

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
3 January 2008 (03.01.2008)

PCT

(10) International Publication Number
WO 2008/002004 A1

(51) International Patent Classification:
B04B 1/06 (2006.01)

(21) International Application Number:
PCT/KR2007/000980

(22) International Filing Date:
26 February 2007 (26.02.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
10-2006-0060515 30 June 2006 (30.06.2006) KR
10-2006-0111265
10 November 2006 (10.11.2006) KR

(71) Applicants (for all designated States except US):
MEDIKAN INC. [KR/KR]; 3f, Gujeong Building 577-7
Sinsa-dong, Gangnam-gu, Seoul 135-891 (KR). **YAHOH
PROGRESSIVE IDEA AREA** [KR/KR]; Yahoh Build-
ing 619-4 Sinsa-dong, Gangnam-gu, Seoul 135-894 (KR).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **LEE, Jun-Seok**

[KR/KR]; 501 Heukseokpark Apt. 888-12, Daeyeon-dong,
Nam-gu, Busan-city 608-020 (KR). **LEE, Heeyoung**
[KR/KR]; 14/5, 919-9 Munhwa-dong, Jungangno1-dong,
Gunsan-city, Jeollabuk-do 573-874 (KR).

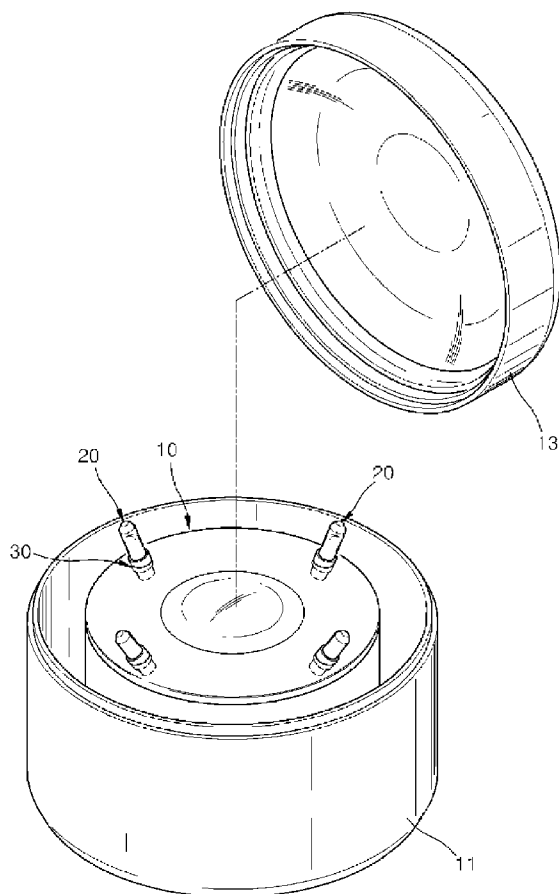
(74) Agent: **Y.P. LEE, MOCK & PARTNERS**; Koryo Build-
ing 1575-1 Seocho-dong, Seocho-gu, Seoul 137-875 (KR).

(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN,
CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI,
GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS,
JP, KE, KG, KM, KN, KP, KZ, LA, LC, LK, LR, LS, LT,
LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MY, MZ,
NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU,
SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR,
TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM,
ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),

[Continued on next page]

(54) Title: CENTRIFUGE AND CENTRIFUGING METHOD



(57) Abstract: Provided are a centrifuge and a centrifugal
method in which layers of a centrifuged material can be classified
and collected accurately and easily without a separation or
washing process by opening or closing an opening portion of
a container in a centrifuging process. The centrifuge includes:
a rotator; a container into which a material is injected and
comprising an opening portion, inclined at a predetermined angle
with respect to a rotation axis of the rotator such that the opening
portion is directed downward, and coupled to the rotator; and
a stopper portion that closes the opening portion, and when the
speed of the rotator reaches a predetermined speed, thereby
centrifuging the material, opens the opening portion such that the
material in the container flows outward.

WO 2008/002004 A1



European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Published:

— *with international search report*

Description

CENTRIFUGE AND CENTRIFUGING METHOD

Technical Field

- [1] The present invention relates to a centrifuge and a centrifuging method, and more particularly, to a centrifuge and a centrifuging method in which, when centrifuging is performed by rotation of a rotator, a layer of a material having low fluid resistance and low specific gravity and a layer having high fluid resistance and high specific gravity among the layers separated by centrifuging can be classified and collected accurately and easily by opening an opening portion of a container.
- [2] The centrifuge and the centrifuging method according to the present invention can be applied to all kinds of materials that can move downward along an inclined surface, that is, both to liquids and solids such as liquid, powder, gel, a mixture of liquid and solid, colloids, and solids that are nearly spherical.

Background Art

- [3] A centrifuge is an apparatus for separating materials using centrifugal force that is generated when an object is rotated. Centrifuges can be classified according to an amount of a sample to be centrifuged, the rotation speed, the rotor, etc.
- [4] A centrifuge is used in biotechnology to separate cells mixed in a liquid or a material having greater weight and adhesive force than a liquid. Recently, intensive research on adult stem cells has been conducted, and a centrifugal method of separating a small amount of stem cells from a large amount of adult tissues (fat, bone-marrow, etc.) is currently being researched.
- [5] As a centrifuge used in biotechnology is required to separate human body cells without destroying them, a smaller centrifugal force is used for separating human body cells than when separating a general material. The centrifugal force required for centrifuging cells is 100 G maximum, usually lower than this. Here, G denotes a gravitational constant. Since a centrifugal force acts against in a centrifuge, a centrifugal force will be represented using the unit 'G'.
- [6] When a complex fluid such as blood is centrifuged using a centrifuge in a biotechnology laboratory, the fluid is divided into several layers according to the specific gravity of each element of the complex fluid. Here, a complex fluid refers to a liquid that includes semisolids such as fine solid components or gel and has a broader range than a polymer; hereinafter, it will be referred to as 'fluid'.
- [7] When a cell is separated using a centrifuge, each centrifuged layer of fluid is stacked in a test tube and can be discriminated visually; however, it is difficult to separate the layers physically. Layers of a fluid centrifuged by a centrifuge are generally separated by hand. However, separating layers of a centrifuged fluid is an

onerous task, and moreover, loss of the centrifuged material may be caused and thus purity of the separated material cannot be secured.

[8] Without a centrifugal force, the cohesive or adhesive force between cells is not distinctively different from that of water, and thus over 50 % of pouring out of a liquid from the tube fails. Even when the pouring is successful, some of the cells in the top layer may be swept away. If the centrifugal force is increased to adhere the cells to each other, the cells may be destroyed.

[9] Thus the testers have proposed using a pipette to remove the upper layer. However, a portion of the liquid to be removed still remains in the test tube and thus at least seven or eight dilution processes need to be performed.

[10] For example, when stem cells are separated from fat tissues, classifying a minimum amount of stem cells by solving a large amount of tissues using a solvent such as collagen and washing the centrifuged material are performed. The separated material is washed for removing unnecessary medical elements and other elements included in the material to use the separated material again in the human body. However, washing requires a lot of time and may destroy the stem cells. In other words, in the washing process, the centrifuged material is manipulated several times, and thus the time the stem cells are exposed to the air is prolonged, thereby increasing the risk of contamination of the stem cells.

Disclosure of Invention

Technical Problem

[11] The present invention provides a centrifuge and a centrifugal method in which a material is separated by a centrifugal force and layers of the separated material are classified and collected accurately and easily.

[12] The present invention also provides a centrifuge and a centrifugal method in which stem cells are accurately classified and collected from layers of a material separated by centrifuge.

Technical Solution

[13] The present invention provides a centrifuge and a centrifugal method in which a layer of a material having a low specific gravity among the layers of the material is separated by a centrifugal force, and layers of the separated material are classified and collected accurately and easily.

[14] The centrifuge and the centrifuging method according to the present invention are for centrifuging a complex fluid (a liquid that includes semisolids such as fine solid components or gel and has a broader range than a polymer; hereinafter referred to as 'fluid') such as blood extracted from a human body, fat, and the like. In detail, according to the present invention, stem cells contained in a small amount in a

complex fluid such as fat extracted from a human body can be centrifuged, and the stem cells moved by the operation of centrifugal force are accumulated in a container that is detachably installed, and thus the stem cells can be accurately and easily collected without any additional separation process or washing process.

- [15] The centrifuge and the centrifuging method according to the present invention can be applied to all kinds of materials that can move downward along an inclined surface, that is, both to liquids and solids such as liquid, powder, gel, a mixture of liquid and solid, colloids, and solids that are nearly spherical.
- [16] The present invention provides a centrifuge and a centrifuging method in which a container is inclined at a predetermined angle with respect to a rotation axis of the centrifuge, and while the centrifuge is rotated, a stopper portion of the container opens or closes an opening portion of the container. Accordingly, the present invention provides a centrifuge and a centrifuging method whereby centrifuging can be performed and segregated layers can be classified accurately and easily and be collected.
- [17] While centrifuging is performed by rotation of the centrifuge, layers formed of materials having high specific gravity and high fluid resistance are positioned away from the center of the rotation axis of the centrifuge, and layers formed of materials having low specific gravity and low fluid resistance are positioned near the center of the rotation axis of the centrifuge. Here, fluid resistance refers to the complex characteristic of a fluid, whereby the fluid is resistant to flow due to adhesive force, cohesive force, viscosity, etc.
- [18] Thus the present invention provides a centrifuge and a centrifuging method using the centrifuge that can accurately separate and collect layers of stem cells in the centrifuge without any additional separation or washing process based on the characteristic of stem cells in a complex fluid such as fat tissue extracted from a human body, which has higher fluid resistance compared to other elements contained in a fluid of fatty tissue and is affected by a relatively greater centrifugal force at the same rotation speed than other materials.
- [19] While centrifuging is completed in the container, and the centrifuge is continuously rotated, the stopper portion which has closed the opening portion of the container is opened and a fluid having a low specific gravity and a low fluid resistance can be discharged to the outside. The rotation speed of the centrifuge during the opening of the opening portion is reduced to a speed lower than the rotation speed during centrifuging. This is for separating a fluid to which a high centrifugal force is applied and another fluid to which a low centrifugal force is applied by adjusting the rotation speed of the centrifuge based on the characteristic that centrifugal force applied during rotation varies according to the specific components of the fluid.

- [20] While the rotation is performed at a reduced rotation speed after segregation of layers is completed, gravity and centrifugal force exerted on each layer vary according to the fluid dynamic characteristic of each of the segregated layers. Some layers to which relatively greater gravity than centrifugal force is applied flow down through the stopper portion and the opening portion of the container, and some layers to which relatively greater centrifugal force than gravity is applied remain attached to the container, being attached to the container.
- [21] When the centrifuge performs centrifuging according to the present invention, the centrifuge is rotated at a maximum speed required for centrifuging, that is, at a first speed for a predetermined period of time to centrifuge a material into segregated layers.
- [22] In order to discharge some layers of the material in the container, the speed of the centrifuge needs to be slowed down from the first speed to a second speed that is lower than the first speed and the centrifuge is rotated again for a predetermined period of time. The container is installed in the centrifuge such that an opening portion of the container directs downward and is inclined at a predetermined angle. Accordingly, while the centrifuge is being rotated at the second speed, and the opening portion of the container is opened, some layers formed of a material having low fluid resistance and low specific gravity in the container can flow down through the opening portion of the container.
- [23] The second speed is determined by the characteristic of the material to be centrifuged, and particularly, by the fluid resistance. When the centrifuge is continuously being rotated at the reduced rotation speed, that is, at the second speed, layers at the outermost edge such as stem cells among segregated layers formed in the container are maintained inside the container by being affected by a centrifugal force that is greater than gravity; however, the other segregated layers may flow down by being affected by a centrifugal force that is less than gravity. In this manner, a critical point at which some of the segregated layers are discharged outside of the container can be determined by adjusting the second speed according to the segregated layers to be centrifuged.
- [24] As described above, by reducing the rotation speed of the centrifuge, some of the layers of the centrifuged material in the container can flow down to the outside of the container by gravitational force; however, some layers can also be discharged to the outside of the container without reducing the rotation speed of the centrifuge. That is, when pressure is produced by a pump in a discharge pipe that is connected to the container through the stopper portion coupled to the opening portion of the container, some layers in the container can be discharged to the outside of the container due to the pressure produced in the discharge pipe.

- [25] According to an aspect of the present invention, there is provided a centrifuge comprising: a rotator rotating around a rotation axis; a container into which a material is delivered and comprising an opening portion, inclined at a predetermined angle with respect to a rotation axis of the rotator such that the opening portion is directed downward, and coupled to the rotator; and a stopper portion that is coupled to the opening portion and closes the opening portion, and when the speed of the rotator reaches a predetermined speed and thus the material is centrifuged, opens the opening portion such that the material in the container flows outward.
- [26] The stopper portion may comprise a valve which is operated according to an external signal and thus opens or closes the opening portion.
- [27] A receiving unit which receives a material when the stopper portion is opened may be formed in the rotator.
- [28] A connecting portion connecting the container to the outside may be connected to the stopper portion.
- [29] The connecting portion may comprise at least one discharge pipe discharging the material of the container.
- [30] The connecting portion may further comprise an inflow pipe delivering a fluid into the container from the outside.
- [31] According to another aspect of the present invention, there is provided a method of centrifuging comprising: (a) delivering a material into a container; (b) detachably coupling the container to a rotator at a predetermined angle with respect to a rotation axis of the rotator such that an opening portion of the container is directed downward; (c) centrifuging the material in the container by rotating the rotator; (d) opening the stopper portion coupled to the opening portion while continuously rotating the rotator to discharge some layers of the centrifuged material to the outside of the container; (e) closing the stopper portion; (f) stopping the rotator; and (g) separating the container from the rotator to collect the centrifuged material.
- [32] In (d), a discharge pipe connected to the container via the stopper portion may be opened to discharge some layers of the centrifuged material.
- [33] The discharge pipe may be connected to a pump, and some layers of the centrifuged material may be discharged to the outside of the container by pressure produced by the pump.
- [34] In (d), an inflow pipe connected to the container via the stopper portion may be opened to deliver an external fluid into the container to maintain the pressure of the container regular.
- [35] The rotator may be rotated at a speed reduced compared to the speed in (c), and the stopper portion may be opened to discharge some layers of the centrifuged material.

Advantageous Effects

- [36] As described above, in the centrifuge and the centrifuging method according to the present invention, centrifuging is performed with a container being maintained at a predetermined angle with respect to the rotation axis of the centrifuge, and an opening portion of the container coupled to a rotator and directing downward. In addition, while the centrifuge is being rotated, a stopper portion coupled to the container opens or closes the opening portion of the container. Thus layers of centrifuged material can be easily classified and collected without additional separation or washing process.

Description of Drawings

- [37] FIG. 1 is a perspective view illustrating a centrifuge according to an embodiment of the present invention;
- [38] FIG. 2 is a side cross-sectional view illustrating the centrifuge of FIG. 1, according to an embodiment of the present invention;
- [39] FIG. 3 is a schematic view illustrating forces applied to a material when a centrifugal force is not present in a centrifuge according to an embodiment of the present invention;
- [40] FIG. 4A schematically illustrates forces of FIG. 3 changed to a state where a high centrifugal force is applied;
- [41] FIG. 4B schematically illustrates forces of FIG. 3 changed to a state where a low centrifugal force is applied;
- [42] FIG. 5 is a side view of a portion of a centrifuge, illustrating a container before centrifuging starts according to an embodiment of the present invention;
- [43] FIG. 6 is a side view of a portion of a centrifuge, illustrating the container of FIG. 5 in which a portion of separated material is collected; and
- [44] FIG. 7 is a flowchart illustrating a centrifuging method according to an embodiment of the present invention.

Best Mode

- [45] The present invention will now be described more fully with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown.
- [46] FIG. 1 is a perspective view illustrating a centrifuge according to an embodiment of the present invention. FIG. 2 is a side cross-sectional view illustrating the centrifuge of FIG. 1.
- [47] The centrifuge illustrated in FIGS. 1 and 2 is an apparatus that separates a material by being rotated around a rotation axis O. The centrifuge according to the current embodiment of the present invention includes a rotator 10, a container 20 coupled to the rotator 10 at a predetermined angle θ , and a stopper portion 30 opening or closing an opening portion 21 of the container 20.
- [48] The rotator 10 rotates around the rotation axis O and supports the container 20. The

rotator 10 is disposed inside a casing 11 and is coupled to a driving motor 12 to rotate in the casing 11 for centrifuging. A cover 13 covering the rotator 11 and the container 20 is coupled to the casing 11.

[49] A receiving unit 15 is formed in the rotator 10. The receiving unit 15 receives the material flowing down from the container 20.

[50] A plurality of containers 20 may be coupled to the rotator 10. The container 20 is coupled to the rotator 10 such that the opening portion 21 of the container 20 is directed downward. Accordingly, the container 20 is inclined at a predetermined angle with respect to the rotation axis O. An angle θ between an axis P in a length direction of the container 20 and the rotation axis O can be determined in consideration of gravity, centrifugal force, and a force by fluid resistance applied to the material so that the material can flow down when a layer of the material separated by the centrifuging is discharged outside the container 20.

[51] The container 20 may be an ordinary test tube into which a material to be centrifuged is received. The opening portion 21 is formed in the container 20, and an end portion of the opening portion 21 away from the rotator 10 has a horizontal cross-section becoming reduced downwardly.

[52] A stopper portion 30 is coupled to the container 20. The stopper portion 30 is coupled to the opening portion 21 of the container 20 and opens or closes the opening portion 21. One side of the stopper portion 30 is coupled to the opening portion 21 of the container 20, and another side of the stopper portion 30 is opened toward the receiving unit 15 of the rotator 10. When the stopper portion 30 is opened, the opening portion 21 of the container 20 is opened toward the receiving unit 15 of the rotator 10.

[53] The stopper portion 30 may include a valve 31 that is operated according to external signals. The valve 31 is connected to a controller 33 via a signal line 32 installed in the rotator 10 and is operated by a driving signal supplied by the controller 33. Accordingly, when the opening portion 21 is opened by the valve 31, the material in the container 20 can flow downward, and when the opening portion 21 is closed, the material stays inside the container 20. The valve 31 may also be operated by external signals wirelessly instead of by being connected to the outside via the signal line 32.

[54] The centrifuge according to the current embodiment of the present invention is operated as follows.

[55] A sample to be centrifuged is filled into the container 20, and the container 20 is coupled to the rotator 10. As the container 20 is coupled to the rotator 10 via the stopper portion 30, the axis P in a length direction of the container 20 is maintained at a predetermined angle θ with respect to the rotation axis O. Here, the stopper portion 30 closes the opening portion 21 of the container 20 such that the material inside the container 20 does not flow outside.

- [56] When the driving motor 12 connected to the rotator 10 is driven, the rotator 10 rotates around the rotation axis O. The container 20 is coupled to the rotator 10 and thus the container 20 is rotated together with the rotator 10. As a centrifugal force is applied to the material in the container 20, the material is centrifuged in the container 20 according to specific gravity. Hereinafter, the rotation speed of the rotator 10 for performing centrifuging is referred to as a first speed.
- [57] When the material is separated into a plurality of layers according to the specific gravity by centrifuging, a layer formed of a material having high specific gravity and high fluid resistance is formed relatively far away from the center of the rotation axis O and a layer formed of a material having low specific gravity and low fluid resistance such as free oil, fat, and water is formed relatively near the rotation axis O. The layer relatively far away from the center of the rotation axis O is a material having high specific gravity such as stem cells. The stem cells are pressurized and adhered to a wall surface of an end of the container 20 due to the adhesive force of the stem cells themselves and the centrifugal force.
- [58] After centrifuging is performed, some of the layers of the separated material are discharged outside to be collected. This process is performed by opening the opening portion 21 of the container 20 by the operation of the stopper portion 30. When a control signal from the controller 33 is input via the signal line 32 to the valve 31 of the stopper portion 30, the valve 31 of the stopper portion 30 is operated such that the opening portion 21 of the container 20 is opened toward the receiving unit 15 of the rotator 10.
- [59] At the same time, the rotator 10 rotates at a second speed that is lower than the first speed. That is, the rotation speed of the rotator 10 is reduced to a second speed which is a critical speed that is predetermined so that some of the centrifuged layers can flow downward due to gravity and so that at the same time the stem cells are maintained inside the container 20.
- [60] When the rotation speed of the rotator 10 is reduced, the centrifugal force is reduced, and the fluid in the container 20 may flow downward by gravity. Centrifugal force and gravity are exerted in opposite directions to each other to the fluid inside the container 20, and thus when the centrifugal force is reduced, layers of a fluid having a low fluid resistance and a specific gravity start to flow toward the center of the rotation axis O. A material having low specific gravity and low fluid resistance such as water, free oil, fat, etc. which flows into the receiving unit 15 of the rotator 10 is affected by gravity and centrifugal force to flow downward of the rotator 10 along inner walls of the receiving unit 15.
- [61] For example, when stem cells are separated from fat tissue, and the angle at which the center axis of the container is inclined with respect to the rotation axis of the rotator

is 40 degrees, centrifugal force of 23G (RCF) is sufficient to retain just the stem cells in the container and make the other fluid flow. Accordingly, here, the second speed can be set as 400 rpm.

[62] The centrifuge according to the current embodiment of the present invention can be applied to all kinds of materials that can move downward along an inclined surface, that is, both to liquids and solids such as liquid, powder, gel, a mixture of liquid and solid, colloids, and solids that are nearly spherical.

[63] Even when the amount of the above material is small, the material is affected by friction because the material flows downward along a surface of the inner wall of the container 20. While the rotator 10 is rotated, a centrifugal force is applied to the material in the container 20, and since the inner wall surface of the container 20 are inclined, the material inside the container 20 is subject to both gravity and centrifugal force. As the speed of the rotator 10 is reduced and thus the centrifugal force becomes less than the gravitational force, the material can flow downward due to gravity. Since resistance to the downward flow of the material exists, the point of time at which the material starts flowing downward depends on the characteristic of the material and thus may vary.

[64] Assuming an ideal state in which no friction is applied, when gravity and centrifugal force applied to the material are the same, an equilibrium state results, in which the material does not flow and the immobility state is maintained. However, in reality, friction, that is, resistance to the fluid exists, and thus should be taken into account.

[65] FIG. 3 is a schematic view illustrating forces applied to a material provided that a centrifugal force is not generated in a centrifuge according to an embodiment of the present invention.

[66] In FIG. 3, the container is fixed to form an angle α with respect to a horizontal surface, thereby having an inclined surface A_s with respect to gravity. Here, it is assumed that the centrifuge does not rotate and thus no centrifugal force is applied. Only gravity G is applied to the material, and a component G_s of the gravity G in the direction of the inclined surface A_s makes the material flow downward along the inclined surface A_s of the container. A frictional force F_s due to a fluid resistance between the material and the inclined surface A_s of the container is applied in an opposite direction to the flow of the material, thereby resisting the downward flow of the material.

[67] FIG. 4A schematically illustrates forces of FIG. 3 changed to a state where a high centrifugal force is applied.

[68] When the rotator is rotated, a centrifugal force C is exerted on the material. The centrifugal force C is applied horizontally, and thus a force C_s of the centrifugal force

on the inclined surface A_s of the container makes the material flow upward. The material is pressurized toward the inclined surface A_s of the container due to a total force T of the centrifugal force C and gravity G . The centrifugal force C is applied to be greater than the gravity G , and thus a force T_s of the total force T applied to the material on the inclined surface A_s of the container is directed upward, and as the force T_s on the inclined surface A_s of the container is greater than the frictional force F_s , the material is moved upward along the inclined surface A_s of the container.

[69] For the material to flow downward, the speed of the rotator needs to be reduced so that the centrifugal force C may be decreased, or the inclined surface A_s needs to be more inclined so that the component G_s of the gravity G in the direction of the inclined surface A_s of the container may increase. In the centrifuge according to the current embodiment of the present invention, the angle of the container is fixed with respect to the rotator, and thus the inclined surface cannot be further inclined. Accordingly, the rotation speed needs to be changed.

[70] FIG. 4B schematically illustrates forces of FIG. 3 changed to a state where a low centrifugal force is applied;

[71] In FIG. 4B, the speed of the rotator is reduced and thus the centrifugal force C is reduced, and a force C_s of the centrifugal force on the inclined surface A_s of the container is decreased. Accordingly, the force T_s of the total force T of gravity G and centrifugal force C on the inclined surface A_s of the container makes the material flow downward. When the speed of the rotator is reduced and the centrifugal force C becomes less than gravity G , the material can flow downward along the inclined surface A_s of the container; however, friction force F_s which is a fluid resistance between the material and the inner wall surface of the container resists the flow of the material. That is, the total force of the force of the centrifugal force C on the inclined surface A_s of the container and the friction force F_s is applied opposite to the component G_s of the gravity G in the direction of the inclined surface A_s . Accordingly, when the force T_s on the inclined surface A_s of the container is greater than the frictional force F_s operating as a resistance, the material can move downward.

[72] The flow of the material downward is affected by two parameters.

[73] First, gravity and centrifugal force are parameters concerning specific gravity. Provided that the rotator is rotated at the same RPM, that is, at the same rotation speed, the greater the rotation radius, the greater the centrifugal force. Accordingly, when the rotation speed of the rotator is reduced, the layer nearest to the rotation axis starts to flow down first. The greater the specific gravity of a layer is, the greater the rotation radius of the layer is. Thus, while the speed of the rotator is reduced, a material positioned at a relatively large rotation radius flows later than a material positioned at a relatively smaller rotation radius. Accordingly, it is easier to obtain a material having a

greater specific gravity. Also, a force that is created to move the material upward by gravity and centrifugal force is called an elevating force, and the material moves upward or downward along the inclined surface of the container depending on the size of the elevating force.

[74] Second, frictional force is a parameter concerning fluid resistance. Forces disturbing the complex flow of a fluid are determined by various parameters. Examples of the parameters are viscosity and cohesive force (surface tension) in the case of liquids, and mobility, friction in the case of solids, and adhesiveness of semisolids (gel) or mixed material. Such forces are types of frictional force. The total of all of such forces can be expressed as anti-flow force or anti-falling force.

[75] In the centrifuge according to an embodiment of the present invention, a material having a large in specific gravity and high flow resistance can be easily separated from a material having a low specific gravity and low flow resistance. In particular, when a cell is separated, since a cell, which is an object material to be obtained, satisfies both characteristics such as a large specific gravity and high flow resistance, and thus the cell can be easily separated.

[76] After all of lower fluids mostly formed of water components are discharged, the valve 31 of the stopper portion 30 is operated to close the opening portion 21 of the container 20. Then the rotation speed of the rotator 10 is reduced to stop the centrifuge. During centrifuging, the fluid of the lowest layer in the container 20 is discharged outside to the receiving unit 15 of the rotator 10, and thus only a material having a high specific gravity, such as stem cells, remains in the container 20. Accordingly, there is no need to segregate the layers that are centrifuged according to specific gravity after the centrifuging, and thus a desired material can be easily obtained.

[77] FIG. 5 is a side view illustrating a supporting structure of a container 20 according to another embodiment of the present invention. FIG. 6 is a side view of a portion of a centrifuge, illustrating the container of FIG. 5 in which a portion of separated material is collected.

[78] The centrifuge illustrated in FIG. 5 includes: a rotator 60 rotating around the rotation axis; a container 20 that is coupled to the rotator 60 at a predetermined angle θ ; and a stopper portion 70 opening or closing an opening portion 21 of the container 20.

[79] In FIGS. 1 and 2, a receiving unit is formed in the rotator 10 to collect a centrifuged material. However, in FIG. 5, instead of a receiving unit, a connecting portion 80 is connected to the stopper portion 70 to discharge the centrifuged material outside and collect the centrifuged material. The connecting portion 80 connects the container 20 to the outside.

[80] The connecting portion 80 may include at least one discharge pipe 81 discharging

the material in the container 20 to the outside and at least one inflow pipe 82 injecting a fluid into the container 20 from the outside. One discharge pipe 81 may be installed for separating only a lower fluid of the container 20, or a plurality of discharge pipes 81 may be installed to distinguish each layer to discharge the layers.

[81] The connecting portion 80 is connected to the container 20 via the stopper portion 70. The stopper portion 70 may include a valve 71 having a function of opening or closing the connecting portion 80. The valve 71 can open or close the connecting portion 80 by being controlled by a controller (not shown). The valve 71 may be connected to the controller (not shown) via a signal line 72 or wirelessly.

[82] The discharge pipe 81 is connected to a collection tank (not shown) that is installed in the centrifuge and may help the material flowing down by gravity to be collected to the collection tank. However, in order to further facilitate the collecting of the centrifuged material, a pump (not shown) may also be used. That is, a pump may be connected to the discharge pipe 81 and a negative pressure (less than atmospheric pressure) produced by the pump is used to discharge the material in the container 20 through the discharge pipe 81 to the collection tank.

[83] The inflow pipe 82 injects a fluid into the container 20. When the material in the container 20 is discharged through the discharge pipe 81, a negative pressure is formed inside the container 20. When a negative pressure is formed inside the container 20, a phenomenon such as reflux may occur. Such phenomenon can be prevented by injecting a fluid such as a dilution solution.

[84] The connecting portion 80 can be connected to the outside of the container 20 through a rotation coupling (not shown). The rotation coupling (not shown) connects the connecting portion 80 to the outside of the container 20 and at the same time is rotated by twisting elasticity of the connecting portion 80, thus preventing the connecting portion 80 from being twisted according to rotation of the rotator 60.

[85] The centrifuge described above is operated as follows.

[86] A material (sample) to be centrifuged is delivered into the container 20 and the container 20 is coupled to the rotator 60. The container 20 is coupled to the rotator 60 by the stopper portion 70 and thus an axis P in a length direction of the container 20 is maintained at a predetermined angle θ with respect to a rotation axis O of the rotator 60. Here, the stopper portion 70 should close the opening portion 21 of the container 20 so that the material in the container 20 may not flow out to the outside.

[87] When a driving motor (not shown) connected to the rotator 60 is driven, the rotator 60 rotates around the rotation axis O. Since the container 20 is coupled to the rotator 60, the container 20 is rotated together with the rotator 60. As a centrifugal force is exerted on the material injected into the container 20, the material in the container 20 is centrifuged according to specific gravity. While the rotator 60 is rotated around the

rotation axis O, the axis P in a length direction of the container 20 is maintained at a predetermined angle θ with respect to the rotation axis O.

- [88] When the material is segregated into a plurality of layers according to specific gravity by centrifuging, an outermost fluid layer 91 formed of a material having a high specific gravity and high fluid resistance such as stem cells is formed relatively far away from the rotation axis O. Inner fluid layers 92 formed of a material having a low specific gravity and low fluid resistance are formed relatively near the rotation axis O. The outermost fluid layer 91 including the stem cells is pressurized and adhered to a wall surface of an end of the container 20 due to the adhesive force of the stem cells themselves and the centrifugal force.
- [89] After centrifuging is completed, some of the layers of the separated material are discharged to the outside to be collected. This process is performed by opening the connecting portion 80 by the operation of the stopper portion 70. When a control signal is input to the valve 71 of the stopper portion 70, the valve 71 of the stopper portion 70 is operated to open the connecting portion 80 connected to the container 20.
- [90] With the connecting portion 80 opened, when a pump (not shown) connected to the discharge pipe 81 is operated, pressure is formed in the discharge pipe 81. The inner fluid layers 92 in the container 20 are discharged to a collection tank (not shown) via the discharge pipe 81 due to the pressure formed in the discharge pipe 81. Here, an external fluid such as a dilution solution is injected into the container 20 via the inflow pipe 82 to maintain a predetermined pressure inside the container 20 so as to prevent formation of a negative pressure that is lower than atmospheric pressure.
- [91] After all of the inner fluid layers 92 mostly formed of water components are discharged, the valve 71 of the stopper portion 70 is operated to close the connecting portion 80 of the container 20. Then the rotation speed of the rotator 60 is reduced to stop the centrifuge. During centrifuging, the inner fluid layers 92 in the container 20 are discharged outside, and thus only a material having a high specific gravity, such as stem cells, remains in the container 20. Accordingly, there is no need to segregate the layers that are centrifuged according to specific gravity after the centrifuging, and thus a desired material can be easily obtained.
- [92] FIG. 7 is a flowchart illustrating a centrifugal method according to an embodiment of the present invention.
- [93] Referring to FIG. 7, the centrifuging method according to the current embodiment of the present invention includes: delivering a material into the container (S100); detachably coupling the container to the rotator such that an opening portion of the container is maintained at a predetermined angle with respect to a rotation axis of the rotator (S110); centrifuging the material in the container by rotating the rotator (S120); discharging some of the layers of the centrifuged material to the outside of the

container by opening the stopper portion coupled to the opening portion while the rotator (S130) is rotating; closing the stopper portion (S140); stopping the rotation of the rotator (S150); and collecting the centrifuged material by separating the container from the rotator (S160).

[94] According to an current embodiment of the present invention, in operation S130 in the centrifuging method where some of the layers of the centrifuged material are discharged outside, the stopper portion is opened while the rotator is continuously being rotated to discharge some of the layers of the material, and the rotation speed of the rotator can be reduced to a second speed that is lower than a first speed in operation S120. The second speed may be set such that some layers that are positioned on the outer edge of the container are remained in the container and the rest of the layers can be discharged through the opening portion of the container by gravity.

[95] According to another embodiment of the present invention, in operation S130, a discharge pipe connected to the container may be opened to discharge some layers to the outside. Then a pump may be connected to the discharge pipe, and the material can be discharged to the outside by pressure produced by the pump. Also, in operation S130, an inflow pipe connected to the container may be opened by the stopper portion to inject an external fluid such as a dilution solution into the container to keep the pressure of the container constant.

[96] The rotation speed of the rotator can be reduced to a second speed in operation S130 in the current embodiment. However, since the material can be discharged outside of the container via the discharge pipe by forming pressure in the discharge pipe, reduction of the rotation speed of the rotator is not necessarily required.

[97] While the present invention has been particularly shown and described with reference to exemplary embodiments thereof, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the present invention as defined by the following claims.

Industrial Applicability

[98] The present invention relates to a centrifuge and a centrifuging method, and more particularly, to a centrifuge and a centrifuging method in which, when centrifuging is performed by rotation of a rotator, a layer of a material having low fluid resistance and low specific gravity and a layer having high fluid resistance and high specific gravity among the layers separated by centrifuging can be classified and collected accurately and easily by opening an opening portion of a container.

[99] The centrifuge and the centrifuging method according to the present invention can be applied to all kinds of materials that can move downward along an inclined surface, that is, both to liquids and solids such as liquid, powder, gel, a mixture of liquid and

solid, colloids, and solids that are nearly spherical.

Claims

- [1] A centrifuge comprising:
a rotator rotating around a rotation axis;
a container into which a material is received and comprising an opening portion, inclined at a predetermined angle with respect to the rotation axis such that the opening portion is directed downward, and detachably coupled to the rotator; and
a stopper portion that is coupled to the opening portion and closes the opening portion, and when the speed of the rotator reaches a predetermined speed thereby centrifuging the material, opens the opening portion such that the material in the container flows outward.
- [2] The centrifuge of claim 1, wherein the stopper portion comprises a valve which is operated according to an external signal and thus opens or closes the opening portion.
- [3] The centrifuge of claim 2, wherein a receiving unit which receives a material when the stopper portion is opened, is formed in the rotator.
- [4] The centrifuge of claim 2, wherein a connecting portion connecting the container to the outside is connected to the stopper portion.
- [5] The centrifuge of claim 4, wherein the connecting portion comprises at least one discharge pipe discharging the material of the container.
- [6] The centrifuge of claim 5, wherein the connecting portion further comprises an inflow pipe delivering a fluid into the container from the outside.
- [7] A method of centrifuging comprising:
(a) delivering a material into a container;
(b) detachably coupling the container to a rotator at a predetermined angle with respect to a rotation axis of the rotator such that an opening portion of the container is directed downward;
(c) centrifuging the material in the container by rotating the rotator;
(d) opening the stopper portion coupled to the opening portion while continuously rotating the rotator to discharge some layers of the centrifuged material to the outside of the container;
(e) closing the stopper portion;
(f) stopping the rotator; and
(g) separating the container from the rotator to collect the centrifuged material.
- [8] The method of claim 7, wherein, in (d), a discharge pipe connected to the container via the stopper portion is opened to discharge some layers of the centrifuged material.
- [9] The method of claim 8, wherein the discharge pipe is connected to a pump, and

some layers of the centrifuged material are discharged to the outside of the container by pressure produced by the pump.

[10] The method of claim 9, wherein, in (d), an inflow pipe connected to the container via the stopper portion is opened to deliver an external fluid into the container to maintain the pressure of the container regular.

[11] The method of claim 7, wherein, in (d), the rotator is rotated at a reduced speed compared to the speed in (c), and the stopper portion is opened to discharge some layers of the centrifuged material.

FIG. 1

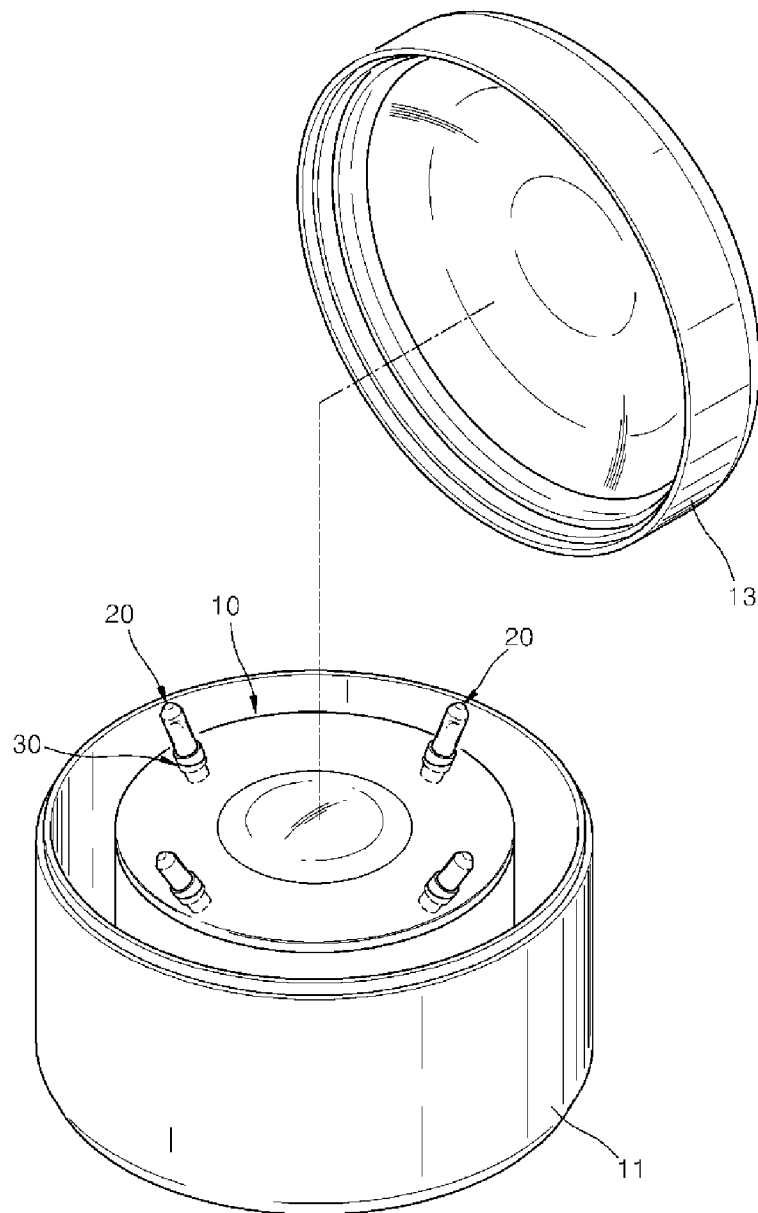


FIG. 2

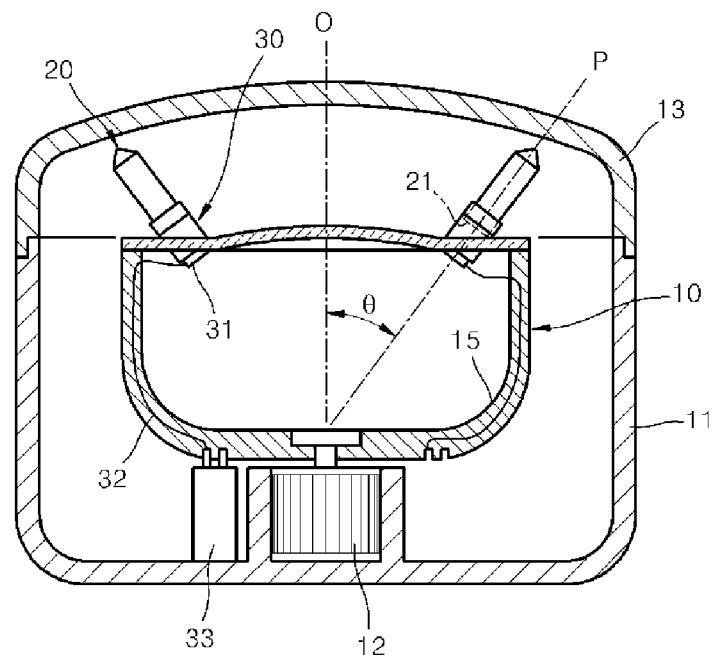


FIG. 3

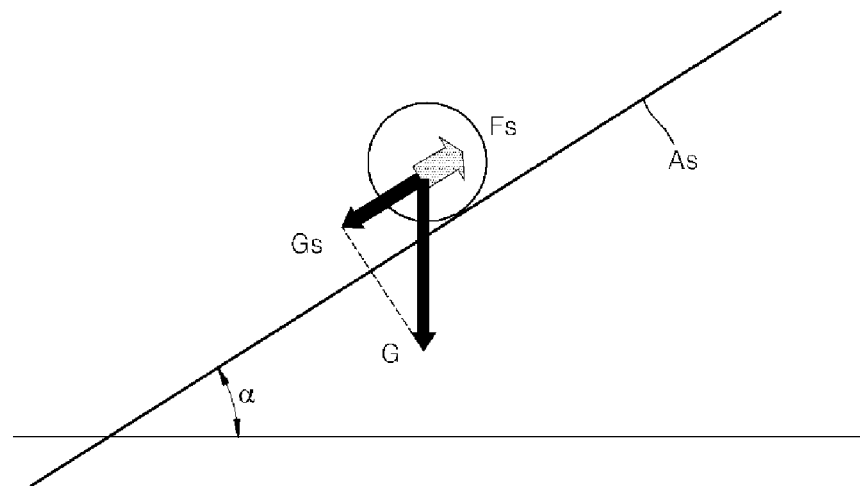


FIG. 4A

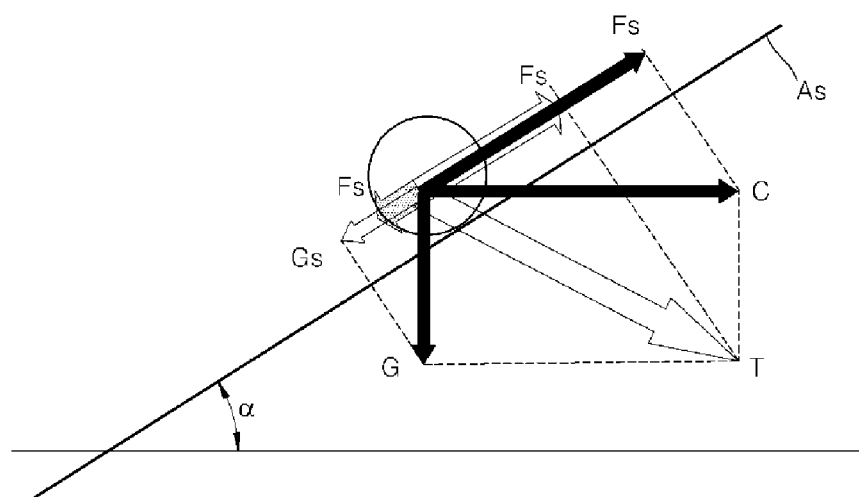


FIG. 4B

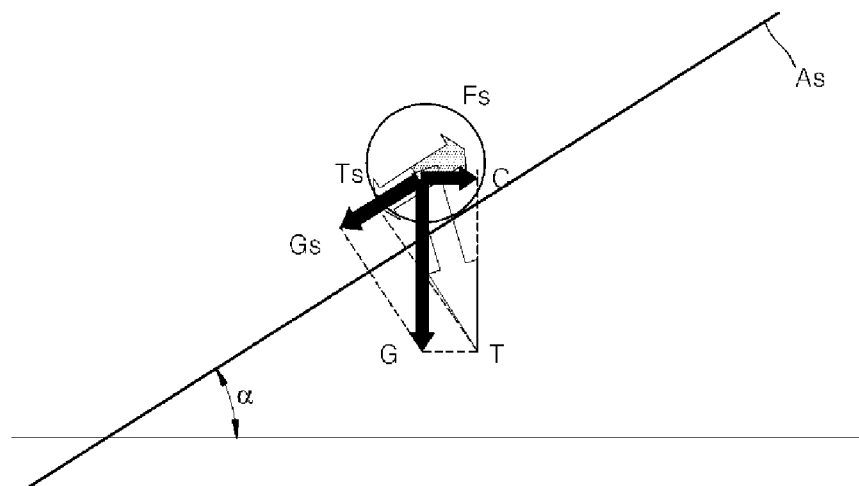


FIG. 5

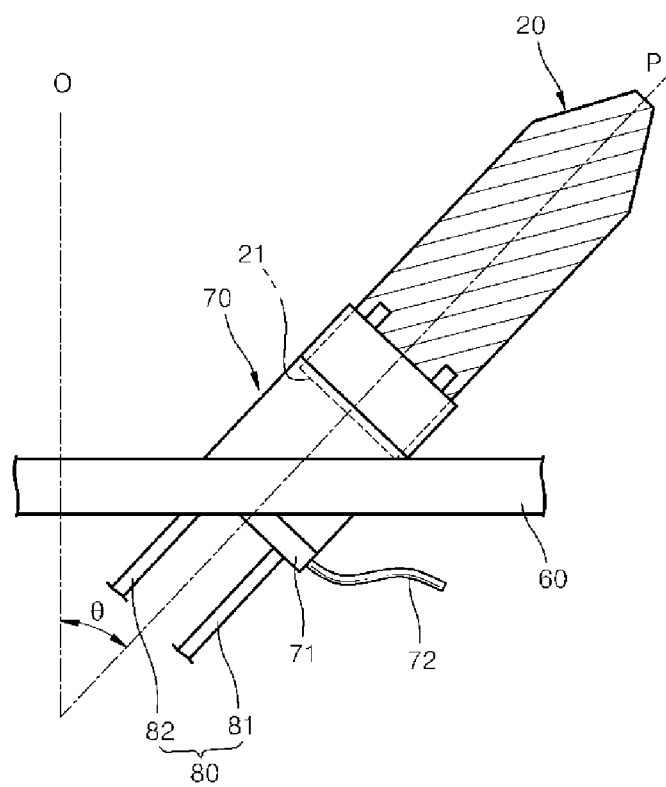


FIG. 6

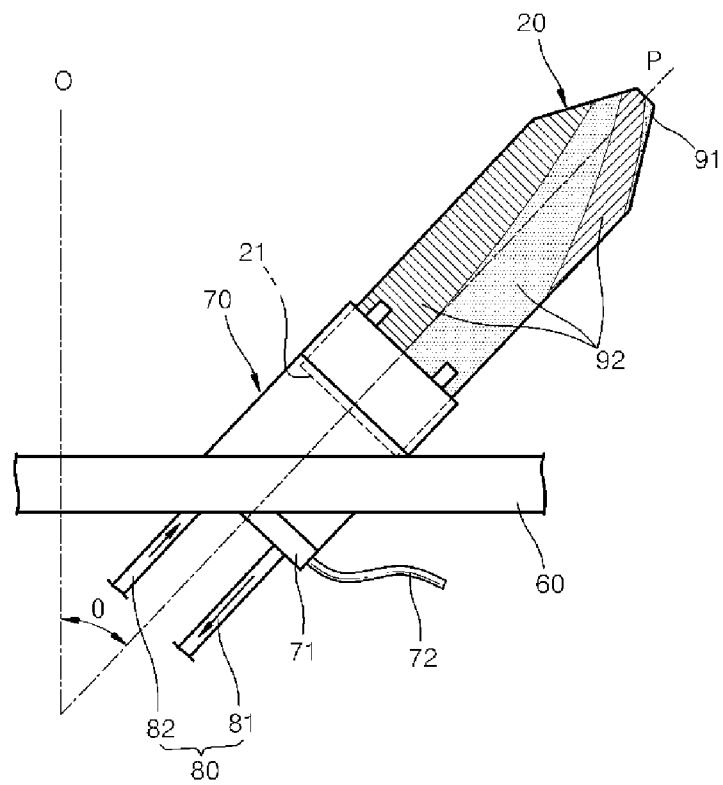
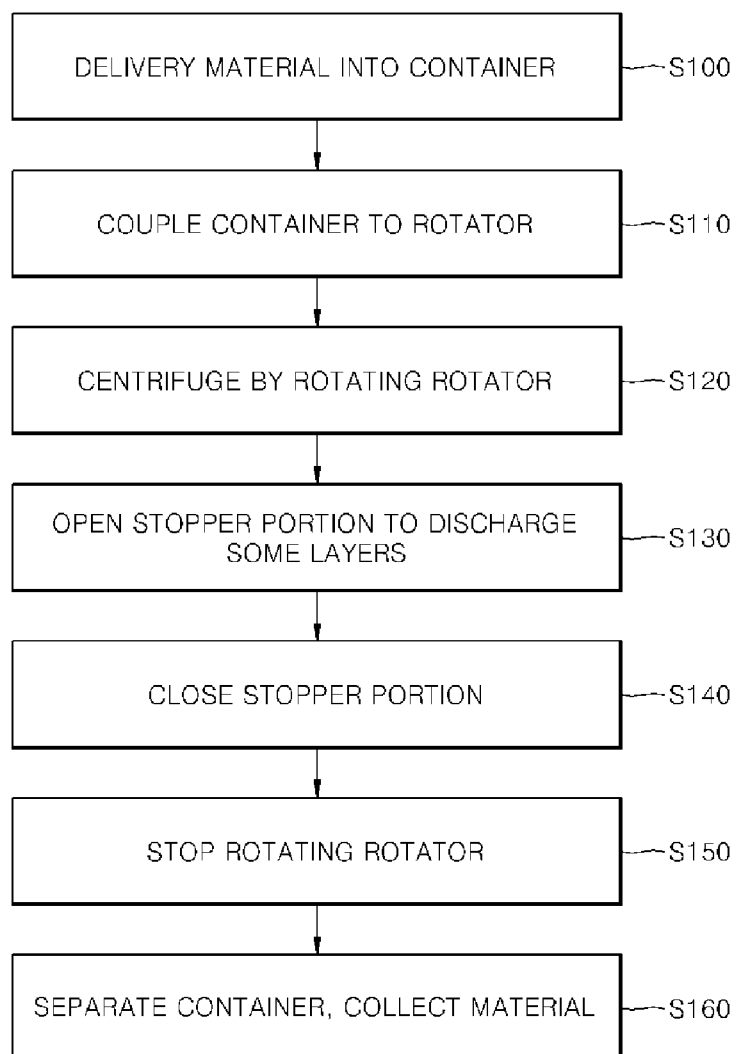


FIG. 7



A. CLASSIFICATION OF SUBJECT MATTER***B04B 1/06(2006.01)i***

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 8: B04B, B01D, C02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility Models since 1975Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKIPASS(KIPO internal) "centrifuge", "container", "stopper" and similar terms**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6273849 B1 (SCHERER) 14 August 2001 see claim 1; fig. 1.	1 - 11
A	US 2005/0274679 A1 (KAO et al.) 15 December 2005 see paragraphs [0019] to [0025]	1 - 11
A	US 5422018 A (SAUNDERS et al.) 6 June 1995 see column 1, lines 60 to column 2, lines 27.	1 - 11
A	JP 2005013783 A (MORIAI SEIKI KK et al.) 4 May 1999 see claim 1; fig. 6.	1 - 11



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

15 JUNE 2007 (15.06.2007)

Date of mailing of the international search report

15 JUNE 2007 (15.06.2007)

Name and mailing address of the ISA/KR

Korean Intellectual Property Office
920 Dunsan-dong, Seo-gu, Daejeon 302-701,
Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

JANG, Sung Won

Telephone No. 82-42-481-8296



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/KR2007/000980

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US06273849B1	14.08.2001	DE19803534A1	12.08.1999
		DE19803534C2	11.11.1999
		DE59901371C0	13.06.2002
		EP00933133A2	04.08.1999
		EP00933133A3	21.06.2000
		EP00933133B1	08.05.2002
		EP933133A2	04.08.1999
		EP933133A3	21.06.2000
		EP933133B1	08.05.2002
		ES2177149T3	01.12.2002
		JP11262684A2	28.09.1999
		JP11262684	28.09.1999
		US6273849B1	14.08.2001
US2005274679A1	15.12.2005	NONE	
US05422018A	06.06.1995	AT218396E	15.06.2002
		AU1689995A1	15.08.1995
		AU680346B2	24.07.1997
		CA2182365AA	03.08.1995
		CA2182365C	01.08.2000
		CA2182365C	03.08.1995
		DE69526924C0	11.07.2002
		DE69526924T2	19.09.2002
		EP00742735B1	05.06.2002
		EP0742735A1	20.11.1996
		EP742735A1	20.11.1996
		EP742735B1	05.06.2002
		EP742735A4	10.06.1998
		JP09508567	02.09.1997
		JP3357369B2	16.12.2002
		JP9508567T2	02.09.1997
		US5422018A	06.06.1995
		W09520428A1	03.08.1995
JP17013783A	20.01.2005	NONE	