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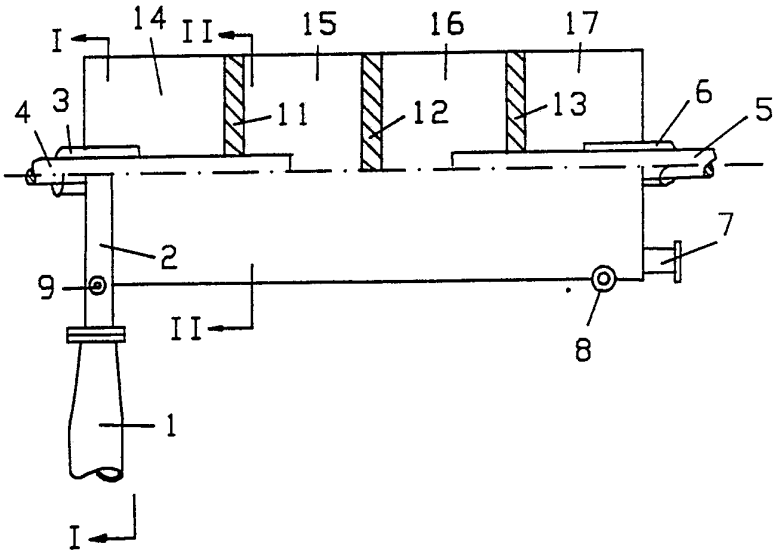
(54) Title: MULTIPLE STEP CYCLONE SEPARATOR



(57) Abstract

Cyclone separator for the stabilization of gas or vapour saturated fluid or a fluid mixture. The fluid phase is led from one separator chamber (14) to a second chamber (15) at a lower pressure, through one or more nozzle ducts (18) in or by a dividing wall (11) between two chambers in a common container (10). The nozzle ducts are designed and placed so that rapid degassing or flashing occurs at the same time as the medium is accelerated through the nozzle ducts, and the outflowing stream from the nozzle ducts (18) is almost tangentially directed towards the periphery of the container (10). Some of the nozzle ducts (18) may be fitted with means (19) of reducing and controlling the total cross-section of the opening.

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Multiple Step Cyclone Separator

The invention comprises a device as stated in the introduction to Claim 1 for stabilizing gas saturated or vapour saturated fluid through combined pressure relief and separation of phases of a media into several pressure stages. The invention is particularly suited for oil and gas separation in the production of petroleum. Other applications may also be relevant.

The technological state of the art

The stabilization of oil by pressure relief and separation of well stream is now done in most cases by pressure relief and flashing in a choke valve or other restriction in a pipeline, after which the phases are separated in a tank separator, mainly under gravitational forces. This type of tank separator consists of a pressure tank that gives sufficient resident time for the separation of the media that flows through. Various types of stationary elements, that are designed to facilitate separation are installed internally in the tank separator.

During the production of oil and gas, pressure relief and separation are usually done in several stages. This is effected by two to four tank separators connected in series. The pressure is reduced in stages from one separator to the next. Apart from the separation of oils and gas at each stage, there is also the need to remove water and solid particles in one or more of the stages. This is termed three-phase separation where water and solid particles are considered as the third phase.

The drawback with normal tank separators is that they require a lot of space and are very heavy, they contain a large volume of flammable hydrocarbons and the functional operation is reduced with movement such as that of vessels and floating platforms.

Another principle of separation is based on the application of centrifugal- rather than gravitational forces

to separate media with different specific gravities. This principle is used in various constructive designs of centrifuges and cyclones. In both cases the medium is subjected to violent rotation meaning that the phase of the medium that has the highest specific gravity, such as water and sand particles are thrown out towards the periphery, whilst the phase that has the lowest specific gravity will be forced against the axis of rotation. The medium in the centrifuge will rotate in a drum, this will normally be at the same rotational velocity as the drum. On the other hand, the medium in a cyclone will rotate in a stationary cylindrical or conical chamber.

Both the centrifuge and the cyclone have numerous applications, so far they have not been successfully used for gas-oil separation. A considerable drawback of previous known designs for cyclones is that they have little flexibility when confronted by changes in the amount and phase condition of the inflowing medium and they cannot be operated efficiently with large flows of media.

Objective of the invention

The main objective of the invention is to produce a device for stabilizing gas saturated fluid through pressure relief and separation of the phases in the media in a more optimal manner than previously. The most important optimal criteria are: small volume, low weight, high separation effect, flexibility with reference to changes in the amount and phase condition of the inflowing medium, lack of sensitivity to movement, mechanical simplicity and functional reliability.

Basic concept of the invention

The invention is based on the principle stated in Claim 1, which can most easily be described as a cyclone comprising a series of separation chambers with different pressures. The media are separated in each chamber. Stabilized fluid is led out of the last chamber, while gas is led out of each chamber at the respective pressure levels.

The fluid part is led further from one chamber to the next chamber where there is a lower pressure level through a set of nozzles located near the periphery. The nozzles can be placed either in dividing walls or in separate ducts that connect two neighbouring chambers on the outside of the container. Among the means of controlling the level of liquid in each chamber is turning on or off a certain number of nozzles. Pressure relief and flashing occur in the nozzles at the same time as the flow velocity of the medium is accelerated when it proceeds from one pressure level to a lower pressure level.

The nozzles are located and designed so that the stream is made to flow in as tangential a direction as possible at the periphery, this will cause the medium to rotate at the inlet to each chamber thereby separating the phases through the influence of centrifugal force.

The principles of the function also include a tailored constructive design for multiphase separation. The heaviest phase, which, for example, can be water with solid particles can be led out of one or more chambers by separate outlets.

Specific advantages

Compared to a traditional solution with a series of separation tanks, the invention is characterized by the pressure energy of the medium being utilized to generate centrifugal forces. This can lead to reduced volume and weight, as each pressure chamber will be considerably smaller and because all pressure stages are integrated in a single unit. The efficiency of the invention is not influenced by motion. Also because of its reduced volume, a unit designed in accordance with the present invention can be designed for higher inflow pressures than large diameter containers.

In relation to known designs based on the cyclone principle, the present invention has considerable advantages in that efficiency levels are maintained even if there are variations in the amount and phase conditions in the inflow

medium. This invention is also suitable for a design with multiple pressure stages in one and the same unit, i.e. a higher number of stages than is usually applied.

Design example

The example below describes the present invention with reference to the drawings, where,

Fig. 1 shows part of a cross section of a cyclone separator designed in accordance with the invention. Fig. 2 shows a perpendicular section on an axial plane along line 1-1 seen from the inflow endto the left in Figure 1. Fig. 3 shows a section along line II-II in Fig. 1 seen facing the dividing wall, and Fig. 4 shows details of a nozzle duct in a dividing wall.

Fig. 1 shows a four-stage cyclone separator for processing wellstream from an oil or condensate field.

The process consists of wellstream being led at high pressure through a pipe 1 and a tangentially-directed inflow section 2 at one end of a container 10, to the left in Figure 1. The inflow medium is separated into three different outflow media, these are: gas, oil and water possibly with solid particles. The gas phase is led out of the unit with four different pressures through coaxially located outflow pipes, respectively 3, 4, 5 and 6.

Stabilized oil is led out from the final chamber, to the right in Figure 1, through pipe spout 7. Water and particles are led out of pipe spouts 8 and 9. Outlet pipes 3, 4, 5 and 6 for gas are connected to their respective separation chambers, 14, 15, 16 and 17. There is a dividing wall between each of the adjacent separation chambers, respectively 11, 12 and 13 laterally in container 10. There are a number of nozzles 18 close to the periphery in each of the dividing walls, these enable the fluid phase to flow through into the next chamber with a lower pressure. The nozzles are located so that the outflow streams in as tangential a direction as possible , as shown in Figure 4. The nozzles or some of them are located with a flap 19 that

can be opened and closed, the control mechanism for this is not illustrated in Figure 4. The purpose of opening and closing the nozzles is that this can regulate the level of fluid in each separation chamber when there are variations in the amount and phase conditions of the inflowing stream.

The operation is as follows: The inflow stream, that can be a mixture of gas, oil, water and solid particles flows at high velocity tangentially to the end of the first chamber 14 through the inflow pipe 1 and the inflow section 2. The medium will then start to rotate because of the high inflow velocity and the circular design of the container 10.

The liquid phase is thrown out towards the periphery and the gas phase is forced in towards the centre. The water and particles have the highest specific gravity and lie facing the outer periphery in a tubular layer, with oil in another tubular layer inside this. Controlled drawing off through pipe 9 leads the water and particles out of the container. The gas is removed through pipe 3. Oil, and any possible water that remains, passes through the nozzles 18 in the dividing wall 11 to chamber 15, that maintains a lower pressure than chamber 14.

After passing though the nozzles 18, the gas is dissolved as a result of the pressure drop, at the same time as the velocity is increased. The mixture that comes almost tangentially out of the nozzles is again forced to rotate and the separation process that has been described is repeated. The same reoccurs for each fall in pressure until the oil in the final chamber obtains the required vapour pressure. Stabilized oil is removed from the container by controlled drainage through pipe spout 7.

The remaining water is drawn off though outlet 8. The gas pressure in each of the pressure chambers is controlled in a normal manner and adjusted so that the pressure relief gives a rotational velocity that is about the same in each chamber, at the same time as the other optimization criteria are met.

The number of chambers can vary, depending on the medium and the capacity requirements.

Instead of nozzles 18 placed in the dividing walls 11-13, guidepipes can be placed on the outside of the container 10, with tangentially directed inlets and outlets.

The flap 19 can also be replaced by another valve mechanism of known principle.

Claims:

1. Cyclone separator for the stabilization of gas saturated or vapour saturated fluid or a fluid mixture by means of pressure relief in one or more stages and the separation of phases of a medium into two or more stages, where the medium is led through a series of separation chambers connected in series in a common cylindrical or conical container (10),
c h a r a c t e r i z e d by the fluid phase of the medium is led from one separator chamber (14) to a second chamber (15) at a lower pressure, through one or more nozzle ducts (18) in or by a dividing wall (11) between two chambers in the common cylindrical or conical container (10), where the nozzle ducts are designed and placed so that rapid degassing or flashing occurs at the same time as the medium is accelerated through the nozzle ducts, and that the outflowing stream from the nozzles is almost tangentially directed towards the periphery of the container (10).

2. Cyclone separator as claimed in Claim 1,
c h a r a c t e r i z e d by that at least some of the nozzle ducts (18) are fitted with means (19) of reducing the total cross section of the opening.

3. Cyclone separator as claimed in Claims 1 and 2,
c h a r a c t e r i z e d by gas being led by a known means through the outflow pipes (3, 4, 5, 6) close to the centre from each of the separator chambers (14, 15, 16, 17) at the respective pressures in the chambers.

4. Cyclone separator as claimed in Claims 1, 2 and 3,
c h a r a c t e r i z e d by more than two media phases that can be separated by devising outlets (8, 9) for the heaviest phase at the base of one or more of the chambers.

5. Cyclone separator as claimed in Claims 1-4,
c h a r a c t e r i z e d by the nozzle ducts being tubular and located on the periphery of the container.

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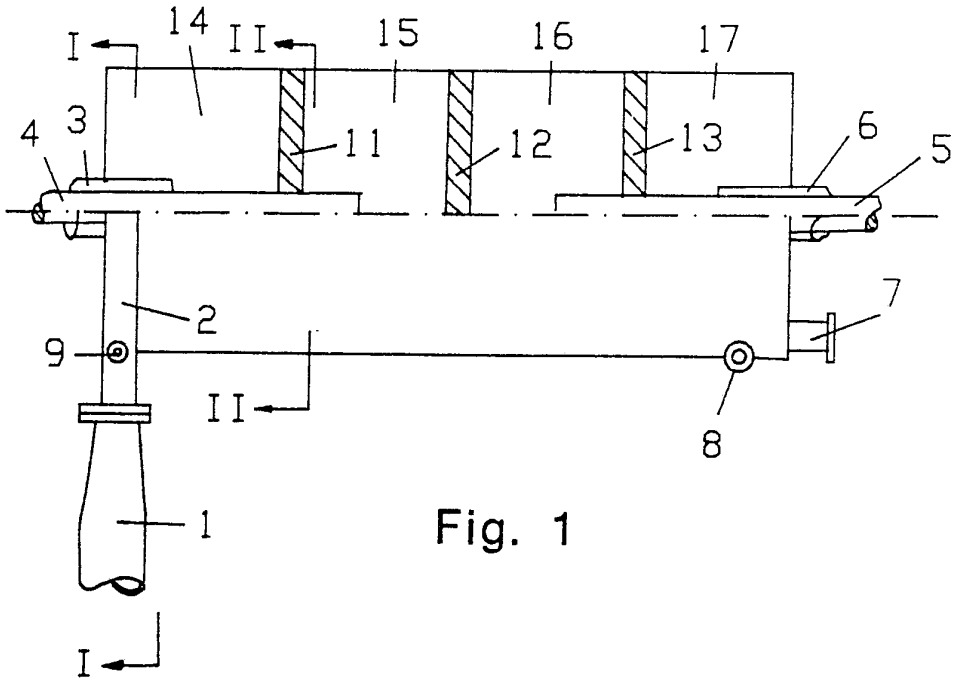

Fig. 1

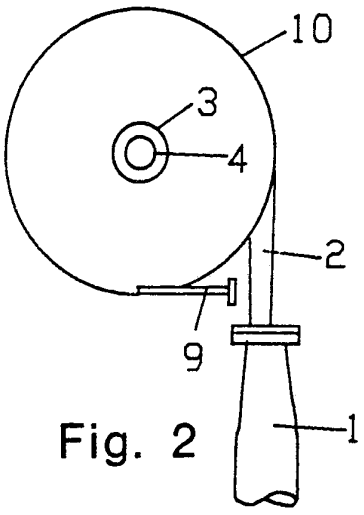

Fig. 2

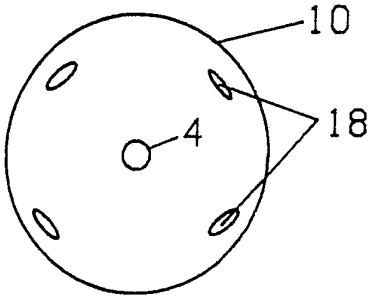

Fig. 3

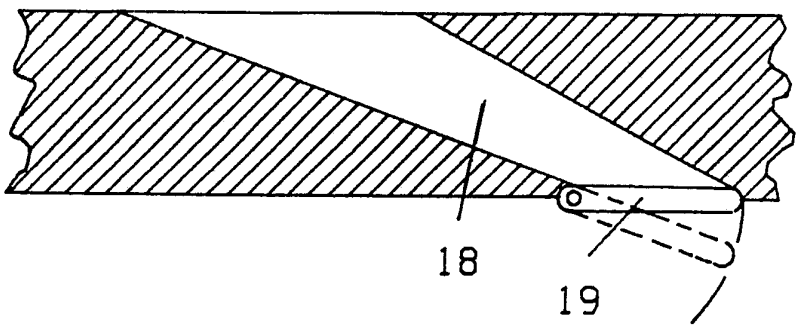

Fig. 4

INTERNATIONAL SEARCH REPORT

International Application No PCT/NO 91/00080

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC5: B 04 C 7/00, E 21 B 43/34, B 01 D 19/00 // C 10 G 33/06

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
IPC5	B 01 D; B 04 C; C 10 G; E 21 B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in Fields Searched[8]

SE,DK,FI,NO classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category *	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
A	WO, A1, 8500851 (CARROLL, NOEL) 28 February 1985, see the whole document --	1
A	Derwent's abstract, No. 84- 4 385/01, SU 1 000 114, publ. week 8401 --	1

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
2nd September 1991	1991 -09- 11
International Searching Authority	**Signature of Authorized Officer**
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ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.PCT/NO 91/00080

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
WO-A1- 8500851	85-02-28	AU-B-	579583	88-12-01
		AU-D-	3213184	85-03-12
		EP-A-	0151604	85-08-21
		GB-A-B-	2153249	85-08-21
		JP-T-	60502241	85-12-26
		US-A-	4698152	87-10-06