Aug. 26, 1958 K. RIETEMA 2,849,117

CENTRIFUGAL SEPARATOR WITH DIFFUSER

Filed June 23, 1955 2 Sheets-Sheet 1

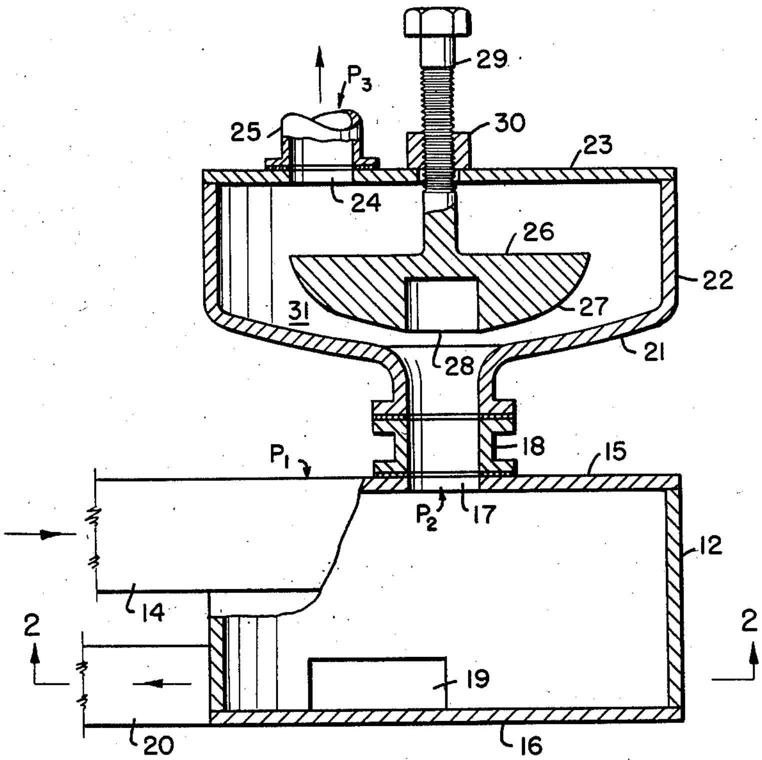

FIG. 1

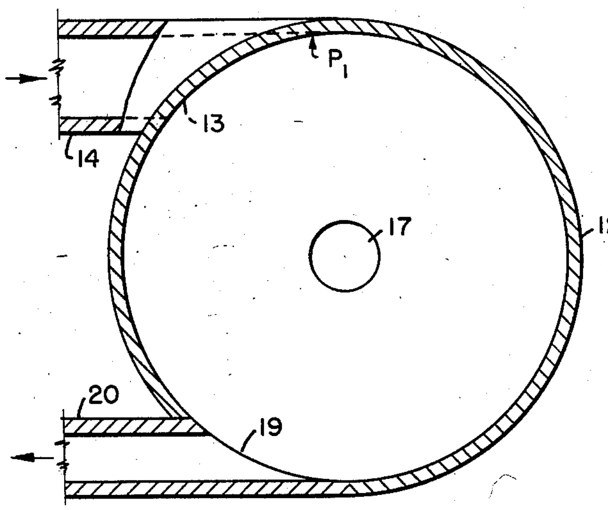

FIG. 2

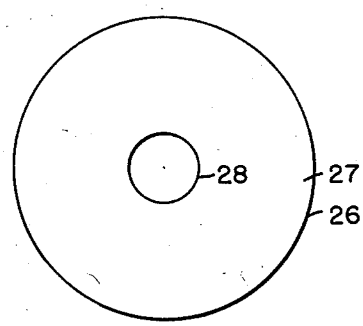

FIG. 3

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CENTRIFUGAL SEPARATOR WITH DIFFUSER

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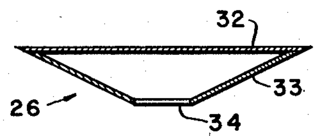

FIG. 10

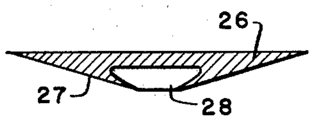

FIG. 9

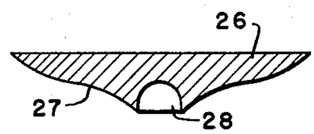

FIG. 6

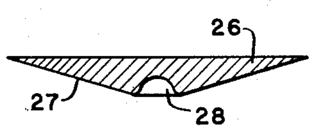

FIG. 8

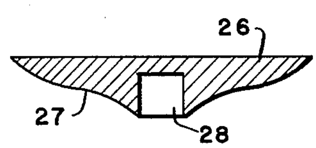

FIG. 5

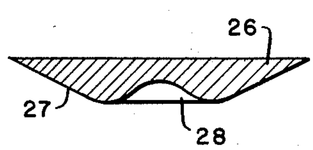

FIG. 7

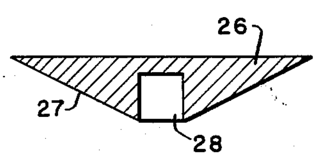

FIG. 4

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2,849,117

CENTRIFUGAL SEPARATOR WITH DIFFUSER

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Application June 23, 1955, Serial No. 517,592

Claims priority, application Netherlands June 30, 1954

6 Claims. (Cl. 209—211)

The invention relates to stationary centrifugal separators including a centrifugation chamber into which the mixture to be separated, such as a suspension, dispersion or emulsion, e. g., a mixture of solids and gas ("gas" being used generically to include vapor) or of liquid with either another liquid or solids, is fed tangentially to effect separation by centrifugal force. The invention is more particularly concerned with an improved diffuser for reducing the pressure drop through the separator as a whole.

A stationary centrifugal separator of the type herein considered includes an enclosed centrifugation chamber usually shaped as a surface of revolution having one or more tangential inlets near one axial end for admitting the mixture to be separated with a flow direction to cause circumferential or vortical motion thereof, an overflow outlet for discharging the separated material of lower density (usually a liquid or a gas) which moves toward the axis, and an underflow outlet for discharging the other component of the mixture, which collects near the radially outer part of the chamber. Such separators are sometimes classified as cyclones and whirl chambers, the invention being applicable to both types: In a cyclone the enclosing wall of the centrifugation chamber includes a substantially tubular part, e. g., a cylinder, at the end near the tangential inlet, the overflow outlet is situated near said end, being usually formed by a vortex-finder discharge tube that extends axially into the centrifugation chamber for a part of the length thereof, and the underflow outlet is at the opposite end, e. g., at the apex when the chamber is upright and the cyclone has a downwardly convergent closure, or at the periphery when the enclosing wall is mainly cylindrical and/or when the axis is horizontal. In the whirl chamber both the overflow and underflow outlets are situated at the same end, which may be remote from the tangential inlet when the chamber is axially elongated; the overflow outlet is a central opening in the end closure wall of the chamber and the underflow outlet is situated either near or at the periphery or is arranged coaxially with the central overflow opening.

From the foregoing description it is clear that the cyclone operates on the countercurrent principle and the whirl chamber on the parallel-flow principle, but this does not constitute any essential difference as regards the invention.

The principle of such separators is based on the fact that a mixture of phases having different specific gravities is separated by means of a gravitational field. Since the centrifugal force increases with the square of the tangential velocity and further decreases linearly as the diameter of the centrifugation chamber increases, it is necessary to use high tangential inlet velocities, particularly with large centrifugation chambers. In order to attain these velocities the feed mixture should be introduced at high pressure. At least one of the separated phases flows out of the centrifugation chamber from the axial region thereof, e. g., through the overflow, with a

considerable rotational velocity and, consequently, with a significant amount of kinetic energy. This kinetic energy is largely lost in most separators now in use, so that the loss of pressure in a centrifugal separator is considerable.

It has been found, especially in the case of cyclones, that the power required to effect a separation between the phases most advantageously is influenced by the "central" or internal pressure drop, viz., the difference between p_1, the pressure at the tangential inlet, and p_2, the pressure at the core of the centrifugation chamber. Thus, the separating efficiency rises with an increase in the difference (p_1-p_2). On the other hand, it is desirable for economic reasons to operate the separator with as little total expenditure of energy as possible, which sets a limit to performance of the separator, since it is desired to keep the total pressure drop, viz., the difference between p_1 and p_3, the pressure at the final outlet, as small as possible.

It is possible to convert a large part of the kinetic energy of rotation in the effluent phase into potential (pressure) energy by providing various appliances. Thus, according to the Swiss Patent No. 238,137, a deflecting body is used in the overflow outlet, causing the effluent phase to be deflected radially. This deflecting body may have any of various shapes, e. g., it may be a flat plate, a cone, or other body of revolution with a convex meridian. The combination of such a deflecting body with an overflow outlet, which may or may not be especially shaped to cooperate with the deflecting body, is called a diffuser. The deflecting body may have a projection or apex extending into the overflow outlet or into the overflow discharge tube that forms a part of such outlet, the latter being flared to conform to the shape of the said body. A description of the latter arrangement may also be found in British Patents Nos. 540,882 and 669,194. The deflecting body may be mounted for adjustment in an axial direction to adjust the width of the annular passage and thereby effect a maximum conversion of rotational kinetic energy into potential energy.

It is the main object of this invention to improve the diffuser associated with an axial outlet of a stationary centrifugal separator so as to achieve a greater "central" pressure drop (p_1-p_2) in relation to the total pressure drop (p_1-p_3), the symbols having reference to pressures at the various points in the separator as indicated on the drawing and previously defined.

A further object is to provide an improved deflecting body for use in such diffusers.

It has now been found that the "central" pressure drop in a centrifugal separator of the character described can be increased in relation to the total pressure drop by providing at one or both outlets from the centrifugal chamber, but always at an outlet that emerges from the central part thereof, a diffuser including an enlarged chamber and a deflecting body, the latter having a central recess aligned with and open toward the said outlet, and an annular deflecting surface surrounding the said recess and having a diameter greater than that of the said outlet and less than that of the enlarged chamber.

The said recess is a bore in the deflector body situated coaxially with respect to the outlet from the centrifugation chamber, closed at the inner end of the bore, and advantageously having a diameter at the mouth thereof that is approximately the same as that of the said outlet. It may have any of several shapes; good results are obtained with recesses formed as surfaces of revolution having the shape of a right circular cylinder, a part of a sphere, e. g., a hemisphere, a cavity with a restricted mouth, or the surface generated by rotating an ellipse.

The invention will be further described with reference to the accompanying drawings forming a part of this specification and showing certain preferred embodiments, wherein:

Figure 1 is a vertical sectional view, taken through the axis of an upright centrifugal separator having a diffuser according to the invention, parts being shown in elevation;

Figure 2 is a transverse sectional view, taken on the line **2**—**2** of Figure 1;

Figure 3 is an end view of the deflecting body; and

Figures 4–10 are vertical sectional views, taken through the axes of seven alternative embodiments of the deflecting body.

Referring to the drawings in detail, and particularly to Figures 1–3, the separator includes a vertical cylindrical side wall **12** defining a shallow centrifugation chamber of circular outline having an inlet opening **13** at the top to which is connected a rectangular inlet duct **14** disposed to admit the mixture of phases to be separated tangentially to the wall **12**. The top and bottom of the chamber are closed by end walls or closures **15** and **16**, respectively. The top closure **15** has a central overflow outlet opening **17** situated at the chamber axis and communicating with a discharge tube **18**, both the opening and tube being circular and of smaller diameter than the chamber. The wall **12** further has an underflow outlet opening **19** situated near the bottom and communicating with a discharge duct **20**.

The tube **18** communicates directly with an enlarged pressure-recovery chamber having a divergent section **21** and a cylindrical section **22** joined to an end closure **23**, the said sections being advantageously shaped as surfaces of revolution. For example, the upper part of the section **21** may have the shape of a hyperboloid of revolution and curved at the extreme top to merge with the cylindrical section **22**, and the lower part thereof may be curved convexly upward to merge with the bore of the tube **18**. The pressure-recovery chamber has a discharge opening **24**, formed in the closure **23** and connected to a discharge duct **25**.

The diffuser includes, in addition to the aforesaid pressure-recovery chamber, a deflecting body **26** situated within the said chamber and having an annular deflecting surface **27** surrounding a recess **28** which is shaped as a surface of revolution, e. g., as a circular cylinder aligned coaxially with the discharge tube **18** and open toward the tube. For best results the circularly cylindrical recess **28** of this embodiment has a depth equal to at least the radius thereof, e. g., 1.6 times the radius as shown. The deflecting body is mounted by a stem **29** which may have a threaded support in a collar **30** which is fixed in the closure **23** to permit axial adjustment of the body. Such axial adjustment makes it possible to vary the width of the annular flow passage **31** between the wall section **21** and the deflecting surface **27**. The deflecting surface **27** is formed as a surface of revolution and has an outer diameter exceeding that of the outlet opening **17**, e. g., such that the ratio of the diameters of the deflecting surface and the outlet opening is between about 2 and 7. The contour of the deflecting surface may conform to that of the section **21**, as shown, but this is not an absolute requirement. Various contours are shown in Figures 4–10, to be described.

Referring to Figures 4–9, six differently shaped deflecting bodies **26** are illustrated, each having an annular deflecting surface **27** surrounding a central recess **28**, both formed as surfaces of revolution. In Figures 4, 7, 8 and 9 the deflecting surfaces are frusto-conical while in Figures 5 and 6 their outlines in section have reversed curves. The recesses **28** have the shape of a circular cylindrical bore in Figures 4 and 5; of a hemisphere in Figure 6; of various ellipsoids of revolution in Figures 7 and 8, the edge being rounded in Figure 7; and of a cavity with a restricted mouth in Figure 9.

A particularly attractive construction is shown in Fig-

ure 10 wherein the deflecting body is built from a flat plate **32** to which is secured a collar **33** having the shape desired for the deflecting surface, e. g., the frustum of a cone as shown. The collar has a central opening **34** forming the restricted mouth for the cavity.

In operation, the mixture of phases is admitted tangentially to the centrifugation chamber through the inlet duct **14** at a pressure p_1 to form a vortex, thereby the denser phase is concentrated near the outer wall **12**, from which it is discharged through the underflow outlet opening **19** and discharge duct **20**. The phase of lower density, wholly or partly freed from the denser phase, gravitates toward the axis and flows out through the overflow outlet opening **17** at a pressure p_2; thence it flows through the discharge tube **18** with rotational kinetic energy and debouches therefrom at the inner part of the annular passage **31** into which it is deflected by the deflecting body **26**, thereby recovering a part of the rotational kinetic energy as potential energy, i. e., by increasing the pressure. This phase is ultimately discharged through the opening **25** at a pressure p_3, which is greater than p_2. It was found that the recess **28** in the deflecting body is effective to produce a comparatively large difference between the pressures p_1 and p_2 for a given difference between the pressures p_1 and p_3, thereby attaining a high separating power with a given overall or total pressure drop.

Example

A centrifugal separator designed generally as shown in Figures 1–3, with the differences noted below, had the following dimensions:

	Millimeters
Diameter of the wall **12**	200
Height of the wall **12**	30
Tangential inlet duct **14**	30 x 30
Diameter of overflow opening **17**	30
Diameter of cylindrical section **22** of pressure recovery chamber	200
Diameter of deflecting body **26**	140
Diameter of recess **28**	30
Depth of recess **28**	25

The divergent section **21** of the pressure recovery chamber was in the form of a hyperboloid of revolution with an asymptotic cone having an apex angle of 150°. The deflecting body was adjusted so that the passage **31** had a width, in the axial direction, of 3 mm., measured on the circumference of the cone.

Comparative tests were made with the above-described deflecting body having the cylindrical recess, and with a deflecting body of like shape but without the recess. In each run 20 cu. meters of air per hour were admitted tangentially to the centrifugation chamber through the inlet opening **13** at the same pressure p_1, all of which was discharged through the overflow opening **17** and final discharge opening **24**. The following values were measured for the pressure differences:

	Deflecting body without recess	Deflecting body with recess
"Central" pressure drop p^1-p^2 (cm. of water)	17.5	24.5
Total pressure drop p^1-p^3 (cm. of water)	10.5	10.5
Ratio of "central" pressure drop to total pressure drop	1.67	2.34

It is noted that there was an increase of 7 cm. of water, amounting to 41%, in the "central" pressure drop (which is the measure of the separation efficiency) by using the improved deflecting body with the recess according to the invention, for the same total pressure drop.

I claim as my invention:

1. In a stationary centrifugal separator including an outer wall enclosing a centrifugation chamber, a tangential inlet for said chamber, an overflow outlet, and an underflow outlet, at least one of said outlets comprising an

opening in said outer wall of lesser diameter than and in coaxial relation to said centrifugation chamber, the improvement of a diffuser including: an enclosing wall defining a pressure-recovery chamber of greater diameter than and in alignment and direct communication with said one outlet; a deflecting body situated predominantly within said pressure-recovery chamber and having a central recess in alignment with and open toward said one outlet, and an annular deflecting surface surrounding said recess and having a diameter greater than said one outlet and less than said pressure-recovery chamber; and an outlet for said pressure-recovery chamber.

2. A separator according to claim 1 wherein said recess is a cylindrical bore in the deflecting body having a diameter substantially equal to that of the said one outlet and a depth at least as great as the radius thereof.

3. A separator according to claim 1 wherein said annular deflecting surface is a surface of revolution sloping outwards from said recess and away from said centrifugation chamber.

4. A separator according to claim 3 wherein said deflecting body comprises a flat plate to the front of which is attached a collar.

5. A separator according to claim 3 wherein said deflecting surface is shaped essentially as the frustum of a cone.

6. In a stationary centrifugal separator including an outer wall enclosing a centrifugation chamber, a tangential inlet for said chamber, an axial overflow outlet including an overflow discharge tube having a diameter less than that of the chamber, and an underflow outlet, the improvement of a diffuser for said overflow outlet including: an enclosing wall defining a pressure-recovery chamber of greater diameter than and situated coaxially with said discharge tube and in direct communication therewith; a deflecting body situated predominantly within said pressure-recovery chamber and having a central recess in alignment with and open toward said discharge tube, and an annular deflecting surface surrounding said recess and having a diameter greater than said discharge tube and smaller than said pressure-recovery chamber; and an outlet for said pressure-recovery chamber.

References Cited in the file of this patent

FOREIGN PATENTS

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607,784	Great Britain	Sept. 6, 1948
669,194	Great Britain	Mar. 26, 1952
687,097	Great Britain	Feb. 4, 1953