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MULTI-STAGE FLASH EVAPORATOR

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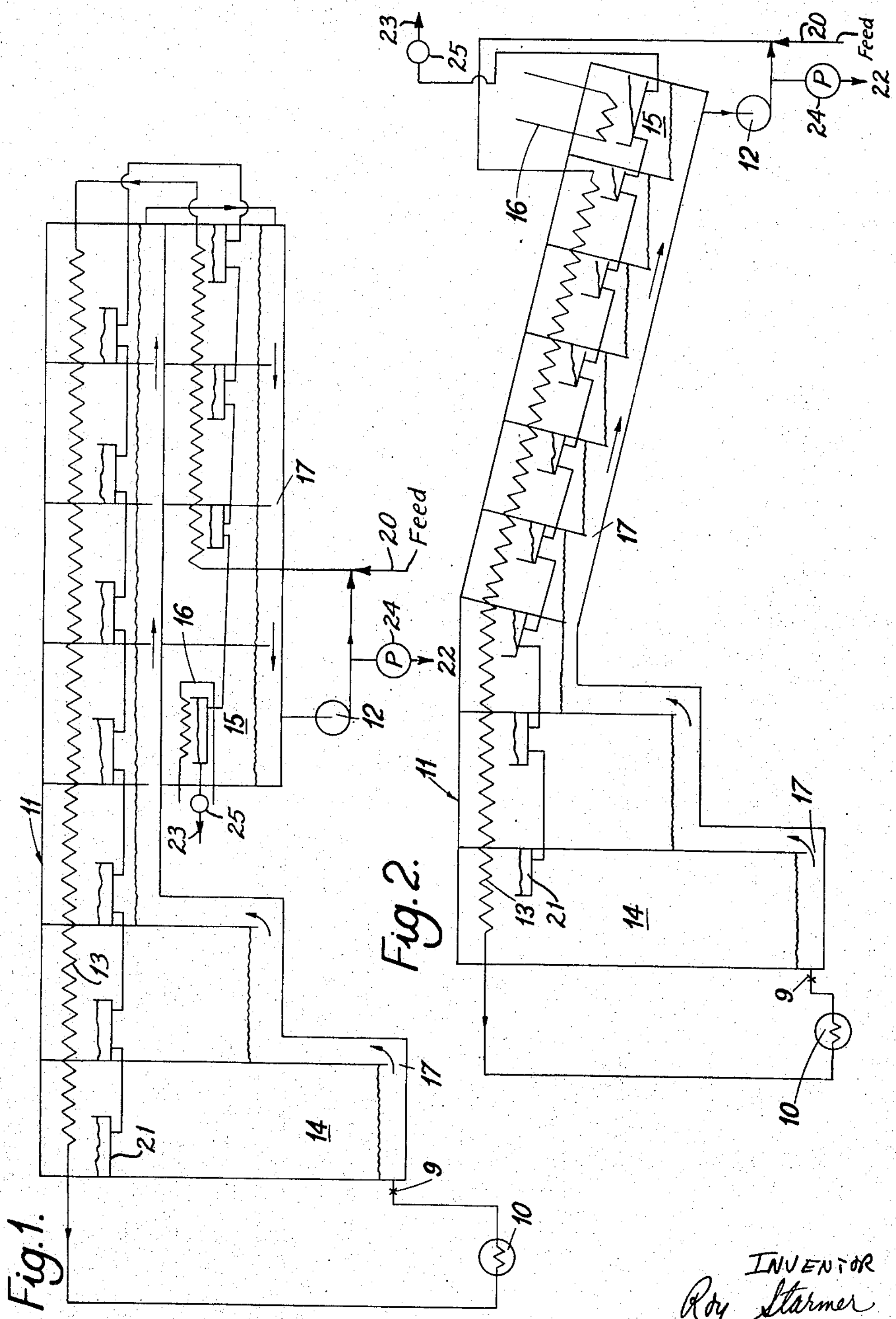

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MULTI-STAGE FLASH EVAPORATOR

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ABSTRACT OF THE DISCLOSURE

A multi-stage flash evaporator in which a succession of flash chambers are interconnected by orifices, and including means for supplying heated liquid to the first chamber in the succession, means for condensing vapors produced in the successive chambers, and for maintaining the chambers in the succession at successively decreasing vapor pressures. The arrangement is such that the vapor pressure differences between chambers at the beginning of the succession are larger than the vapor pressure differences between chambers later in the succession. There are at least two chambers at the beginning of the succession of which the second, or in other words the chamber with the lower vapor pressure, is at a higher level than the first chamber, or in other words the chamber with the higher vapor pressure. Thus, the liquid tends, by reason of the vapor pressure differences between the chambers, to rise from one chamber to the next.

The invention relates to apparatus for the evaporation of liquids in distillation plants and more specifically relates to improvements in multi-stage flash evaporators.

In multi-stage flash evaporators a liquid to be evaporated in continuously circulated from one stage (usually the last) through a tube heat exchanger and a heater into another stage (usually the first) of a series of flash chambers through which the liquid then flows in succession, a proportion of the liquid being evaporated in each chamber and the vapour being condensed by heat exchange with the liquid in the heat exchanger. A plurality of orifices connect the chambers together and, although a small fraction of the liquid is vapourised in each chamber, the majority flow through the orifices between the stages which are maintained as successively decreasing vapour pressures. The vapour pressure difference between stages at the high temperature end is, or may be, greater than the pressure difference between stages at the low temperature end.

The invention provides a multi-stage flash evaporator in which there is a succession of flash chambers interconnected by orifices, means for supplying heated liquid to the first chamber in the succession, means for condensing vapours produced in the successive chambers and for maintaining the chambers in the succession at successively decreasing vapour pressures, with the vapour pressure differences between chambers at the beginning of the succession larger than the vapour pressure differences between chambers later in the succession, and in which the chambers at the beginning of the succession are at progressively higher levels whereby the liquid is caused, by the vapour pressure differences between the chambers, to rise from one chamber to the next.

Preferably the said chambers at the beginning of the succession are arranged in step-like form, the static head of liquid threby being gradually and constantly increased.

In one form of the invention the chambers later in the succession are arranged in two (or more) tiers, one above the other, the circulation of liquid progressing from the initial chambers through the top tier of chambers and then through the lower tier of chambers.

In another form of the invention the chambers later in

the succession are arranged at progressively lower levels. In this form the chambers may be arranged in step-like form, the static head of liquid thereby being gradually and constantly, decreased.

In yet another form, the chambers later in the succession are either all at the same height or the first of these chambers are at the same height and the remainder at progressively lower levels.

The circulation of liquid is preferably assisted by means of a pump.

The invention also provides the method of evaporating a liquid which comprises the steps of passing the liquid through a succession of chambers, maintaining the vapour pressure in the chambers at successively decreasing values along the succession, the differences in pressure between successive stages at the beginning of the succession being greater than the pressure differences between successive chambers later in the succession, and utilising the greater pressure differences to lift the liquid between stages at the beginning of the succession.

The flow of the liquid between chambers later in the succession may be downward.

By way of example two forms of flash evaporator in accordance with the invention will now be described with reference to the accompanying drawings in which:

FIGURE 1 is a diagrammatic view of a first form of evaporator, and

FIGURE 2 is a diagrammatic view of a second form of evaporator.

Referring to FIGURE 1, the evaporator comprises a circuit through which a liquid (e.g. brine) is continuously circulated. The circuit comprises a heater **10**, a control valve **9**, a succession of heat evaporation stages or chambers **11**, a pump **12** and a tube system **13** for heat recovery. Brine is fed into the evaporator through a pipe **20** and is passed by the pump **12** through the tube system **13** where it is heated and then to the heater **10**. The brine then flows into the chamber **14** at the high temperature end of the evaporator and thence through a series of orifices **17**, through the chambers to a chamber **15** at the low temperature end of the evaporator. The chamber **15** is cooled by externally supplied heat transfer means **16**. As the vapor pressures of successive chambers are lower the liquid flashes as it enters a chamber and the flash distillate is condensed in the tubes **13** and is collected in pans **21**. The blowdown is pumped from the apparatus at **22** by a pump **24**. The distillate is pumped from the apparatus at **23** by a pump **25**.

Erosion around the orifices **17** is dependent on the velocity of flow therethrough. Hence, if the velocity of flow is reduced, the rate of erosion is also reduced. However, the velocity of flow through the orifices is dependent on the pressure differences on opposite sides thereof. These differences are, in turn, dependent on the level of the liquid on the opposite sides and the pressure differences between pairs of chambers, which differences are greater at the high temperature end than at the low temperature end of the succession.

It will be seen from FIGURE 1 that the initial chambers are arranged in step-like form one above the other to cause the liquid to rise from one chamber to the next. In this way the pressure difference across the orifice is reduced which not only reduces the velocity of flow and hence the rate of erosion of the orifices over this portion of the evaporator, but also greatly assists the action of the pump.

Referring to FIGURE 2, the circuit is identical to the circuit described above except for the arrangement of the chambers later in the succession which in this case are in step-like form one below the other. The references of FIGURE 2 correspond to those of FIGURE 1.

For further explanation of apparatus in accordance with the invention, the following table is included:

	Column			
	1	2	3	4
Stage temperature (° F.)	250	250	100	100
Stage temperature drop (° F.)	5	5	5	5
Stage pressure drop (ft. of water)	5.35	5.35	0.39	0.39
Water lift (ft.)	0	3.85	0	−1.11
Pressure drop a./c. orifice (ft.)	5.35	1.50	0.39	1.50
(Erosion force) Equivalent velocity (ft./sec.)	18.5	9.8	5.0	9.8
Orifice area to pass 10^5lb/hr. (sq. ft.)	0.4	0.75	1.48	0.75

This table is for operation of the apparatus for water. Column 1 gives the values of various characteristics of the flow of water across an inter-stage orifice when the general temperature is 250° F. (i.e. at the higher temperature end of the evaporator) and the stage temperature drop per chamber is 5° F. Column 2 gives the modified values when the pressure difference between the stages is utilized to lift the water a given distance between the stages. It will be noticed that the velocity of the water through the orifices is considerably reduced. Column 3 gives the values when the general temperature is changed to 100° F. (i.e. at the low temperature end of the evaporator and the stages are at the same height). Finally column 4 gives the modified values when the flow is assisted by the arrangement of the chamber as in FIGURE 2 where the pressure between stages is used to lift the water between stages. It will be seen that although the size of the orifice required for the circumstances of column 2 is greater than that required for the circumstances of column 1, this is more than off-set by the saving in orifice area at the low temperature end of the evaporator as shown in column 4 with regard to column 3.

I claim:

1. A multi-stage flash evaporator in which there is a succession of flash chambers interconnected by orifices, means for supplying heated liquid for distillation to the

first chamber in the succession, means comprising a condenser tube arranged in the upper section of said chambers and through which said liquid flows for condensing vapours produced in the successive chambers and for maintaining the chambers in the succession at successively decreasing vapour pressures, with the vapour pressure differences between chambers at the beginning of the succession larger than the vapour pressure differences between chambers later in the succession, and in which said succession of chambers comprise a first group and a second group connected together, the first group comprising a plurality of chambers arranged in step-wise form one above the other, the second group comprising a plurality of chambers arranged in step-wise form and in a downwardly inclined path one below the other to the last chamber.

2. A multi-stage evaporator as claimed in claim 1 and including a heat exchanger for condensing the vapours produced in the succession of chambers and means for passing the liquid to be evaporated through the exchanger in heat exchange relation with the vapours and thence through a heater to the succession of chambers.

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