(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 129 782 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
05.09.2001 Bulletin 2001/36

(51) Int Cl.[7]: **B04B 1/20**, B04B 9/10, B04B 15/06

(21) Application number: **00121286.9**

(22) Date of filing: **06.10.2000**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **03.03.2000 JP 2000063343**

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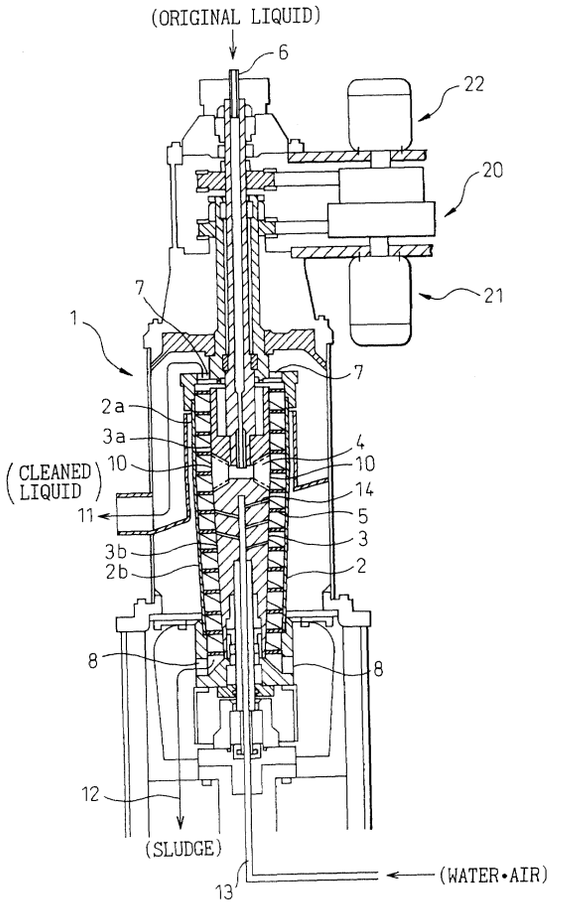
(54) Vertical type solid-liquid separating apparatus

(57) A vertical type solid-liquid separating apparatus comprises a frame; an outer cylinder rotatably supported on the frame; an inner cylinder coaxially and rotatably disposed within the outer cylinder to define an annular separating chamber therebetween; a screw blade fixedly attached to the outer circumference of the inner cylinder so that a small gap remains between the screw blade and the inner wall of the outer cylinder. An original liquid is supplied into the separating chamber. The separated, cleaned liquid is discharged from an upper part of the separating chamber and sludge is discharged from a lower part of the separating chamber. The driving means comprises a first motor for driving the outer cylinder, a planetary means connected to both the outer cylinder and the inner cylinder, and a second motor for setting a speed difference of the planetary means, so that the outer and inner cylinders are rotated in a same rotational direction and the rotational speed of the outer cylinder is slightly larger than that of the inner cylinder.

Fig.1



EP 1 129 782 A2

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a vertical type solid-liquid separating apparatus for separating solid from liquid, in various kinds of sewage or other materials, and collecting each of them. Particularly, the present invention relates to a vertical type solid-liquid separating apparatus comprising a vertical outer rotary cylinder supported for rotation and an inner rotary cylinder supported for rotation within the interior of the outer rotary cylinder to define an annular separating chamber between both cylinders which are rotated in such a manner that a slight difference in the rotational speed is generated between them by using a differential type speed changer.

2. Description of the Related Art

[0002] In the prior art, various solid-liquid separating apparatuses were developed, which can be used for separating solid from liquid in return water sludge in sewage treatment, in waste water generated in dredging operations at coasts, rivers, lakes and marshes, in waste water generated in coal mining and in solid-liquid separation of various kinds of sludge or in the clarification of oils.

[0003] Particularly, in sewage treatment, solid-liquid separation is a basic technology and a method for treating and disposing of contaminants or sewage sludge is important in sewage treatment. A specific feature of sewage sludge is its high content of organic components and water, and therefore, the removal of water by the solid-liquid separation is important for the purpose of attaining "weight reduction and stability" which is a basic principle for obtaining a waste product. In this regard, since the sludge is inevitably generated by the sewage treatment, the need for place for the purpose of reclaimed land will be infinite if the final disposal relies only on use for reclaimed land and it will soon encounter the difficulty in availability thereof. In fact, securing of land to be used for the final disposal has become difficult from year to year. Because resources of the earth are finite, the effective use of sewage sludge is a socially important problem. The sewage itself can be a source of valuable organic matter if contaminants are removed therefrom. Also, inorganic matter can be used as raw material, for suitable applications, and water separated from the solid matter is usable again after being subjected to a chemical treatment.

[0004] Accordingly, an improvement in the performance of a solid-liquid separating apparatus of a centrifugal type is eagerly expected.

SUMMARY OF THE INVENTION

[0005] An object of the present invention is to improve the above-mentioned prior art solid-liquid separating apparatus by providing a solid-liquid separating apparatus comprising an outer rotary cylinder and an inner rotary cylinder which rotate in the same direction where the outer rotary cylinder rotates faster than the inner rotary cylinder with a slight difference in rotational speed between the cylinders, in a predetermined range, and wherein the separating apparatus is capable of accurately adjusting the slight rotational speed difference between the outer and inner rotary cylinders.

[0006] According to the present invention, there is provided a vertical type solid-liquid separating apparatus comprising: a frame; an outer cylinder supported on the frame rotatably about a vertical axis; an inner cylinder coaxially and rotatably disposed within the outer cylinder to define an annular separating chamber between an inner wall of the outer cylinder and an outer circumference of the inner cylinder; a screw blade fixedly attached to the outer circumference of the inner cylinder so that a small gap remains between the screw blade and the inner wall of the outer cylinder; means for supplying an original liquid into the separating chamber; means for discharging a separated, cleaned liquid from an upper part of the separating chamber; means for discharging a sludge from a lower part of the separating chamber; and driving means comprising a first motor for driving one of the outer and inner cylinders, a planetary means connected to both the outer cylinder and the inner cylinder, and a second motor for setting a speed difference of the planetary means, so that the driving means rotate the outer and inner cylinders in a same rotational direction and with a rotational speed of the outer cylinder slightly larger than that of the inner cylinder and the difference in rotational speed is set within a certain limited range.

[0007] The outer cylinder comprises a vertically cylindrical upper half having a substantially constant inner diameter and a tapered lower half having an inner diameter which is gradually reduced in the downward direction, and in the same manner the inner cylinder comprises a vertically cylindrical upper half having a substantially constant outer diameter and a tapered lower half having an outer diameter which is gradually reduced in the downward direction.

[0008] The original liquid supplying means comprises a pipe extending in the inner cylinder along a vertical axis about which the inner cylinder rotates.

[0009] The inner cylinder is provided with an annular chamber between the upper half and the lower half thereof, the lower end of the pipe is opened to the annular chamber, and the annular chamber is provided with a plurality of radially arranged distributor plates between which a plurality of radial passages are defined, so that the original liquid is supplied from the pipe, through the annular chamber and the radial passages

to the annular separating chamber defined between the outer cylinder and the inner cylinder.

[0010] Each of the separating plates has a such a shape that the vertical dimension thereof is increased at the radially outward end.

[0011] The screw blade has a substantially constant pitch on the upper half of the inner cylinder and, on the other hand, the pitch is gradually reduced on the tapered, lower half of the inner cylinder. The screw blade has a double spiral shape.

[0012] The planetary means comprises an internal sun gear, a planetary gear engaged with the internal sun gear, an external sun gear engaged with the planetary gear and coaxially arranged with the internal sun gear, and a carrier for rotatably supporting the planetary gear. The first motor is connected to the internal sun gear and to the outer cylinder, the second motor is connected to the external sun gear, and the carrier is connected to the inner cylinder. The planetary means comprises a plurality of planetary gear pieces which are arranged equi-angularly around and respectively engaged with the external sun gear.

[0013] A speed reduction ratio of the planetary means is 1/200 so that the rotational speed ratio between the outer cylinder and the inner cylinder is 3000:2999, if the first motor rotates at 3000 rpm and the second motor rotates at 2800 rpm.

[0014] The planetary means comprises: a wave-generator comprising an elliptic cam and a circumferential bearing for the elliptic cam; a flex-spline made of elastic metal and having an inner circumference in contact with the wave-generator by means of the bearing and an outer circumference provided with gear teeth; and a circular spline having an inner circumference with gear teeth arranged at same pitch as the gear teeth of the flex-spline. The first motor is connected to the circular-spline and to the outer cylinder, the second motor is connected to the wave-generator, and the flex-spline carrier is connected to the inner cylinder. The number of gear teeth of the circular-spline is two more than the number of gear teeth of the flex-spline carrier.

[0015] According to another aspect of the present invention, there is provided a vertical type solid-liquid separating apparatus comprising: a frame; an outer cylinder supported on the frame rotatably about a vertical axis; an inner cylinder coaxially and rotatably disposed within the outer cylinder to define an annular separating chamber between an inner wall of the outer cylinder and an outer circumference of the inner cylinder; a screw blade fixedly attached to the outer circumference of the inner cylinder so that a small gap remains between the screw blade and the inner wall of the outer cylinder; means for supplying an original liquid into the separating chamber; means for discharging a separated, cleaned liquid from an upper part of the separating chamber; means for discharging a sludge from a lower part of the separating chamber; means for driving the outer and inner cylinders so that the outer and inner cylinders are rotated in a same rotational direction and a rotational speed of the outer cylinder is slightly larger than that of the inner cylinder and a difference in rotational speed is set within a certain limited range; and means for cleaning or drying the annular separating chamber with cleaning water or air.

[0016] The cleaning means comprises a conduit provided in the inner cylinder for supplying cleaning water or air and a plurality of nozzles connected to the conduit for injecting the cleaning water or air from the outer circumference of the inner cylinder toward the inner wall of the outer cylinder.

[0017] The nozzles are inclined so that the cleaning water or air is injected at an acute angle with respect to the inner wall of the outer cylinder.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018]

Fig. 1 is a schematic vertical sectional view illustrating a main part of one embodiment of a vertical type solid-liquid separating apparatus according to the present invention;

Fig. 2 is an enlarged vertical sectional view of an inner rotary cylinder shown in Fig. 1;

Fig. 3(a) is a horizontal sectional view of distributor plates taken along a line A-A' in Fig. 2;

Fig. 3(b) is a vertical sectional view of the distributor plates taken along a line B-B' in Fig. 3(a);

Fig. 4(a) is a vertical sectional view of a water-air supply nozzle;

Fig. 4(b) is a horizontal sectional view of part thereof;

Fig. 5(a) is a schematic view of a planetary gear mechanism;

Fig. 5(b) is a schematic side view of the planetary gear mechanism;

Fig. 6(a) is a view showing a state wherein a differential speed motor is mounted to the upper portion of the apparatus; and

Fig. 6(b) is a schematic view of another embodiment of a planetary mechanism.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0019] The present invention will be described in detail below with reference to the preferred embodiments illustrated in the attached drawings.

[0020] A vertical type solid-liquid separating apparatus 1 according to one embodiment of this invention includes an outer rotary cylinder 2, screw blades 5, an annular separating chamber, an inner rotary cylinder 3 to which distributor plates 4 are attached, an original liquid supply pipe 6, cleaned liquid exits 7, a sludge exit 8 and a drive 9 for the outer and inner rotary cylinders.

[0021] The outer rotary cylinder 2 is rotatably support-

ed by the apparatus frame and constituted by a vertical cylindrical upper half 2a whose inner diameter is substantially constant and a tapered cylindrical lower half 2b whose inner diameter becomes smaller downward, both the halves being continuously formed integral with each other.

[0022] The inner rotary cylinder 3 is coaxially and rotatably supported in the interior of the outer rotary cylinder 2, and has an upper half 3a corresponding to the vertical cylindrical upper half 2a of the upper rotary cylinder 2, a lower half 3b corresponding to the tapered lower half 3b of the outer rotary cylinder and four distributor plates 4a, 4b, 4c and 4d radially disposed for connecting both the halves and transporting a liquid flow received therein while distributing the same in the vertical direction.

[0023] A slope of a predetermined angle is formed at each opposed end surface of the upper half 3a and the lower half 3b of the inner rotary cylinder 3, and four grooves 3c are radially formed for fixing the distributor plates on both the slopes in correspondence to the latter.

[0024] Each of the four distributor plates 4 is of a shape diverging outward so that upper and lower edges thereof are fixedly fitted to the above-mentioned grooves 3c. As shown in Figs. 3(a) and 3(b), these distributor plates 4 are arranged equi-angularly at 90°. Also, a vertical dimension of each distributor plate 4 is increased radially outward.

[0025] An annular separating apparatus chamber having a generally constant width in the diametrical direction is formed between the inner circumference of the outer rotary cylinder 2 and the outer circumference of the inner rotary cylinder 3. The annular separating apparatus chamber is of a shape wherein the upper half thereof is substantially cylindrical and the lower half is gradually converged downward in correspondence to the outer rotary cylinder 2 and the inner rotary cylinder 3.

[0026] The screw blades 5 are fixedly secured to the outer circumference of the inner rotary cylinder 3 to define a small gap between the outer peripheral edge thereof and the inner circumference of the outer rotary cylinder 2.

[0027] The screw blades 5 are of a double-spiral structure wherein two spiral blades are arranged at an angular distance of 180 degrees. That is, if the inner rotary cylinder 3 rotates once, the spiral advances by two pitches. Also, the screw blades 5 are arranged at a constant pitch in the upper half 3a of the inner rotary cylinder, and the pitch becomes smaller downward in the tapered lower half 3b, as shown in Fig. 2.

[0028] The original liquid supply pipe 6 extends downward from above the inner rotary cylinder 3 along a center line thereof and has an opening at the lower end of the upper half 3a of the inner rotary cylinder 3.

[0029] Water and air are used for rinsing and drying the interior of the apparatus 1, improving the cleaning degree of removed cleaned liquid or facilitating the reduction of a water content in solid matter, and are supplied via a pipe 13 extending upward from beneath the lower end of the inner rotary cylinder 3 along a center line thereof and injected from tip nozzles 14 obliquely provided in the inner rotary cylinder 3 toward the inner wall of the outer rotary cylinder 2.

[0030] As shown in Figs. 4(a) and 4(b), the tip nozzles 14 are provided at positions between the adjacent screw blades 5 while directed to the outer rotary cylinder 2 at an angle as acute as possible so that water or air impinges thereon in the upward/downward direction. If an improvement in the cleaning degree is desired, water is injected, while if the reduction of water content in solid matter is desired, air is ejected. Upon the completion of solid-liquid separation, the interior of the apparatus 1 is first rinsed with water and, then, air is supplied to dry the interior of the apparatus 1.

[0031] A plurality of cleaned liquid exits 7 having a structure capable of adjusting the degree of opening are provided in a top plate of the outer rotary cylinder 2 along the upper peripheral edge of the upper half 2a of the outer rotary cylinder 2.

[0032] The sludge exit 8 is formed at the lower end of the outer rotary cylinder 2 for discharging sludge which is a solid component resulted from the solid-liquid separation and discharged out from the lower end of the outer rotary cylinder 2.

[0033] The outer rotary cylinder 2 and the inner rotary cylinder 3 are made to rotate in the same direction so that the outer rotary cylinder 2 move slightly faster than the inner rotary cylinder 3 while maintaining a speed difference in a predetermined range. According to the present invention, to accurately preset the slight difference in rotational speed between the outer and inner rotary cylinders 2 and 3, a planetary mechanism 20 and two motors 21, 22 are used.

[0034] As shown in Figs. 5(a) and 5(b), a planetary gear mechanism 20 includes a sun internal gear 23, a plurality of (three in the illustrated embodiment) planet gears 24 arranged at an equal angular pitch to be intermeshed with the sun internal gear 23, a sun external gear 25 arranged coaxially with the sun internal gear 23 to be intermeshed with the planet gears 24, and a carrier 26 for supporting the planet gears 24 in a rotatable manner.

[0035] The main motor (first motor) 21 is directly coupled to the sun internal gear 23 of the planetary gear mechanism 20 and is also connected to the outer rotary cylinder 2 via a gear or a pulley. On the other hand, the differential speed motor (second motor) 22 is directly coupled to the sun external gear 25 of the planetary gear mechanism 20. The carrier 26 of the planetary gear mechanism 20 is coupled to the inner rotary cylinder 3 via a gear or a pulley.

[0036] The difference in rotational speed between the outer and inner rotary cylinders 2 and 3 is preset to be an extremely small value. For example, if a reduction ratio is 1/200, the rotational speed of the outer rotary cylinder 2 is 3,000 rpm and that of the inner rotary cyl-

inder 3 is 2,999 rpm, wherein the main motor 21 rotates at 3,000 rpm and the differential speed motor 22 rotates at 2,800 rpm.

[0037] Figs. 6(a) and 6(b) illustrate another embodiment of a planetary mechanism. The planetary mechanism 30 according to this embodiment includes a wave generator 31, a flex-spline (elastic gear) 34 and a circular spline (internal gear) 36. The wave generator 31 includes an elliptic cam 32 and a circumferential bearing 33. The flex-spline 34 is formed of a thin-walled cup-like elastic metal brought into contact with the wave generator 31 via the bearing 33 by the inner circumference thereof and provided with gear teeth 35 of an involute type on the outer circumference thereof. The circular spline 36 is a rigid ring provided with gear teeth 37 on the inner circumference thereof at the same pitch as that of the gear teeth 35 of the flex-spline 34. The number of gear teeth 37 of the circular spline 36 is two more than that of the gear teeth 35 of the flex-spline 34.

[0038] The main motor (first motor) 21 is coupled to the outer rotary cylinder 2 via a gear or a pulley and also to the circular spline 36 of this planetary mechanism 30. On the other hand, the differential speed motor (second motor) 22 is mounted to the upper part of the apparatus and directly coupled to the wave generator 31 of this planetary mechanism 30, unlike the preceding embodiment. This planetary mechanism 30 is directly coupled to the inner rotary cylinder 3. When this planetary gear mechanism 30 is used, the outer and inner rotary cylinders 2 and 3 are made to rotate in the same direction while maintaining an accurate difference in rotational speed between both the cylinders so that the outer rotary cylinder 2 is only slightly faster than the inner rotary cylinder 3. In this regard, it may be possible to arrange the second motor 22 in the same manner as in the preceding embodiment to be coupled to the wave generator 31 via a gear or a pulley.

[0039] Next, the operation of the embodiment having the above-mentioned structure will be described below.

[0040] The original liquid, containing solid substances, supplied from the original liquid pipe 6 reaches the lower end of the upper half 3a of the inner rotary cylinder 3 and is equally distributed by the four distributor plates 4 arranged at the same pitch in the circumferential direction. At this time, the solid matter in the original liquid is finely cut due to the high speed rotation, which facilitates the performance for solid-liquid separation to a great extent and improve the cleaning degree of discharged liquid. Liquid and solid in the original liquid smoothly supplied to the screw blades 5 are separated from each other upward and downward, respectively, during the rotation of the screw blades 5, and the cleaned liquid 11 is discharged outside the apparatus from the upper cleaned liquid exits 7, while the sludge 12 is discharged outside the apparatus from the lower sludge exit 8.

[0041] In such a manner, the separation and the recovery of solid and liquid are carried out in a continuous manner. By adjusting a supply rate of the original liquid to the original liquid supply pipe 6 and an opening degree of the cleaned liquid exit 7, it is possible to regulate the ratio between the cleaned liquid and the sludge as well as the discharge rate thereof.

[0042] In the above case, since the screw blades 5 are arranged in a double-spiral configuration, and a pitch of the screw blade 5 is constant in the upper half 3a having a constant diameter while being smaller downward in the lower half 3b having a smaller diameter downward, solid substances such as sludge moves slowly downward in a longer time due to the low speed of pitch movement in spite of the high rotational speed of the inner rotary cylinder 3. Thereby, the solid-liquid separation is sufficiently facilitated and, in particular, the fractionation of the solid component is further enhanced.

[0043] According to the present invention, as described above, it is possible to always separate sludge as a solid component from a cleaned liquid at a desired ratio by rotating the outer and inner rotary cylinders 2, 3 in the same direction so that the outer rotary cylinder 2 rotates slightly faster than the inner rotary cylinder 3, for example, at a ratio of 3,000 : 2,999 while maintaining an extremely slight but accurate difference in rotational speed between both the cylinders.

[0044] After completing the solid-liquid separation, as described before, water for rinsing the apparatus is supplied to the annular separating chamber of the apparatus 1 via the pipe 13, the tip nozzles 14 and a space between the adjacent distributor plates 4 to carry out the rinsing operation. Thereafter, air is supplied through the same pipe 13 into the apparatus 1 to dry the interior thereof. This rinsing/drying operation is carried out during the rotation of the outer and inner rotary cylinders 2 and 3.

[0045] According to the above-mentioned embodiments, the planetary gear mechanism 20 and the two motors 21, 22 are used for setting the accurate slight difference in rotational speed between the outer and inner rotary cylinders 2 and 3. Thereby, the difference in rotational speed between both the cylinders 2, 3 is extremely accurately maintained to always separate sludge as a solid component from cleaned liquid at a desired ratio. Also, since the rotation of the outer and inner rotary cylinders 2, 3 is stable, vibration is low to result in a safe operation and the repair thereof becomes easy.

Claims

1. A vertical type solid-liquid separating apparatus comprising:

   a frame;
   an outer cylinder supported on said frame rotatably about a vertical axis;
   an inner cylinder coaxially and rotatably dis-

posed within said outer cylinder to define an annular separating chamber between an inner circumference of said outer cylinder and an outer circumference of said inner cylinder;
a screw blade fixedly attached to said outer circumference of the inner cylinder so that a small gap remains between said screw blade and said inner circumference of the outer cylinder;
means for supplying an original liquid into said separating chamber;
means for discharging a separated, cleaned liquid from an upper part of said separating chamber;
means for discharging a sludge from a lower part of said separating chamber; and
driving means comprising a first motor for driving one of said outer and inner cylinders, a planetary means connected to both said outer cylinder and said inner cylinder, and a second motor for setting a speed difference of said planetary means, so that said driving means rotate said outer and inner cylinders in a same rotational direction and a rotational speed of said outer cylinder is slightly larger than that of said inner cylinder and a difference in rotational speed is set within a certain limited range.

2. A separating apparatus as set forth in claim 1, wherein said outer cylinder comprises a vertically cylindrical upper half having a substantially constant inner diameter and a tapered lower half having an inner diameter which is gradually reduced in a downward direction, and said inner cylinder comprises a vertically cylindrical upper half having a substantially constant outer diameter and a tapered lower half having an outer diameter which is gradually reduced in a downward direction.

3. A separating apparatus as set forth in claim 1, wherein said original liquid supplying means comprises a pipe extending in said inner cylinder along a vertical axis about which said inner cylinder rotates.

4. A separating apparatus as set forth in claim 3, wherein said inner cylinder is provided with an annular chamber between said upper half and lower half thereof, a lower end of said pipe is opened to said annular chamber, and said annular chamber is provided with a plurality of radially arranged distributor plates between which a plurality of radial passages are defined, so that the original liquid is supplied from said pipe, through said annular chamber and said radial passages to said annular separating chamber defined between said outer cylinder and said inner cylinder.

5. A separating apparatus as set forth in claim 4, wherein each of said separating plates has a such a shape that a vertical dimension thereof is increased radially outward.

6. A separating apparatus as set forth in claim 2, wherein said screw blade has a substantially constant pitch on said upper half of the inner cylinder and, on the other hand, the pitch is gradually reduced to downward on said tapered, lower half of the inner cylinder.

7. A separating apparatus as set forth in claim 1, wherein said screw blade has a double spiral shape.

8. A separating apparatus as set forth in claim 1, wherein said planetary means comprises an internal sun gear, a planetary gear engaged with said internal sun gear, an external sun gear engaged with said planetary gear and coaxially arranged with said internal sun gear, and a carrier for rotatably supporting said planetary gear.

9. A separating apparatus as set forth in claim 8, wherein said first motor is connected to said internal sun gear and to said outer cylinder, said second motor is connected to said external sun gear, and said carrier is connected to said inner cylinder.

10. A separating apparatus as set forth in claim 8, wherein said planetary means comprises a plurality of planetary gear pieces which are arranged equiangularly around and respectively engaged with said external sun gear.

11. A separating apparatus as set forth in claim 8, wherein a speed reduction ratio of said planetary means is 1/200 so that the rotational speed ratio between said outer cylinder and said inner cylinder is 3000:2999, if the first motor rotates at 3000 rpm and the second motor rotates at 2800 rpm.

12. A separating apparatus as set forth in claim 1, wherein said planetary means comprises a wave-generator comprising an elliptic cam and a circumferential bearing of said elliptic cam, a flex-spline made of elastic metal and having an inner circumference in contact with said wave-generator by means of said circumferential bearing and an outer circumference provided with gear teeth, a circular-spline having an inner circumference with gear teeth arranged at same pitch as said gear teeth of the flex-spline.

13. A separating apparatus as set forth in claim 12, wherein said first motor is connected to said circular-spline and to said outer cylinder, said second motor is connected to said wave-generator, and

said flex-spline carrier is connected to said inner cylinder.

14. A separating apparatus as set forth in claim 12, wherein the number of gear teeth of said circular-spline is two more than the number of gear teeth of said flex-spline carrier.

15. A vertical type solid-liquid separating apparatus comprising:

a frame;
an outer cylinder supported on said frame rotatably about a vertical axis;
an inner cylinder coaxially, rotatably disposed within said outer cylinder to define an annular separating chamber between an inner circumference of said outer cylinder and an outer circumference of said inner cylinder;
a screw blade fixedly attached to said outer circumference of the inner cylinder so that a small gap remains between said screw blade and said inner circumference of the outer cylinder;
means for supplying an original liquid into said separating chamber;
means for discharging a separated, cleaned liquid from an upper part of said separating chamber;
means for discharging a sludge from a lower part of said separating chamber;
means for driving said outer and inner cylinders so that said outer and inner cylinders are rotated in a same rotational direction and a rotational speed of said outer cylinder is slightly larger than that of said inner cylinder and a difference in rotational speed is set within a certain limited range; and
means for cleaning or drying said annular separating chamber with cleaning water or air.

16. A separating apparatus as set forth in claim 15, wherein said cleaning means comprises a conduit provided in said inner cylinder for supplying cleaning water or air and a plurality of nozzles connected to said conduit for injecting the cleaning water or air from the outer circumference of the inner cylinder toward said inner circumference of the outer cylinder.

17. A separating apparatus as set forth in claim 15, wherein said nozzles are inclined so that the cleaning water or air is injected at an acute angle with respect to said inner circumference of the outer cylinder.

Fig.1

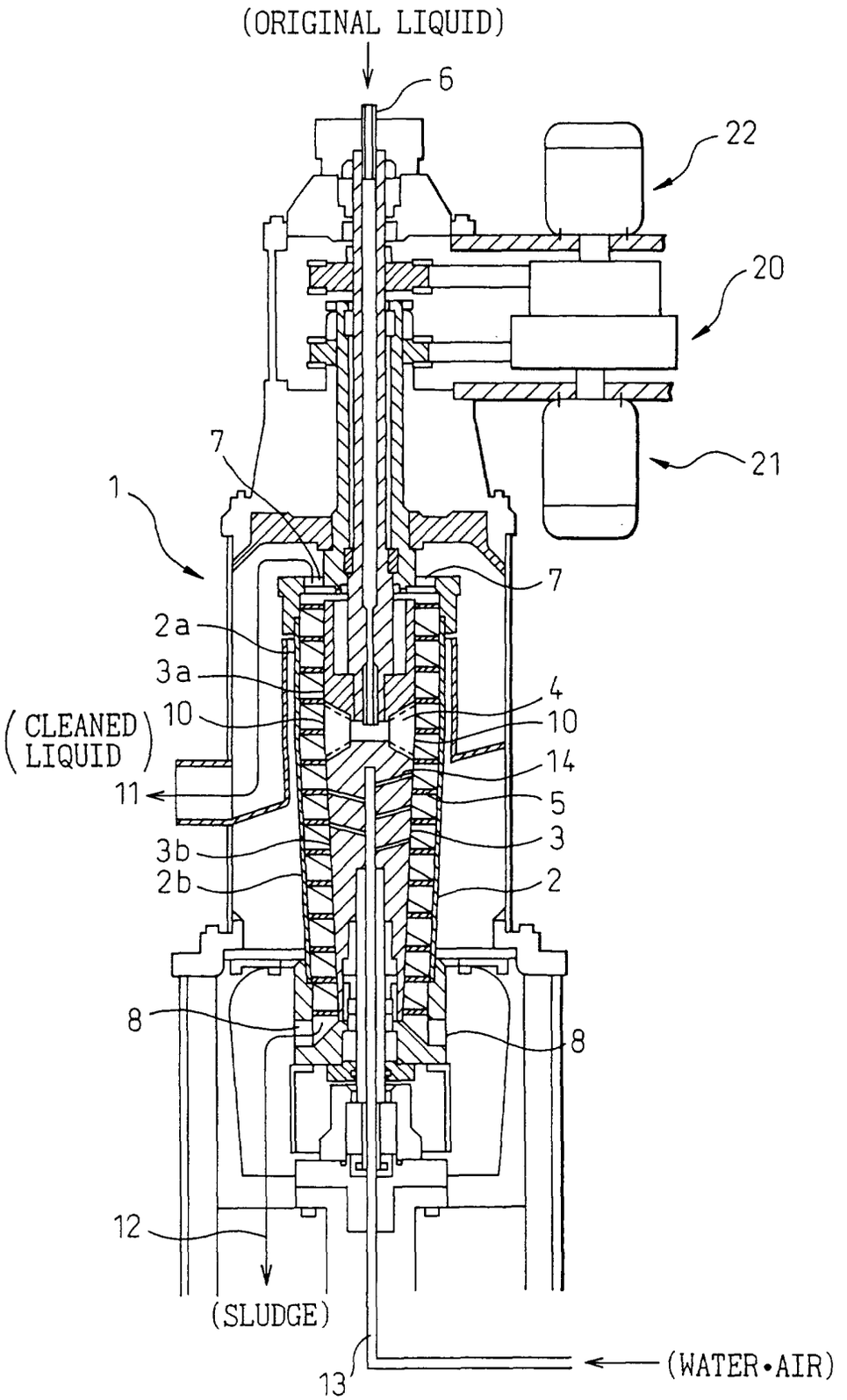

(ORIGINAL LIQUID)
6
22
20
21
7
1
7
2a
3a
4
10
(CLEANED LIQUID)
10
14
11
5
3
3b
2b
2
8
8
12
(SLUDGE)
13
(WATER•AIR)

Fig.2

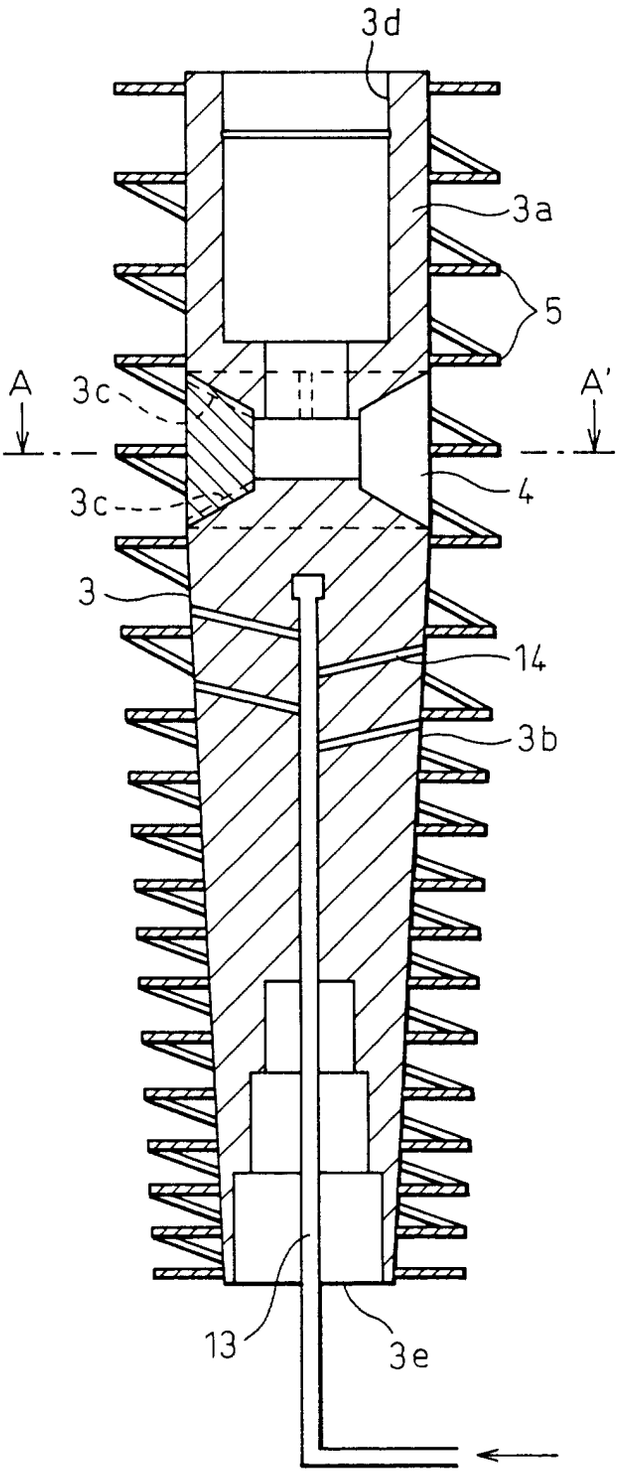


Fig.3(a)

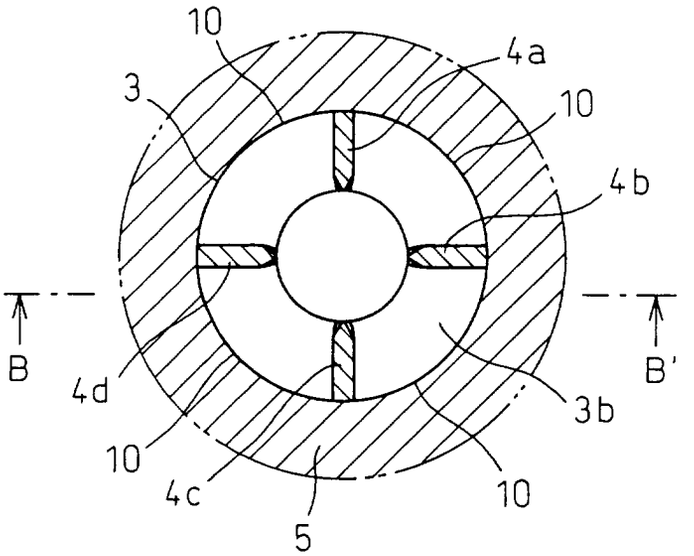


Fig.3(b)

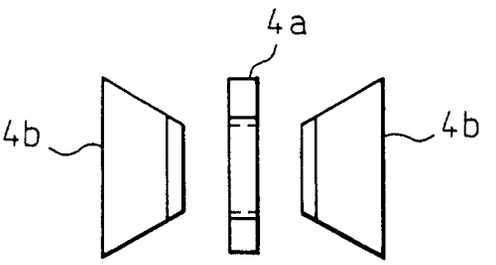


Fig.4(a)

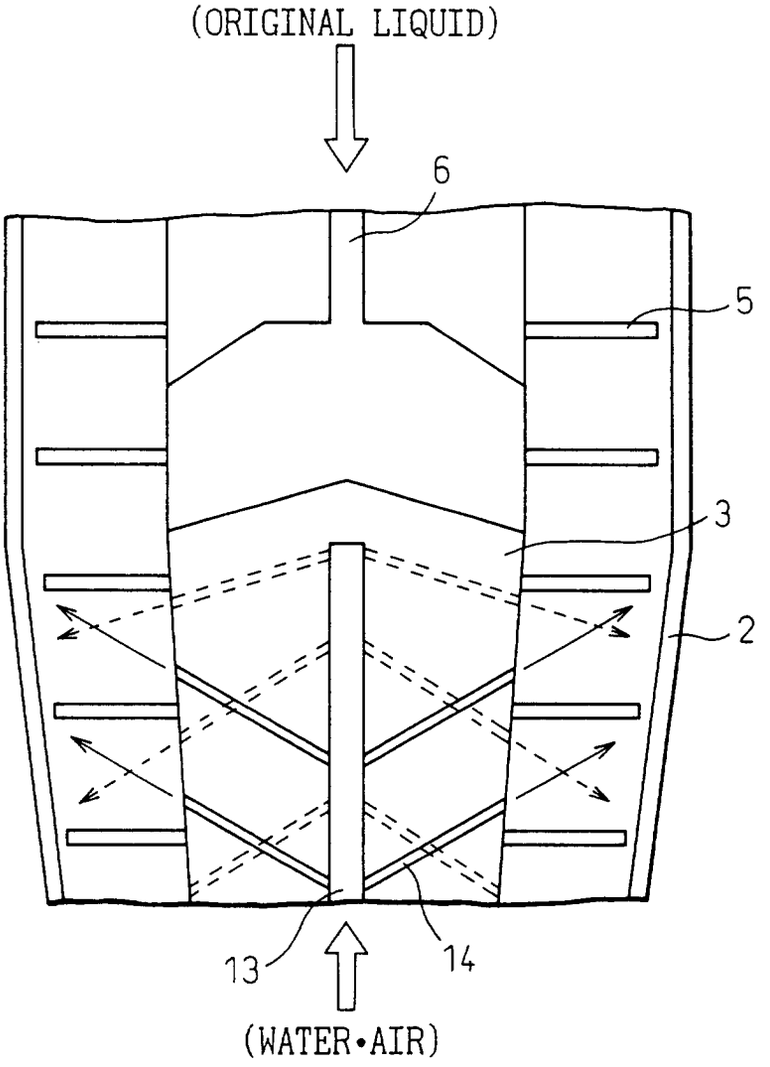


Fig.4(b)

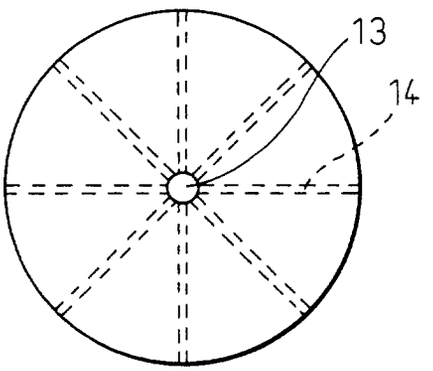
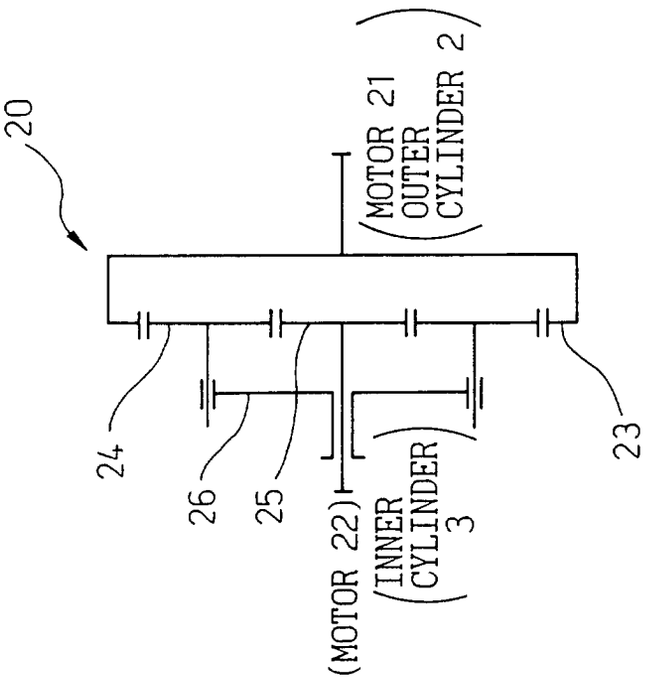


Fig.5(b)


20
(MOTOR 21
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CYLINDER 2)
24
26
25
(MOTOR 22)
(INNER
CYLINDER
3)
23

Fig.5(a)

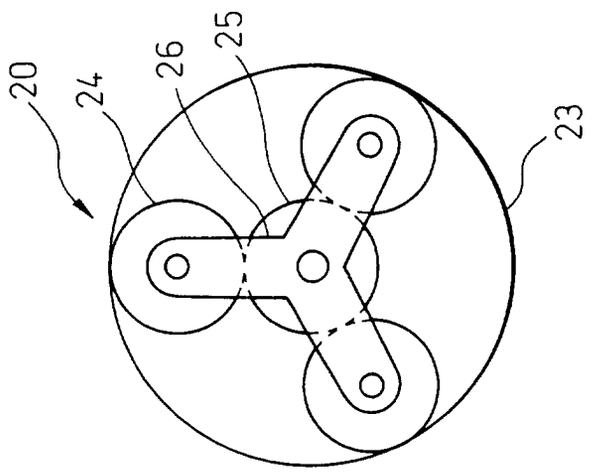
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Fig.6(a)

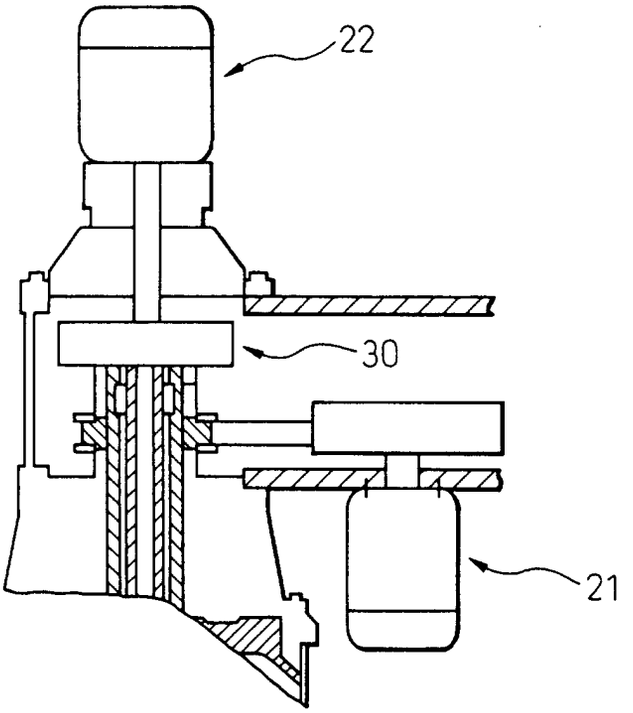

Fig.6(b)