Sept. 22, 1970 R. C. ROE 3,529,662

HORIZONTAL TUBE CONDENSER

Filed Nov. 13, 1967 3 Sheets-Sheet 1

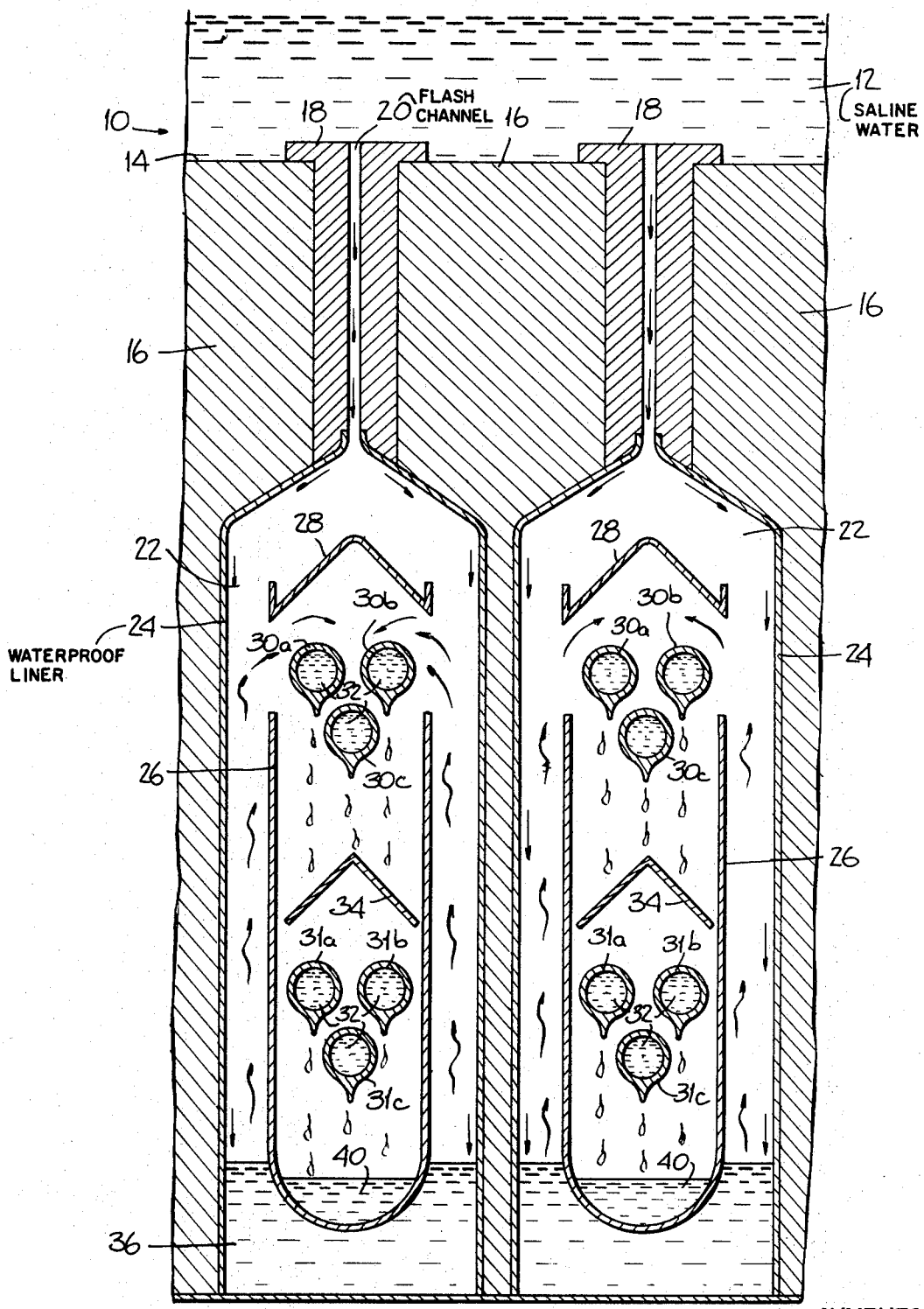


Fig. 1.

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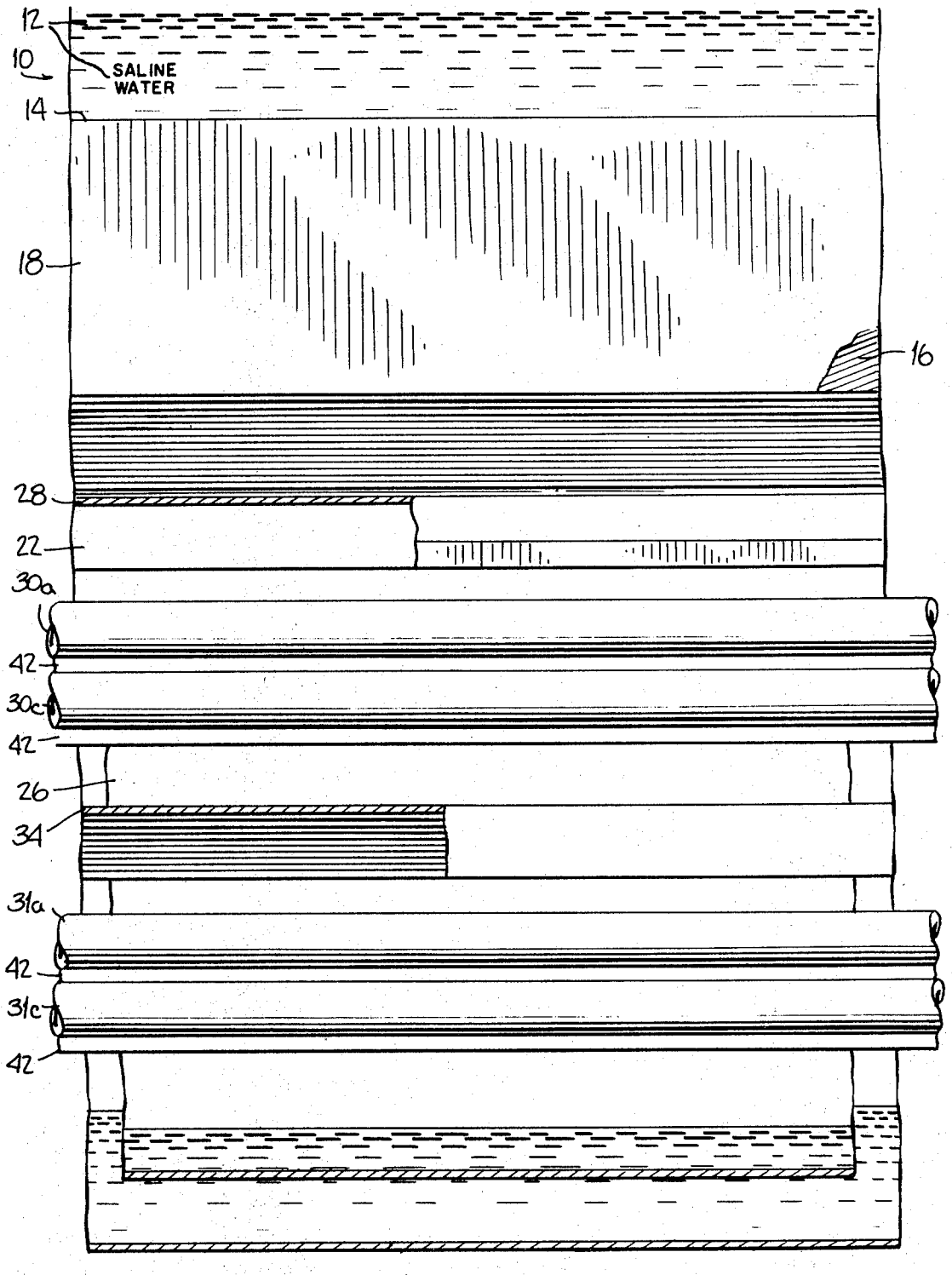


Fig. 2

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Fig. 3.

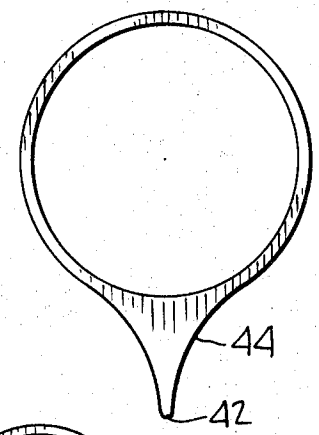


Fig. 4.

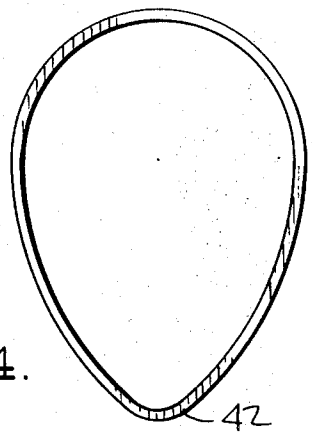


Fig. 5.

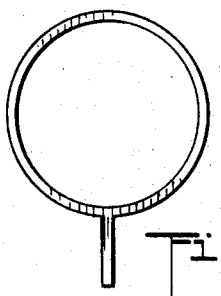
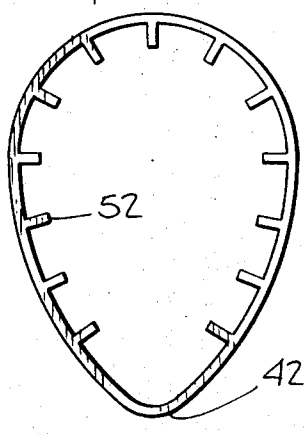


Fig. 8.

Fig. 7.



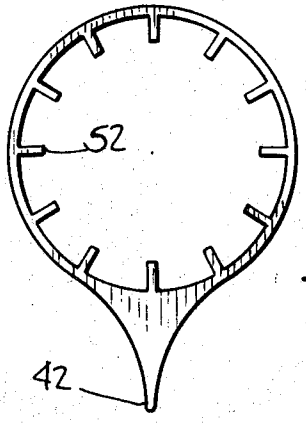


Fig. 6.

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United States Patent Office 3,529,662
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3,529,662

HORIZONTAL TUBE CONDENSER

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Filed Nov. 13, 1967, Ser. No. 682,362
Int. Cl. B01d 5/100; C02b 1/06
U.S. Cl. 165—111 6 Claims

ABSTRACT OF THE DISCLOSURE

A surface condenser with condenser tubes having fins depending in the direction of condensate flow to provide an edge whereby the effective or working surface of the condenser tubes is increased.

This invention relates to vapor condensation, and more particularly it concerns novel surface condenser structures useful in the condensation of steam and the like.

Surface condensers are widely used in connection with steam power plants in order to reduce the volume and therefore the back pressure of exhausted steam, so that a greater measure of power may be obtained from the system. Surface condensers have also been used in evaporation-condensation systems for the recovery of fresh water from saline or otherwise contaminated solutions.

The basic constructional configuration of a surface condenser unit involves an enclosure or outer elongated covering which is closed at each end by means of a tube sheet. A plurality of circular condenser tubes extend along the interior of the enclosure and pass through the tube sheets at each end thereof. A cooling fluid is caused to pass through the circular condenser tubes and serves to maintain their surfaces at a low temperature. Steam or other vapor to be condensed is then admitted into the enclosure; when it contacts the cooler surface of the condenser tubes, it condenses thereon into liquid form and drips down into a collection trough located below the tubes.

In order to obtain maximum efficiency in condenser units, it has been the practice to utilize a very large number of circular condenser tubes, each usually extending along the interior of the condenser enclosure and passing through the tube sheets at each end thereof. Typical prior art condenser units have anywhere from 22% to 45% of their tube sheet area occupied by condenser tubes.

One of the chief commercial drawbacks of a conventional surface condenser unit is its construction cost. The cost of each of the large number of condenser tubes used in the unit accounts for a major portion of the expense. In addition, the joining of each of the condenser tubes with the tube sheets is extremely expensive and time consuming since each joint must be skillfully sealed and examined for leaks. Moreover, structural problems result from the use of a large number of condenser tubes, since very little of the tube sheet remains at each end of the condenser to provide support for the condenser tubes. As a result, costly reinforcing structures are often provided.

The present invention provides a novel surface condenser tube which substantially increases the overall efficiency of the surface condenser unit. Since the overall efficiency of such units is increased substantially, fewer condenser tubes are necessary than were used in prior units of comparable capacity. Accordingly, the present invention provides a surface condenser unit which is less

complex and much more economical to construct than prior systems of comparable capacity.

I have found that the use of ordinary circular condenser tubes in surface condenser units involves certain inherent disadvantages. Thus, I have found that as the vapors condense into fluid on the surface of each of the circular condenser tubes and flow down and around the tubes before finally dripping off, the bottom of the tubes are coated with a thick fluid film in the area where fluid droplets form. In some instances, this area may range from 10 to 12% of the total surface area of each tube. The fluid film formed on this surface resists heat transfer that is necessary to carry out the desired condensation. Accordingly, the accumulation of this film on the surface of the condenser tubes reduces their overall effective or working surface.

According to one aspect of the present invention, I minimize the noted reduction of effective surface area on a surface condenser tube by reducing the area on which the water fluid can accumulate before dripping off. By reducing this area, I also reduce the area on which the undesirable water film develops and thereby increase the working area or effective surface of the condenser. The reduction in the area on which the condensate accumulates is effected by providing each condenser tube with a fin depending in the direction of condensate flow in such a way that a rather sharp edge is provided on the bottom surface of each. This edge may be formed by the fusion or addition of a drip-extension to the circular condenser tubes or by streamlining their surfaces to the desired configuration. Of course, further means known for expediting heat transfer in condenser tubes may also be used. For example, conducting fins may be provided on the internal surface of the condenser tube to further increase the cooling capacity of the tube.

According to another aspect of the present invention, the area on which the fluid accumulates is further reduced by serrating a condenser tube of the type herein discussed lengthwise along the apex of its depending fin configuration. The lengthwise serration of the condenser tube forms a series of point-like structures along the bottom of the tube, thus additionally decreasing the area in which the condensate may accumulate.

According to still another aspect of the present invention, the overall efficiency of surface condenser units is further increased by arranging condenser tubes of the type herein discussed in accordance with the teachings of my copending application Ser. No. 617,642, filed Feb. 21, 1967. As taught in the mentioned copending application Ser. No. 617,642, the efficiency of a surface condenser unit may be increased by arranging the condensers so that no condenser tube extends directly above another tube. With this arrangement, the condensate which forms at any location along any of the tubes, drops directly to the condensate collection means and avoids all further contact with tubes. As a result, the condenser tubes develop less condensate film than in previously known units and therefore are maintained at a higher heat transfer effectiveness. By shaping the condenser tubes in the constructional manner hereinabove discussed and by arranging these tubes in the manner taught in my copending application Ser. No. 617,642, not only will these combined features decrease the build-up of fluid film in surprisingly efficient manner, but also a more compact condenser unit may be built. Since the novel condenser tubes have a rather sharp edge or points on which the water accumulates, these structures aid in channeling the condensate directly to the collection trough in such a manner that the condenser tubes may be more closely arranged with each other in both the horizontal and vertical directions while still being vertically disaligned

so that the drippings of one tube do not touch another tube.

There has thus been outlined rather broadly the more important features of the invention in order that the detailed description thereof that follows may be better understood, and in order that the present contribution to the art may be better appreciated. There are, of course, additional features of the invention that will be described hereinafter and which will form the subject of the claims appended hereto. Those skilled in the art will appreciate that the conception upon which this disclosure is based may readily be utilized as a basis for the designing of other structures for carrying out the several purposes of the invention. It is important, therefore, that the claims be regarded as including such equivalent constructions as do not depart from the spirit and scope of the invention.

Certain specific applications of the invention have been chosen for purposes of illustration and description, but the invention should not be limited thereto since the surface condenser tubes disclosed herein have uses in all surface condenser units. These specific applications are shown in the accompanying drawings and are described in the following portions of the specification.

In the drawings:

FIG. 1 is a fragmentary sectional view of a condenser system embodying novel condenser tube structures according to the present invention;

FIG. 2 is a side view, partially broken away, illustrating the condenser system of FIG. 1;

FIG. 3 is a cross-sectional view of the condenser tubes in the system of FIG. 1;

FIG. 4 shows an alternative embodiment of a surface condenser tube in accordance with the present invention;

FIG. 5 shows another alternate embodiment of a surface condenser in accordance with the present invention;

FIG. 6 shows a condenser tube similar to that of FIG. 3 but having internal heat conducting fins;

FIG. 7 shows a condenser tube similar to that of FIG. 4 but having internal heat conducting fins;

FIG. 8 shows a lengthwise perspective of a further condenser tube in accordance with the present invention.

As shown in FIGS. 1 and 2, there is provided a fresh water recovery unit illustrated generally at **10**. At the top of this unit there is provided a reservoir of saline water **12** from which fresh water is to be recovered. The body of saline water **12** rests upon an upper surface **14** formed by a plurality of elongated structural members **16**. These elongated structural members are interrupted periodically by downwardly extending channel members **18**. The channel members **18**, as illustrated in FIG. 2, extend horizontally along with the structural members **16** from the front to the back of the unit **10**. The channel members **18** each define a narrow evaporation channel **20** which opens to and extends vertically between the reservoir of saline water **12** and an associated condenser region **22**. The condenser regions **22** are of considerably greater width than their associated evaporation channels **20**; and, as illustrated in FIG. 2, they also extend from the front to the rear of the device.

Each condenser region **22** is lined with a waterproof liner **24** and is provided with a U-shaped separator element **26** which extends from the front to the back of the device.

Approximately halfway between the top of the U-shaped separator elements **26** and the top of the condenser regions **22**, there is a canopy-like upper baffle **28** which extends over the separator elements **26** to prevent any liquid droplets from falling directly down into the U-shaped separator element. This baffle **28**, as well as the remaining baffles hereinafter described, may take alternative shapes. For example, the baffle may consist of an inclined flat metal sheet which deflects the liquid droplets to one side of condenser region **22**.

As shown in FIG. 1, there is provided an upper set of condenser tubes **30***a*, **30***b*, and **30***c*, within the condenser region **22**. There is also provided a lower set of condensing tubes **31***a*, **31***b* and **31***c* just under the upper set within the condenser region. The condenser tubes extend horizontally between the front and back tube sheets of the device (not shown) and are supplied with coolant liquid **32** from an external source (not shown). It will be noted that the condenser tubes in each of the sets are arranged along a triangular pattern so that no tube in any set is directly above another tube in that set. This vertical disalignment of the tubes serves to prevent drippage of condensate from any one tube down upon another tube in the set.

An intermediate baffle **34** is placed between the two sets of tubes **30** and **31** in order to direct the condensate which falls from the upper set away from the tubes of the lower set. This baffle **34** may take alternative shapes in the same manner as baffle **28**, discussed above.

In the preferred embodiment, condenser tubes **30***a–c* and **31***a–c* are each of like configuration. As shown in FIGS. 1, 3 and 6, the surface of each tube is streamlined in the direction of condensate flow so as to provide a rather sharp edge, indicated generally at **42**, on the bottom area of the condenser tube. Edge **42** may be formed, for example, by fusing or mechanically adding a drip extension or fin **44** to a circular condenser tube, or the tubes may be formed in the configuration illustrated. Alternatively, as shown in FIGS. 4 and 7, a teardrop shaped tube may be used to provide the desired edge-like surface; or, as shown in FIG. 5, a straight ribbon fin mechanically added or fused to an otherwise ordinary circular condenser tube may provide the desired configuration. As an alternative to the edge-like structure provided by each of the embodiments discussed hereinabove, the condenser tube **48** illustrated in FIG. 8 may be used. This tube provides a series of points **50** on the bottom of the tube **48**. The tube may be constructed by serrating a condenser tube of substantially the same configuration as FIG. 3 lengthwise along the apex of its streamlined configuration. This construction additionally streamlines a tube of the configuration of FIG. 3 in the longitudinal direction and thus further reduces the area on which water film can accumulate. Additionally, the condenser tube configuration of FIG. 5 may also be lengthwise serrated in the same manner.

As shown in FIGS. 6 and 7, further heat transfer, and thus greater overall efficiency, may be obtained by providing internal heat conducting fins **52** in each of the condenser tube embodiments previously mentioned.

The system described above operates in the following manner: The saline water **12** located above the upper surface **14** is maintained in a saturation condition. The saturated saline water flows gradually down through the evaporation channels **20** in the channel members **18** toward the condenser regions **22**. During this downward flow, the water experiences a gradual pressure drop which results in a controlled flashtype evaporation whereby a portion of the saline water is vaporized. The vapors generated are impelled at a rapid rate downwardly through the channel **20** and are accompanied by a smoothly distributed pressure gradient along the channel which results in a gradual evaporation along the channel. This evaporation is similar to the controlled flash achieved according to U.S. Pat. No. 3,214,350. Any unevaporated liquid follows, for the most part, the walls of the condenser region **22** down to a saline water collection trough **36** at the bottom of the condenser region **22**. Baffle **28** prevents drippage from the unevaporated saline water from entering the interior of the U-shaped separator element **26**.

The generated vapors fill the greater portion of condenser region **22**, and directly contact the outer surfaces of the streamlined condenser tubes **30***a–c* and **31***a–c* whereby condensate is formed on the surfaces thereof.

The condensate formed on each of the surfaces flows around and down the streamlined surface toward the edge or apex **42**. The condensate accumulates on the edge **42** and finally drips off to be collected in the fresh water trough, shown generally at **40**.

As fully explained in my aforementioned copending application Ser. No. 617,642, condenser tubes **30***a–c* are arranged in vertical disalignment so that no condenser tube is directly above another. As a result, the condensate formed on each tube passes directly to intermediate baffle **34** without touching the other tubes and from there to the fresh water trough **40**. Condenser tubes **31***a–c* are similarly vertically disaligned so that the drippings of each pass directly to the fresh water collection trough **40**.

It will be noted from the above that the condensate accumulates in the area along the edge or apex of the streamlined condenser tubes. While some water film will form in this area, the extent of this area is much smaller than would be the case with a circular condenser tube. Accordingly, the present invention increases the working area or effective surface of condenser tubes to a degree not heretofore obtainable by circular condenser tubes and thereby substantially increases the overall efficiency of the condenser unit. Since the overall efficiency of this unit is substantially increased, fewer condenser tubes are necessary than are used in condenser systems of comparable capacity but which utilize circular condenser tubes. Accordingly, the condenser unit is less complex and more economical to construct than prior condensers of comparable capacity.

It will also be noted from the above that by arranging the condenser tubes in accordance with the teachings of my copending application Ser. No. 617,642, not only are the beenfits disclosed therein derived, but also a more compact condenser unit may be built. Since the streamlined condenser tubes have a rather sharp edge, these structures aid in channeling the condensate directly to the collection trough in such a manner that the condenser tubes may be more closely arranged with each other in both the horizontal and vertical directions while still being vertically disaligned so that the drippings of one tube do not touch another tube.

It will be appreciated from the above that the present invention increases the efficiency of otherwise known surface condensers. Thus, by providing condenser tubes having a fin depending in the direction of condensate flow to provide a lengthwise edge, a very efficient condenser unit is achieved.

What is claimed as new and desired to be secured by Letters Patent is:

1. In a condenser for the recovery of condensate from an evaporation and condensation system, the combination of means defining a chamber, a plurality of condenser tubes extending horizontally through said chamber and arranged therein with their axes in vertical disalignment so that no condenser tube extends directly above another tube whereby the condensate which forms at any location along each of said tubes drops directly down from said location and avoids further contact with said tubes, means for admitting vapor into said chamber to be condensed therein and on said tubes, and a condensate collection trough positioned under said plurality of said condenser tubes; the improvement wherein at least part of the surface of each of said condenser tubes is streamlined in the direction of condensate flow to provide lengthwise a rather sharp edge whereby the accumulation of water condensate film on the surface thereof is substantially reduced.

2. The condenser as in claim **1** wherein each of said condenser tubes comprises a circular condenser tube having a straight ribbon fin.

3. The condenser as in claim **1** wherein each of said condenser tubes is serrated lengthwise along the apex of their streamlined configuration.

4. The condenser as in claim **1** wherein each of said condenser tubes is cross-sectionally teardrop shaped.

5. The condenser as in claim **1** wherein each of said condenser tubes includes a circular tube with a drip extension.

6. The condenser as in claim **1** wherein each of said condenser tubes includes internal heat conducting fins.

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165—117; 202—185, 198; 203—10