

Aug. 15, 1933.

J. EPSTEIN

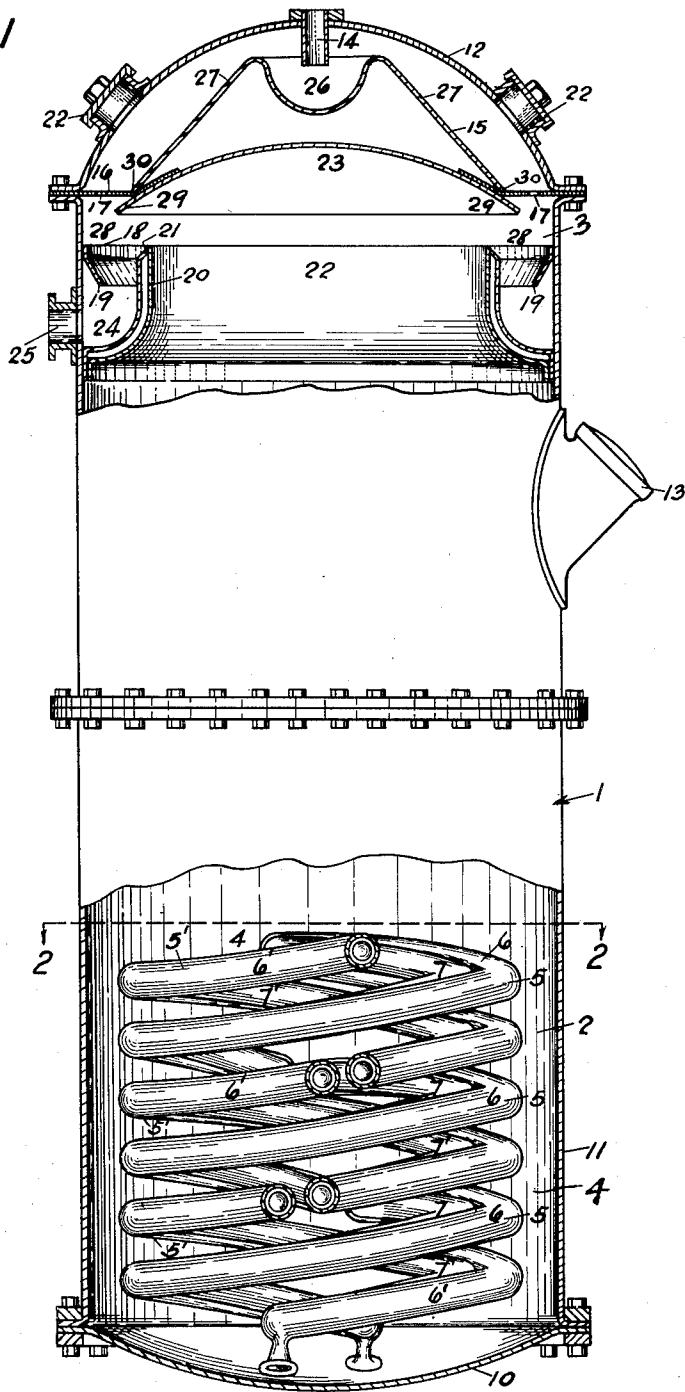
1,922,844

HEAT EXCHANGE DEVICE

Filed May 14, 1930

4 Sheets-Sheet 1

FIG. 1



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FIG. 4

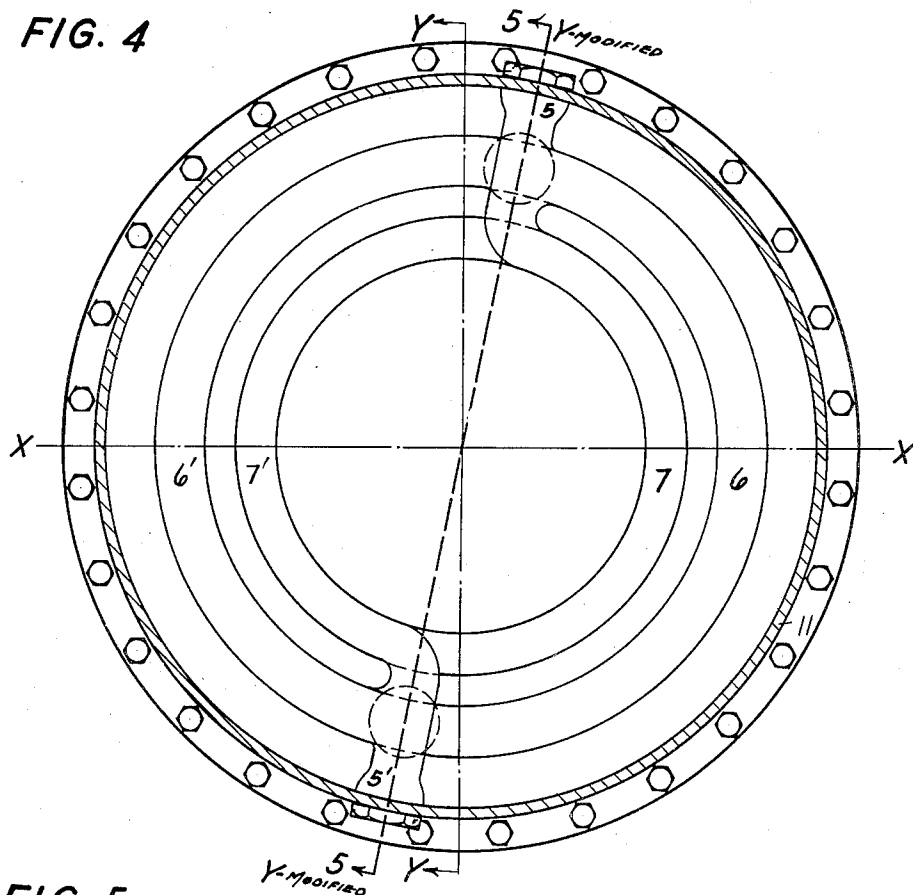
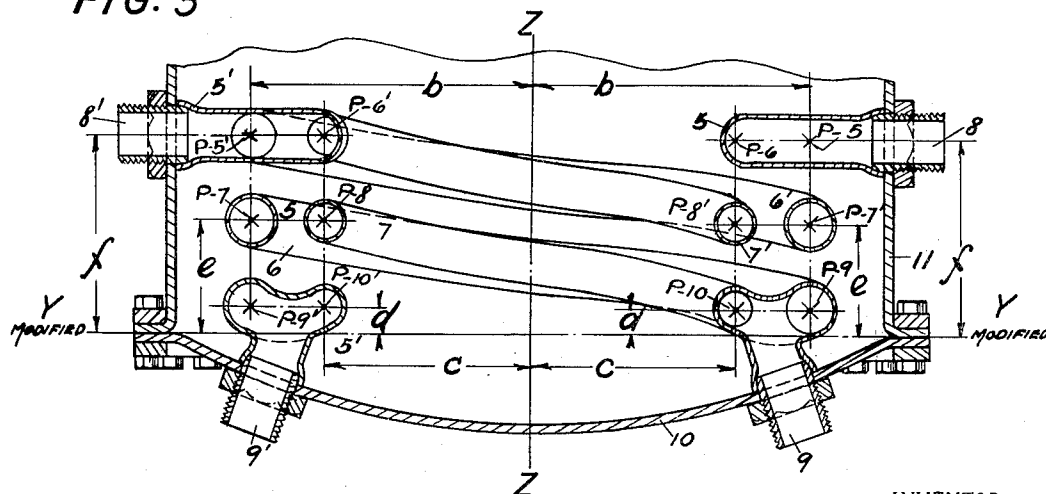


FIG. 5



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FIG. 6

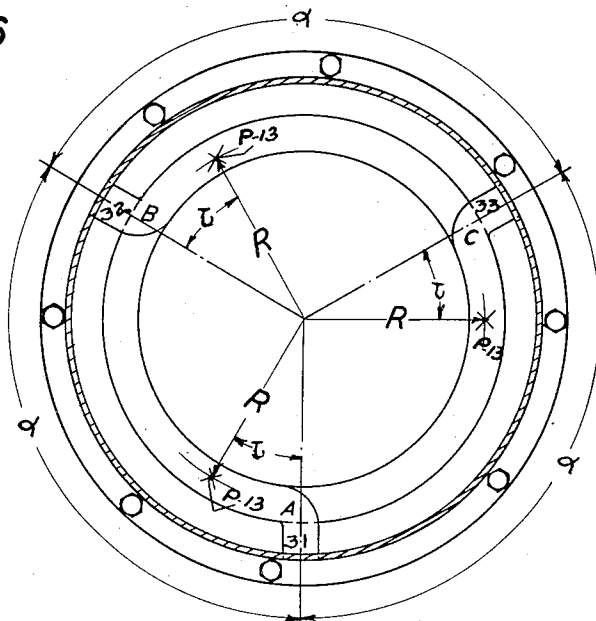
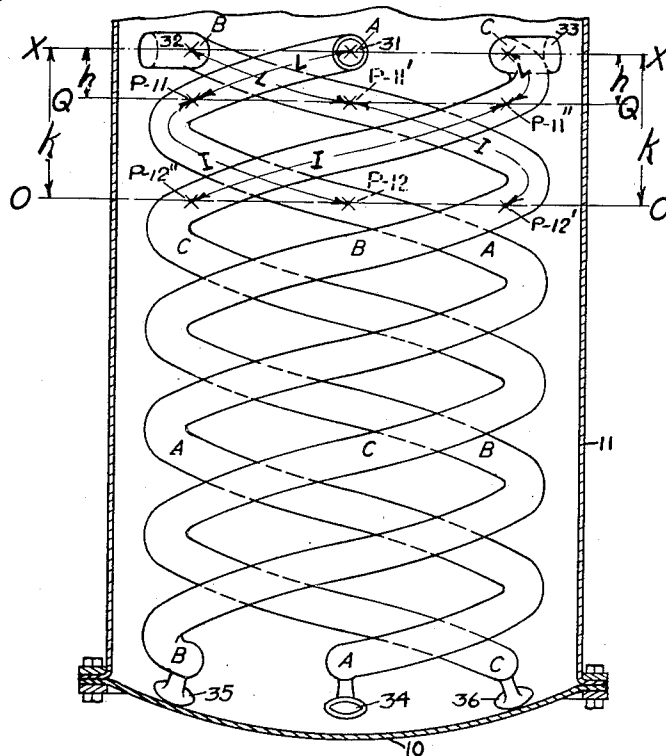


FIG. 7



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HEAT EXCHANGE DEVICE

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2 Claims. (Cl. 257—229)

This invention relates to heat exchange apparatus and has for its object the production of an improved apparatus of this class.

This invention relates further to evaporators and has for its object the production of a new and improved evaporator.

Evaporators now in general use have either a plurality of an inclined coils or a plurality of non-inclined coils. Any plane which is at right angles to the axis of the imaginary cylinder around which the coils are wound will cut the axis of each of the said coils in a certain point. However, the temperature of the heating element in the said coils will be different at each of the points so cut. This results in many serious disadvantages among which are unequal evaporation, unbalanced convection currents, improper circulation and uneven velocity in the substance being evaporated. It is an object of this invention to produce an evaporator having a plurality of coils and so constructed that equal temperature conditions will exist at all points cut by the coils in any plane at right angles to the axis of the imaginary cylinder around which the coils are wound and that all such points will be equally spaced around the circumference of the said imaginary cylinder, thus eliminating the above enumerated as well as other objections due to unequal temperature conditions at equivalent points in the same plane. This is effected by the use of multiple thread coils, that is a plurality of equal slanting coils having a common imaginary cylinder at their base, having all of the inlets in a common plane and equally spaced around a given periphery and further having all of their outlets in a common plane and also equally spaced around a given periphery.

Another object of this invention is to produce an evaporator wherein the maximum heating efficiency will be secured for the space occupied.

Another object of this invention is to produce an evaporator having an improved condenser element whereby the efficiency of the entire device will be increased.

Another object of this invention is to produce an evaporator with coils or fluid chambers having an appreciably greater pitch than that now in use without in any way lowering the efficiency of the unit.

These as well as other objects and advantages which result from my novel construction will become more apparent from the following description and the drawings which form a part thereof.

In the drawings Figure 1 is a front view show-

ing the invention embodied in a milk evaporator. Parts of the shell are broken away to better show the novel features and portions of these are shown in perspective. In this particular embodiment each unit is composed of two coils and each coil in the unit is made up of an outer and inner coil member.

Figure 2 is a section taken along the line 2—2 of Figure 1.

Figure 3 is an enlarged front view with the shell broken away and showing a coil unit.

Figure 4 is a section taken along the line 4—4 of Figure 3.

Figure 5 is a section taken along the line 5—5 of Figure 4.

Figure 6 is a section taken similarly to Figure 2 of a unit having three independent coils.

Figure 7 is a front view of the disclosure shown in Figure 6.

Referring more particularly to the drawings wherein similar reference numerals denote similar parts, reference numeral 1 denotes the evaporator as a unit composed of a heating section 2 and a condenser section 3, contained in a shell having a bottom portion 10, a cylindrical body portion 11 and a top portion 12. The evaporator is provided with a manhole 13 and the usual gage (not shown), neither of which constitutes a part of this invention and for that reason will not be here further discussed.

The heating section 2 is composed of the usual portion or pan 4 adapted to hold the milk to be treated and a plurality of equal, cooperating, equally slanting and oppositely disposed pairs of coils 5—5'. It is to be noted that the two coils form a multiple thread. The coils which appear on the same half section of the imaginary cylinder around which they are wound slant in the same direction. Those which appear on opposite faces only slant in opposite directions.

Each of the coils 5 is composed of an outer coil 6 and a substantially parallel inner coil 7 having a common inlet 8 and common outlet 9, while each of the coils 5' is composed of an outer coil 6' and a substantially parallel inner coil 7' having a common inlet 8' and a common outlet 9'. The inlets 8 and 8' and the outlets 9 and 9' are connected to steam manifolds in the manner well known in the art and for that reason will not be further described here. The inlets 8 and 8' are in the same plane, are oppositely disposed and are substantially at the same distance from the source of steam supply. The outlets 9 and 9' are in the same plane and oppositely disposed. (Since there are only two coils in the unit and

since they are equally spaced around the periphery of a given circle the inlets or the outlets must be 180 degrees apart or oppositely disposed.) Because of this particular structure, the cooperating, equal, equally slanting, and oppositely disposed pairs of coils have the following characteristics:—

(a) Two coils fit together to form a cooperating pair, see particularly Figures 1 and 3, thus resulting in the maximum heating efficiency for the space occupied.

(b) The coils have equal gradients so that the following results are obtained:

(1) The grade in the coils permits the steam which condenses in the coils to drain away. Thus there is always exposed to the milk which is being evaporated coils which are always full of steam and which are the same temperature at all points of any given cross sectional area of the coil, thus causing an even and rapid circulation of the milk around the coils. Caking of the milk on the coils is thus prevented.

(2) The coils being full of steam the entire coil surface at any point takes part in the heat exchange at the heat exchange value of steam, no wet areas being present to change the heat exchange value at any point of the coil on a given circumference with respect to the other points.

(c) The particular structure of the coils further results in the fact that all points which the coils cut on any horizontal plane (that is the plane at right angles to the axis of the imaginary cylinder around which the coils are wound) are equidistant from the inlets of the said coils and are equally spaced around the periphery of the circumference of the said cylinder, thus assuring equal temperatures for all equivalent points in the same plane, since two such points of any two cooperating coils are at the same distance from the entrance into the coil of steam coming from a common source and therefore have the same potential heat exchange capacity.

This feature can be seen by inspecting any figure of the drawings and has been particularly illustrated in Figures 2, 3, 4 and 5.

An inspection of Figures 1, 3 and 5 discloses that any horizontal plane will cut only a pair of cooperating coils and at diametrically opposite points both the inner and outer coils will be cut.

An examination of Figures 2 and 4 discloses any two diametrically opposite points P and P' on the outside coil members 6 and 6' of a cooperating pair of coils 5 and 5' have equivalent x and y coordinates. That is the points may lie in different quadrants causing the coordinates to have different algebraic signs but they are numerically equal. The same holds true for any two diametrically disposed points P—1 and P—1' on the inner coils 7 and 7' respectively.

An examination of Figures 3 and 5 discloses that the same is true for points having x — z or y — z coordinates.

In Figure 3 compare points P—3 with P—3' on the outer coils 6 and 6': Also points P—4 with P—4' on the inner coils 7 and 7' respectively.

In Figure 5 compare points P—5 with P—5', P—7 with P—7', P—9 with P—9', all on the outer coils 5 and 5' respectively. Also compare points P—6 with P—6', P—8 with P—8', P—10 with P—10' all on the inner coils respectively. It is seen that the coordinates, which have been denoted by letter as to numerical value, are equal for similar points. (It is to be noted that instead of taking the true y — y axis for Figure 5 it has

been shifted somewhat and a modified y axis used. This has been done for the double purpose of picking a point off the conventional right angular axes and also for the purpose of more clearly illustrating the relative positions of the entrance and exit points of a cooperating pair of tubes 5 and 5'.)

(d) As a direct result of the fact that the temperature conditions at any two diametrically disposed points on any cooperating pair of coils are equal, the following advantages are obtained:

(1) Balanced and symmetrical convection currents.

(2) Even circulation of the contents being evaporated.

(3) Even velocity in the contents being evaporated.

(4) Equal rate of evaporation of all points in the evaporator having equivalent x , y , z coordinates.

From the above it is seen that the novel structure here disclosed gives all of the benefits which are obtained from a constant, steady heat.

The condenser portion 3 is composed of cooling element inlet means 14, a baffle 15, a plate 16 having a plurality of perforations 17 therein, a plate 18 formed in an inverted frustum of a cone and having its lower edge 19 terminating below the top edge 21 of the funnel or outlet 20. A plurality of the usual cleaning plugs or manhole 22 are provided in a manner well known in the art.

Although the operation of the device is believed to be obvious from the above disclosure yet to obviate any possibility of misunderstanding the following detailed description is here given.

The milk which is to be evaporated is introduced into the evaporator in the usual manner well known in the art in the amount desired. Steam is introduced into the coils in the usual manner. As the liquid evaporates it proceeds upward in a vapor through the mouth 22, striking the bottom plate 23 of the baffle 15 and is deflected towards the space 24 and where it is condensed and drawn out through the opening 25 by a vacuum pump, not shown, in the manner well known in the art.

The condensing fluid (water in this particular case) enters through the pipe 14, accumulates in the cup shaped portion 26 of the baffle 15 and trickles over the sides 27 of the baffle 15 onto the plate 16, through the perforations 17, from where it drops into the opening 28, meeting the vapors which are being deflected and drawn into the space 24 by the plate 23 of the baffle 15 and by the pump, not shown. It is to be noted that the ends 29 of the deflector plate 23 extend beyond the edges 21 of the funnel 20 and also beyond the edge 30 of the sides 27.

The condensing fluid takes up the heat of the vapors and helps to condense them so that they may be drawn off through the outlet 25 by the pump, not shown. Because of the peculiar construction of the plate 18 the vapors rising from the evaporator and the condensing liquid are both constricted into a smaller space in their passage from the space 28 to the space 24. This results in a better intermingling of the condensing liquids with the vapors rising from the evaporator, thus making for better condensation.

When the evaporation process has been carried to the point desired, the supply of steam is cut off and the steps well known in the art are followed. The solid substance remaining in the kettle is withdrawn in the manner well known

in the art. These steps do not constitute a part of this invention, are well known in the art, and for these reasons will not be described in any detail here.

5 During the evaporation process steam continually enters through the inlets 8 and 8' of each coil and leaves by the outlets 9 and 9' of the said coils. It is to be noted that the steam for any pair of cooperating coils 5 and 5' comes from a
10 common source and enters the coil at practically the same temperature. Since the x, y, z coordinates of any two diametrically opposite points of cooperating coils are always equivalent, it is obvious that the steam in its course through the
15 coils 5 and 5' meets the same temperature conditions at all points having equivalent x, y, z coordinates and, therefore, the reaction caused and the heat exchanged at these points by either coil will always be equal to that of the other.

20 It is to be distinctly understood that although the invention has been described in detail by reference to a single pair of cooperating coils 5 and 5', each of the said coils 5 and 5' being composed of an outer and inner coil respectively, it is not
25 to be limited to such a structure. Any number of coils may be used whether odd or even. In Figures 6 and 7 a modification employing three or an odd number of coils is shown.

Referring more particularly to Figures 6 and 7
30 it is seen that the evaporator is provided with three equal coils A, B and C having inlets 31, 32 and 33 respectively in the same plane and equally spaced around the periphery of a circle which
35 could be circumscribed or inscribed around the coils. In this particular illustration the inlets must be spaced 120 degrees apart since there are three inlets. The coils A, B and C are arranged at an equal gradient in multiple thread formation. It is to be noted that coils on the same
40 half section of the imaginary cylinder around which they are wound slant in the same direction, while those around on the opposite side slant in the opposite direction. The numerical value of the tangent or gradient is equal however
45 for the coils on either half-section. The inlets 31, 32 and 33 are connected to a common source of steam so that the steam entering any one coil is of equal quality to that entering any of the
50 other coils.

The coils A, B and C have common outlets 34, 35 and 36 respectively in the same plane and
55 equally spaced around the periphery of a circle which could be circumscribed around or inscribed within the coils. In this particular case the outlets, since there are three, must be spaced one hundred and twenty (120) degrees apart.

It is to be noted that the coils are equal, equally slanting, have inlets in a common plane and
60 equally spaced around the periphery of a circle circumscribed about or inscribed within the coils or around the circumference of the cylinder around which the coils are wound, have outlets in a common plane and equally spaced around the
65 periphery of a circle which may be circumscribed about or inscribed within the coils or around the circumference of the cylinder around which the coils are wound and that this structure results in the fact that any horizontal plane (that is the
70 plane at right angles to the axis of the imaginary cylinder around which the coils are wound) will cut points on each of the three coils that are equally distant from their respective inlets and equally spaced around the periphery of the circumference of the said cylinder, thus resulting in
75 equal temperatures for all equivalent points in

the said plane and the advantages outlined hereinabove.

This becomes evident from an examination of Figures 6 and 7. In this particular case reference must be had by the use of polar coordinates since Cartesian coordinates used in connection
80 with Figures 1 to 5 cannot be used. (Cartesian coordinates were used in connection with Figures 1 to 5 since the use of only two coils resulted in the coils being spaced 180 degrees apart as to
85 inlets and outlets.)

It is to be noted that since the inlets 31, 32 and 33 are equally spaced around the periphery of a circle angle $\alpha = \text{angle } \alpha = \text{angle } \alpha = 120$ degrees.

In any horizontal plane any point (P—13)
90 chosen on any coil (coil A) at a vector distance r and angle τ from a base line determined by the diameter passing through center of the inlet 31 of the said coil will have equivalent points
95 P—13' and P—13'' respectively on the remaining coils B and C, at a vector distance r and at the angles α which is constant at 120 degrees) plus τ and 2α plus τ respectively, from the said base line. The coordinates α, r and $2\alpha, r$ fall on a
100 line passing through the center of the inlets 32 and 33. The points having coordinates $(\alpha + \tau)r$ and $(2\alpha + \tau)r$ are, therefore, at an angle τ distant from the inlet base lines of their respective coils. The points P—13, P—13' and P—13'' are
105 therefore equally spaced around the periphery of the circumference of the said imaginary cylinder.

Compare further points P—11, P—11' and P—11'' on coils A, B and C respectively in Figure
110 7 which were cut by the horizontal plane Q—Q at a distance h from the horizontal plane passing through the center lines of the inlets 31, 32 and 33 respectively. These points are equally spaced around the periphery of the said imaginary cylinder. It is seen that the distance "L,"
115 measured along the coil A from the inlet 31 to P—11 is equal to that from the inlets 32 and 33 to points P—11' and P—11'' respectively.

Compare further points P—12, P—12' and P—12'' on coils A, B and C respectively cut by
120 the horizontal plane O—O at a distance k from the horizontal plane passing through the center line of the inlets. As has been previously proved the points are equally spaced around the periphery of the imaginary cylinder. The distance
125 I measured along the coil A from the points P—11 to P—12 is equal to that from the points P—11' and P—11'' to P—12' and P—12'' respectively.

It is to be distinctly understood that the above
130 disclosure is by the way of illustration only and not by the way of limitation since many changes may be made in the construction here shown without departing in any way from the spirit of my invention.

For instance, the number of pairs of coils may
135 be varied: Or instead of using a plurality of pairs of double coils, an inner and outer coil for each unit in a pair of coils, coils having only one coil in each coil unit may be used: Or, instead of using two or three coils in each unit
140 any other number may be used. It is understood from the above disclosure that if four coils are used the inlets are spaced

$$\frac{360}{4}$$

145

or 90 degrees apart, if five coils are used, the inlets are spaced

$$\frac{360}{5}$$

150

or 72 degrees, etc. The outlets of course are similarly spaced. All the inlets, however, are in one plane, all the outlets are in one plane and the gradient is equal for all coils no matter how many are used: Or the gradient and/or size of the coils may be varied: Or, instead of evaporating milk, used in the specific embodiment herein disclosed, any other substance of the same nature or requiring equivalent treatment may be used: Or, instead of using steam as the heat exchange medium in the coils, any medium may be used: Or, instead of using the coils herein disclosed in the evaporator, it may be used in any heat exchange device, including refrigerators and refrigerating plants: Or the material and shape of any particular unit here disclosed may be varied.

It is, therefore, my desire that the claims which are hereto appended and which define my invention should be limited only by the prior art.

It is obvious from an examination of Figures 1 to 5 inclusive that the pitch of coils 5 and 5' is double that of the coils now in use. In the disclosure herein the coil 5 is stretched so that the distance from inlet to outlet occupies the space occupied in previous art disclosures by two coils one on top of the other. By placing coil 5' within coil 5 in the manner herein disclosed the potential heat exchange value present in the previously known art is not lost. In fact greater efficiency is obtained since the heat exchange medium passes through a greater portion of the portion to be heated. From Figures 6 and 7 it is seen that where three coils are used in a unit the pitch is increased threefold. Likewise where four coils would be used the pitch is increased fourfold, etc.

Having described my invention what I claim as new and useful is:—

1. An evaporator consisting of a shell, a pan member for holding a substance to be treated, the said pan member terminating in a funnel outlet for the vapor, a chamber formed between the outer walls of the said funnel outlet of the said pan member and the said shell; one or more units of plural, equal, cooperating and equal slanting coils mounted in the said pan member for delivering a heat exchange fluid to the matter to be treated at an equal temperature for all points in the same horizontal plane, the said coils in any one unit having their inlets in the same plane, their outlets in the same plane and

their inlets and outlets equally spaced around the circumference of the imaginary cylinder around which the coils are wound; and a condenser for condensing the fluids distilled from the substance being treated, the said condenser consisting of a baffle member placed above the mouth of the said funnel having a concave bottom plate the edges of the said plate terminating beyond the edges of the said pan outlet, means for supplying a cooling fluid to the said baffle member, a perforated plate mounted above the edges of the said concave bottom baffle member, the said concave member, the said perforated plate and the said funnel outlet combining to form a condensation chamber and means within the said chamber and below the top of the said outlet for constricting the area of the said condensation chamber; and a pump outlet formed in the said shell for permitting the condensed liquid to be drawn off.

2. An evaporator consisting of a shell, a pan member for holding a substance to be treated, the said pan member terminating in a funnel outlet for the vapor, a chamber formed between the outer walls of the said funnel outlet of the said pan member and the said shell; one or more pairs of equal, cooperating and equal slanting coils mounted in the said pan member for delivering a heat exchange fluid to the matter to be treated at an equal temperature for all diametrically opposite points in the same horizontal plane; and a condenser for condensing the fluids distilled from the substance being treated, the said condenser consisting of a baffle member placed above the mouth of the said funnel having a concave bottom plate the edges of the said plate terminating beyond the edges of the said pan outlet, means for supplying a cooling fluid to the said baffle member, a perforated plate mounted above the edges of the said concave bottom baffle member, the said concave member, the said perforated plate and the said funnel outlet combining to form a condensation chamber and means within the said chamber and below the top of the said outlet for constricting the area of the said condensation chamber, the said means consisting of a plate in the form of an inverted frustrum of a cone; and a pump outlet formed in the said shell for permitting the condensed liquid to be drawn off.

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