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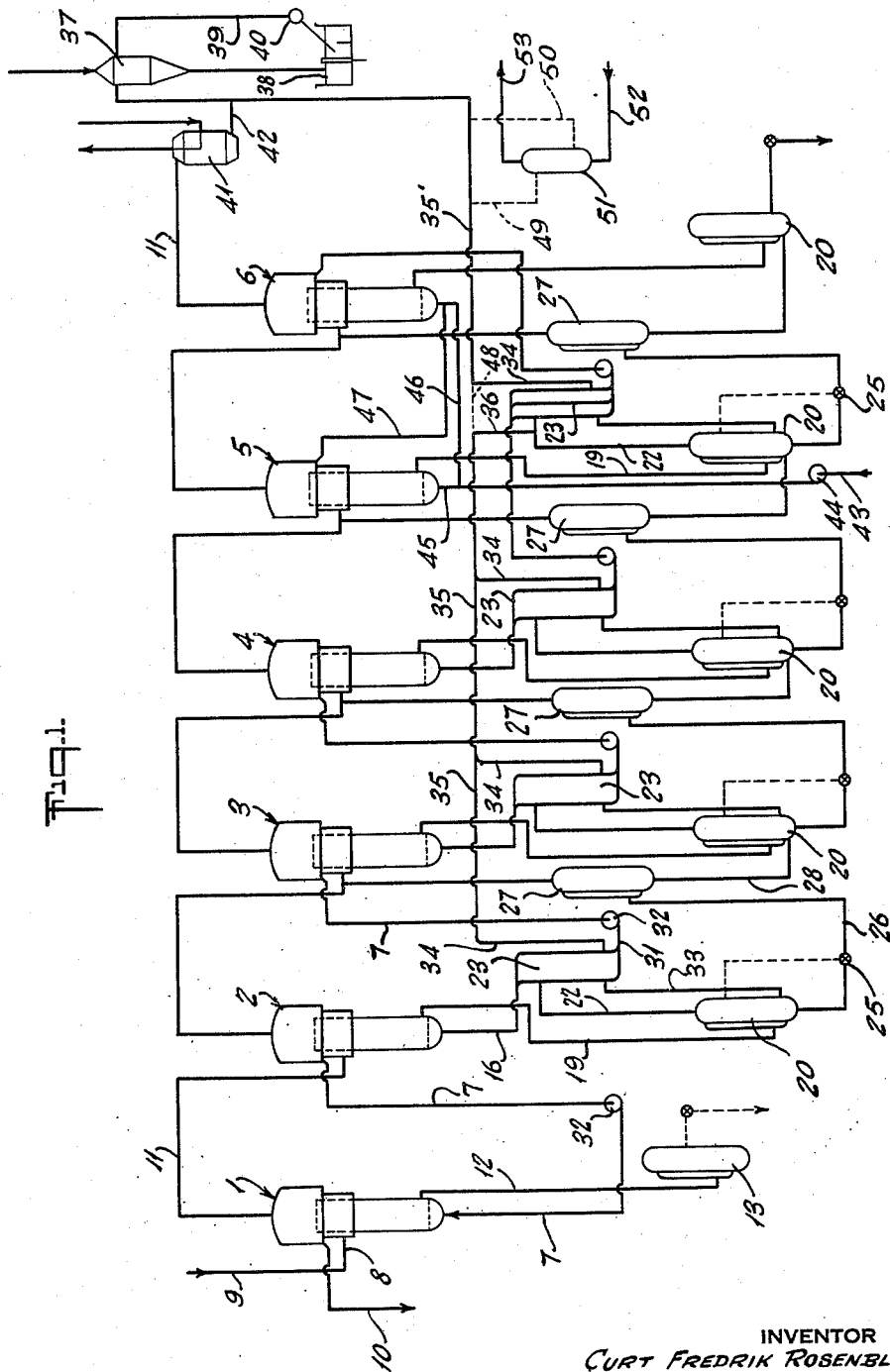
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MULTIPLE EVAPORATION METHODS

Filed March 14, 1955

2 Sheets-Sheet 1



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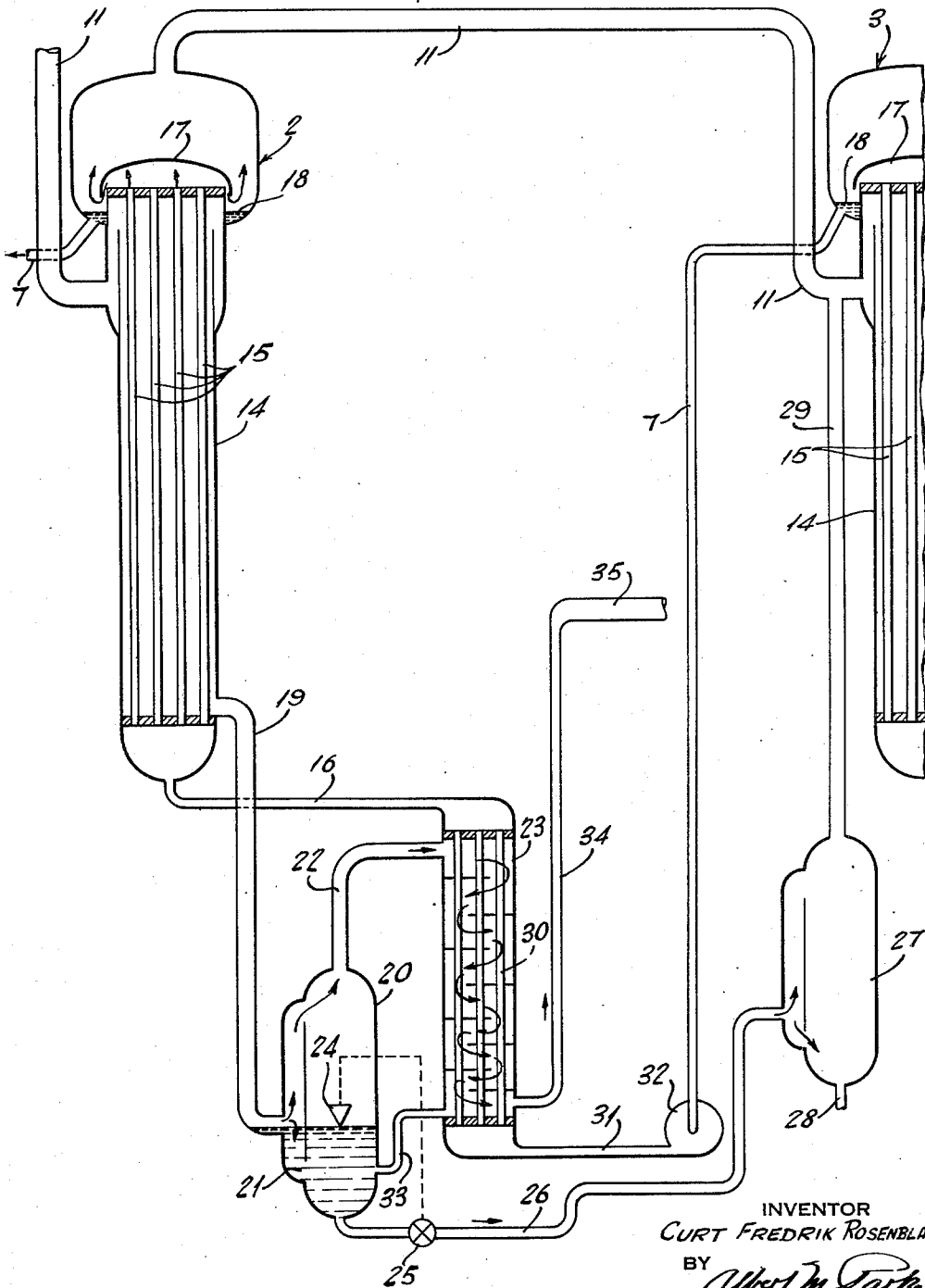
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Fig. 2.



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MULTIPLE EVAPORATION METHODS

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4 Claims. (Cl. 159—47)

This invention relates to multiple stage evaporating systems and methods and is particularly concerned with such systems employed in the kraft and sulphate pulp industry and with the utilization of more of the heat in such evaporating systems by the provision of improvements in such utilization.

Heretofore in multiple stage evaporating systems in the pulp industry the vapors given off in the vaporization of black liquor in the first effect and employed, or rather their heat is employed, in the second effect for vaporization of black liquor and so on down the line to the last effect. The vapors so created and transmitted from one stage to another contain a percentage of uncondensable gases. This percentage is increased if condensed vapor from one effect is introduced into the next effect along with the vapor coming from the previous effect. Not only do these uncondensable gases cause corrosion of the tubes in the evaporators so that if the evaporator is to have any substantial life, the equipment must be made of stainless steel, or other expensive corrosion resistant material, but even then they reduce the efficiency of the system by causing deposits on the tubes and by reducing the dew point of the vapor of which they form part so that full condensation of it, which is to be desired for full efficiency, is prevented. The action of the uncondensable gases becomes increasingly pronounced in relation to the increase in concentration of them in the vapor of which they form part.

In some instances the undesirable effects of the uncondensable gases have been offset by merely venting the last small part of the vapor in each stage to atmosphere. This, of course, is a highly wasteful practice since the latent heat of the steam part of such vapors is lost. An effort to correct this situation has been made by the taking off of such small remaining portion of the vapor in each effect and reintroducing it into the next effect part way down the evaporator shell. This, however, introduced further drawbacks and increased the uncondensable gases as the stages went along. This was still found to be so even though the vapor drawn off in the bottom effect was introduced into the subsequent effect along with the new vapor coming from the prior effect.

The instant invention eliminates the foregoing and other defects of prior art systems and methods and introduces improvements into the art in a number of respects. The vapor containing the high concentration of uncondensable gases vented from one effect is used in a liquor preheater so that the heat content that would be lost by venting such vapor to atmosphere is fully recovered, then the preheater rather than the evaporator is the piece of apparatus which receives the full corrosive effect of uncondensable gases. Hence the relatively small and inexpensive preheater rather than the evaporator can be made of stainless steel or other non-corrosive material. Such vapor containing uncondensable gases as remains at the end of the liquor preheating step is drawn off and conducted to a low temperature heating element, the heat

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exchanger of the last effect, or is taken directly to the end of the system where it is condensed and where the uncondensable vapors are separated out.

This system enables an excess of the steam vapor to be employed in the evaporator body since that excess gives up its heat in the liquor preheater and is used rather than being wasted.

The apparatus and method of the invention is not only useable in new installations but can be applied to any existing installation with consequent substantial increase in efficiency and increase in life with reduction of maintenance of the equipment through the reduction of the corrosion factor.

It is accordingly the principal object of this invention to improve the utilization of heat in a multiple effect evaporator system.

Another object is to reduce the effects of the corrosive action of the vapors in a multiple effect evaporation system.

Still another object is to provide for the drawing off of a portion of the vapor created by the evaporation from a multiple effect evaporation system without losing the heat effect thereof.

A further object is to employ vapors drawn off from the bottom of a vertical evaporator to preheat the liquor to be evaporated and subsequently utilize the remaining heat content of the vapor vented from such liquor preheater.

A still further object is to reduce the maintenance cost of multiple effect vaporizing system in the kraft industry by substantially removing the corrosive action from the evaporators.

A still further object is to reduce installation costs by enabling the utilization of materials in the fabrication of evaporators, which materials could not heretofore be used due to their lack of resistance to corrosion.

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

In the drawing:

Fig. 1 is a schematic view of a multiple effect evaporation system in accordance with the invention.

Fig. 2 is a sectional diagrammatic view of one, and part of another, of the effects of the invention including the intermediate elements in sufficient detail to enable an understanding of the invention to be obtained.

The evaporation system of the invention as here illustrated employs six effects which are numbered from 1 to 6 in the accompanying drawing where such numerals indicate the actual evaporators. It is to be understood, however, that the invention is not necessarily limited in applicability to a six-effect system since it could be employed with systems having a greater or lesser number of effects. In the first effect, as is common in the art, considering the system from the standpoint of utilization of heat, the liquor to be subjected to the vaporization action is introduced into the evaporator through the lines 7 and passes up through the usual tubes in the course of which it is vaporized by the action of fresh live steam entering at 8 through conduit 9 from a separate source. The liquor is vaporized and the vapors are caught in the usual trap above the header for the tubes where the liquor is separated from the vapor. Black liquor is drawn off through the conduit 10 while the vapors escaping past the trap, which are in part made up of steam and part of uncondensable gases, pass off from the top of the evaporator through the conduit 11 to serve as a heating medium for the next effect. The steam used for heating in the first effect is substantially all condensed and is run off through the conduit 12 to the trap 13 from which

the water is lead to a drain unless the use of it is desired for low temperature heating.

Commencing with the second effect the heating action for the evaporator is provided by the vapor from the preceding effect and the instrumentalities operating between each of the remaining effects are substantially the same. They will accordingly be given the same reference characters and it is to be understood that the showing of them from Fig. 2 and the description of them for that figure will serve for all of them so that it need not be repeated. Thus, in the second effect as indicated at 2 vapor enters the evaporator shell 14 through the conduit 11 and that is the vapor resulting from the vaporization of the black liquor in the first effect. This vapor surrounds the tubes 15 through which passes the liquor being concentrated from the conduit 16. As the vapor and liquor going along with it emerges from the top of the tubes into the trap 17, the vapor passes out around that trap while the concentrated black liquor collects in the well 18 and flows off through the conduit 7 to the first effect. Vapor from the head of the evaporator then flows through another conduit 11 to enter the shell of the third effect in the same manner as similar vapor enters the shell of the second effect as just described.

Adjacent to the bottom of shell 14 in the second effect condensate and some remaining vapor including uncondensable gases pass through the pipe 19 into a trap 20 where the vapor and condensate are separated. The condensate collects in the bottom of trap 21 while the vapors pass upward out of the trap through the pipe 22 into the shell of a heat exchanger 23. The level of the liquid condensate in the trap 21 is controlled by a float 24 which controls the action of a valve 25 in the condensate line 26. This condensate is directed into a flash tank 27 where due to the reduced pressure, part of the liquor is again vaporized and passes up as vapor. The remainder, in liquid form, flows downwardly into the condensate pipe 28 and into the liquid containing section of the trap 20 of the next effect. The vapor from the flash tank 27 flows up the pipe 29 and enters the pipe 11 just prior to its joinder with the shell 14 of the evaporator of the third effect.

Returning to the heat exchanger 23 it will be noted that vapor from the pipe 22, which is made up of a condensable steam component and uncondensable gas, flows down through the shell of the heat exchanger, condensing as it goes and giving off its heat to the black liquor flowing up through the tubes 30 to heat the same prior to its entering into the bottom of the evaporator of the second effect. This black liquor is pumped into and through the heat exchanger through the pipe 31 by the action of the pump 32. It comes from an outlet pipe 7 which draws from the well 18 in the head of the evaporator of the third effect.

The venting of some of the vapor carrying uncondensable gases from the evaporator into the heat exchanger 23 prior to complete condensation in the evaporator makes for considerable saving in evaporator construction. In this manner the uncondensable gases are prevented from exerting much of their corrosive effect within the evaporator thus rendering it unnecessary to make the evaporator out of expensive corrosion resistant material. Instead, it is merely necessary to employ such material in the making of the heat exchangers 23 which are obviously much smaller and less expensive than the evaporators.

At the bottom of the heat exchanger 23 condensate from the vapor flows through the pipe 33 into the lower part of the trap 20 where it joins the condensate 21 already there. A certain amount of vapor still remains in the heat exchanger however, and by this time it has a high concentration of uncondensable gas in it. This vapor vents through the pipe 34 to a conduit 35.

Reverting now to the Fig. 1 it will be seen that

exhaust vapor from the heat exchangers of the third and fourth effects also vent into the conduit 35 which continues along to the heat exchanger 23 for the fifth effect. Here the vapor from the conduit 35 is seen to join with vapor from the pipe 22 leading up from the flash tank 20 for the fifth effect. This joining is by means of the pipe 36. Thus in this embodiment of the invention the heat exchanger for the fifth effect receives vapor directly from the heat exchangers of the second, third and fourth effects, as well as that which results from its own action. In this effect, however, the system is operating at a substantially lower temperature than the gradually increasing temperatures of the preceding effects so that the heat loss due to the action of the uncondensable gases in the vapor is considerably less than it would be at a higher temperature stage in the system. In this way heat loss due to the venting of some of the vapor from the evaporators of the preceding effects is reduced to the barest minimum. The invention accordingly enables a substantial saving to be made in operation along with the savings in maintenance and installation.

In this particular embodiment it is seen that any vapor venting from the heat exchanger of the fifth effect along with its contained uncondensable gases is vented through the pipe 34 to a continuation of the conduit 35 at 35' through which it is introduced into a jet condenser 37. Condensate from this condenser is collected at 38 and the uncondensable gases are removed through the pipe 39 by means of the vacuum pump 40. At the same time the heat contained in the vapor given off from the sixth effect through its pipe 11 is used in some suitable manner such as for the heating of water in a heat exchanger 41. Any of that vapor then remaining joins the conduit 35' through the pipe 42 to flow into the jet condenser 37.

The supply of thin liquor for the system is shown as entering the system through the pipe 43 by means of the pump 44 where part of it flows into the bottom of the fifth effect through the pipe 45 while a portion of it flows through a branch 46 of that pipe into the bottom of the sixth effect. Just prior to its entry into the bottom of the sixth effect, this flow is joined by the flow of initially concentrated liquor from the fifth effect through the pipe 47.

As an alternate to the foregoing system for collecting the vapor venting from the various heat exchangers and introducing the same into the heat exchanger 23 for the fifth effect, the conduit 35 can if desired be joined up directly with the continuing conduit 35' through a joining conduit 48 indicated in dotted lines in Fig. 1. In this instance the pipe 36 would be eliminated so that all of the vapor collected from the various heat exchangers could, if desired, be passed into the jet condenser 37.

Preferably, however, such combined vapor should first be employed for heating a fluid in another heat exchanger. Conduits for such flow are illustrated by the dotted lines 49 and 50 whereby the vapor is bypassed from the conduit 35' through a heat exchanger 51. Here it can serve for low temperature preheating of water or some other fluid entering at 52 and flowing out at 53. There are many instances in a mill where this grade of heating can be made effective.

By employing the additional heat exchanger 51, utilization of practically all of the heat from the vapors and uncondensable gases flowing from the prior heat exchangers is effected. Thus, though a small percentage of the vapor is drawn off from each evaporator before complete condensation is effected, practically all of the heat content is utilized and at the same time the evaporators are protected against the corrosive action of the uncondensable gases in the vapor. Thus the necessity of making the large, expensive evaporators out of corrosion resistant material is eliminated and substantial saving is effected since the only elements of the system which need to be made of such materials are the heat exchangers 23

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themselves. They may, of course, be made of stainless steel or other effective corrosion resistant materials.

It is, of course, to be understood that the details of equipment illustrated in the accompanying drawing and described in the foregoing are submitted for purposes of illustration, rather than limitation. Speaking more generally, since certain changes in carrying out the above method and in the constructions set forth, which embody the invention, may be made without departing from its scope, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

Having described my invention, what I desired to secure by Letters Patent is:

1. In the operation of a multiple effect evaporator system, for the evaporation of liquor having the tendency to liberate uncondensable gases when vaporized, including operation of evaporator bodies heated by vapor resulting from the vaporization of such liquor, those method steps which comprise partially condensing in one of the evaporator bodies such heating vapor delivered to that evaporator body while leaving a part of such heating vapor uncondensed, withdrawing said part of said heating vapor and the uncondensable gases from said evaporator body, employing said withdrawn heating vapor and uncondensable gases in combination in a preheating stage outside of said one evaporator body for the preheating of liquor to be vaporized in said evaporator body thereby condensing a further portion of said employed heating vapor, withdrawing the remainder of said heating vapor and said uncondensable gases from said preheating stage, combining said remainder of said heating vapor and said uncondensable gases with similar remainders of heating vapor and uncondensable gases from similar preheaters connected with subsequent evaporator bodies with regard to vapor flow of an evaporator system and employing said combination of vapor and gases for heating purposes in a low temperature heat transfer system outside of all of the evaporator bodies of said system.

2. In the operation of a multiple effect evaporator system, for the evaporation of liquor having the tendency to liberate uncondensable gases when vaporized, including operation of evaporator bodies heated by vapor resulting from the vaporization of such liquor, those method steps which comprise partially condensing in one of the evaporator bodies such heating vapor delivered to that evaporator body while leaving a part of such heating vapor uncondensed, withdrawing said part of said heating vapor and the uncondensable gases from said evaporator body, employing said withdrawn heating vapor and uncondensable gases in combination in a preheating stage outside of said one evaporator body for the preheating of liquor to be vaporized in said evaporator body thereby condensing a further portion of said employed heating vapor, withdrawing the remainder of said heating vapor and

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said uncondensable gases from said preheating stage, combining said remainder of said heating vapor and said uncondensable gases with similar remainders of heating vapor and uncondensable gases from similar preheaters connected with subsequent evaporator bodies with regard to vapor flow of an evaporator system and employing said combination of vapor and uncondensable gases for the preheating of liquor in the lowest temperature preheater of said system.

3. Method as in claim 2 and including extracting the uncondensable gases from the heating vapor remaining after employment in said lowest temperature preheater of the evaporator system and condensing the remaining vapor.

4. In the operation of a multiple effect evaporator system, for the evaporation of liquor having the tendency to liberate uncondensable gases when vaporized, including operation of evaporator bodies heated by vapor resulting from the vaporization of such liquor, those method steps which comprise partially condensing in one of the evaporator bodies such heating vapor delivered to that evaporator body while leaving a part of such heating vapor uncondensed, withdrawing said part of said heating vapor and the uncondensable gases from said evaporator body, employing said withdrawn heating vapor and uncondensable gases in combination in a preheating stage outside of said one evaporator body for the preheating of liquor to be vaporized in said evaporator body thereby condensing a portion of said employed heating vapor, withdrawing the remainder of said heating vapor and said uncondensable gases from said preheating stage, combining said remaining heater vapor and said uncondensable gases with similar remaining heating vapor and uncondensable gases from similar preheaters connected with subsequent evaporator bodies with regard to vapor flow of said evaporation system outside of all of the evaporator bodies of said system, condensing said combined vapor and extracting the uncondensable gases therefrom.

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