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N. A. COPELAND

2,498,752

TUBULAR FALLING FILM EXCHANGER

Filed Dec. 30, 1944

Fig. 1.

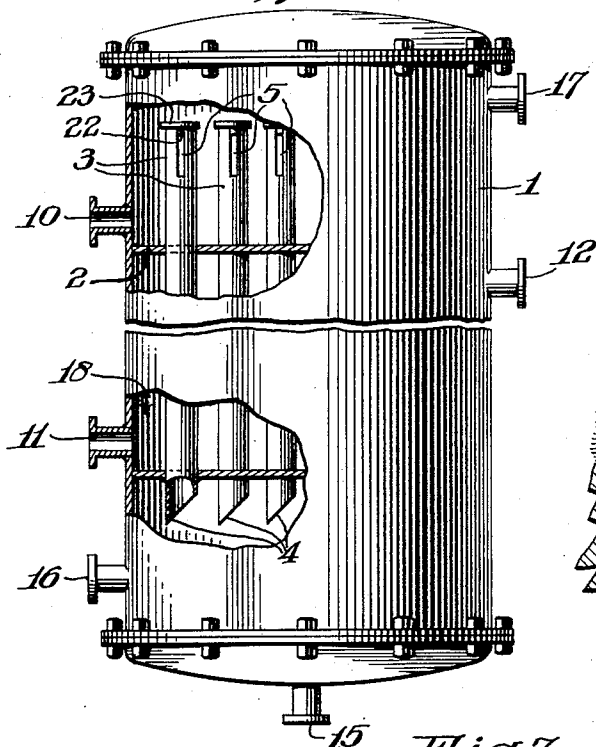


Fig. 3.

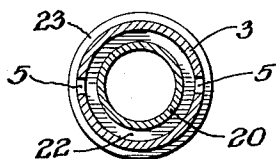


Fig. 2.

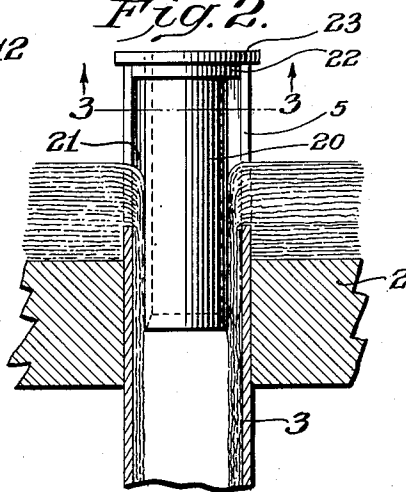


Fig. 5.

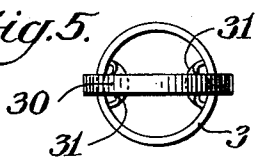


Fig. 7.

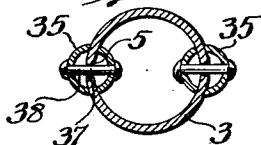


Fig. 9.

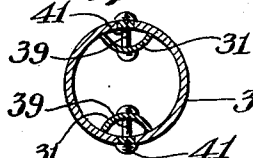


Fig. 4.

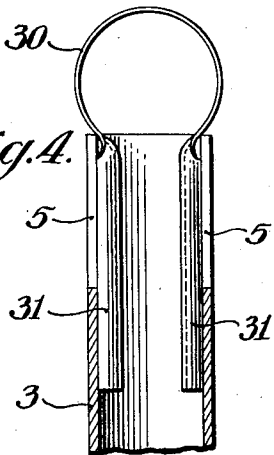


Fig. 6.

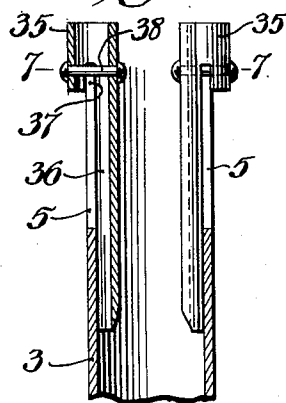
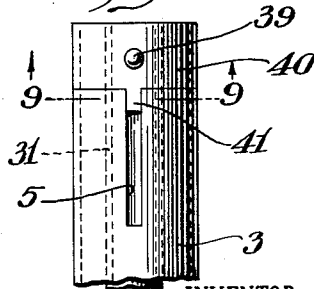


Fig. 8.



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TUBULAR FALLING-FILM EXCHANGER

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5 Claims. (Cl. 257—56)

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This invention relates to improvements in apparatus for boiling liquids or for effecting exchanges of heat and material between gases and liquids, and especially to such apparatus in which the liquid flows downwardly as a film on tubular walls of the elements and gas or vapor occupies the open space thereof, such as falling-film tubular strippers, boilers and absorbers.

The use of apparatus employing tubular falling-film elements is desirable in that small liquid hold-up in the tubes, good heat transfer and ease of cleaning is experienced as compared to other apparatus for such uses, such as packed columns. A minimum of liquid hold-up is desirable when treating materials which are sensitive to extended heating in order that the liquid may be subjected to heating for only a short time as compared to the exposure to heating in other forms of apparatus used for similar purposes wherein it is necessary to have considerable hold-up. Thus desirable relatively high temperature differentials can be used in falling film apparatus where the liquid hold-up is reduced to an extremely small amount. In falling-film tubular apparatus the tubular elements are commonly arranged in a vertical bundle in which the tubes are secured near their ends in tube sheets and at the top the tubes project above the tube sheet. The upper part of the apparatus may be in the form of a tank or receptacle with the tube sheet constituting the bottom thereof. In order to avoid unequal distribution of liquid among the tubes, it is common to extend the tubes above the top tube sheet and then cut notches or slots downwardly from the tops of the tubes in order to provide weirs through which the liquid issues into the tubes. In operation the level of liquid is carried considerably above the bottoms of the tubes so that the distribution of liquid among the tubes is satisfactorily uniform as to quantity, but the spill of the liquid into the tube constitutes obstructions near the tops which impair the capacity of the tubes to handle the ascending gas. The capacity of the tube to handle gases is limited by loading at the top where the liquid spills from the weirs and means are desired to provide relatively more space for the passage of gas and to increase the maximum gas rate through the tubes without loading.

It is among the objects of the present invention to provide means for improving the distribution of liquor in the tubes near the tops. Another object of the invention is to provide means for admitting of relatively higher gas velocities with tubes of given diameter and a given

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feed of liquor. Other objects of the invention will be apparent from the following description which is made with reference to the drawings in which

5 Figure 1 is a partial side elevational view with parts broken away of a tubular falling-film stripper,

Figure 2 is a partial side elevational view, partly in cross section of one tube of a falling-film stripper showing one modification of the present invention embodied therein,

Figure 3 is a cross sectional view taken along the line 3—3 of Figure 2,

Figure 4 is a view partially in side elevation and partially in cross section of a down flow tube showing another embodiment of the invention,

Figure 5 is a top plan view of the modification shown in Figure 4,

Figure 6 is a side elevational view of a further modification of the invention showing its method of attachment to the falling-film tube, the latter being shown fragmentally,

Figure 7 is a cross sectional view along the line 7—7 of Figure 6,

Figure 8 is a side elevational view of still another modification of the invention, and

Figure 9 is a top plan view of the device of Figure 8 assembled on a tube.

The general arrangement of the tubes in a falling-film exchanger is illustrated in Figure 1 which shows the shell 1 enclosing the tube sheets 2 forming a dome above the upper tube sheet, an enclosure below the lower tube sheet and an enclosure or belt for a heating or cooling medium between the tube sheets. The tubes 3 are sealed into the upper and lower tube sheets and tight joints are formed. This may be done by expanding the tubes into the tube sheets. The lower ends of the tubes are expanded into the lower tube sheet and they may be extended below the sheet and cut off obliquely for providing drip points 4. The lower ends of the tubes may also be enlarged to avoid loading at the bottom. The upper ends of the tubes 3 are extended above the upper tube sheet 2 a sufficient distance to permit the slots, notches or weirs 5 to be cut through the walls of the tubes at the ends thereof. Unslotted portions of tube may desirably be provided above the tube sheet. The latter allowance provides a reservoir for feed liquor surrounding the tubes 3 so that a uniform level of feed liquor will be assured on all the tubes when the feed liquor is supplied through the pipe 10.

The closed space between the tube sheets is traversed by the tubular elements and it consti-

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tubes a belt wherein heating or cooling medium may be introduced through the lower pipe 11 and conducted away through the upper pipe 12. Below the lower tube sheet is a receptacle or receiver which may be cone shaped at the bottom for collecting the liquid after it has passed through the tubes 3. A discharge pipe 15 is located at a low point in the receptacle and a gas-inlet pipe 16 is provided at a point in the receiver above the level of the outlet pipe 15. At the tops of the tubes 3 of Figure 1, the ejectors shown in detail in Figures 2 and 3 are mounted.

Referring to Figures 2 and 3, the ejector comprises a tube portion 20 having somewhat less diameter than the falling-film tube 3 so as to provide an annular space or passage 21 between the ejector and the inner wall of the tube 3. At the upper end an annular spacer 22 even with the upper end of tube 3 is brazed or otherwise secured to the tube 20 for retaining it in annular relationship. Secured to the end of tube 20 is a perforated cap 23 which may be in the form of a washer having an inner margin the diameter of the inner opening in tube 20 and an outer diameter slightly larger than the outer diameter of tube 3 so that the ejector will be retained at the top of the tube 3. The opening in cap 23 may be varied but it is desirably made to give the maximum passage for the gas issuing from the tubes.

In operation feed liquor is introduced through the pipe 10 until it rises above the lower ends of the slots or weirs 5. The liquor overflows into the tubes 3 and impinges on the tubular portion 20 or baffle portion of the ejector. The liquor then spreads out in the annular passage 21 and then downwardly along the inner wall of the tube 3. The gas which is fed into the lower header through the pipe 16 passes upwardly through the pipe 3 contacting with the falling film of liquid which flows down the inner walls of the tubes 3; then the gas is conducted past the weirs 5 through the tube 20 and thence into the dome and through the discharge pipe 17. In operations which require heating or cooling of the falling-film of liquor, an appropriate heating or cooling medium is maintained in the drum 18. If heating is desired and it is done with steam, the steam is passed into the steam belt through the pipe 12 and condensate is removed through the pipe 11. If a hot liquor or a cold liquor is used, it may be introduced through pipe 11 and removed through pipe 12.

The modification of the ejector shown in Figure 4 is in general the shape of the letter U with an enlarged bow portion 30 at the base which is larger than the inner diameter of the tube for limiting axial movement. The ejector may be constructed of a strip of flat metal. The terminal branches 31 of the ejector are grooved or bent longitudinally so as to form channels extending downwardly from the weirs 5 when the legs or extensions are disposed inside of the tubes 3 over the weirs. The legs or branches 31 are shaped to fit along the inner surfaces of the tubes 3 and the outer bowed portion 30 is sufficiently widened to rest on the end of the tube over the end of the weirs 5 as shown in Figure 5. The portion 30 is preferably made of metal which has considerable spring action and the member is shaped so that its terminal branches normally diverge from each other so that upon compressing them into parallel relationship the spring action of the part 30 will hold the channels in place by friction with the tube.

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In the modification shown in Figures 6 and 7, each ejector is designed to co-operate separately with each weir or slot. This modification comprises a tubular head member 35, a grooved extension 36 which extends along the tube 3 over the weir 5 and a slot 37 in the tubular head in which the wall of the tube 3 is inserted when the ejector is mounted. A rivet or bolt 38 extending through the tubular head and slot 37 fits into the weir 5 of tube 3 and retains the ejector in place.

In the modification shown in Figures 8 and 9, the head of the ejector is a band 40 which rests upon the top of tube 3 and the channel members 31 are supported from the collar 40 and attached thereto by rivets, bolts or studs 39. Ears or tabs 41 on the edge of the collar are formed to slide into the tops of the slots 5 for retaining the channel members in place so that the channels will communicate with the slots.

The invention provides means for greatly increasing the output of devices of the kind described. The improvement in operation of the devices results in large measure from the ability to handle greater quantities of gas in the tubes and to pass the gas at greater velocity with a given liquor feed and tube diameter. In an operation in which a volatile constituent was removed from a liquor by passing nitrogen through vertical tubes in countercurrent to a descending film of the liquid in the tubes, arranged in the manner illustrated in Figure 1, and heated by passing hot water through the heating belt, an increased handling of 50% of nitrogen over that which formerly caused loading at the top of the tubes was made possible by utilizing the invention. The increase in handling capacity of the gas resulted in processed liquid containing much less of the undesired volatile constituent per pass of liquid through the apparatus.

It will be apparent from the foregoing description that the invention is capable of modification without departing from the spirit and scope thereof, and it is to be understood that the invention is not restricted to the particular embodiments thereof which are specifically described.

I claim:

1. In a falling-film tubular exchanger having an upper tube sheet and an upright heat exchanger tube terminating above said tube sheet, said tube having an opening through the wall thereof above the tube sheet for admitting liquor thereto; of an ejector for preventing intermingling of liquid and gas where the liquid discharges into said tube which comprises a wall member facing the inside wall of the tube for forming a duct extending lengthwise of the tube and overlapping the portion of the tube having said opening, and means for maintaining the wall member in place.

2. In a falling-film tubular exchanger having an upper tube sheet and an upright heat exchanger tube terminating above said tube sheet, said tube having an opening through the wall thereof above the tube sheet for admitting liquor thereto; of an ejector for preventing intermingling of liquid and gas where the liquid discharges into said tube which comprises a wall member facing said opening and the inside surface of the tube wall, said wall member forming with the tube a conduit which extends downwardly along the tube wall from said opening, said conduit having a discharge opening issuing downwardly and parallel with the inside surface of the tube.

3. In a falling-film tubular exchanger having an upper tube sheet and an upright heat ex-

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changer tube terminating above said tube sheet, said tube having an opening through the wall thereof above the tube sheet for admitting liquor thereto; of an ejector for preventing intermingling of liquid and gas where the liquid discharges into said tube which comprises a channel member disposed inside of said tube with its axis parallel thereto and the wall of the channel member being spaced therefrom for forming an annular passage along the inner wall, means on said channel member for retaining its axis in parallel relationship with the tube, and means for suspending said tubular member from the slotted end portion of the tube.

4. In a falling-film tubular exchanger having an upper tube sheet and an upright heat exchanger tube terminating above said tube sheet, said tube having an opening through the wall thereof above the tube sheet for admitting liquor thereto; of an ejector for preventing intermingling of liquid and gas where the liquid discharges into said tube which comprises an elongated channel member forming a passage with the inner wall of the tube for conducting liquid in a stream parallel with said inner wall and to a point below the ends of the slots, an anchor member at one end for engaging the top of the tube and preventing longitudinal displacement of the member and means to prevent circumferential displacement of the member.

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5. In a falling-film tubular exchanger having an upper tube sheet and an upright heat exchanger tube terminating above said tube sheet, said tube having an opening through the wall thereof above the tube sheet for admitting liquor thereto; of an ejector for preventing intermingling of liquid and gas where the liquid discharges into said tube which comprises a pair of channel members forming ducts with the inner wall of the tube, extending into the slotted end of the tube and overlapping the slotted portions thereof, the walls of said channel members being joined at their outer ends by an elongated member bent for engaging the upper end of the tube and preventing longitudinal and circumferential displacement of said channel members.

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