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[Continued on next page]

(54) Title: SUBMERGED EVAPORATOR

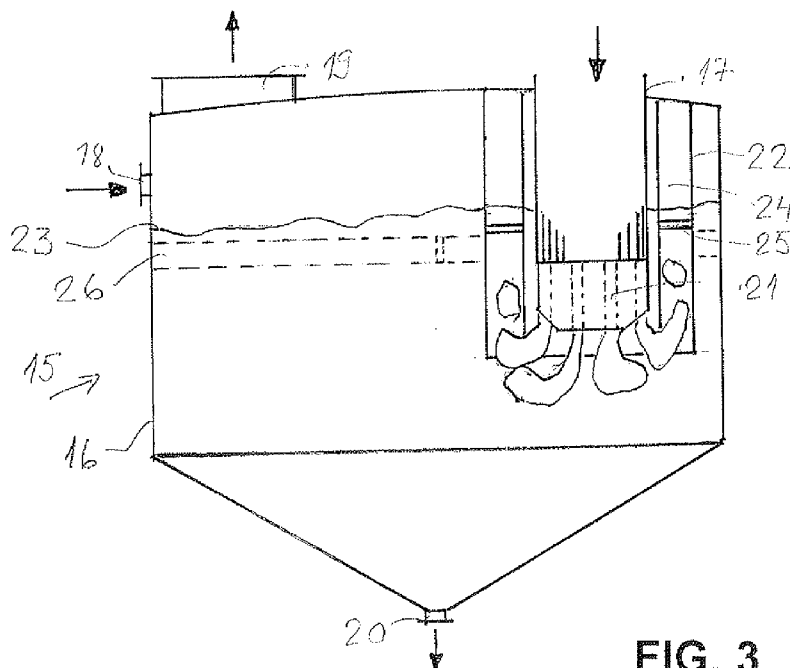


FIG. 3

(57) Abstract: The invention relates to a submerged evaporator, which can attenuate the surface fluctuation of the liquid in the evaporator by means of the structures positioned inside it and thus control the vibration that is generated and prevent the formation of splashes.



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- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))* — *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*
- *of inventorship (Rule 4.17(iv))*

Published:

- *with international search report (Art. 21(3))*

SUBMERGED EVAPORATOR

FIELD OF THE INVENTION

- 5 The invention relates to a submerged evaporator, which can attenuate the surface fluctuation of the liquid in the evaporator by means of the structures positioned inside it and thus control the vibration that is generated and prevent the formation of splashes.

10 BACKGROUND OF THE INVENTION

The term submerged evaporator denotes a device in which hot flue gases are directed below the surface of a liquid to be evaporated, thus achieving the vaporization of the liquid and simultaneously the crystallization of the desired product from the liquid.

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In direct immersion evaporation, the hot gases discharging from the immersion pipe are allowed to bubble through the liquid. In this way it is possible to produce a highly effective transfer of material and heat from the gases into the liquid being evaporated. Since heat exchangers are not
20 required, the question of materials is not a problem. For this reason, direct immersion evaporators are used especially in chemical and metallurgical processes in which corrosive conditions cause problems with materials. Typically this kind of problem occurs in the heating, evaporation and crystallisation of strongly acidic solutions, such as metal sulphate solutions.

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In submerged evaporators, the immersion pipe is usually fitted in a vertical position in order to minimise the amount of construction material that comes into direct contact with the liquid to be treated.

- 30 US patent 4,278,494 describes a submerged evaporator, where there is one large pipe for feeding the hot gas. This results in the vibration of the evaporator and splashes of liquid, and for that reason the evaporator is

equipped with a horizontal combustion chamber and a joint piece with bellows. As the amount of gas increases, the size of the bubbles generated also increases, since the gas cannot be fed at a very high speed, because it is known that the penetrability of the gas jet increases as the speed
5 increases. When the speed of the gas is relatively low, it is not absorbed well into the liquid into which it is fed, and that is why the buoyancy force brings about a strong bulging effect in the gas.

US patent 2,867,972 describes a submerged evaporator, which strives to
10 minimise vibration by serrating the gas discharge conduit with a sawtooth profile.

In the solution according to DE patent 34 47 337, the submerged evaporator operates by suction, whereby only a very small immersion depth can be used
15 for the discharge conduit. Separate tubes installed obliquely are used in the apparatus. The disadvantage of these is that since the tubing is lifted out during maintenance, the lid has to be provided with an opening of corresponding size.

20 In the solution according to FI patent 85337, gas is fed into the liquid to be evaporated via several rather small vertical tubes. The advantage is that gas can be fed at relatively high speed, but nevertheless penetrability remains small, because the nozzle size is small. In practice, despite this, the attenuation of fluctuation has not been sufficient overall.

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PURPOSE OF THE INVENTION

The purpose of the submerged evaporator structure accordant with this invention is to reduce the drawbacks that have appeared in submerged
30 evaporators, such as fluctuation in the surface level, which brings about splashes causing corrosion and the vibration of the whole evaporator that causes even further fluctuation.

SUMMARY OF THE INVENTION

The essential features of the invention will be made apparent in the attached claims.

- 5 The invention relates to a submerged evaporator, which comprises a cylindrical liquid container and an immersion pipe attached to it, through which hot gas is fed through several separate vents and via the nozzle connected to them to below the surface of the liquid, and a circulation pipe equipped with openings surrounding the immersion pipe, so that at least
10 three radial vertical plates are fixed to the inner wall of the circulation pipe.

The number of vertical plates fixed to the circulation plate is at least 3, preferably 4 – 6. It is typical of the structure of a submerged evaporator that a gap is left between the vertical plates and the immersion pipe for removing
15 the immersion pipe while the circulation pipe is in place.

According to one embodiment of the invention, a horizontal plate is attached to the vertical plates situated essentially in the horizontal position in the vicinity of the surface of the liquid, but below it. The width of the horizontal
20 plate is preferably 2 – 8% of the circumference of the circulation pipe.

According to another embodiment of the invention, the liquid tank is equipped with a grid of plates, which is composed of two plates set perpendicularly to each other. The plate grid is positioned below the surface of the liquid and its height is 2 – 7% of the height of the cylindrical section of the tank.
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LIST OF DRAWINGS

Figure 1 is a principle drawing of one solution of the prior art,

Figure 2 is a principle drawing of another solution of the prior art,

- 30 Figure 3 is a principle drawing of a submerged evaporator equipped with attenuation according to the invention, and

Figure 4 is a cross-section of the submerged evaporator of Figure 3.

DETAILED DESCRIPTION OF THE INVENTION

Figure 1 is a principle drawing of a submerged evaporator described in the prior art, which comprises a tank 1, which contains the liquid to be evaporated 2 and one large immersion pipe 3, via which the hot gas is fed below the surface of the liquid in the tank. The liquid is fed into the tank via pipe connection 4 and the gases are removed via connection 5. Crystallised salt is removed from the lower section of the tank via connection 6. The gas jet is known to obtain an area of negative pressure around it, whereupon the solution in the surrounding area of the discharge opening in particular is mixed well with the jet. The greater the speed of the jet, the stronger the mixing.

Especially when large submerged evaporators are used, the flow velocity of the gas has to be reduced in order to decrease the penetrability of the gas. As a result, the gas bulges to the surface of the liquid as large bubbles. As shown in the principle drawing and known from practical experience, large bubbles induce noticeable surface fluctuation and result in the vibration of the entire submerged evaporator.

Figure 2 is a depiction of another submerged evaporator arrangement, which consists of a tank 7 and immersion pipe 8. The lower part of the immersion pipe comprises several tubes directed downwards 9 and all the gas is discharged into the liquid 10 in the tank via these tubes. The liquid is fed into the tank via pipe connection 11, the gases are removed via connection 12 and the crystallised salt via bottom connection 13. The submerged tubing made up of separate gas vents is surrounded by circulation pipe 14, in which openings are placed, from which the gas fed into the liquid or the mixture of gas and liquid are allowed to discharge into the liquid.

In the arrangement of Figure 2, at first small separate jets are formed, but they have the tendency to combine into larger jets, forming bubbles that rise

upward in the circulation tube. The advantage of this method compared with the method revealed in Figure 1 is the fact that a higher gas flow velocity can be used than in the solution shown in Figure 1, while the gas penetrability nevertheless remains reasonable. As a result, the buoyancy force is considerably smaller and as a further consequence there is less surface fluctuation than in the case of Figure 1. In terms of flow, the solution of Figure 2 is very good, but in practice, however, the separate tubes do not last.

Figures 3 and 4 depict a submerged evaporator 15 accordant with the invention, which is comprised of a cylindrical liquid tank 16 and an immersion pipe 17. The liquid to be heated and evaporated is fed in via feed connection 18, the gas is removed via gas connection 19 and the crystallised solid is removed via discharge pipe 20, which is connected to the conical lower section of the tank. Several vents 21 are formed in the bottom of the immersion pipe either during manufacture or by machining afterwards. In this way the wear of the vents formed in the immersion pipe is less than that of separate tubes. A circulation pipe 22 is positioned around the immersion pipe, and is equipped with openings from which the gas routed into the liquid or the mixture of gas and liquid is able to discharge into the liquid.

In order to attenuate the fluctuation of the surface of the liquid 23 and the subsequent vibration of the submerged evaporator, at least three, preferably 4 – 6 vertical plates 24, are placed in the circulation pipe. The number of vertical plates depends on the size of the immersion pipe. When the number is a minimum of three, the surface fluctuation can be prevented in two directions i.e. both the vertical and transverse direction. Vertical plates are preferably fixed radially to the inside wall of the circulation pipe and they are typically the length of the circulation pipe. A gap is left between the vertical plates and the wall of the immersion pipe, enabling its unhindered removal for maintenance purposes, even though the circulation pipe is in place. Vertical plates can essentially help to prevent splashes that corrode the

immersion pipe from rising upwards from the surface of the liquid, as well as preventing surface fluctuation.

In order to even out surface fluctuation, the circulation pipe belonging to the submerged evaporator accordant with the invention may be equipped further with horizontal plates 25 fixed to the vertical plates 24, which preferably extend horizontally on both sides of the vertical plate. The horizontal plates are located in the vicinity of but below the surface of the liquid. The extent of the horizontal plate from the circulation pipe wall towards the immersion pipe is typically the same as that of the vertical plate. The width of the horizontal plate is such that it does not essentially prevent the rise of gas bubbles, and typically the width of one horizontal plate is 2 – 8 % of the length of the circumference of the circulation pipe.

One more way to attenuate surface fluctuation is to position a plate grid 26 in the submerged evaporator tank 16, outside the circulation pipe and below the surface of the liquid 23, which further evens out the surface throughout the tank. The grid is composed of two plates set perpendicularly to each other. The grid is typically set in horizontal position, extends right up to the edges of the tank and has a height in the order of 2 – 7 % of the height of the cylindrical part of the tank. The plate grid is beneficial particularly in smaller evaporators.

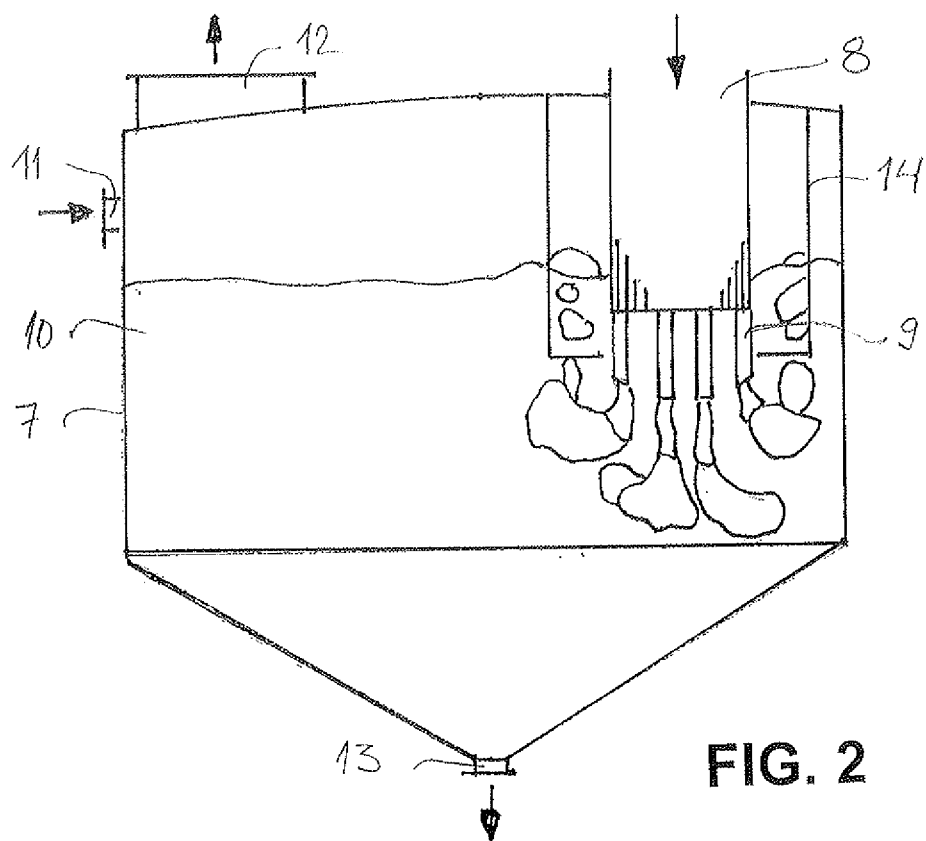
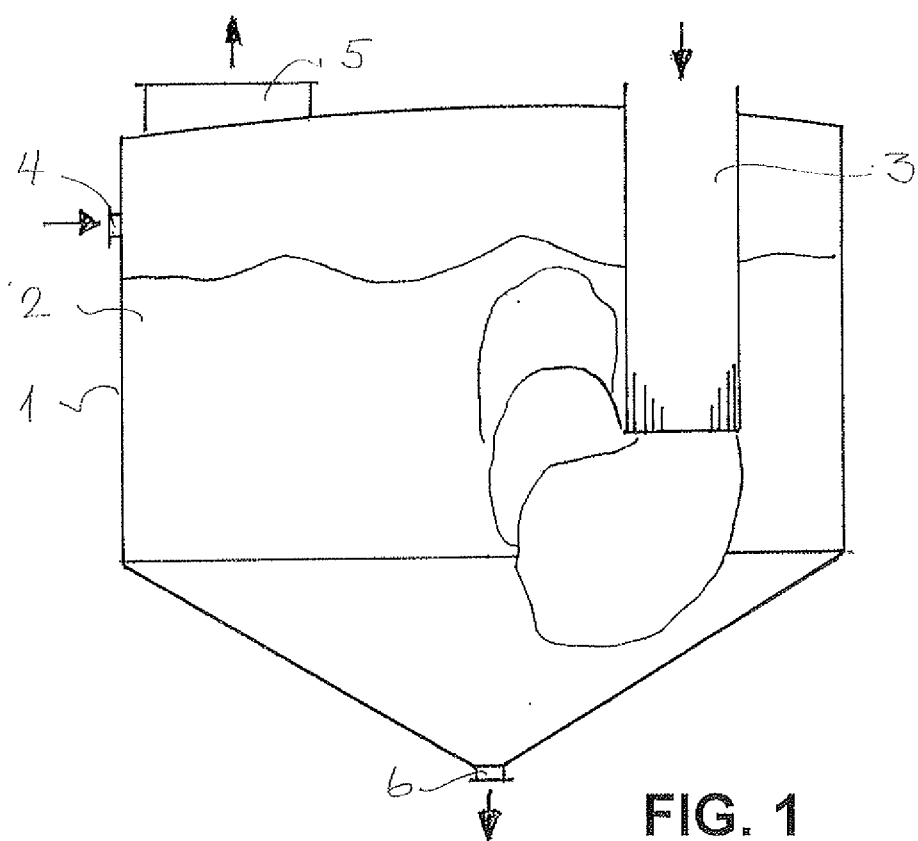
It is to be noted that, although Figures 3 and 4 present three different ways of evening out the surface of the liquid in a submerged evaporator, vertical plates in particular may be used in accordance with the invention without horizontal plates or a grid plate or in combination with only one of the structures.

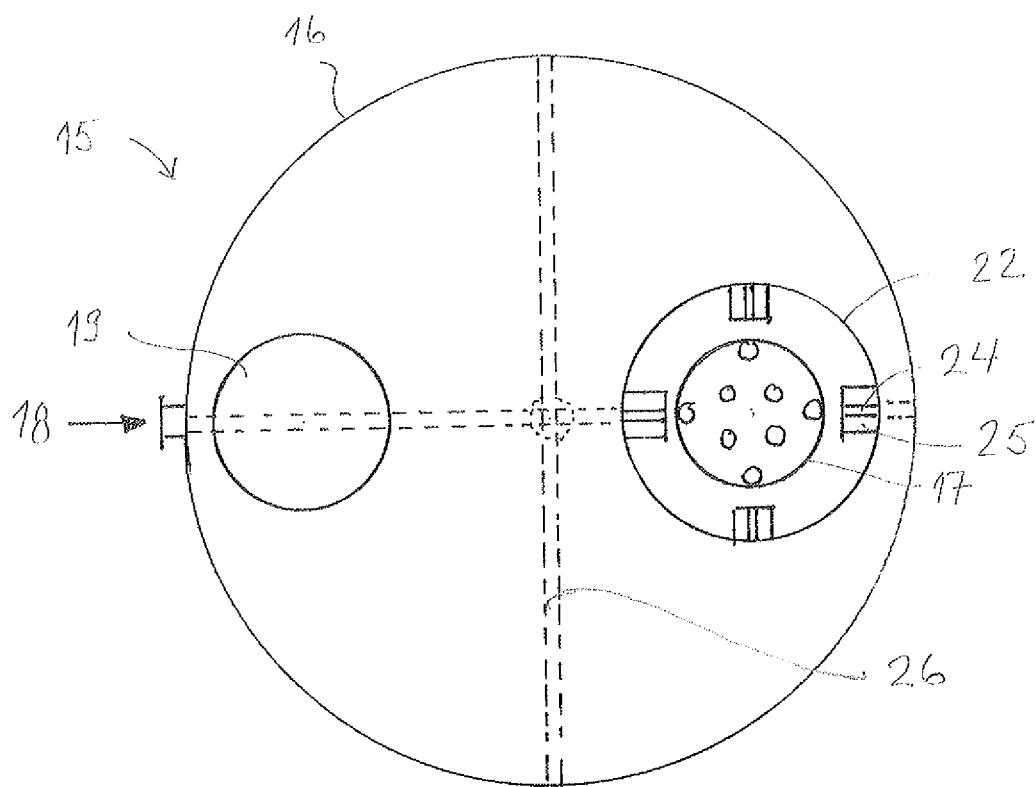
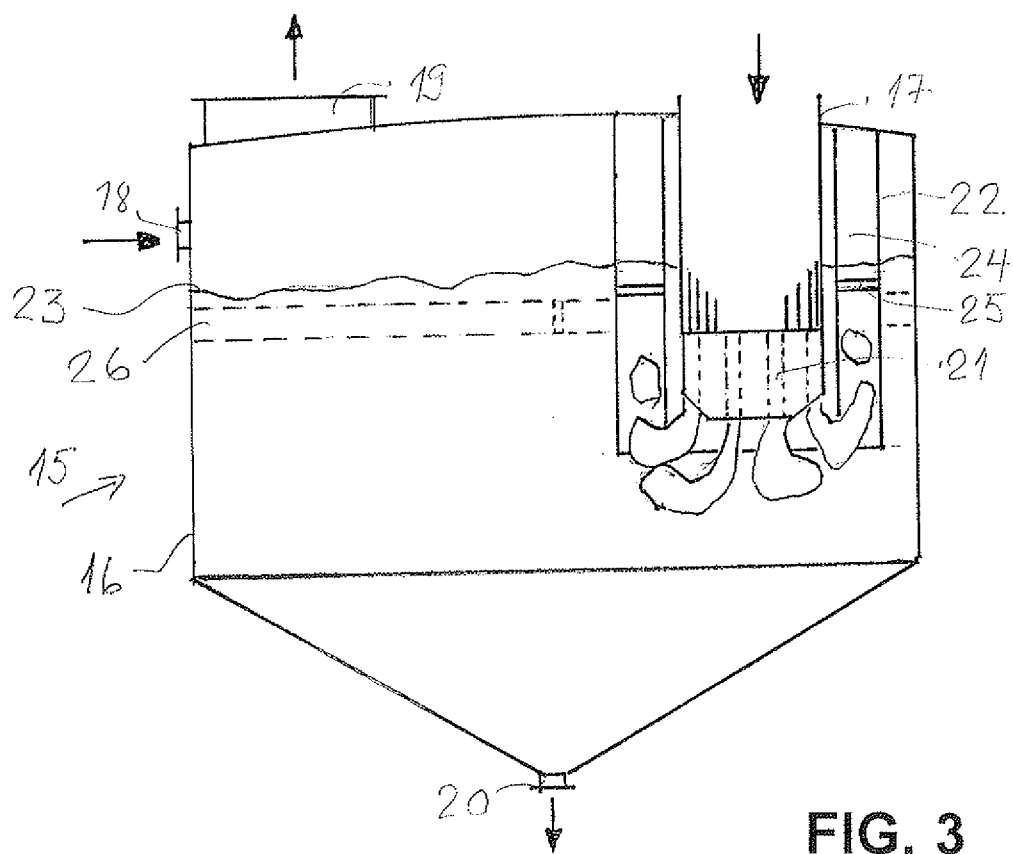
PATENT CLAIMS

1. A submerged evaporator (15), which is composed of a cylindrical tank (16) and an immersion pipe (17) connected to it, through which hot gas is fed below the surface via several separate gas vents (21), as well as a circulation pipe (22) furnished with openings, which surrounds the immersion pipe, **characterised in that** at least 3 radial vertical plates (24) are fixed to the inner wall of the circulation pipe.
2. A submerged evaporator according to claim 1, **characterised in that** the number of vertical plates is at least 3, preferably 4 – 6.
3. A submerged evaporator according to claim 1, **characterised in that** a gap is left between the vertical plates (24) and the immersion pipe (17) in order to remove the immersion pipe when the circulation pipe (22) is in place.
4. A submerged evaporator according to claim 1, **characterised in that** a horizontal plate (25) is fixed to the vertical plates (24) essentially in a horizontal position in the vicinity of but below the surface of the liquid (23).
5. A submerged evaporator according to claims 1 and 4, **characterised in that** the width of the horizontal plate (25) is 2 – 8% of the length of the circumference of the circulation pipe (22).
6. A submerged evaporator according to claim 1, **characterised in that** the evaporator tank for liquid (16) is equipped with a plate grid (26), which is composed of two grid bars set perpendicularly to each other.
7. A submerged evaporator according to claims 1 and 6, **characterised in that** the plate grid (26) is located essentially below the surface of

the liquid (23) essentially in a horizontal position and that its height is 2 – 7% of the height of the cylindrical part of the tank (16).

- 5 8. A submerged evaporator according to claim 1, **characterised in that**
the gas vents (21) are formed into the bottom of the evaporator.





INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2009/050531

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

FI, SE, NO, DK

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Epo-Internal, WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FI 85337 B (OUTOKUMPU OY) 05 October 1991 (05.10.1991), page 3, last paragraph - page 6, first paragraph; figures 3 and 4	1-8
A	SU 912183 A1 (KHARCHENKO MIKHAIL A et al.) 15 March 1982 (15.03.1982), figures 1-3 & abstract [online] EPOQUENET WPI & machine translation in English [online] (23.09.2009)	1-8
A	SU 1243756 A1 (VNI PI OCHISTKE T GAZOV) 15 July 1986 (15.07.1986), figure & abstract [online] EPOQUENET WPI	1-8
A	WO 2007014085 A1 (LIQUID SOLUTIONS LLC et al.) 01 February 2007 (01.02.2007), paragraphs [0035]-[0040]; figures 3 and 4	1-8

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/FI2009/050531

Patent document cited in search report	Publication date	Patent family members(s)	Publication date
FI 85337 B	05/10/1991	None	
SU 912183 A1	15/03/1982	None	
SU 1243756 A1	15/07/1986	None	
WO 2007014085 A1	01/02/2007	US 2008272506 A1 US 2008265446 A1 AR 057682 A1 UY 29693 A1 US 2007114683 A1	06/11/2008 30/10/2008 12/12/2007 28/02/2007 24/05/2007

INTERNATIONAL SEARCH REPORT

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CLASSIFICATION OF SUBJECT MATTER

Int.Cl.

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