Dec. 6, 1966 A. E. ROSENBLAD 3,289,735

MULTIPLE EFFECT EVAPORATOR OF THE SWITCHING TYPE

Filed July 15, 1964 2 Sheets-Sheet 1

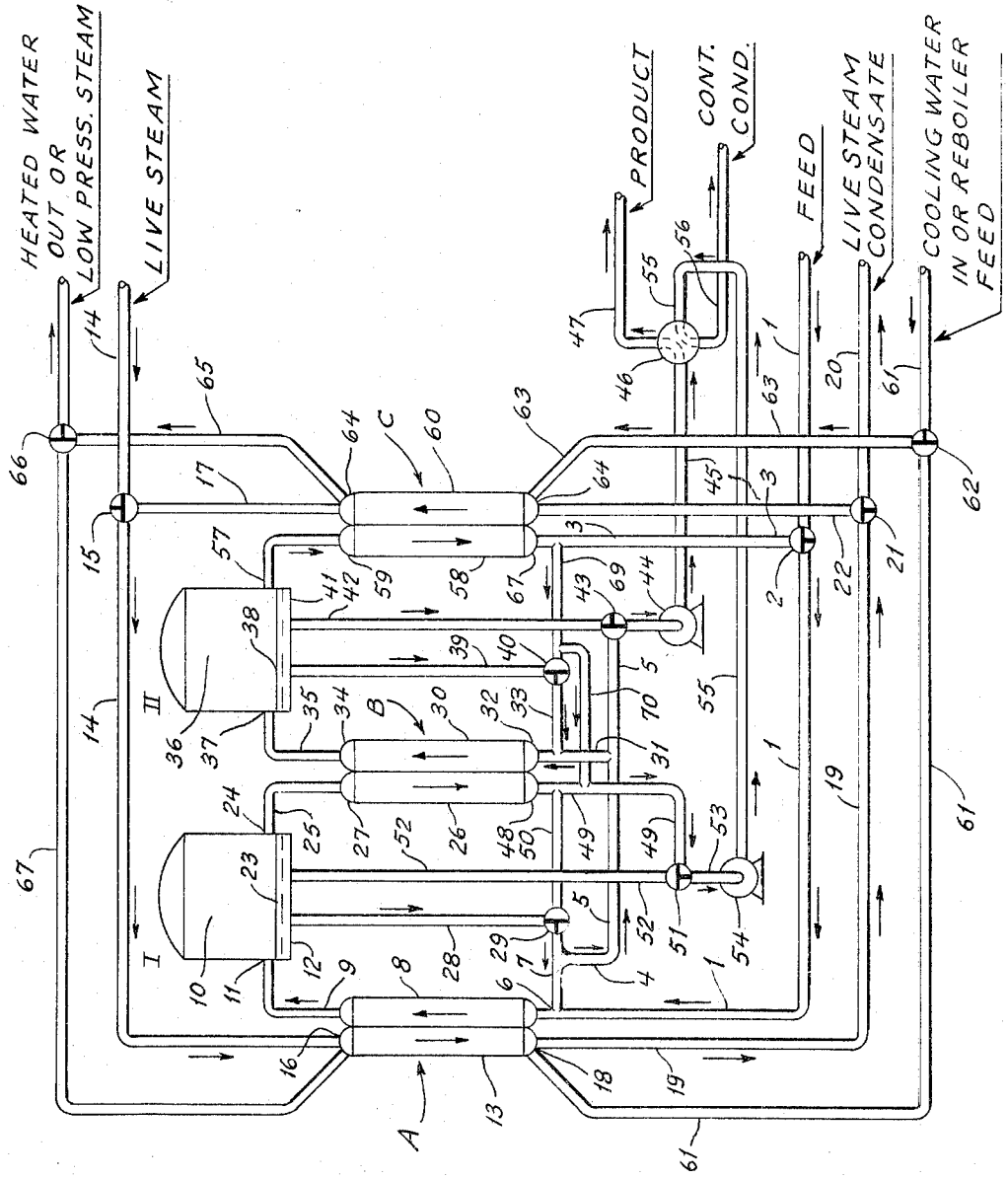


Fig. 1.

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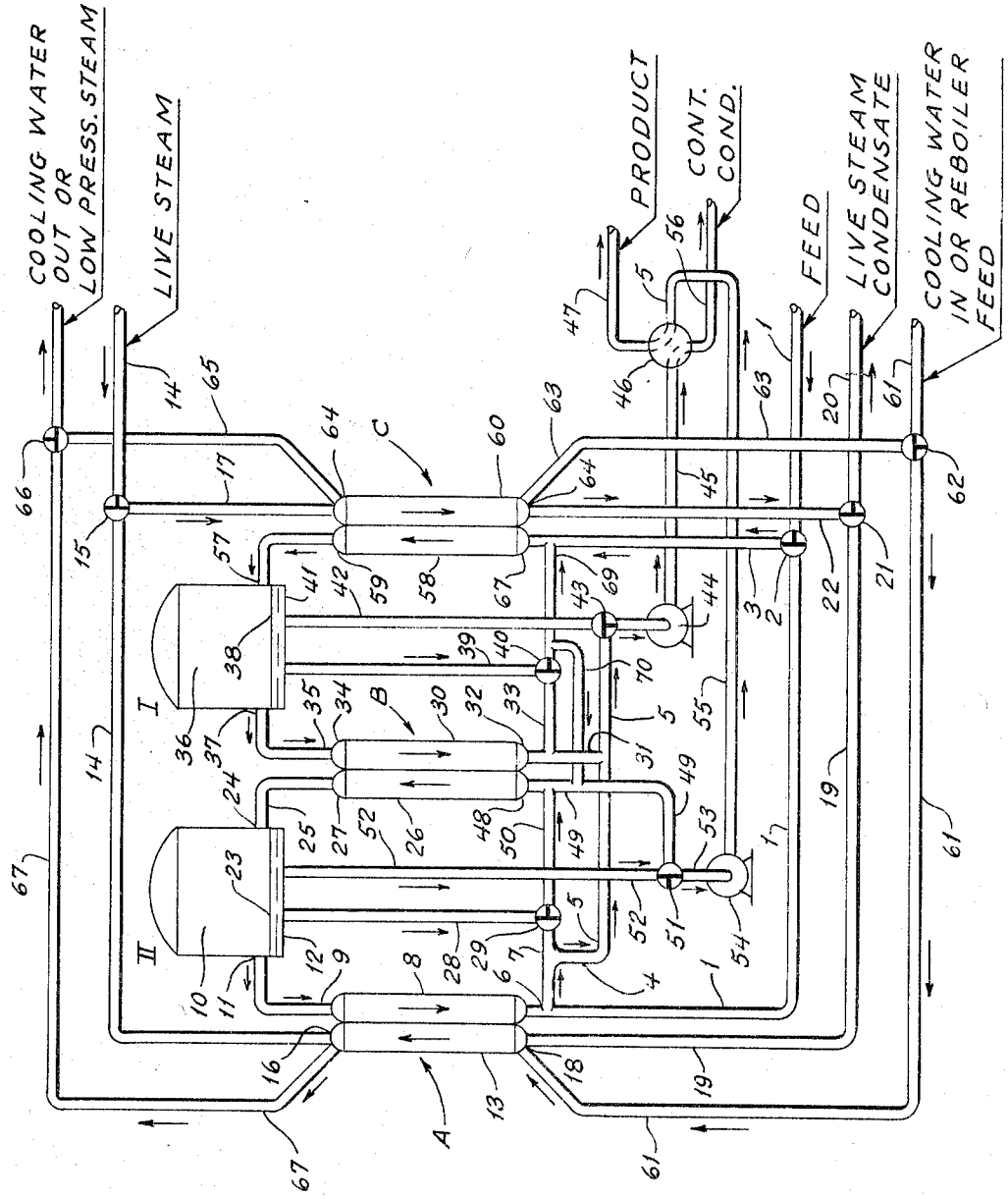


Fig. 2.

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United States Patent Office 3,289,735 Patented Dec. 6, 1966

3,289,735

MULTIPLE EFFECT EVAPORATOR OF THE SWITCHING TYPE

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Filed July 15, 1964, Ser. No. 382,903
2 Claims. (Cl. 159—20)

This invention relates to improvements in multiple effect evaporators of the channel switching type and is particularly concerned with apparatus for retaining all the benefits of the channel switching of the so called "mirror" type while eliminating the drawbacks of contamination of the live steam condensate with consequent limitation of its utilization.

Switching type evaporators, an illustration of which is shown in the U.S. Patent to Lockman #2,734,565 of February 14, 1956, have all the same disadvantages in common. This is that the live steam condensate cannot be returned to the live steam boiler because it is contaminated. This contamination is caused by the fact that, in switching, heating vapor and liquor to be heated are switched back and forth periodically from one side to the other of each heating element. Thus the live steam which at on time is introduced into the heating element of the first effect will alternately, due to the switching, be introduced into the previous liquor side of the last effect. Such a system, which is variously referred to as a "mirror" or "station" switching system, is the most efficient method for controlling scaling, not only on the heating surfaces but in the whole system including vapor bodies, valves, pumps and conduits. Thus it is most desirable to retain the efficiency of it.

In such a multiple effect evaporator it has been common practice to utilize the heat in the vapor from the last effect for some useful purpose. The manner in which it can be used, however, is limited because being vapor given off from liquor, it is contaminated. It can, of course, be used in an indirect heat exchanger for heating water in the other side to produce a supply of clean hot water, or to produce, or help in the production of, clean process steam in similar manner.

In accordance with the invention, however, and in spite of the switching, clean passages are permanently provided for the live steam in the heating element for the first effect, by having the same passage supplied with clean water when, after switching, the same heating element will serve as a surface condenser for condensing vapors from the last effect. Such fluid is heated in indirect heat exchange by the vapor from the last effect and the cleanliness is maintained when the materials passing through the end passages are reversed. This switching can be done continuously without concern about the live steam condensate or the heated fluid being contaminated. The necessity of making special provision in order to take advantage of the heat content of the vapor in the last effect is eliminated while nevertheless the advantages of channel switching, as between liquor and vapor within the evaporator itself, are maintained. The live steam condensate can be returned directly to the boiler as feed water and when, on switching, the passage which received the live steam is caused to receive a fluid to be heated instead, that passage can, of course, serve as a surface condenser or as the boiler water side for the re-boiler.

In previous switching evaporators, also with the first and last effect vapor bodies being interechangeable, it was necessary to have vapor piping to connect both of these to a common surface condenser. This called for large piping or ducting, plus two large vapor valves, to alternately isolate the effects from the condenser. The invention effects a saving by eliminating the necessity for such piping and such valves.

Another saving is the elimination of one vapor body as against the number required for prior art mirror switching evaporators. In the prior art there was need of one more vapor body than the number of heating elements. In the invention, the vapor bodies and heating elements in the evaporator proper are the same in number.

It is, accordingly, an object of the invention to provide for the direct reuse of the condensate from live steam employed as heating medium at either end of a switching type multiple effect evaporator as boiler feed water for the production of further live steam.

Another object is to provide for the utilization of such live steam while protecting the condensate thereof from contamination.

Another object is to provide for the heating of a fluid at one end or the other of a switching type multiple effect evaporator without contamination of the same from the results of the liquid being evaporated in the evaporator.

Still another object is to provide in a multiple effect switching type evaporator for preventing live steam used for initial heating and the condensate therefrom and a medium to be heated by evaporation vapors developed within the evaporator from being contaminated by the material being evaporated or its residue while still retaining channel switching within the evaporator for cleaning the same.

A further object is to provide a multiple effect switching type evaporator with interchangeable heat exchange passages for live steam for heating at one end and for fluid to be heated at the other end while isolating such passages from the contaminating effects from the liquor being evaporated though such passages are switched simultaneously with the channel switching of the evaporator.

A further object is to eliminate vapor ducting and valves heretofore thought necessary in switching type evaporators; and

A still further object is to reduce the number of vapor bodies required for switching type evaporators.

Further and more detailed objects will in part be obvious and in part be pointed out as the description of the invention taken in conjunction with the accompanying drawing proceeds.

In that drawing:

FIG. 1 is a diagrammatic showing of a switching type evaporator modified in accordance with the teaching of the invention and with the primary heating medium being passed through one end passage and with the opposite end passage being used as the cooling side of a surface condenser.

FIG. 2 shows the same evaporator as in FIG. 1, but illustrates the reverse condition of the passages after channel switching has been effected.

For the purposes of illustration, the invention has been shown as applied to a multiple effect evaporator of the channel switching type where the minimum number of effects, two in all, are employed. It is to be understood, however, that this number of effects is merely for illustrative purposes since, for efficiency of operation, more than two effects would normally be used.

Turning then to the detail of the drawing and considering, first, the inner workings of the evaporator, the feed to be evaporated, which may be spent liquor from the pulping industry or some other spent liquid utilized in a chemical process, is shown as being introduced through the pipe 1 from the end thereof labelled "feed." The feed flows through this pipe 1 in the direction as shown by the arrows and, in the case of FIG. 1, flows directly through a two position valve 2 which can connect the pipe 1 with an upwardly extending pipe 3, or continues the same straight through the valve 2 into the continuation of the pipe 1, as is the case here. The pipe 1, then, turns upwardly and is joined at 6 to another pipe 7 ex-

tending out to the right from the pipe 1. The pipe 1 continues from there and connects with the passage 8 of the heat exchanger, generally indicated at A, through the bottom end thereof. In this instance the heat exchanger A is at the feed heating end of the evaporator. The passage 8 communicates at its upper end with a pipe 9, which extends therefrom to enter the vapor body 10 of the evaporator at the position 11 just above the bottom 12 thereof.

The other passage of the heat exchanger A, indicated at 13, receives live steam through the pipe 14 which extends directly through a two position valve 15 into communication with the interior of the passage 13 at its upper end 16. The two position valve 15, when turned to its other position, isolates the portion of the pipe 14 aligned with the entrant end thereof from that end and instead connects the interior of the pipe 14 with a pipe 17 extending at right angles downwardly from the pipe 14.

At its bottom end 18 the passage 13 of the heat exchanger A is connected with a condensate return pipe 19 through which condensate from the steam condensed in the passage flows, as seen by the arrows, to the outlet end 20 of the pipe 19. This end may discharge the condensate into a feed water boiler, or other apparatus where the hot clean condensate can be utilized. Just inwardly of the position 20, however, the pipe 19 has a two position valve 21 seated in it. In one of its positions the valve 21 provides direct communication along the pipe 19 to the end 20. When turned to its other position the valve 21 shuts off that direct communication and, instead, puts an upwardly extending pipe 22 into communication with the interior of pipe 19.

Returning now to the vapor body 10, it will be seen that a portion of the liquor 23, flowing into that vapor body through the pipe 9, having been heated in the heat exchanger A, vaporizes with that vapor collecting above the remaining concentrated liquor; such vapor flows out at 24 through the pipe 25 into the heating side 26 of the heat exchanger B, through the upper end 27 thereof. At the same time, the partially concentrated liquor 23 collected in the bottom of the vapor body 10 flows down through a pipe 28 extending through the bottom 12 of the vapor body and flows to the left through the two position valve 29 into the pipe 7. From here part of the concentrated liquor joins feed flowing up the pipe 1 at the position 6 and, mingling with that feed, is recirculated through the heat exchanger 8 back into the vapor body 10. Another part flows down through the short pipe section 4 into the pipe 5 through which it flows to the right as indicated by the arrows.

The heat of the vapor from the vapor body 10 is utilized in the indirect heat exchanger B for heating further feed in the passage 30 of that heat exchanger, which passage is in heat exchange relationship with respect to the passage 26. The passage 30 receives feed in the form of partially concentrated liquor from the pipe 5, which feed flows up through the pipe section 31 into the passage 30 through the bottom 32 thereof after passing a right angled pipe 33 joining the pipe 31 just below the bottom 32. Here, again, the feed liquor which is heated in the passage 30 flows up through the top 34 thereof and through the pipe 35 into the vapor body 36 at the position 37. Vapors are given off from the heated liquor while the concentrated liquor settles at 38 in the lower part of the vapor body. In this instance, however, the arrangement is different from that in the vapor body I, for part of the concentrated liquor recirculates through the pipe 39, the two position valve 40, the pipe 33 and the heat exchanger passage 30 back into the vapor body 36. Another part of it, however, is drawn off from the bottom 41 of the vapor body through a second pipe 42, through a two position valve 43, to a pump 44 and into an outlet line 45. From the line 45 it passes out through the two position, four part valve 46 into and out of the outlet pipe 47 as the product.

Returning to the heat exchanger B, it will be seen that the condensate from the vapor utilized for heating in the passage 26, flows out of the bottom 48 of that passage, through the pipe 49, past a joining pipe 50 and down to a two position valve 51 which serves to connect either the pipe line 49 or vertically extending pipe 52 to a short pipe section 53, a pump 54 and an outlet pipe 53. The pipe 55 connects with the two position valve 46 and, assuming that the valve 46 is set to continue the passage through the pipe into the short exit pipe section 56; enables the contaminated condensate to be taken off for the recovery of its heat content, or other utilization of it, through the pipe end labelled "cont.cond." (Contaminated condensate).

Returning to the vapor body 36, it will be seen that the vapors from evaporation of the liquor in this body flow out through the pipe 57 and into the passage 58 of the heat exchanger C, through its upper end 59. Here these vapors give off heat to the fluid in the other passage 60 of this heat exchanger, which lies in heat exchange relationship to the passage 58. This fluid may either be cooling water to be heated, or re-boiler feed. It is introduced into the passage 60 through a pipe 61 and is directed through a two position valve 62 up through a pipe 63 which enters the bottom 64 of the passage 60. This liquid being heated by and thus condensing the vapors in the passage 58 flows out of the upper end 64 of the passage 60 through the pipe 65 and the two position valve 66 to emerge as heated water or low pressure steam.

The condensate from the passage 58 flows out into the upper end of the pipe 3 but the condensate cannot flow far down the pipe 3 since the valve 2 at the bottom end of the pipe is closed to flow therethrough. Thus the condensate flows to the left through a communicating pipe 69, and jogs into a pipe 70 due to the valve 40 being closed off against direct passage. The pipe 70 joins with the pipe 49 carrying condensate from passage 26 of the heat exchanger B so the contaminated condensate from the passage 58 joins that from the passage 26 and is also drawn down through the pipe 49, the valve 51 and the pump 54 to be taken out of the system through the pipe 55. This, then, is the situation and flow path which exists in the evaporator with the passage 13 of the heat exchanger A serving to receive the live steam for creating and maintaining the operation of the evaporator with the effects going in the order seen by I and II positioned above the vapor bodies 10 and 36. Clearly, the live steam passage from its entrance 14 to the exit of its condensate at 20 is completely isolated from any comingling with contaminating material being evaporated on one hand and concentrated on the other in the evaporator itself. Likewise, the cooling water or re-boiler feed, which is introduced at 61, passes up through the pipe 63, through the passage 60 of the indirect heat exchanger C, and out through the pipe 65, so is just as clearly isolated from any contamination by liquor in the evaporator, or vapor being evaporated. Nevertheless, switching or interchanging of the passages within the evaporator can be readily achieved, and switching of the passages 13 of the heat exchanger A and 60 of the heat exchanger C can be just as readily effected. This enables the system to be operated with full economy and devoid of contamination of heating steam or cooling water, regardless of the operating direction of the evaporator.

For the showing of the switched position and operation thereof, reference is made to FIG. 2. Here it will be seen by the reverse positions of the numerals I and II that the first effect, previously indicated at I, now becomes the second effect as indicated at II and the previous second effect II now becomes the first effect as indicated at I. The previous steam passage 13 of the heat exchanger A now becomes the passage for the cooling water to be heated or the re-boiler feed with the heating effect being achieved by the condensing of the vapors from the vapor body 10 in the other passage 8 of the heat exchanger A.

Switching of the passage **13** from steam to liquid is accomplished by first changing the position of the valve **15** in the live steam pipe **14** so that, instead of the steam continuing to flow straight along the pipe, it is turned at right angles, by the setting of the valve **15** at right angles, and flows down the pipe **17** and through the passage **60** of the heat exchanger C. This passage **60** previously received the cooling water or re-boiler feed to be heated by heat from vapor condensing in the passage **58** of the heat exchanger C. Passage **58** now contains the feed introduced through the pipe **1**, which feed, instead of continuing along that pipe, is caused to flow upwardly through the pipe **3** by a setting of the valve **2** at right angles to its previous position. Accordingly the feed flows into the bottom of the heat exchanger passage **58**, out of the upper end of that passage and through the pipe **57** into the vapor body **36**.

Before going further, it is significant to note that in this phase of the complete system, as well as in the opposite phase, the passages **13** and **60** remain completely isolated from the interior working elements of the evaporator. Thus no flow of contaminated vapor, or liquor being concentrated, can find its way into either of the passages **13** or **60**. What flows through them is merely live steam in one and clean water, or re-boiler feed, in the other, so that when they are reversed there is no contaminating material to be removed by the live steam, nor is there any to be washed out by the cooling water. Thus, as regards the live steam condensate and the cooling water they can be switched back and forth without the necessity of any intermediate and additional cleaning steps. This is something that could not be done in accordance with the prior art where the live steam joined with the contaminated vapor in the system and became contaminated by it.

The live steam condensate in the passage **60** flows down through the pipe **22** and its flow is turned at right angles by the valve **21**, having been turned at right angles, to flow out through the pipe **19** at **20**. Likewise, the cooling water, or re-boiler feed which, in this instance, flows straight along the pipe **61** due to the valve **62** having had its straight through passage aligned with the pipe **61**, instead of being turned at right angles, flows upwardly through the passage **13**. From there it flows out through the pipe **67**, communicating with the top of the passage **13**, through the valve **66**, now set with its passage in straight alignment with the pipe **67**, and out of the end of that pipe.

Returning now to the feed and the internal arrangement and operation of the evaporator, feed heated in the passage **58** by the live steam in the passage **60** of the heat exchanger C gives off vapors when introduced into the vapor body **36**. This feed is concentrated at **38** in the lower part of the vapor body of the first effect. Part of that concentrated feed is continuously recycled through the pipe **39**, since the valve **40** is now turned at 180° from its FIG. 1 position. This causes a portion of the liquor to flow through the pipe **69** where it joins the initial feed pipe **3** to be again passed through the passage **58**. Another portion of the liquor flows from the pipe **69** into the pipe **70** and then upwardly in the pipe **49** to serve as feed for the second effect. This portion of the liquor cannot flow downwardly in the pipe **49** since the valve **51** at the lower end of the pipe **49** is set vertically to allow flow from the pipe **52** directly down into the pipe **53** blocking off any flow from the pipe **49** at this position.

The vapor given off in the vapor body **36** passes down through the pipe **35** and down through the passage **30** of the heat exchanger B. This passage previously had concentrated liquor flowing through it in the opposite direction so the switching has the effect of cleaning from the passage any residue left therein by the concentrated liquor.

The vapor gives off its heat in the passage **30** and the condensate therefrom flows from the bottom of the passage **30** into the pipe **31** and down into the pipe **5**. In this instance the flow continues to the right since the valve **53** is set to pass it through at right angles into the short pipe section **72** from which it is pumped out of the system through the pump **44** and the pipe **45**. In this instance the two position four port valve **46** has been turned so that one of its passages puts the interior of the pipe **45** in communication with the interior of the pipe **56** which, as previously stated, is the outlet pipe for the contaminated condensate.

The passage **26** of the heat exchanger B in this instance has feed flowing up through it, part of which is recirculated from the liquor quantity **23** in the bottom of the vapor body **10** through the pipe **28**, the valve **29** and the pipe **50**. Added liquor, as already pointed out, comes through the pipe **70** from the liquor quantity in the lower part of the vapor body **36** of the first effect. The passage **26** previously received vapor flowing down from the vapor body **10** so has been cleaned from that vapor of any residue left by a previous liquor flow.

Part of the concentrated liquor **23** is drawn off as product from the bottom of the vapor body **10** through the pipe **52**, straight down through the valve **51**, through the short pipe section **53** and is pumped out through the pipe **55** by means of the pump **54**. The valve **46** joins the passage through the pipe **55** with the outlet pipe section **47** as in the previous case.

Finally, vapor from the vapor body **10** now flows out at **11** through the pipe **9** and flows downwardly through the passage **8** of the heat exchanger A. Here it gives up its heat for the heating of the water in the passage **13** and, at the same time, cleans the passage **8**. From that passage its condensate flows a short distance down the pipe **1** but is diverted to the right at **6** through a short section of the pipe **7**, and down through the short section **4** into the pipe **5**, since the valve **2** in the pipe **1** is now set to prevent flow down and out through the pipe **1**. Accordingly, the condensate from the contaminated vapor flows along the pipe **5** where it joins the condensate from the passage **30** and together they are directed by means of the valve **43** to the pump **44** which pumps the condensate out through the line **45**.

From the foregoing it is believed to be clearly apparent how, in accordance with the invention, clean condensate, formed from the live steam used in the first effect, is returned to the steam supply. This has been achieved by having the first effect act as a surface condenser after switching, at which time the former steam chamber receives cooling water. Thus the chambers which alternately receive live steam and cooling water are kept clean at all times.

Another thing to note is that, in this instance, where two effects are employed for illustrating the invention, only three indirect heat exchangers and two vapor bodies are needed because the live steam and its condensate are kept isolated from the liquor and its vapor. The same relationship would exist regardless of the number of effects there always being one more (n) heat exchangers than vapor bodies ($n-1$). Thus there is this substantial saving in equipment. Additionally, the whole arrangement is simplified over the prior art in that there, the vapor bodies of the first and last effect, being interchangeable by the switching, had to be piped, or ducted, and valved so as to be alternately connectable to a common surface condenser. That is not necessary in accordance with the arrangement of the instant invention, so all such large ducting and the necessary isolating valves are eliminated. It will be apparent from the above that when the system is operating in the manner shown in FIG. 1, the illustrated evaporator proper, that is, the evaporating portion of the system, includes the two heat exchangers A and B, and the two vapor bodies I and II, the heat exchanger C then functioning, for example, to heat water by the vapor discharged from vapor body II. When the system is operating in the manner shown in FIG. 2, the

illustrated evaporator proper, that is, the evaporating portion of the system, includes the two heat exchangers C and B, and the two vapor bodies II and I, the heat exchanger A then functioning, for example, to heat water by the vapor discharged from vapor body I.

It is, of course, to be understood that the illustrative showing applied to two effects, the particular piping arrangements for the same and other aspects of the showing could be extended to vaporizers of a greater number of effects. It is within the province of those skilled in the art to make such extension as well as making other variations in the construction and arrangement of the elements of the invention without departing from the spirit and scope of the invention. It is accordingly intended that all matter contained in the above description and shown in the accompanying drawing shall be interpreted in an illustrative and not in a limiting sense.

Having described my invention, which I claim as new and desire to secure by Letters Patent is:

1. A channel switching multiple effect evaporator, comprising n indirect heat exchangers, $(n-1)$ vapor bodies, n being a positive whole number, each heat exchanger having separated first and second channels in heat exchanging relationship to each other, first conduit means including a respective one of the vapor bodies connecting the second and first channels of successive heat exchangers, means to remove liquid product from the lower end of the vapor bodies, a second conduit means having valves therein selectively operable, (1) in a first condition to direct liquor to be evaporated into the second channel of the first and all subsequent heat exchangers except the last heat exchanger, and upon channel switching, (2) in a

second condition, to direct liquor to be evaporated into the first channels of the last and all prior heat exchangers except the first heat exchanger, the terms "first," "second," and "last" referring to position only, considered from left to right, a third conduit means having valves therein operable when the evaporator is operating in said first condition to introduce heating steam into the first channel of the first heat exchanger and to exhaust condensate therefrom, and to introduce water into the second channel of the last heat exchanger and to exhaust such water in heated condition therefrom, and a fourth conduit means having valves therein operable when the evaporator is operating in said second condition to introduce heating steam into the second channel of the last heat exchanger and to exhaust condensate therefrom, and to introduce water into the first channel of the first heat exchanger and to exhaust such water in heated condition therefrom.

2. An evaporator as claimed in claim **1**, wherein n is equal to at least 3.

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