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(54) MULTI-STAGE FLASH EVAPORATOR

(71) We, SNAMPROGETTI S.p.A., an Italian company, of Corso Venezia 16, Milan, Italy, do hereby declare the invention, for which we pray that a patent may be granted to us and the method by which it is to be performed to be particularly described in and by the following statement:-

This invention relates to a multi-stage flash evaporator and to a method of desalination using the evaporator.

Desalination processes carried out in multi-stage flash evaporators are known. These processes essentially comprise a series of expansions, in a number of consecutive stages, of a stream of saline solution at gradually decreasing pressures within a temperature range usually of from 125°C to 25°C.

The vapours evolved in each individual stage of flashing are caused to be condensed on a surface which is cooled by a stream of cold saline solution, which is thus preheated, and the resultant condensates are the desired salt-free water.

One of the major drawbacks of this kind of installation is the transfer of the saline solution and the condensate from one stage to the next without giving rise to a surplus or deficit of liquid in the individual stages. The liquid transfer from one stage to the next is generally achieved by means of a submerged overfall.

In the expansion, small variations of the rate of flow cause considerable variations in the level of the liquid in the individual stages, the result being either a surplus or a deficit of liquid in the individual stages. Stated otherwise, the system can easily become unstable and difficult to control. For this reason, attempts have been made to have these installations operating under a rigorously constant load and gates are provided in the different stages of flash for controlling from the exterior the liquid levels. In addition, during the expansion of the liquid in the submerged overfall, the saline solution and the evolved vapour flash cause a decrease of the specific gravity of the liquid (which thus becomes a liquid vapour emulsion), a fact which makes the regulation still harder.

According to the present invention, there is provided a multi-stage flash evaporator having a plurality of chambers, in which each chamber is separated from the or each of its neighbours by a partition and in which each chamber communicates with the or each of its neighbours by a hole in or beneath the lower end of the partition therebetween, wherein there is provided, on the downstream side (in terms of the intended direction of flow of liquid from one chamber to the next) of the or each partition, a compartment partly defined by the lower end of the partition and partly defined by a wall parallel to the partition, the compartment having the hole as its inlet and having apertures, as its outlets and above the inlet, in the wall parallel to the partition, the cross-section of the hole being sufficiently large such that in use the pressure drop of the liquid passing through the hole is negligible, whereby, in use, flashing occurs as the liquid passes through the compartment and/or as the liquid passes out through the apertures.

Preferably the apertures of the or each compartment are generally rectangular slots.

In a preferred embodiment, a trough extends through the chambers and the portion of the trough in each chamber communicates with the portion of the trough in the or each neighbouring chamber by a hole in the partition therebetween, there being provided, on the downstream side (in terms of the intended direction of flow of liquid from the portion of the trough in one chamber to the portion of the trough in the next chamber) of the or each partition, a compartment partly defined by the partition and partly defined by a wall parallel to the partition, the compartment having the hole as its inlet and having apertures, as its outlets and above the inlet in the wall parallel to the partition, the cross-section of the hole being sufficiently large such that in use the pressure drop of the liquid passing through the hole is negligible, whereby, in use, flashing occurs as the liquid passes through the compartment and/or as the liquid passes out through the apertures.

The present invention also provides a method for the desalination of a saline solution in which the apparatus employed is that according to the present invention and in which flashing occurs as the solution passes through the or each compartment and/or as the solution passes through the apertures.

The present invention reduces the instability associated with the operation of known installations in that it allows a simple and safe regulation to be made of the liquid levels in the flashing stages of the multi-stage flash evaporator.

For a better understanding of the present invention and to show how the same is to be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 is a vertical section along the length of part of one embodiment of a multi-stage flash evaporator according to the present invention;

Figure 2 is a vertical cross-section taken along the line II - II in Figure 1;

Figure 3 is a vertical section, on an enlarged scale, through part of the evaporator shown in Figure 1; and

Figure 4 is an isometric view of that part of the evaporator shown in Figure 3.

Referring firstly to Figures 1 and 2, it can be seen that the evaporator has a flat base 1, two opposing side walls 2 and 3, and an arcuate upper region 4.

Extending lengthwise in an upper part of the evaporator is a pipe 5 for conveying brackish water which is to be preheated. Below the pipe 5 is a trough 6 having a base 7 and outwardly inclined side walls 8 and 9, the trough being for collecting water which condenses on and drips from the pipe 5. The trough 6 is held in spaced relationship from the side walls 2 and 3 by perforate supports 10 which allow water vapour to pass upwardly from the zone 11 below the trough 6 to the zone 12 above the trough 6.

At intervals along the evaporator are upper partition members 13^1, 13^2 ..... 13_n and lower partition members 14^1, 14^2 ..... 14_n which divide the evaporator into (n + 1) chambers. The lower ends of the upper partition member 13 stop short of the base 7 to define slots 15, and the lower ends of the lower partition members 14 stop short of the base 1 to define slots 16. The only means of communication between one chamber and the next are the slots 15 and 16.

As is more clearly shown in Figures 3 and 4, parallel to the partition members 14 are walls 17 extending from the base 1 to a point above the lower end of the partition members 14, the walls 17 being on the downstream side (in terms of the flow of liquid through the slots 16) of the partition members 14. Parallel to the base 1 are walls 18 which extend from the top of walls 17 to the nearest partition member 14. The uppermost regions of the walls 17 are provided with apertures 19 which in the illustrated case are square and which are above the lower ends of the partition members 14. A series of compartments 20 is thus defined by the lower end regions of partition members 14, the base 1, the walls 17 and the walls 18.

Compartments 20 are also defined near the slots 15 below the upper partition members 13 by walls equivalent to walls 17 and 18, the vertical walls being provided with apertures like apertures 19.

In the illustrated embodiment, the apertures 19 are so sized as to allow a rate of flow larger than the nominal flow rate (i.e. the flow rate for which the evaporator was designed), for example with an excess of 20% to 30% thereover, under a pressure drop, ΔP, equal to the sum of (i) the pressure differential P_1-P_0 (wherein P_1 and P_0 are the pressures existing in two consecutive stages), and (ii) the hydraulic head differential $\gamma g.\Delta H_0$ in which γ is the specific gravity of the liquid, g is the acceleration attributable to gravity, and ΔH_0 is the difference of level in two consecutive stages.

The cross-sectional area of the slots 15, 16 is sufficiently large so as to make the pressure drop of the liquid in this region negligible. Under these conditions the device operates as shown in Figure 3, in which the pressure drop is localized in the region of the apertures 19 and the flashing takes place as the liquid passes out through the apertures. If the flow rate in the downstream chamber is reduced to the usual minimum value or less, the upstream chamber will tend rapidly to become emptied and the difference ΔH_0 will be reduced to zero or become negative. The liquid will be able to reach the outlet slots at the expense of its pressure only, thus becoming supersaturated and evolving flash vapour. It is this vapour which, due to its greater volume relative to the liquid, will occupy a large part of the cross-section of the apertures and effectively close the apertures to the liquid. The system thus tends to become self-adjusted and the emptying of the stage will be prevented, and, concurrently there-with, the flow of vapour from one chamber to the next will be impeded and the attendant instability phenomena also.

Figure 4 shows the liquid levels during the normal operating conditions. In the compartment, the liquor rises to a geometric height higher than the initial height. There is formed flash vapour which, occupying a portion of the cross-section of the apertures, acts like a regulation valve.

As outlined above, the apertures are so sized as to permit a flow rate larger than the nominal flow rate, the compartment thus being constantly operated under flashing conditions during the run when the flow rate is equal to or less than the nominal flow rate.

WHAT WE CLAIM IS:-

1. A multi-stage flash evaporator having a plurality of chambers, in which each chamber is separated from the or each of its neighbours by a partition and in which each chamber communicates with the or each of its neighbours by a hole in or beneath the lower end of the partition therebetween, wherein there is provided, on the downstream side (in terms of the intended direction of flow of liquid from one chamber to the next) of the or each partition, a compartment partly defined by the lower end of the partition and partly defined by a wall parallel to the partition, the compartment having the hole as its inlet and having apertures, as its outlets and above the inlet, in the wall parallel to the partition, the cross-section of the hole being sufficiently large such that in use the pressure drop of the liquid passing through the hole is negligible, whereby, in use, flashing occurs as the liquid passes through the compartment and/or as the liquid passes out through the apertures.

2. An evaporator according to claim 1, wherein the apertures of the or each compartment are generally rectangular slots.

3. An evaporator as claimed in claim 1 or 2, wherein a trough extends through the chambers and wherein the portion of the trough in each chamber communicates with the portion of the trough in the or each neighbouring chamber by a hole in the partition therebetween, there being provided on the downstream side (in terms of the intended direction of flow of liquid from the portion of the trough in one chamber to the portion of the trough in the next chamber) of the or each partition, a compartment partly defined by the partition and partly defined by a wall parallel to the partition, the compartment having the hole as its inlet and having apertures, as its outlets and above the inlet, in the wall parallel to the partition, the cross-section of the hole being sufficiently large such that in use the pressure drop of the liquid passing through the hole is negligible, whereby, in use, flashing occurs as the liquid passes through the compartment and/or as the liquid passes out through the apertures.

4. An evaporator according to claim 3, wherein a pipe extends through the partitions, vertically above the trough.

5. An evaporator according to claim 3 or 4, wherein perforate supports extend from side regions of the trough to side walls of the chambers to divide the latter into upper and lower zones.

6. An evaporator according to claim 1, substantially as hereinbefore described with reference to, and/or as illustrated in, the accompanying drawings.

7. A method for the desalination of saline solution, in which the desalination is effected in an apparatus according to any preceding claim and in which flashing occurs as the solution passes through the or each compartment and/or as the solution passes through the apertures.

8. A method according to claim 7, substantially as hereinbefore described.

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2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

Fig.1

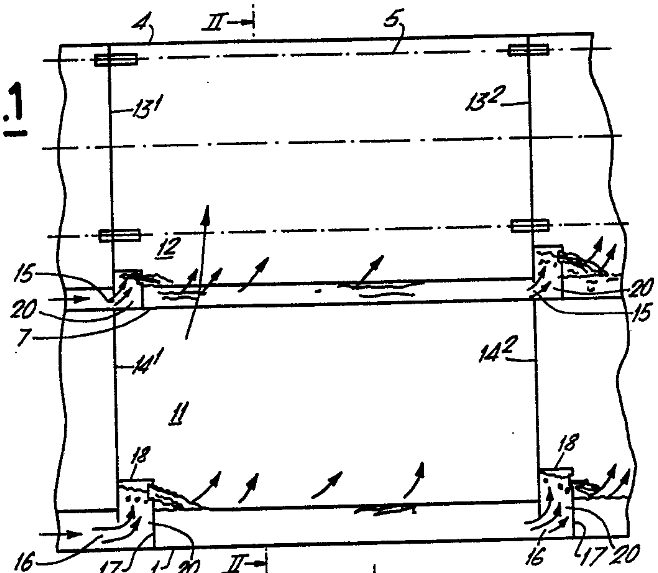

Fig.2

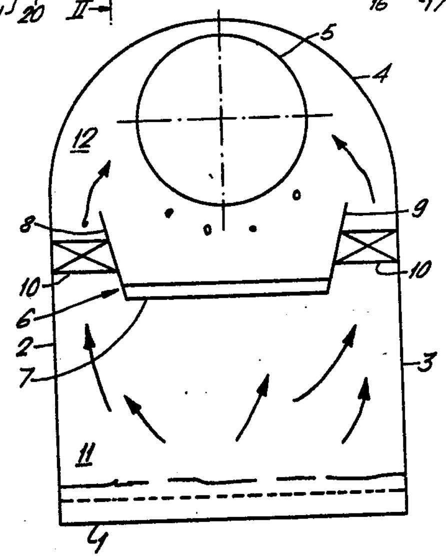

Fig.3

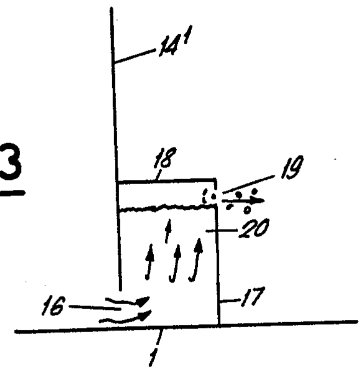

Fig.4