is provided with a plurality of con cave or inwardly directed arcuate portions 62. Pursuant to the present modification, the bottom rim 28A of the side wall member 16A is extended beyond the bottom wall 18A. Said rim 28A is provided with the circular recess or seat 64, for the spring ring 60. It will be noted that the bottom wall is provided with a slight bevel, as at 66, at the outer edge thereof adjacent the recess 64. Said bevel extends into the path of movement of the spring when it snaps into the seat so that the spring ring presses against said bevelled portion to provide for a tight liquid seal between the parts. During the rotation of the vessel 10, and as the centrifugal force increases, the diameter of the ring 60 tends to increase thus anticipating the apertures 58 thereof, which move outwardly against the bevelled portion 66 so that an increased force is exerted upwardly against the bevelled surface, to tighten the liquid seal.

The blood donation may be taken from the patient and deposited in the vessel 10 in any suitable manner, for example, as described in the patent to No. 2,461,674. In the usual quantity of blood, ordinarily about 500 cc., which is taken from the donor and re-
ceived in the vessel 18, there will be approximately 250 cc. of red cells. Accordingly for a donation of this amount, the trough 32 is designed to have a capacity somewhat larger than 250 cc. so that after the operation of the centrifuge is completed all of the red cells will be in trough 32 and thus completely separated from the plasma most of which will be disposed, externally of the trough, in the dish portion 20 of the bowl.

With the donated blood contained in the vessel 10, the latter is secured to the collar 12, as previously described, and the vessel is then rotated at a suitable high speed. Said speed may be approximately 7,000 r.p.m. to centrifuge the blood into separate components in the vessel. Due to the centrifugal action, the plasma and the red cells separate during the rotation of the vessel 10. However, since the red cell component is heavier than the plasma component, the former is subjected to a greater centrifugal force than the latter and therefore the inclined wall 16 applies a greater downward force to the red cells than to the plasma so that the trough fills up substantially with the red cell component which therefore causes the plasma to flow out of the trough into part 20 of the bowl. Thus, when the rotation of the vessel is stopped, the red cells and the plasma are maintained segregated from each other in separated parts, respectively, of the bowl. As previously indicated, the trough is designed to have a capacity such that it is almost completely filled by the heavier red cell component so that the lighter plasma, which cannot be accommodated in the trough, flows into and is retained in the portion 20 at the termination of the rotation of the vessel 10 and there will be no red cell in the plasma. Therefore, substantially the total amount of donee-available plasma, for a stated donation of blood, is greatly increased and since the plasma is devoid of red cells the danger from a donor of a different blood type is obviated. It will be understood that the fins 34 cause the blood in the vessel 10 to rotate therewith and thus improve the centrifugal action for separating the plasma from the red cells in vessel 10 in the centrifuging operation.

As previously indicated, said fins are spaced from the surface 12 of the bottom wall 18 so that all of the red cells which are contained in the trough may be readily removed therefrom for reinfusion in the donor, if desired. In this connection, it will be understood that the plasma may be removed from the portion 20 and the red cells removed from the trough 32 by suitable apparatus, for example as illustrated and described in the above mentioned patent. However, it is understood that any other suitable means may be utilized to separately withdraw the plasma and the red cells after the centrifuging action has been completed. It will be observed that since the red cells are entirely separated from the plasma and disposed in separated compartments of the centrifuge bowls, there is no danger of the red cells mixing with the donee-available plasma.

The inner surfaces of the vessel 10 are preferably coated with polytetrafluoroethylene, which is sold under the trade name of "Teflon," or with other suitable anti-welding material. While the operation of the centrifuge vessel 10 has been described in connection with the separation of the red cells from the plasma in whole blood, it will be understood that it is within the scope of the present invention to utilize the centrifuge vessel 10 for other purposes, for example to separate plasma into serum albumin and gamma globulin.

While I have shown and described the preferred embodiment of my invention, it will be understood that various changes may be made without departing from the underlying idea or principles of the invention within the scope of the appended claims.

Having thus described our invention, what we claim and desire to secure by Letters Patent is:

1. A centrifuge for separating the plasma and red cells of blood into segregated constituent volumes, comprising a vessel rotatable about a vertical axis to perform a centrifuging operation and having defined at the bottom thereof a central well and a trough disposed radially outwardly thereof, said well having an outer periphery defining the inner side wall of said trough, said trough having an open upper end at the periphery of the well and the latter being inclined downwardly from its periphery to the axis of rotation, whereby, with said trough having a capacity not less than the separate constituent red cell volume in a predetermined volume of blood received in said vessel for centrifuging but less than said predetermined volume of blood, said trough, upon completion of the centrifuging operation, will contain all of the said separate constituent red cell volume of said predetermined volume of blood, said vessel having a bottom wall provided with said well and an outer side wall extending upwardly therefrom, said outer side wall being conical and converging upwardly from said bottom wall and forming the outer wall of said trough, said inner side wall of the trough converging upwardly from said bottom and the upper surface of said well being dish-shaped and terminating at the top of said inner side wall of said trough, said outer side wall of the trough extending upwardly beyond the top of said inner wall.

2. A centrifuge for separating the plasma and red cells of the blood into segregated constituent volumes, comprising a frusto-conical bowl rotatable about a vertical axis, said bowl having means defining an annular trough converging upwardly from the bottom thereof and a centrally dished portion disposed radially inwardly of the trough and having a concave upper surface extending to the upper open end thereof, said trough having a capacity not less than the separate constituent red cell volume in a predetermined volume of blood received in said vessel for centrifuging but less than said predetermined volume of blood, whereby after the centrifuging operation is completed, said trough will contain said separate constituent red cell volume and said dished portion will contain plasma free of red cells.

3. A centrifuge vessel for separating the plasma and red cells of blood into segregated constituent volumes, said vessel comprising a frusto-conical bowl rotatable about a vertical axis, said bowl having means defining an annular trough converging upwardly from the bottom thereof and a centrally dished portion disposed inwardly of the trough and extending to the upper open end thereof, said trough having a capacity not less than the separate constituent red cell volume in a predetermined volume of blood received in said vessel for centrifuging, but less than said predetermined volume of blood, whereby after completion of the centrifuging operation, said trough will contain all of said separate constituent red cell volume and said dished portion will contain plasma free of red cells, and a plurality of spaced vanes having portions extending into and terminating above the bottom of said trough.

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