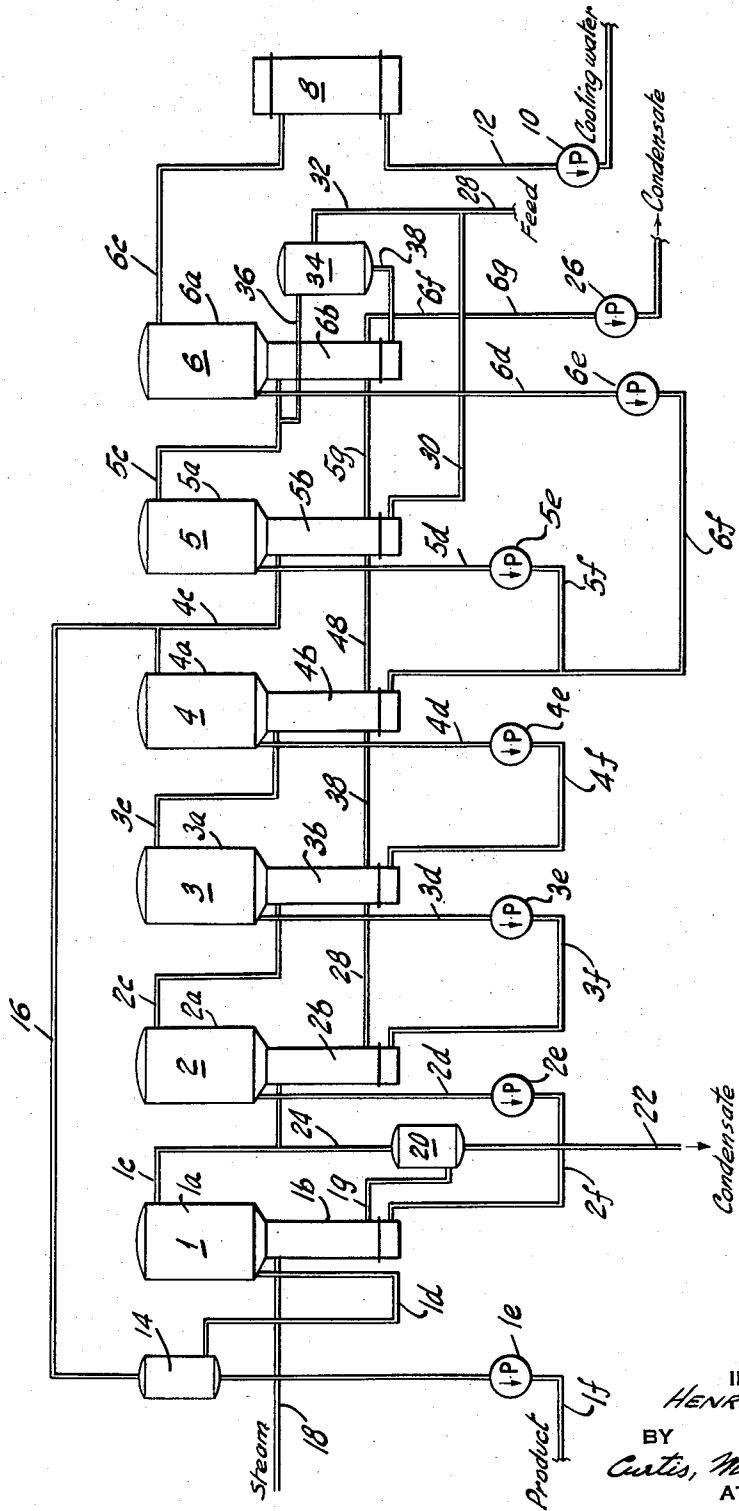


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MULTIPLE EFFECT EVAPORATOR

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MULTIPLE EFFECT EVAPORATOR

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This invention relates to multiple effect evaporators and more particularly to a novel arrangement of a feed liquor flash tank in such an evaporator. The evaporating system of the present invention is particularly useful in the counter-flow multiple effect evaporation of feed liquors which normally have a temperature substantially above the operating temperature of the feed effect. A typical example of such feed liquors is the "black liquor" obtained as incident of the manufacture of paper pulp by the soda or sulphate process.

In the evaporation of such relatively high temperature liquors in counter-flow evaporators it is generally undesirable to introduce the liquor directly into the last effect of the evaporator because of the fact that the liquor flashes to produce a large volume of vapor that tends to overload the last effect and also interferes with proper evaporation of the liquor therein. To circumvent these difficulties it has become the usual practice to pass the feed through a flash tank before it is introduced into the evaporator. In the flash tank a portion of the liquor flashes into vapor which is conducted either directly to the condenser or more commonly to the vapor pipe that interconnects the vapor space of the last effect with the condenser. Since the flash tank is thus effectively connected to the vapor space of the last effect, liquor flowing from the flash tank to the evaporator is at substantially the operating temperature of the last effect, and the formation of an excessive volume of vapor in the last effect due to flashing of feed liquor therein is avoided.

While this method of operation avoids the difficulties outlined above it is open to a number of other objections. Thus since the vapors from the flash tank go directly to the condenser the latent heat of vaporization of these vapors is essentially wasted. Moreover although it is possible to locate the flash tank at a sufficient elevation to permit the liquor to flow therefrom to the evaporator by gravity, it has been found that such gravity feed is subject to unpredictable variations and that in order to secure uniform feed flow an additional pump must be provided to transfer the liquor from the flash tank to the evaporator.

It is accordingly an object of the present invention to provide a multiple effect evaporator that eliminates the difficulties outlined above. It is another object of the invention to provide a multiple effect evaporator having improved efficiency in evaporating feed liquors of relatively high temperature. It is still another object of the invention to provide an improved method of evaporating a relatively high temperature liquor in a multiple effect evaporator. Other objects of the invention will be in part obvious and in part pointed out hereafter.

The objects and advantages of the present invention can best be understood and appreciated by reference to the accompanying drawing which illustrates diagrammatically a multiple effect evaporator incorporating a preferred embodiment of the invention.

Referring to the drawing, the multiple effect evaporator there illustrated is of the counter-flow type and comprises

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six evaporative effects designated 1-6 respectively. Each evaporative effect comprises a vertically arranged heat exchanger section and a superposed vapor body or vapor-liquid disengaging chamber, the vapor bodies being designated 1a to 6a respectively and the heat exchangers 1b to 6b respectively. The vapors formed in each effect are used in the usual manner as the heating medium of the next effect. More specifically, the vapor bodies 1a to 5a are connected to the heat exchangers 2b to 6b respectively by the vapor pipes 1c to 5c respectively. The vapor line 6c of the last effect 6 leads to a condenser 8 which is supplied with cooling water by a pump 10 through a pipe 12.

Concentrated liquor from the first effect passes from the vapor body 1a through a pipe 1d to a flash tank 14, whence it is pumped by a pump 1e through a product pipe 1f to a suitable point of storage or use. Vapors generated in the flash tank 14 flow through a pipe 16 to the vapor pipe 4c leading to the heat exchanger 5b of the fifth effect. Concentrated liquor from the second effect flows from vapor body 2a through a pipe 2d, pump 2e and pipe 2f to the heat exchanger 1b of the first effect for further heating and evaporation. In like manner liquor concentrated in the third, fourth and fifth effects flows from the respective vapor bodies through pipes 3d, 4d and 5d respectively, pumps 3e, 4e and 5e respectively and pipes 3f, 4f and 5f respectively to the heat exchangers 2b, 3b and 4b of the second, third and fourth effects respectively. The liquor concentrated in the sixth effect flows from vapor body 6a through a pipe 6d, pump 6e and pipe 6b to the liquor transfer pipe 5f. Thus the fifth and sixth effects are operated in parallel with regard to liquor flow and the concentrated liquor from each of these effects is combined as a feed to the fourth effect.

Steam to heat the first effect is supplied to the heat exchanger 1b through a pipe 18 and condensate formed therein flows out of the heat exchanger near the bottom thereof through a pipe 1g to a flash tank 20 whence it flows through a pipe 22 to a suitable point of disposal. Vapors generated in flash tank 20 flow through a pipe 24 to the vapor pipe 1c leading to the second effect. Condensate formed in the second and later effects is transferred to the heat exchangers of successive effects. More particularly condensate formed in the heat exchangers 2b, 3b, 4b and 5b is transferred by the condensate transfer pipes 2g, 3g, 4g and 5g respectively to the heat exchangers of the next successive effect. Condensate formed in the heat exchanger 6b flows through pipe 6g and pump 26 to a suitable point of disposal.

The feed liquor to be evaporated is supplied through a pipe 28 and a portion thereof flows through branch pipe 30 to the fifth effect whereas the remainder of the feed flows through a pipe 32 to a flash tank 34 associated with the sixth effect. As indicated above, this feed liquor is substantially above the operating temperature of the sixth effect and it is desirable that the feed liquor temperature be lowered before it is introduced into that effect in order to avoid an excessive amount of vapor in the sixth effect which might overload it and interfere with proper evaporation within that effect. On the other hand the fifth effect operates at a high enough temperature so that the liquor flowing through branch pipe 30 can be introduced directly into the fifth effect without first passing through a flash tank.

In the flash tank 34 flash evaporation of the feed liquor occurs and the generated vapors flow through a pipe 36 to the vapor pipe 5c leading to the heat exchanger 6b of the sixth effect. More specifically, the liquor temperature is reduced to a value corresponding substantially to the vapor pressure in pipe 5c. Since the pressure in pipe 5c is higher than that in 6c the liquor tempera-

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ture of the liquor flowing through pipe 38 to heat exchanger 6b is still somewhat above the operating temperature of the sixth effect, but not sufficiently above the sixth effect temperature to cause any serious difficulties. On the contrary, the temperature of the liquor entering the sixth effect through pipe 38 is such that a further small amount of flash evaporation will occur within the heat exchanger 6b, thereby improving the heat transfer within this effect.

The connection of the vapor space of flash tank 34 with the vapor side of heat exchanger 6b rather than with the vapor pipe 6c as was the prior practice, provides a number of significant advantages. In the first place, although the pressures in pipes 5c and 6c vary in accordance with the rate at which liquor is evaporated in the evaporator, the difference between these pressures remains relatively uniform over a fairly wide range of feed rates. Hence by connecting the flash tank 34 as shown in the drawing and just described, the temperature of the feed liquor to the sixth effect is maintained a small, relatively constant amount higher than the liquor temperature within the sixth effect. Also no pump is required to transfer liquor from the flash tank 34 to the heat exchanger 6b because of the fact that a positive differential pressure between the vapor and liquor sides of the heat exchanger is available to effect transfer of this liquor. A still further advantage of connecting the vapor outlet of the flash tank 34 to the vapor pipe 5c is that the vapor generated in the flash tank is utilized as a heating medium in the sixth effect and is not wasted as would be the case if it were conducted through pipe 6c and thence directly to the condenser 8. Thus with the arrangement shown both the thermal economy and the evaporative efficiency of the evaporator are improved.

I claim:

1. A multiple effect evaporator of the counter-flow type comprising a series of evaporative effects including at least one feed effect, each of which includes a vertically arranged tube-in-shell heat exchanger having a vertical tube bundle through the tubes of which the liquor to be evaporated passes and a shell side supplied with a condensible heating vapor for supplying heat through the tube walls to the liquor to be evaporated, each of said evaporative effects also including a vapor disengaging chamber mounted above said heat exchanger and connected to receive the heated liquor from said heat exchanger and separate said heated liquor from its vapors, vapor transfer conduits for conducting condensible vapors from the vapor disengaging chamber of each effect to the shell

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side of the heat exchanger of the next effect, a flash tank associated with a feed effect of said series and mounted at approximately the same level as the heat exchanger of said feed effect, said flash tank having a liquor inlet connection in its side wall, a conduit free from flow-restricting means interconnecting the bottom of said flash tank with the bottom of said heat exchanger whereby liquor can flow unrestrictedly from said flash tank into the lower ends of the tubes of the tube bundle of said feed effect, and a conduit effectively connecting the upper portion of said flash tank to the shell side of the heat exchanger of said feed effect.

2. A multiple effect evaporator of the counter-flow type comprising a series of evaporative effects including at least one feed effect, each of which includes a vertically arranged tube-in-shell heat exchanger having a vertical tube bundle through the tubes of which the liquor to be evaporated passes and a shell side supplied with a condensible heating vapor for supplying heat through the tube walls to the liquor to be evaporated, each of said evaporative effects also including a vapor disengaging chamber mounted above said heat exchanger and connected to receive the heated liquor from said heat exchanger and separate said heated liquor from its vapors, vapor transfer conduits for conducting condensible vapors from the vapor disengaging chamber of each effect to the shell side of the heat exchanger of the next effect, a flash tank associated with a feed effect of said series and mounted at approximately the same level as the heat exchanger of said feed effect, said flash tank having a liquor inlet connection in its side wall, a conduit free from flow-restricting means interconnecting the bottom of said flash tank with the bottom of said heat exchanger whereby liquor can flow unrestrictedly from said flash tank into the lower ends of the tubes of the tube bundle of said feed effect, and a conduit connecting the top portion of said flash tank and the vapor transfer conduit leading to the heat exchanger of said feed effect.

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