Oct. 28, 1958 W. J. D. VAN DIJCK 2,857,979

GAS-LIQUID SEPARATOR WITH POROUS WALL

Filed June 27, 1955

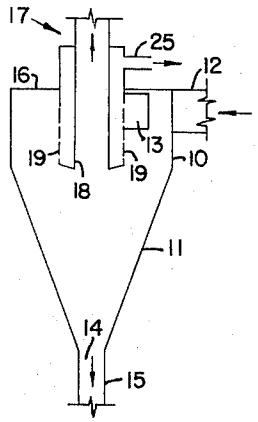

FIG. 1

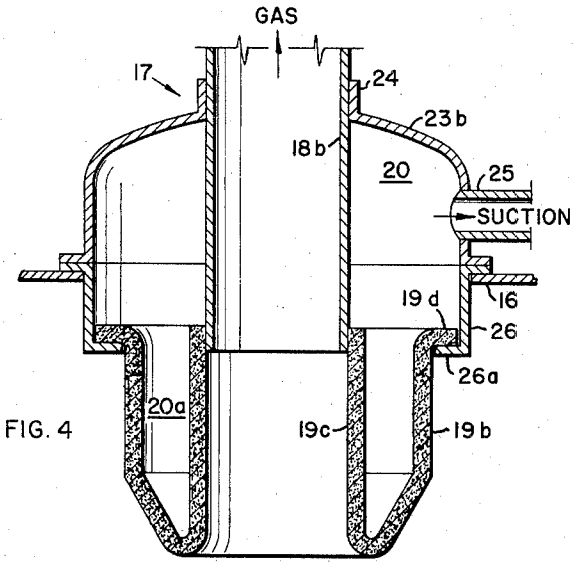

FIG. 4

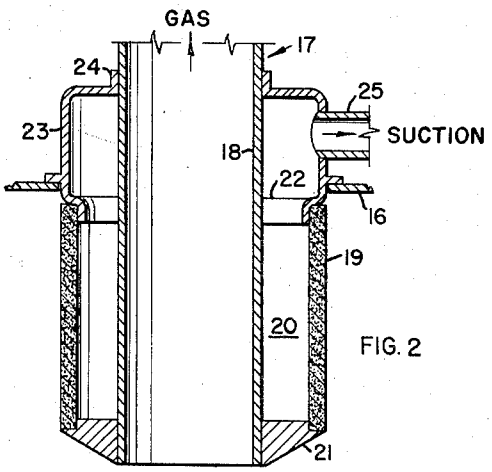

FIG. 2

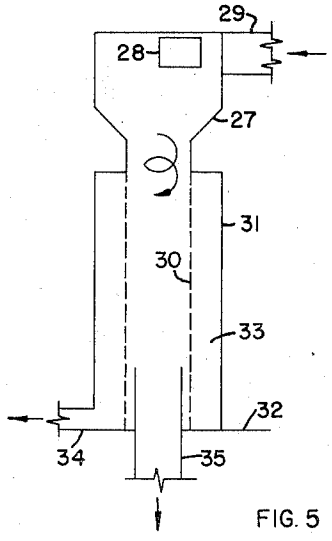

FIG. 5

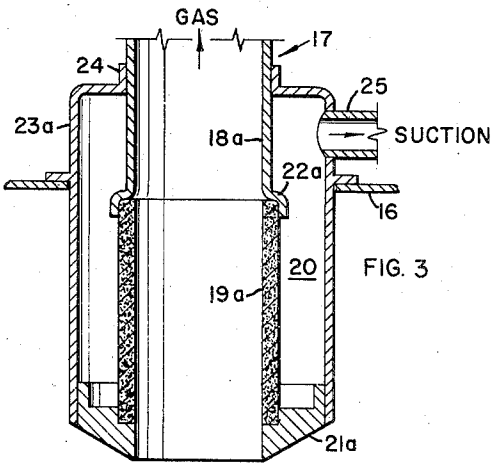

FIG. 3

INVENTOR
WILLEM J.D. van DIJCK
BY Oswald J. Milmore
HIS ATTORNEY

United States Patent Office 2,857,979 Patented Oct. 28, 1958

2,857,979

GAS-LIQUID SEPARATOR WITH POROUS WALL

Willem J. D. van Dijck, The Hague, Netherlands, assignor to Shell Development Company, New York, N. Y., a corporation of Delaware

Application June 27, 1955, Serial No. 518,177

Claims priority, application Netherlands June 30, 1954

10 Claims. (Cl. 183—34)

The invention relates to apparatus for effecting separation between gas and liquid ("gas" being used generically to include vapor) including an enclosed flow zone for the gas which is bounded by a wall on which a film of liquid is formed by creep from another part of the separator and/or by deposition from the gas as a result of rotational movement of the gas or by other gas turbulence, wherein said liquid film is separated from the gas by passage through a portion of said wall into a collecting chamber which is maintained at a reduced pressure. It finds especial application in the gas outlet (also known as overflow outlet) of stationary centrifugal separators wherein liquid drops are separated centrifugally from a gas which is charged tangentially into a centrifugation chamber, but is also applicable to other devices.

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 gas, burdened with liquid, in a direction to cause circumferential or vortical motion thereof, an overflow outlet for discharging the dried gas from the vicinity of the chamber axis, and an underflow outlet for discharging the liquid, which collects near the radially outer part of the chamber; the terms overflow and underflow relate the outlets to the density of the phase discharged and do not denote the relative elevations of the outlets. Such separators are sometimes classified as cyclones and whirl chambers, the invention being applicable to both types: In a cyclone the enclosing wall usually includes a tubular part, e. g., a cylinder, at the end of the tangential inlet, the overflow outlet is situated near said end and usually includes a discharge tube that extends axially into the centrifugation chamber for a part of the length thereof to form a vortex-finder, and the underflow outlet is at the opposite end, e. g., at the apex when the chamber is upright and closed at the bottom by 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 an end closure of the chamber and the underflow outlet is situated either near or at the periphery or is arranged coaxially with the 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.

It is found in practice that some liquid is discharged through the overflow outlet together with the so-called dry gas. Such liquid may occur as dispersed droplets that were initially present in the feed stream but were not separated in the centrifugation chamber because of their small size, due to the fact that such devices are more effective for separating larger drops. Also, such liquid may be re-entrained from a confining wall of the apparatus, such as the inner wall or the end closure of the centrifugation chamber, or the inner or outer wall of the overflow outlet duct, it having been observed that liquid flows or creeps as a film along the above-mentioned walls into the overflow outlet, wherein the film is disrupted and the liquid is entrained by the whirling gas. Such liquid may also be swept along the outlet duct without actual entrainment. It is evident that the flow of liquid through the overflow outlet, by whatever method, reduces the separating efficiency of the separator, and that the operating efficiency could be improved by preventing or reducing such flow.

According to a publication by Ter Linden in Chemie-Ingenieur-Technik (Weinheim/Bergr.), vol. 25 (1953), page 330, the creep of liquid toward the overflow outlet of a cyclone having a vortex-finder is limited considerably by mounting a cylindrical baffle on the end closure concentrically about and in spaced relation to the vortex-finder. This, however, does not completely prevent creep and does not influence the flow of fine drops that were not separated from the gas in the main centrifugation chamber.

According to other proposals the wall of the overflow outlet duct is provided with gaps or slots establishing communication with an auxiliary liquid-collecting chamber which is maintained under reduced pressure to induce liquid creeping along the duct wall or deposited thereon by the rotation of the effluent gas to enter the collecting chamber. Arrangements of this type are suggested in U. S. Patents Nos. 1,231,371; 1,408,693 and 2,425,588, and French Patent No. 1,035,313, but result in the passage of an appreciable amount of gas together with the liquid into the collecting chamber where it must be separated from the liquid and from which it must be withdrawn against an adverse pressure gradient; these circumstances present added difficulties.

It is the main object of the invention to provide an improved apparatus for separating liquid from gas wherein the liquid occurs on the wall of an enclosed flow zone for gas and suction is applied to draw the liquid into an auxiliary collecting chamber, the apparatus being so constructed that the flow of gas together with the liquid into the collecting chamber is prevented or greatly reduced.

A further object is to improve the operating efficiency of stationary centrifugal separators of the type indicated by providing the overflow outlet with an improved auxiliary liquid collector that operates without or with greatly reduced entry of gas into the liquid collector.

According to the invention it was found that liquid occurring as a film on the wall enclosing a gas-flow zone can be drawn off without or with only an insignificant amount of gas by forming at least a part of said wall of a porous material, such as ceramic or sintered metal, and applying a reduced pressure to the liquid-collecting chamber on the opposite side of said wall, so that the liquid film on the gas side of the porous part of the wall is not broken to any appreciable extent.

The liquid film may be formed on said enclosing wall by any or by a combination of the modes considered above, e. g., by deposition from the gas as a result of turbulence in the gas or as a result of rotational, vortical flow thereof leading to centrifugal forces, or by wall creep. As applied, for example, to the overflow outlet duct of a stationary centrifugal separator, the inside wall of the overflow duct may be formed in part of such porous material and suction is applied to an auxiliary liquid-collecting chamber situated behind said porous part. When the separator has the overflow duct extending into the centrifugation chamber to form a vortex-finder the porous portion may be

provided on the outside of the duct or on the inside, or both on the inside and outside. The porous wall section on the outside of the outlet duct effectively prevents or reduces the creep of liquid into the inside of the duct, to prevent re-entrainment of liquid in the dry gas, while such a porous section on the inside is further useful for separating liquid deposited on the inner surface from the effluent, rotating gas due to the increased centrifugal forces developed by the increased angular speed and reduced diameter within the duct, and is used when the nature of the dispersed liquid is such that the deposition is a problem. Suction pressure is applied to the liquid-collecting chamber by any suitable means, such as a suction pump or by a connection to a region of the separator or other unit of the plant operating at reduced pressure.

The advantage of such a porous wall in contrast to gaps or other openings through the wall is that a considerably greater pressure difference between the opposite faces of the porous wall is required for dry suction, depending upon the interfacial tension of the liquid to be drawn off and the size of the pores of the porous wall, so that breakage of the liquid film (which would cause gas to be sucked off in addition to liquid) can be prevented by applying the proper degree of suction. The sizes of the said pores are preferably less than 0.1 mm.

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

Figure 1 is a diagrammatic view in vertical section through a cyclone provided with one form of auxiliary liquid collector on the overflow outlet duct;

Figure 2 is an enlarged detail view of the overflow duct indicated in Figure 1;

Figures 3 and 4 are vertical sectional views through the overflow outlet duct showing two alternative arrangements; and

Figure 5 is a diagrammatic view of a parallel flow separator provided with a different form of the liquid collector.

Referring to Figures 1 and 2, there is shown a cyclone having a centrifugation chamber enclosed by an outer wall including an upper cylindrical part **10** and a lower, frusto-conical part **11**, both formed as surfaces of revolution about a vertical axis. An inlet duct **12** is disposed tangentially to the upper part and opens into the centrifugation chamber through an inlet opening **13**, whereby an entering feed stream of gas, burdened with liquid, forms a vortex from which the liquid is separated against the outer wall by centrifugal force. The separated liquid for the greater part flows downward and is discharged through a central underflow outlet opening **14** and a discharge duct **15**. The cyclone further includes a top closure **16** having a central opening through which extends an overflow discharge duct provided with the auxiliary liquid collector of the invention and collectively designated by the number **17**. The duct preferably extends to a level below the lower edge of the opening **13** to form a vortex-finder which leads off the dried gas from the core of the vortex.

In this embodiment a portion of the outer surface of the discharge duct below the closure **16** is formed of porous material. This is achieved by making the duct double-walled, the inner wall **18** being a non-porous tube and the outer wall including a ring **19** of porous material, e. g., ceramic or sintered metal. This ring, represented by dashed lines in Fig. 1, is situated in annularly spaced relation to the tube **18** to provide an intervening annular liquid-collecting chamber **20**, and may be mounted in any convenient manner. Thus, the ring may be supported and positioned by an annular, shouldered support ring **21** which is removably secured to the bottom of the tube **18** and may have a taper at the bottom to reduce the wall thickness of the duct at the bottom. The top of the ring is shown to be positioned by a flange **22** on a casing **23** that closes the top of the collecting chamber, rests on the closure **16**, and supportingly engages the tube **18** by a flange **24**. A pipe **25** communicates with the collecting chamber and is connected to any suitable source of suction, such as a suction pump.

In the modified embodiment of Figure 3 the inner surface of the discharge duct is in part formed of porous material. The duct is again double-walled and includes a non-porous tube **18***a* terminating in a positioning flange **22***a* which positions a porous ring **19***a* the inner surface of which preferably lies substantially in the same cylindrical surface as that of the tube. The ring is supported by an annular, shouldered support ring **21***a* which is removably secured to the bottom of the casing **23***a* and may have a taper as shown. The casing is spaced from the ring to provide a liquid-collecting chamber **20**, rests on the closure **16**, and supportingly engages the tube **18***a* by a flange **24**; it is fitted with a suction pipe **25**.

In the modified embodiment of Figure 4 both the inside and the outside of the discharge duct are formed in part of porous material. The duct includes a non-porous tube **18***b* which is supported by a flange **24** at the top of the upper section **23***b* of the casing enclosing the collecting chamber **20**; this section rests on a separable lower casing section **26** having support on the closure **16**. The collecting chamber is evacuated by a suction pipe **25**. The porous parts of the duct wall are formed of a single tip of porous material, having integral outer and inner walls **19***b* and **19***c* which are joined at the bottom but otherwise spaced apart to define the annular lower part **20***a* of the collecting chamber **20**. The tip may be supported by an outward flange **19***d* at the top of the outer wall **19***b* coacting with an inward flange **26***a* at the bottom of the casing section **26**. In the arrangement shown the inner wall **19***c* has a sliding fit with the tube **18***b*.

In the operation according to each of the above embodiments, liquid occurring as a film on the wall of the overflow outlet duct **17** flows under suction through the porous wall **19**, **19***a*, **19***b* or **19***c* into the liquid-collecting chamber **20**, from which the collected liquid is withdrawn under suction through the pipe **25**. This liquid can be united with the liquid which is discharged through the underflow outlet **14**. The suction applied to the chamber **20** is always such as to establish a pressure gradient through the porous wall but should be insufficient to break the liquid film and so cause the passage of any appreciable amount of gas.

In the case of the arrangements according to Figures 1, 2 and 4, the porous part **19** or **19***b* largely prevents liquid that creeps along the wall **10**, closure **16** and downwards along the outside of the vortex-finder from reaching the inside of the overflow outlet duct, thereby reducing the amount of liquid that passes out through the latter together with the dry gas; this improves the separating efficiency of the separator. In the case of the arrangements according to Figures 3 and 4 the porous part **19***a* or **19***c* draws off liquid that occurs on the inner surface of the overflow outlet duct for any cause; thus, in Figure 3 such liquid may be present as a film because of creep downwardly on the outside of the casing **23***a* and ring **21** and thence upwardly into the duct, and, further, by deposition on the inner surface of liquid carried by the effluent gas and separated therefrom by centrifugal forces and/or turbulence. In Figure 4 the same causes may contribute to liquid on the inner surface, but the contribution of the creep may be minor in view of the action of the outer porous section **19***b*.

Referring to Figure 5, the apparatus includes a cylindrical wall **30**, shaped as a surface of revolution and formed in whole or in part of porous material, preferably sintered material, into which gas burdened with liquid is admitted at the top by any arrangement produc-

ing turbulent and/or rotational flow. For example, the gas may be given rotational motion by mounting at the top of the wall **30** an enlarged whirl chamber **27** having an inlet opening **28** to which is connected a tangential inlet duct **29**. The wall **30** is surrounded in spaced relation by an impervious casing wall **31** having a bottom closure **32** to provide an annular liquid-collecting chamber **33**. A suction pipe **34** is connected to the bottom of the casing wall and to a suction pump or other source of reduced pressure. A non-porous drawoff tube **35** extends upwardly through the closure **32** into the wall **30** and preferably with a small annular clearance. It is advantageous to extend the tube **35** to a height above the pipe **34** to prevent the overflow of liquid that may collect in the lower part of the separator.

In operation, gas, burdened with liquid, is admitted through the duct **29** and forms a vortex in the chamber **27**, from which it enters the gas flow zone inside of the wall **30**. During the ensuing downward flow liquid is deposited as a film against the inside of the wall **30** by centrifugal force. When a suitable degree of suction is applied to the pipe **34** the chamber **33** is under reduced pressure and the liquid passes through the porous wall, being eventually discharged through the pipe **34**. The degree of suction is preferably adjusted so that the top part of the porous wall **30** is just dry and no significant amount of gas flows through the wall; the lower parts of this wall will be moist due to the capillary rise of liquid.

In Fig. 5 the gas is shown in downflow; it is however, also possible and often advantageous to use upflow of the gas.

I claim as my invention:

1. A gas-liquid separator including a wall bounding a gas flow zone, a portion of said wall being formed of porous, sintered material; means for admitting gas and liquid into said flow zone at one side of said wall; means for discharging said gas from the said flow zone on the same side of said wall; a wall structure defining a liquid-collecting chamber at the side of said porous portion remote from said flow zone; and means for applying suction to said liquid-collecting chamber.

2. A gas-liquid separator including an enclosing wall defining a chamber and shaped substantially as a surface of revolution; means for admitting a gas burdened with liquid with a rotary motion into said chamber to form a vortex therein; a gas discharge duct communicating with the central part of said chamber, a portion of said duct exposed to said gas being formed of porous, sintered metal; a wall structure defining a liquid-collecting chamber at the side of said porous portion remote from that exposed to said gas; and means for applying suction to said liquid-collecting chamber.

3. A gas-liquid separator according to claim 2 wherein said first-mentioned chamber is the centrifugation chamber of a stationary centrifugal separator and is provided with an underflow outlet for liquid, said outlet duct constituting the overflow outlet of the chamber.

4. A gas-liquid separator according to claim 2 wherein said first-mentioned chamber is a whirl chamber and said discharge duct is the only outlet to said chamber, whereby the total gas and liquid admitted to the chamber is discharged into said gas discharge duct, said porous portion being on the inner surface of the discharge duct.

5. A gas-liquid separator according to claim 2 wherein said portion of porous material is a ring of sintered metal.

6. A cyclone including an enclosing wall shaped substantially as a surface of revolution enclosing a centrifugation chamber and having a tangential inlet for gas burdened with liquid; an underflow outlet for liquid; an overflow outlet for gas including a vortex-finder tube extending centrally into said centrifugation chamber, a portion of said tube exposed to gas in said chamber being formed of porous, sintered metal; a wall structure defining a liquid-collecting chamber at the side of said porous portion remote from that exposed to said gas, and means for applying suction to said liquid-collecting chamber.

7. A cyclone according to claim 6 wherein said portion of porous material is on the outside of the vortex-finder.

8. A cyclone according to claim 6 wherein said portion of porous material is on the inside of the vortex-finder.

9. A cyclone according to claim 6 wherein said vortex-finder tube has porous portions on both the inside and outside thereof.

10. A cyclone according to claim 9 wherein said vortex-finder tube includes a tip made of sintered metal and having concentric walls joined at the bottom and spaced apart above said bottom to define an annular space forming a part of said liquid-collecting chamber.

References Cited in the file of this patent

UNITED STATES PATENTS

1,680,243	Becker	Aug. 7, 1928
2,344,898	Rathbun	Mar. 21, 1944
2,354,722	Walton	Aug. 1, 1944
2,521,107	Wiley	Sept. 5, 1950

FOREIGN PATENTS

1,035,313	France	Apr. 15, 1953