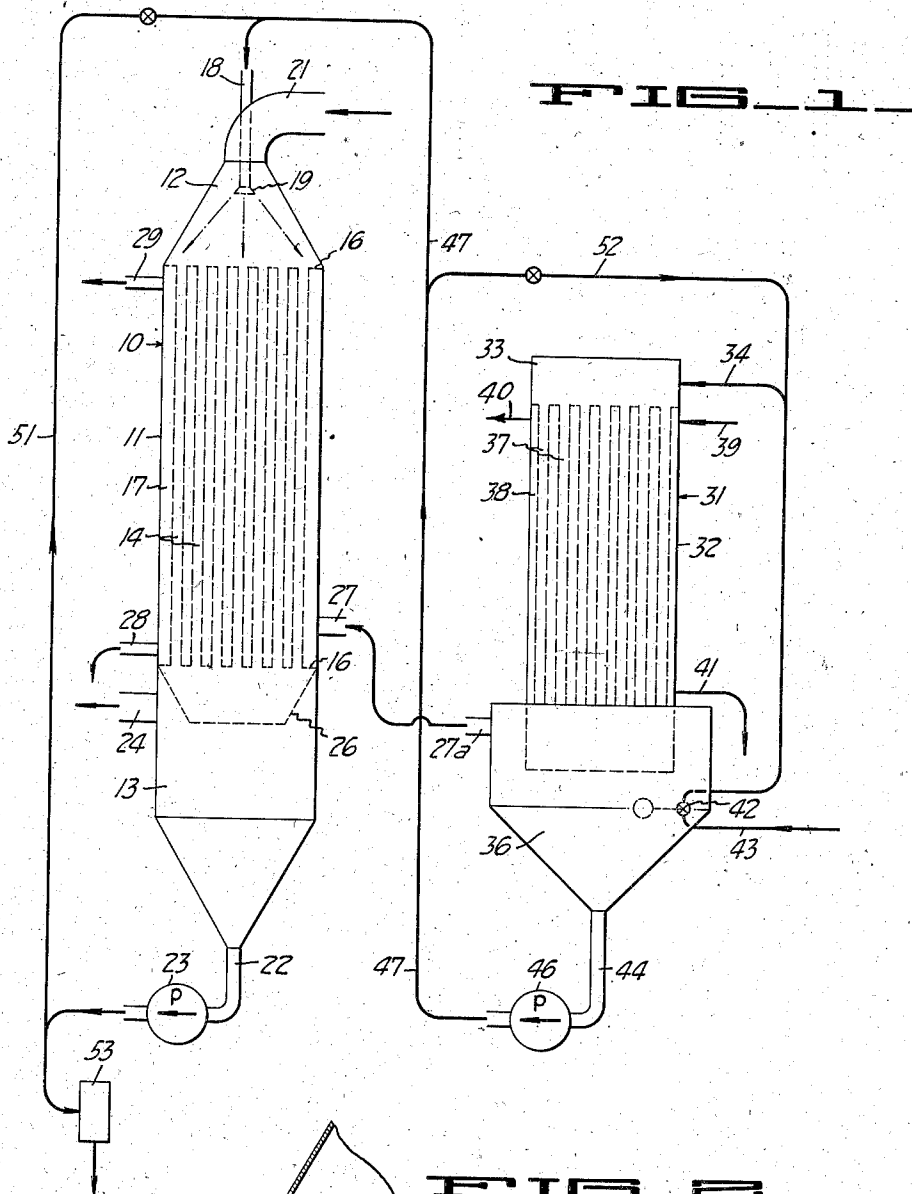


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HEAT EXCHANGE METHOD

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HEAT EXCHANGE METHOD

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1 Claim. (Cl. 159-47)

This invention relates generally to methods and apparatus which utilize an interchange of heat between two or more fluids, and which have various commercial applications, including the concentration of liquids by evaporation.

It is an object of the invention to provide an apparatus of the above character which will afford relatively high efficiency with respect to heat transfer.

A further object of the invention is to provide an apparatus for the concentration of liquids by evaporation, which will make possible high concentrations during a relatively short time period of heat treatment.

Another object of the invention is to make possible creation of a vacuum without the use of cooling water as in conventional condensing methods and apparatus.

Further objects of the invention will appear from the following description in which the preferred embodiment of the invention has been set forth in detail in conjunction with the accompanying drawing.

Referring to the drawing:

Fig. 1 is a diagrammatic view illustrating apparatus incorporating the present invention.

Fig. 2 is a cross sectional detail illustrating the construction of part of the heat exchange apparatus.

The present invention effects a heat transfer through a heat conducting wall, such as a metal tube, with heat being absorbed by vaporization of a liquid intermingled with a current of non-condensable gas. The intermingling of the liquid and non-condensable gas is such that a maximum amount of vaporization occurs, in conjunction with a high rate of heat transfer for a given area of heat transferring surface.

Before attempting a more detailed explanation of my method, I shall first describe the apparatus and system illustrated in Fig. 1. Apparatus 10 is a heat exchanger, which in this instance is being utilized primarily for the concentration of a liquid by evaporation. It consists of a shell 11, having the upper portion 12 thereof formed to afford a gas inflow chamber. The lower portion 13 of this shell forms an outflow chamber, and is also constructed to function as a separating means. Extending between and connecting the portions 12 and 13 are the heat exchange tubes 14. The ends of these tubes communicate through tube sheets 16, whereby the space 17 surrounding the tubes is isolated to form a chamber for receiving steam or like fluid.

The liquid to be evaporated and concentrated

is introduced into the inflow chamber 12 by means of pipe 18, the inner end of which is formed to afford a spray head 19. A stream of non-condensable gas is also introduced into the chamber 12 by means of conduit 21. Liquid is removed from the lower chamber 13 through pipe 22 and pump 23, while gas and vapor are removed through conduit 24. A baffle 26 is shown extending down from the lower tube sheet, in order to afford better separating action and in order to avoid drawing of liquid particles into conduit 24.

Assuming that the fluid in space 17 is steam, a vapor connection is indicated at 27, while pipes 28 and 29 are indicated for removing condensate and small amounts of non-condensable gas, respectively. Where the pressure in chamber 17 is below atmospheric, pipe 28 is connected to a condensate pump or a barometric leg to afford a seal, while pipe 29 is connected to a suitable vacuum pump.

In the system illustrated for concentrating liquid, apparatus 10 can be utilized in conjunction with a further apparatus 31 for effecting an initial concentration, thus affording a multiple effect evaporator. Apparatus 31 is of a type similar to that disclosed and claimed in my co-pending application Serial No. 698,751, filed November 20, 1933. Briefly, it consists of a housing 32, the upper chamber 33 of which receives liquid from pipe 34. The lower portion of the housing connects with a separator 36. Communicating between the chamber 33 and the interior of separator 36 are the heat transfer tubes 37. The ends of these tubes communicate through tube sheets, thereby forming a closed space 38 about the tubes for receiving a heating fluid such as steam. Thus, a steam line connection to space 38 is indicated by line 39, and a condensate draw-off is indicated by line 41, which may be through a barometric leg or a condensate pump. Non-condensable gases can also be drawn off from space 38, as indicated by line 40.

For controlling the flow of liquid into chamber 33, I have shown a float control valve 42 which is actuated in accordance with the level of liquid in the separator 36. This valve controls the rate of flow of liquid through line 34, from the liquid supply line 43. In connecting the concentrating apparatus 31 with the heat exchanger 10, liquid drawn from the separator 36 through the liquid outflow pipe 44 is delivered by pump 46 through outflow pipe 47 and to the spray pipe 18. The vapor delivery conduit 27a from separator 36 connects to the pipe 27 of apparatus 10. Thus, evolved water

vapor from the separator 36 serves to supply heat to the space 17 surrounding the tubes 14 of apparatus 10, while the liquid concentrated in the evaporator 31 is delivered to the apparatus 10 for further concentration.

Under certain conditions of operation, it is desirable to effect a re-circulation of liquid passing through the apparatus 10. For this purpose I have indicated a valve controlled return line 51, which serves to divert a portion of the outflow from pump 23 back to the spray pipe 18. Apparatus 31 can similarly be provided with a valve controlled return pipe 52.

The mode of operation of the apparatus described above, and the carrying out of my method, can be briefly outlined as follows:—Assuming that no re-circulation is carried on through lines 51 and 52, liquid is supplied to the spray pipe 18, and at the same time a stream of non-condensable gas, such as air, is supplied to the conduit 21. The air stream entering the upper ends of tubes 14 carries with it the particles or drops of liquid, and the velocity of gas flow through each of the tubes 14 is sufficient to cause considerable turbulence. Turbulent flow through tubes 14 is an important aspect of the present invention, in making possible certain new results. In the first place, such a turbulent flow causes a maximum amount of relative movement between the air and the particles of liquid, thus causing a sweeping away of vapor being evolved from the liquid, with the result that rapid evaporation of the liquid is promoted. Furthermore, such turbulence causes a continual bombardment of liquid particles upon the inner side walls of the tubes, which bombardment is simultaneously accompanied by a continual whipping-off of liquid from the inner side walls and back into entrainment with the air. Such action is conducive to good transfer of heat from the walls of the tubes 14 to the liquid being carried through the same. Likewise, such action avoids incrustations or coatings upon the inner walls of the tubes, where the liquid contains solid matter and is being concentrated to a high degree. The net result of such action within tubes 14 is that the material discharged from these tubes consists of the air introduced through conduit 21 together with the remaining liquid and the vapor evolved from the same. A separation between the liquid and the other components is effected in chamber 13, whereby collected liquid is removed through pipe 22, and the air, together with vapor, is discharged through conduit 24. It will of course be apparent that the heat transfer which is effected in this manner through the walls of tubes 14, and which goes largely toward supplying heat of vaporization for the liquid which is being evaporated, is supplied or absorbed from the steam or like vapor in space 17 surrounding the tubes.

If, in the operation of the apparatus 10, a certain amount of the liquid removed through pipe

22 is redelivered to spray pipe 18 through pipe 51, this returned liquid is resubjected to further evaporation, while the liquid for final delivery is drawn off at some suitable point in the circuit. Thus as indicated in the drawing, the liquid is being drawn off through device 53 for final delivery. In the event the liquid in its treatment within apparatus 10 tends to foam to an undesired degree, it is evident that pump 23 should be capable of handling both foamed and unfoamed components, while device 53 can be constructed to have a defoaming action. In many instances, however, device 53 need not be used.

Assuming that the apparatus 10 is utilized in conjunction with the evaporator 31, which is desirable in order to obtain relatively high concentration by evaporation, the liquid as partially concentrated in apparatus 31 is delivered to apparatus 10 by pump 46. Likewise, steam or water vapor which is evolved from the liquid in apparatus 31 is delivered to apparatus 10, thus effecting an economy in heat consumption. By way of example, with such a system it is feasible to carry the concentration of a liquid, such as milk, to 25% solids in apparatus 31, and to 45% solids in apparatus 10. Concentration to this degree, and even greater concentration, are obtained without an unduly long time period of treatment, whereby possible injury to organic liquids such as milk is avoided.

It has previously been stated that the non-condensable gas introduced into apparatus 10 through conduit 21 induces rapid evaporation from the liquid introduced through spray pipe 18. Thus, a relatively dry gas or air is preferred, having a substantial moisture-carrying capacity.

In the particular apparatus described above, a considerable vacuum is maintained in space 17, about the tubes 14. Thus my invention may be employed for such purpose, particularly in localities where a supply of cooling water may be scarce. Maintenance of a vacuum in space 17 also serves to maintain a vacuum in chamber 36, so that apparatus 10 operates as the second evaporating effect of a double effect evaporator, and as a condenser for vapor evolved from the first effect formed by apparatus 31.

I claim:

In a method of effecting concentration of a liquid by evaporation, where a heat transfer tube is employed, introducing into the tube a liquid to be evaporated, causing a stream of non-condensable gas to flow through the tube at sufficient velocity to cause turbulence and maintenance of liquid in the tube in the form of droplets entrained in the turbulent gas flow, transferring heat through the walls of the tube to cause evaporation of liquid in transit through the same, and then separating and collecting the concentrated liquid droplets discharged from the tube apart from discharged non-condensable gas and vapor.

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