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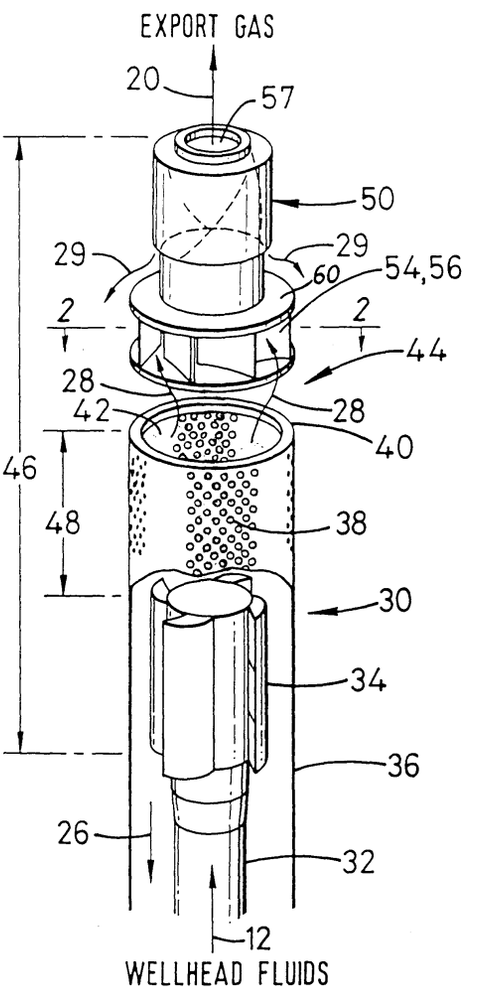
(54) Gas/liquid mixture separation

(57) A secondary separator vane design is used in an arrangement for separating a gas and liquid mixture. The arrangement has a vessel with an inlet (12) for entry of the gas and liquid mixture and an outlet (20) for exit of a separated gas, a primary centrifugal separator (30) in the vessel for centrifugally separating the gas from the mixture and a secondary centrifugal separator (50) in the vessel for further centrifugally separating the gas from the mixture. The secondary separator (50) has an enclosure (60) with an annular gas/liquid separator space (62). An outer circumferential inlet (64) and an inner circular outlet (66) communicate with the separator space (62) and a plurality of fluid directing vanes (56) are circumference spaced around the separator space (62). Each vane (56) is curved in the same direction of curvature from the inlet (64) to the outlet (66) to improve fluid flow.

FIG. 1



EP 1 029 596 A1

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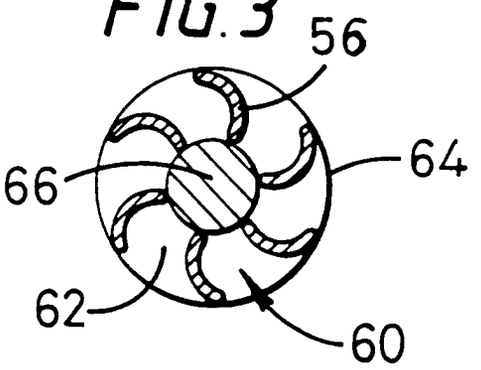
FIG. 3



Description

[0001] The present invention relates, in general, to separation systems and, in particular to gas/liquid mixture separation, for example including a secondary separator for an arrangement for separating a multiple phase mixture into separate vapor and liquid phases utilizing pairs of centrifugal cyclone separators.

[0002] Most of the known gas/oil separation systems rely on natural or gravity separation which requires large vessels to achieve the desired separation performance. When natural separation is used in a relatively small vessel, the throughput or vapor flux of that system is significantly smaller when compared to other systems not relying on natural separation. An example of a system which uses natural separation is described in U.S. Patent No. 4,982,794.

[0003] One known separation system is disclosed in U.K. Patent Application No. GB 2 203 062A and uses centrifugal separation for a primary separation stage and inertial separation (i.e., scrubbers) for a second stage of separation. Although this system most likely has higher separation capacities than a system relying on natural separation, it most likely has higher separation capacities than a system relying on natural separation, it most likely has less capacity when compared to a system that could employ centrifugal separation for both stages.

[0004] U.S. Patent Application Serial No. 08/337,359, filed November 10, 1994. abandoned in favor of Continuation U.S. Patent Application Serial No. 08/695.947. filed August 13, 1996. (and corresponding EP-A-0 711 903 to which reference is directed), discloses an improved separator which uses centrifugal separation modules for the primary and secondary stages of separation.

[0005] The separation arrangement utilizes one or more curved-arm, centrifugal force, primary separators) and one or more secondary centrifugal cyclone separator(s). The primary separator is similar to the separator described in U.S. Patent No. 4,648,890. The secondary separator is similar to the separator described in U.S. Patent No. 3,324,634. The combination of a centrifugal-type primary and secondary separator provides a compact and highly efficient separator arrangement. The separator arrangement can be used in multiple pairs (two or more primary and secondary separators) or as a single-module pair. The multiple pairs are typically used for topside applications while a single-modular pair will satisfy most sub-sea applications.

[0006] An aim of at least an embodiment of the present invention is to modify the inlet vanes of the secondary separator in a gas/liquid separator containing both primary and secondary separator stages, which improves fluid flow past the vanes and overall separator efficiency. The vanes are curved and may be cast, thus permitting the separator to be manufactured using dies rather than welding the vanes in place as was done in the prior art.

[0007] Accordingly, the present invention provides an arrangement for separating a gas and liquid mixture, the arrangement having a vessel with an inlet for entry of the gas and liquid mixture and an outlet for exit of a separated gas, at least one primary centrifugal separator in the vessel for centrifugally separating the gas from the mixture; and at least one secondary centrifugal separator in the vessel for further centrifugally separating the gas from the mixture; characterised by: the secondary separator having means defining an enclosure with an annular gas/liquid separator space having an outer circumferential inlet, and an inner circular outlet; and a plurality of fluid directing vanes circumference spaced around the separator space, each vane being curved in the same direction of curvature from the inlet to the outlet.

[0008] The invention will now be described by way of example with reference to the accompanying drawings, throughout which like parts are referred to by like references, and in which:

Fig. 1 is a perspective view of part of the primary and all of the secondary separator in a separator arrangement in accordance with an embodiment of the present invention;

Fig. 2 is a sectional view taken in the direction of line 2-2 in Fig. 1, showing the prior art use of vanes in the secondary separator; and

Fig. 3 is a sectional view taken along the same direction as Fig. 2, but showing the vanes as constructed according to an embodiment of the present invention.

[0009] A primary separator 30 shown in Fig. 1 comprises a riser tube 32, four sets of multilayered curved arms 34, and an outer can or return cylinder 36 surrounding riser 32 and arms 34. The gas/liquid mixture 12 enters at the bottom of the primary riser 32 and flows up and through the curved arms 34 where the majority of the centrifugal separation occurs. During the separation process, a film of liquid 26 develops on the inner wall of the return cylinder 36 and cascades down to the main inventory of liquid (not shown) below the separator 30. The return cylinder 36 extends above the top of the curved arms 34 where there are a number of half-inch (12.5 mm) diameter perforations 38 and a retaining lip 40 at the open top of separator 30 which are used to improve the liquid removal capabilities of the separator 30 at high gas and liquid flows especially where slug conditions can exist. The wet gas 12 exits the top of the primary separator(s) 30 in a substantially open interstage region 44 which is used to more evenly distribute the wet gas prior to its entering the secondary cyclone (s) 50.

[0010] The distance between the multi-layered curved arms 34 and the top of the primary cyclone separator 30 is indicated at reference numeral 48 and pref-

erably ranges from approximately 15 to approximately 18 inches (380 mm to 460 mm).

[0011] As the two-phase mixture 12 flows through the curved arms 34, separation occurs and the heavier liquid droplets 26 migrate to the outer radius of the curved arms 34 and the less dense vapor migrates to the inner radius of the curved arms 34.

[0012] The secondary cyclone 50 also operates on the principle of centrifugal separation. The wet gas 28 enters the cyclone 50 through tangential inlet vanes 54 at the bottom of the cyclone 50 which imparts a centrifugal motion on the fluid. Any liquid remaining in the gas is then forced to the inner wall of the cyclone 50 where it is separated by skimmer slots and spills into a secondary compartment (not shown). Bypass holes are placed in a top plate of the secondary compartment to allow a certain amount of gas flow 29 to bypass through the secondary skimmer slots to enhance the skimming action. The separated liquid then drains via a drain tube (not shown) back into and becomes a part of the main pressure vessel's liquid inventory. The drain tube isolates the returning separated liquid from the upflowing main gas flow and avoids the re-entrainment of separated liquid by the incoming gas/liquid mixtures 12. Dry gas exits at 20 through outlet 57.

[0013] The secondary cyclone 50 has an inherent advantage over scrubber or mesh type dryers. Both the scrubber and mesh dryers are limited in flow capacity by the droplet entrainment threshold beyond which liquid droplets are entrained with the vapor and are carried downstream. The secondary cyclone 50, on the other hand, can efficiently operate at vapor fluxes typically two to three times higher than the entrainment threshold.

[0014] As best shown in Fig. 2, the enclosure 60 of the secondary separator defines a separator space with an outer circumferential inlet 64 for receiving gases latent with liquid and an inner axially directed circular outlet 66 for discharging liquid free gases. The plurality of vanes 54 which each extend at an angle from the inlet to the outlet, have conventionally been made of sheet metal and have been welded in place between the upper and lower plates of the enclosure 60.

[0015] As shown in Fig. 3, the vanes 56 according to an embodiment of the present invention are curved and arc from the inlet 64 to the outlet 66. Each vane 56 has a thickness and is cast. The shape may also be wing- or foil-shaped to improve fluid flow of fluid entering the enclosure 60. A die can be used to extrude or cast the vanes, for example, of aluminum or other metal.

[0016] While a specific embodiment of the invention has been shown and described in detail to illustrate the application of the principles of the invention, it will be understood that the invention may be embodied otherwise without departing from such principles.

Claims

1. An arrangement for separating a gas and liquid mixture, the arrangement having a vessel with an inlet (12) for entry of the gas and liquid mixture and an outlet (20) for exit of a separated gas, at least one primary centrifugal separator (30) in the vessel for centrifugally separating the gas from the mixture and at least one secondary centrifugal separator (50) in the vessel for further centrifugally separating the gas from the mixture; characterised by:

   the secondary separator (50) having means defining an enclosure (60) with an annular gas/liquid separator space (62) having an outer circumferential inlet (64), and an inner circular outlet (66); and
   a plurality of fluid directing vanes (56) circumference spaced around the separator space (62), each vane being curved in the same direction of curvature from the inlet (64) to the outlet (66).

2. An arrangement according to claim 1, wherein the vanes (56) are cast.

3. An arrangement according to claim 1 or claim 2, wherein each vane (56) is foil-shaped.

FIG. 1

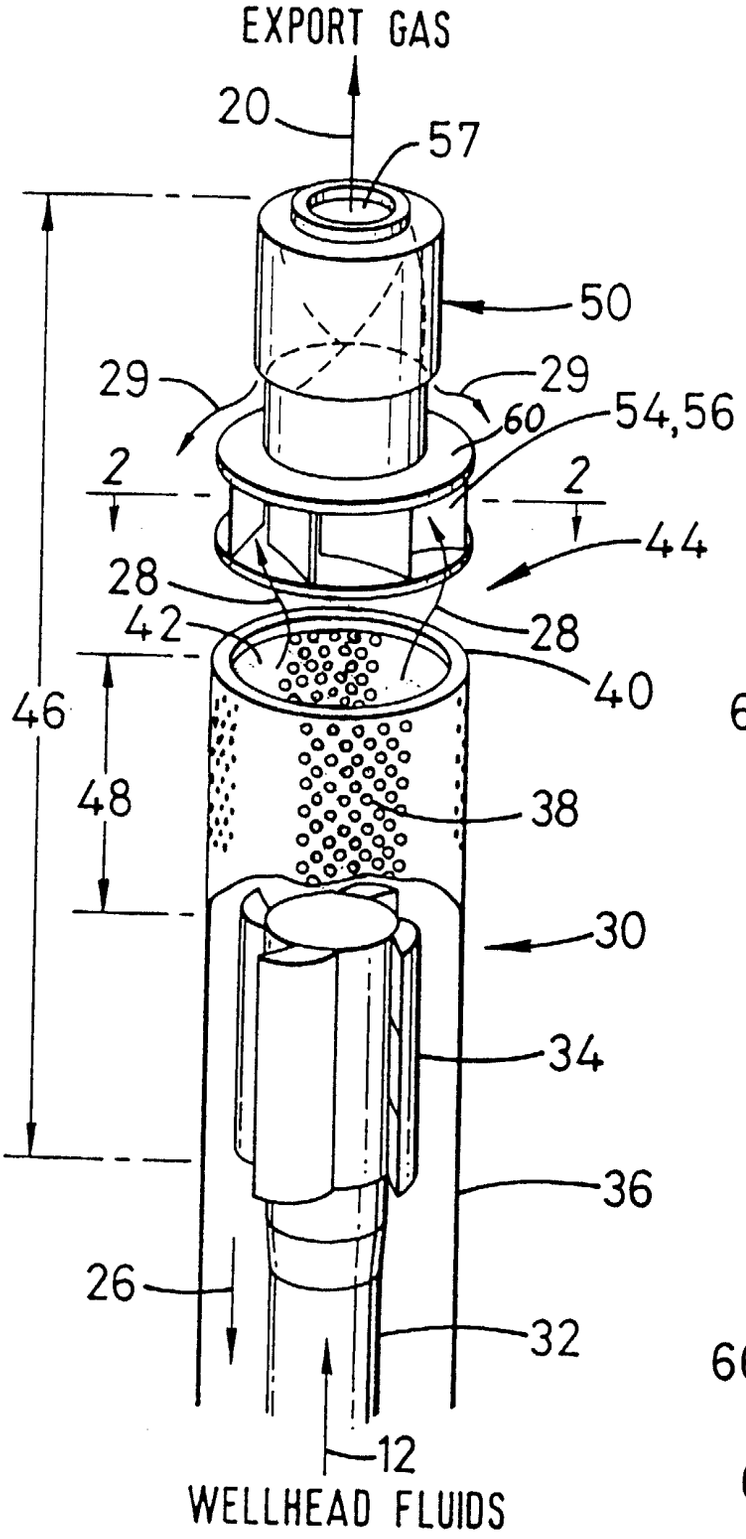


FIG. 2
PRIOR ART

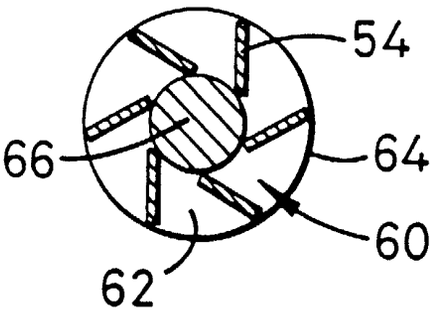
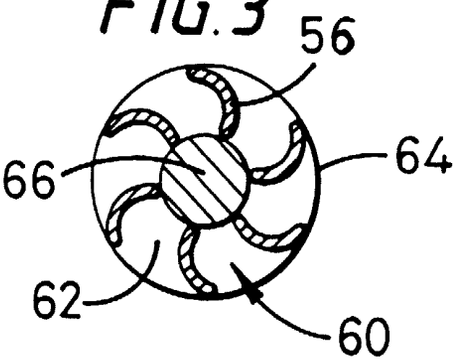


FIG. 3



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EUROPEAN SEARCH REPORT

Application Number
EP 99 30 9077

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
D,Y	EP 0 711 903 A (THE BABCOCK & WILCOX COMPANY) 15 May 1996 (1996-05-15) * abstract * * column 6, line 13 - line 17; figure 5 *	1-3	B04C5/04 B04C7/00 B04C3/06 E21B43/36
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TECHNICAL FIELDS SEARCHED (Int.Cl.7)
B04C E21B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	23 May 2000	Van der Zee, W

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 99 30 9077

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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23-05-2000

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