

[54] **CENTRIFUGE CUPS FOR AUTOMATIC
CHEMICAL ANALYZER**

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Calif.

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[21] Appl. No.: 303,500

Related U.S. Application Data

[63] Continuation-in-part of Ser. Nos. 845,992, July 30,
1969, Pat. No. 3,722,790, and Ser. No. 253,167, May
15, 1972.

[52] U.S. Cl. 23/259, 23/292, 233/27

[51] Int. Cl. B011 3/00

[58] Field of Search..... 23/253 R, 258.5, 259, 292;
233/1 R, 4, 14 R, 24 R, 25, 26, 27; 215/1 R,
1 A, 1 C; 128/2 F, DIG. 28

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2,883,103 4/1959 Whitehead et al. 233/27

Primary Examiner—Morris O. Wolk

Assistant Examiner—Timothy W. Hagan

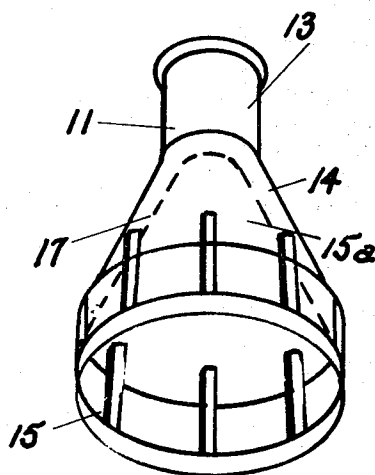
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[57]

ABSTRACT

A hollow container for centrifuging purposes, having at its top a generally tubular vertical neck for the addition of material to the container or removal of material therefrom, having below said neck an annular chamber of frusto-conical cross section formed of a first wall, coaxial with said neck and a second wall inwards of and substantially parallel to said first wall and having a diameter substantially greater than the maximum diameter of the neck and communicating with the neck, said annular chamber being adapted to receive and retain the heavier ingredients of such material upon high speed rotation of the container on its axis, the lighter ingredients taking a position inwardly therefrom in the container and generally aligned with said neck upon cessation of said rotation, and a plurality of baffles disposed at intervals in said side chamber extending partially between said walls so as to permit even distribution of the sediment on centrifuging, but preventing remixing of the sediment on decelerating.

19 Claims, 29 Drawing Figures



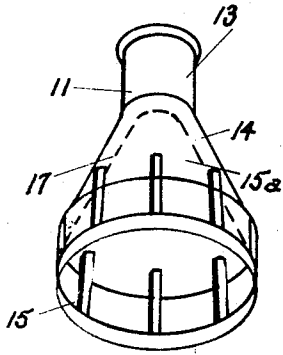


FIG. 1a

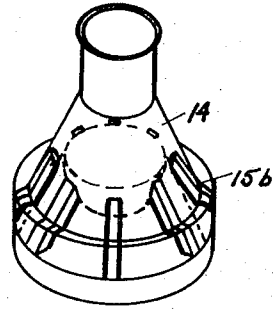


FIG. 1b

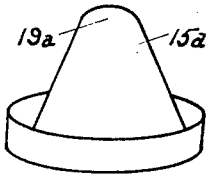


FIG. 2a

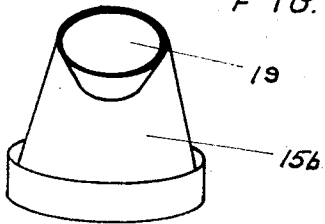


FIG. 2b

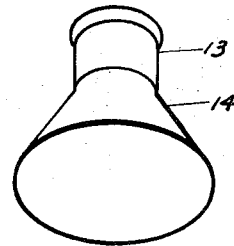


FIG. 2c

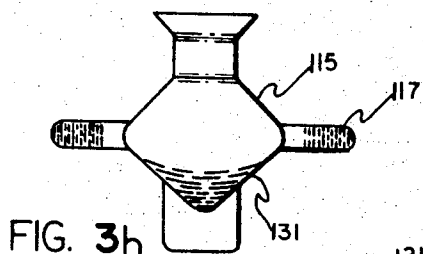
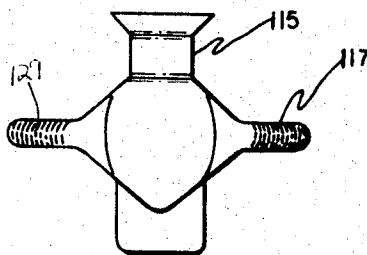
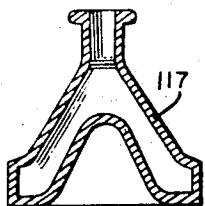
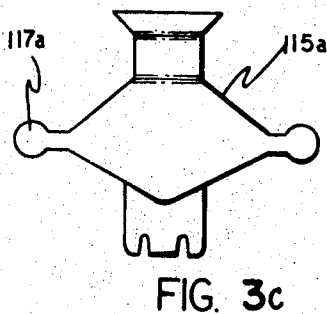
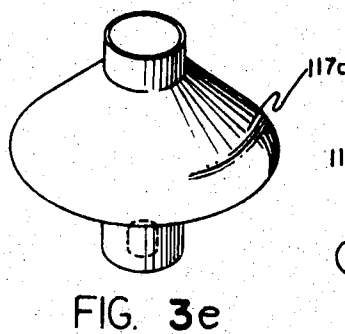
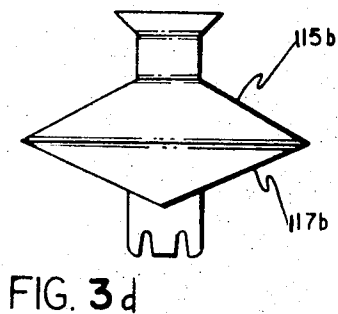
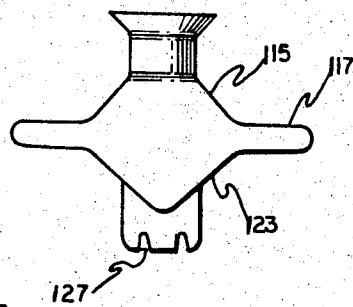
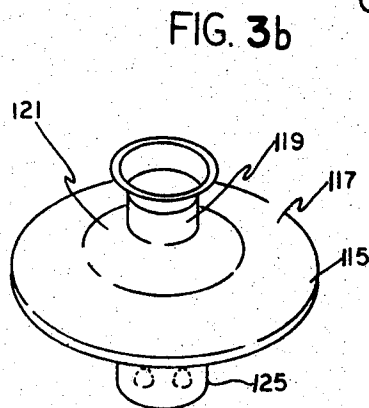


FIG. 3a



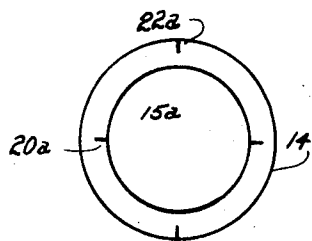


FIG. 4a

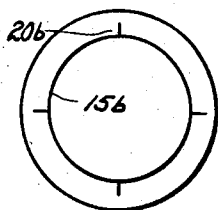


FIG. 4b

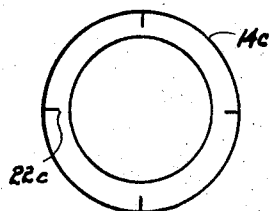


FIG. 4c

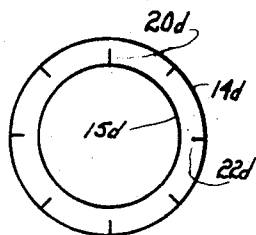


FIG. 4d

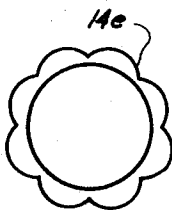


FIG. 4e

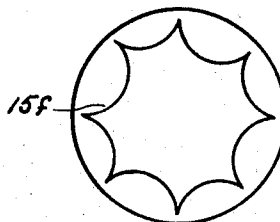


FIG. 4f

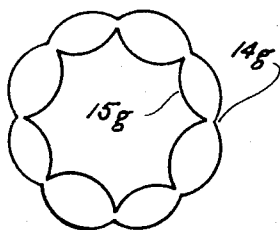


FIG. 4g

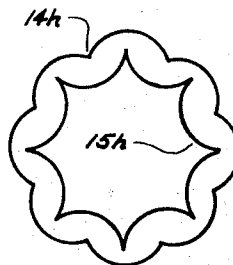


FIG. 4h

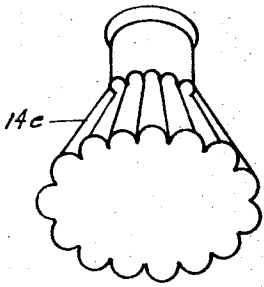


FIG. 5

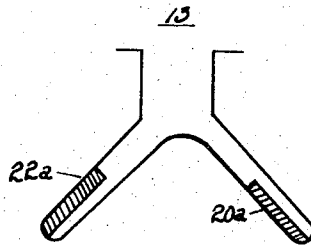


FIG. 6a

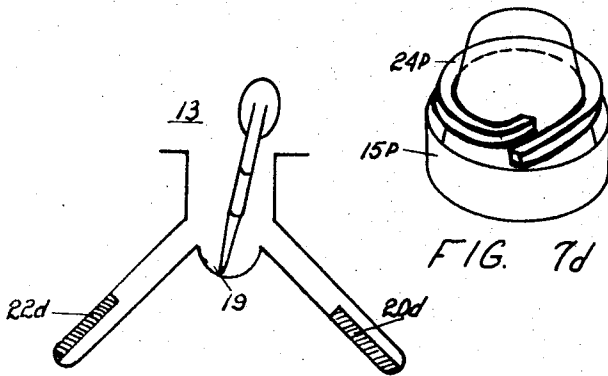


FIG. 6b

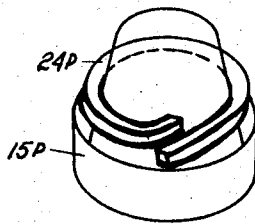


FIG. 7d

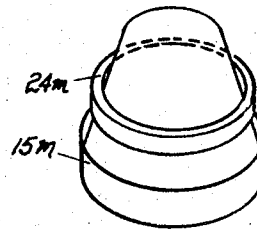


FIG. 7a

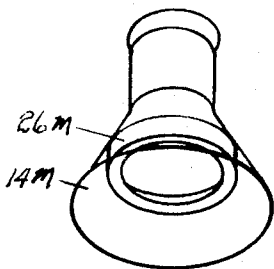


FIG. 7b

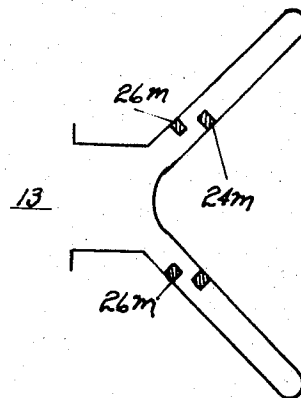


FIG. 7c

CENTRIFUGE CUPS FOR AUTOMATIC CHEMICAL ANALYZER

This application is a continuation-in-part of U.S. Patent applications, Ser. Nos. 845,992 (now U.S. Pat. No. 3,722,790) and 253,167 filed, respectively, on July 30, 1969 and May 15, 1972.

BACKGROUND OF THE INVENTION

The present invention relates to centrifuge containers and more particularly to containers used in an automatic chemical analyses apparatus for small quantities of a sample such as blood.

BRIEF DESCRIPTION OF THE PRIOR ART

As hereinbefore described in the Samuel Natelson U.S. Pat. applications, Ser. Nos. 845,992 and 253,167, it is advantageous to use a container having a side chamber which is rotated on its own axis so as to separate materials of different densities. When a mixture such as blood containing erythrocytes is placed in such a container and rotated at high speeds, the cells will sediment and separate from the plasma which remains towards the center whereas the cells move outwards to the side chamber. As rotation slows down however, there is a tendency for rotation of the liquid to continue in the side chamber due to the inertia of the fluid mass. This then causes a partial remixing of the samples.

SUMMARY OF THE INVENTION

Generally speaking, the present invention contemplates a container for use in an automated centrifuge arrangement whereby said container may be rotated on its substantially vertical axis so as to separate materials of different density, said container having a flange neck forming a cylinder around said vertical axis, suitable for insertion of a stopper, an upper, outer wall continuous with said neck at the lower end of the cylinder, said upper wall making an angle greater than 90 degrees but less than 180 degrees with said cylinder, said upper wall having a section meeting and continuous with a lower inner wall so that said container is formed with a side chamber between portions of said outer and inner wall at least partially surrounding said central axis. The improvement contemplated herein generally comprises having a plurality of baffles disposed at intervals in the side chamber extending partially between the walls of the side chamber so as to permit even distribution of the sediment on centrifuging, but prevent remixing of the sediment on decelerating. Both vertical and horizontal baffles are contemplated.

Broadly stated therefore, the present invention contemplates providing baffles between the inner and outer walls of the side chamber to prevent the remixing of the sample.

The invention as well as other objects and advantages thereof will be better understood from the following detailed description when considered together with the accompanying drawings in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1a is a perspective view of one type of container contemplated herein;

FIG. 1b shows a perspective view of another type of container contemplated herein;

FIG. 2a shows the inner wall of the container of FIG. 1a in perspective;

FIG. 2b shows the inner wall of FIG. 2a in perspective;

FIG. 2c shows the same outer wall and neck for both the containers of FIGS. 1a and 1b in perspective;

FIGS. 3a through 3i shown examples of containers described in my co-pending application hereinbefore mentioned;

FIG. 4a shows a sectional view of a cut across the container which provides an explanation of the inventive concept, illustrating good results;

FIG. 4b presents a view similar to FIG. 4a but with poor results;

FIG. 4c again shows a view similar to FIG. 4a and with good results;

FIG. 4d is also a view similar to FIG. 4a with exceptionally good results;

FIG. 4e likewise shows a view similar to FIG. 4a and with good results;

FIG. 4f contains also a view similar to FIG. 4a but with poor results;

FIG. 4g is also a view similar to FIG. 4a and with good results;

FIG. 4h is a view similar to FIG. 4a and with poor results;

FIG. 5 depicts a perspective view of a container shown in sections in FIG. 4e;

FIG. 6a shows a cross-sectional view of a container with baffles as contemplated herein;

FIG. 6b is another cross-sectional view of a baffle arrangement contemplated herein;

FIG. 7a shows an arrangement in perspective with horizontal baffles;

FIG. 7b is another perspective arrangement with horizontal baffles;

FIG. 7c illustrates a sectional view of a container with horizontal baffles in the pouring position;

FIG. 7d illustrates a view of a spiral baffle on the inner wall.

DETAILED DESCRIPTION

The general form of these containers is of the structures shown in FIGS. 1a and 2a. These containers 11 have a conical shape with a neck 13 which becomes an outer wall 14 and a central cone as an inner wall 15a, sealed together in such a way that a narrow side chamber 17 is created circularly around the central axis of the container. The container of FIGS. 1a and 2a differs from that of FIGS. 1b and 2b in that a depression 19b is formed in the apex of the central cone inner wall 15b. These can be better seen when the inner wall is separated from the outer wall as shown in FIGS. 2a, 2b and 2c. In FIGS. 2a and 2b, a portion of the outer wall is shown attached to the inner wall to show how either the cone of FIGS. 2a or 2b may be sealed by inserting into the bottom of 2c. Thus, the neck 13 and outer wall 14 is the same shown in FIGS. 1a and 1b. In FIGS. 1a and 2a, the central cone 15a has a rounded apex 19a. In FIGS. 1b and 2b, the apex has a depression 19b. Also, the present inventive concept is also applicable to the containers shown in FIGS. 3a through 3i described in my co-pending applications hereinbefore mentioned.

If the mixture, such as a blood containing erythrocytes, is placed in the container and the container is rotated at high speeds, usually of approximately 8,000 - 15,000 r.p.m., the cells will sediment and separate from the plasma. On being allowed to come to rest, the plasma will be found above the cells, and may then be

readily separated. Of especial value in this application is a container having a central cone 15b with a depression 19b as shown in FIG. 2b. In this case, the plasma may be removed by an aspirator without any danger of dipping the aspirator into the cells since there are no cells remaining in the depression formed at the apex of the inner cone.

On slowing down, to come to rest, there is a tendency for rotation of the liquid to take place in the cup side chambers due to the inertia of the fluid mass. This results in partial remixing of the specimen, unless the precipitate is a tightly adhering material. This is not the case with blood. This may be stopped by an obstruction, such as a barrier being placed between the inner and outer wall. This suffers from the defect that the cells will tend to pile up against this barrier. This is particularly bad if the blood is clotted, in which case the whole clot may stand up against the barrier. In summary, the barrier tends to prevent the even distribution of the sediment around the side chamber, or narrow space between the walls of the inner and outer cone.

VERTICAL BAFFLES

According to the present inventive concept, vertical baffles are placed around the annular space between the inner wall 15a or 15b and outer wall 14 or in the side chamber, which does not extend completely from the outer to the inner walls. The various possible designs, as examples of this type of structure are shown in FIGS. 3a to 3i and as applied to FIGS. 1a and 1b are shown schematically in FIGS. 4a to 4h where a horizontal cross-section is taken of the container showing the inner wall 15a or 15b, the outer wall 14 and the baffles disposed around the walls.

FIG. 3a shows a top-shaped round container 115 with a central disc-shaped section 117 called the side chamber with a neck 119 and a barrel-shaped center 121. The side chamber is defined by a central disc 117, a narrowing bottom 123, a cylindrical item section 125 to hold the container with inner bottom depressions 127 to serve as holding or spinning means.

The container shown in FIGS. 3a and 3b is designed to hold 5 ml of blood. These can be made in any size. They may or may not contain an anticoagulant.

If the container shown in FIG. 3a is spun around its vertical axis, the blood is driven laterally by centrifugal forces taking the position shown in FIG. 3g. When spinning stops the serum or plasma will slide down taking the position shown in FIG. 3h. The heavier cells with or without the clot will be driven into the side chamber.

The design of the container can take to form of FIG. 3c showing a container 115a with the side chamber having knob-like wings 117a in which case a large volume can collect in the side chamber without making the container orifice unduly wide. Other shapes are also possible and one is shown in FIG. 3d showing a container 115b with large wings 117b. It is also advantageous to use the configuration shown in FIGS. 3c and 3f with inclined wings 117c. The container with the configuration shown in FIGS. 3e and 3f have the advantage that a narrow orifice to the side chamber is unnecessary. When the container stops spinning, the erythrocytes will remain in the side chamber held by gravity. This is particularly useful where larger volumes are used.

When spinning, the device shown in FIG. 3a will drive the cells 129 into the outer disc (FIG. 3g). The cell free serum or plasma 131 will then fall free when the spinning stops leaving the cell behind in the disc (FIG. 3h).

In subsequent operations, where a protein precipitant is added to the serum, the precipitate has strong coherence. In this case, a design such as FIG. 3d can be used. If spun at 12,000 r.p.m., this precipitate will collect in the corners of wings 117b and pack. On stopping the rotation the centrifugate will drop to the bottom, the precipitate adhering to the corners.

FIGS. 4a through 4h show a horizontal cross-section of a cut through containers contemplated herein to indicate the form of the annular space of the side chamber.

FIG. 4a illustrates the principle. In this embodiment there are inner baffles 20a attached to the inner wall and outer baffles 22a attached to the outer wall. As the rotating container speeds up and rotates, a tortuous pathway is presented for the distribution of the cells or the clot if blood is being centrifuged. The high torque at the high speeds forces an even distribution of material in order to achieve balance. As the container slows down, the packed material and the supernatant now have difficulty in swirling because a clear pathway does not exist, and the baffles overlap. At the low speeds of deceleration, the force is weak and the container is moving slowly. The distance between walls is of the order of 4mm. The baffles are approximately 3mm. in size allowing only 1 mm. for passage. This serves as an adequate restriction so that remixing due to swirling does not take place.

FIG. 4b is an example of an unsatisfactory design. If the vertical baffles are attached only to the inner wall 15b they will act as stirrer paddles and remix the specimens as the container slows to rest. This is so since the material is caught by the baffles and thrown outward. On the other hand, FIG. 4c is effective in this regard since the baffles 22a are on the outside wall 14c and obstruction is presented to remixing. The effect is opposite to FIG. 4b. For this reason it is advantageous to place most of the baffles on the outer wall.

As the number of vertical baffles increases, the efficiency of separation increases. However, a practical limit exists since soon there is no residual volume for the precipitate to collect in. A highly effective design is to have eight baffles 20d, 22d all but one or two 20d sealed to the outer wall 14d. This is shown in FIG. 4d where seven baffles 22d are on the outer wall 14d and one baffle 20d is on the inner wall 15d.

A similar effect may be achieved by vertically scalloping the outer wall or both inner and outer walls. This permits the use of larger volume capacity without decrease in efficiency in preventing remixing. FIGS. 4e, 4g and 4h are examples of this design all of which are effective. FIGS. 4e to 4h are variants of FIGS. 4a to 4d. In FIG. 4e the outer wall 14e is scalloped; in FIG. 4f it is the other wall 15f; in FIG. 4g both walls 14g and 15g; in FIG. 4h the walls 14h and 15h are both scalloped but are offset. As would be expected, FIG. 4f, being like 4b will tend to remix the specimens and is undesirable. FIG. 5 is a three dimensional representation of FIG. 4e for clarity.

A vertical cross-section of the container showing the location of an inner and outer vertical baffle is shown in FIGS. 6a and 6b, the baffles being applied to the two

cups of FIGS. 1a and 1b respectively. It is to be noted that the baffles extend only part way up the cone. This is done purposely since it permits ready distribution of specimen initially during centrifuging. After centrifugation, the sediment is in the bottom sections and the baffles do not need to extend any higher. A second reason for not extending the baffles is that they interfere when pouring out the solution. They tend to act as a guide bringing up the material from below to the top, thus aiding in remixing when attempting to pour off the supernatant.

The supernatant may be removed by aspirating with a syringe or by pouring over. When aspirating, the design of FIG. 6b is advantageous since one is prevented from dipping the aspirator into the lower layer when one dips into the cup. When the sediment is desired, this may also be aspirated.

As an alternative, one may wish to pour the supernatant off. This is of particular importance since it is easier to pour than aspirate for certain purposes. Further, when one wants the residue, which may be tightly packed, it is advantageous to pour off the supernatant. If the sediment is loosely packed it will tend to slip out from under the upper layer remixing the specimens.

HORIZONTAL BAFFLES

To avoid the foregoing problem of the remixing of specimens during pouring, it is advantageous to provide one or several horizontal baffles as shown in FIGS. 7a, 7b, 7c. In FIG. 7a is shown the inner wall 15m of a container with a horizontal baffle 24m in the form of a ring which encircles the inner wall. A portion of the bottom of the annular space and outer wall is attached to show how it seals to either FIG. 2c, FIG. 5 or FIG. 7b. In FIG. 7b the outer wall 14m is shown with a baffle 26m on the outer wall, likewise in the form of a ring. These baffles do not extend from wall to wall, thus permitting the material to sediment and still serve the function of aiding in pouring without mixing. How this affects the decantation is seen in FIG. 7c where horizontal baffles are provided on the inner and outer walls. As shown in FIG. 7c, inner baffle 24m holds back the precipitate located in the upper part of the container during pouring while at the same time the outer baffle 26m serves to retain sediment from pouring out from the lower part of the container. Thus, one outer and one inner baffle, 24m, 26m, serve to retain sediment when pouring as shown in the vertical cross section of FIG. 6c.

It has been found that when blood is several hours old the clot tends to become hard and rubbery. This produces a coherent elastic material which tends to sit on top of the vertical baffles. In this case a spiral horizontal baffle as shown in FIG. 7d is particularly advantageous. The container rotates in such a way as to act as a screw forcing the clot downward. In FIG. 7d there is shown a spiral baffle 24P attached to the inner wall 15P. Naturally, this type of baffle could also be attached to the outer wall as in FIG. 7b. The spiral baffle is in reality a cross between the vertical and horizontal baffle and serves to take advantage of the properties of each.

I claim:

1. In a container for use in an automated centrifuge arrangement whereby said container may be rotated on its substantially vertical axis so as to separate materials of different density, said container having a flanged neck forming a cylinder around said vertical axis, suit-

able for insertion of a stopper, an upper outer wall continuous with said neck at the lower end of the cylinder, said upper wall making an angle greater than 90 degrees but less than 180 degrees with said cylinder, said upper wall having a section meeting and continuous with a lower inner wall so that said container is formed with a side chamber between portions of said outer and inner wall at least partially surrounding said central axis, the improvement therein comprising, a plurality of baffles attached to one wall of said outer or inner walls, said baffles being disposed at intervals in said side chamber and extending partially between the walls of said side chamber so as to permit passage of and even distribution of the sediment on centrifuging but to prevent remixing of the sediment on decelerating.

2. A container as claimed in claim 1 wherein said baffles are vertical.

3. A container as claimed in claim 1 wherein said baffles are horizontal.

4. A container as claimed in claim 2 wherein said baffles are attached to said outer wall.

5. A container as claimed in claim 2 wherein at least over one-half of said baffles are attached to the outer wall.

6. A container as claimed in claim 5 wherein said baffles are defined by a scalloped wall.

7. A container as claimed in claim 5 wherein said baffles are defined by scalloped walls.

8. A container as claimed in claim 4 wherein said baffles are vertical partitions extending partly between the walls.

9. A container as claimed in claim 5 wherein said baffles are vertical partitions extending partly between the walls.

10. A hollow container for centrifuging purposes, having at its top a generally tubular vertical neck for the addition of material to the container or removal of material therefrom, having below said neck an annular chamber of frustoconical cross section formed of a first wall, coaxial with said neck and a second wall inwards of and substantially parallel to said first wall and having a diameter substantially greater than the maximum diameter of the neck and communicating with the neck, said annular chamber being adapted to receive and retain the heavier ingredients of such material upon high speed rotation of the container on its axis, the lighter ingredients taking a position inwardly therefrom in the container and generally aligned with said neck upon cessation of said rotation, and a plurality of baffles attached to one wall of said first or second walls, said baffles being disposed at intervals in said side chamber and extending partially between said walls so as to permit passage of and even distribution of the sediment on centrifuging, but preventing premixing of the sediment on decelerating.

11. A container as claimed in claim 10 wherein said baffles are vertical.

12. A container as claimed in claim 10 wherein said baffles are horizontal.

13. A container as claimed in claim 11, wherein said baffles are attached to said outer wall.

14. A container as claimed in claim 11 wherein at least over one-half of said baffles are attached to the outer wall.

15. A container as claimed in claim 13 wherein said baffles are defined by a scalloped wall.

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- 16. A container as claimed in claim 14 wherein said baffles are defined by scalloped walls.
- 17. A container as claimed in claim 13, wherein said baffles are vertical partitions.
- 18. A container as claimed in claim 14, wherein said

baffles are vertical partitions.

- 19. A container as claimed in claim 10, wherein said baffles are of a spiral arrangement.

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