

Jan. 21, 1941.

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2,229,306

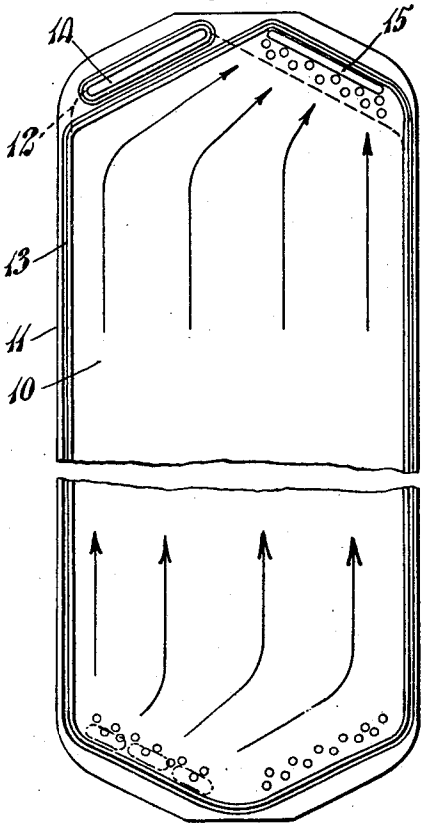
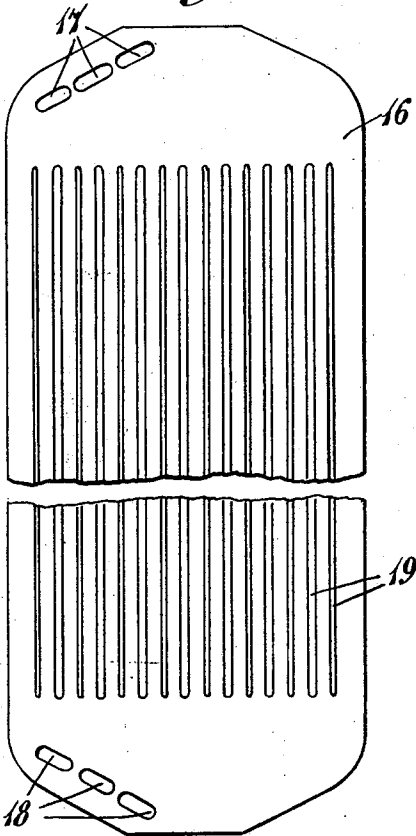
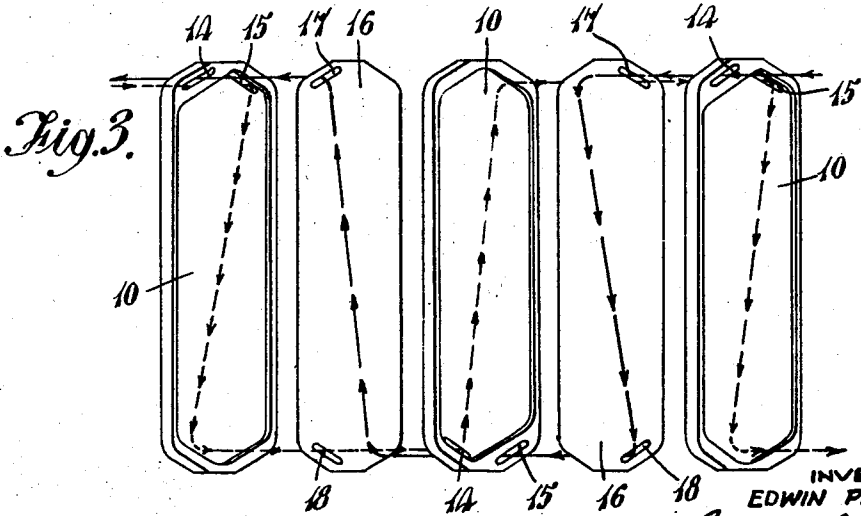
PLATE-TYPE HEAT-EXCHANGE APPARATUS

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Fig. 1.

Fig. 2.



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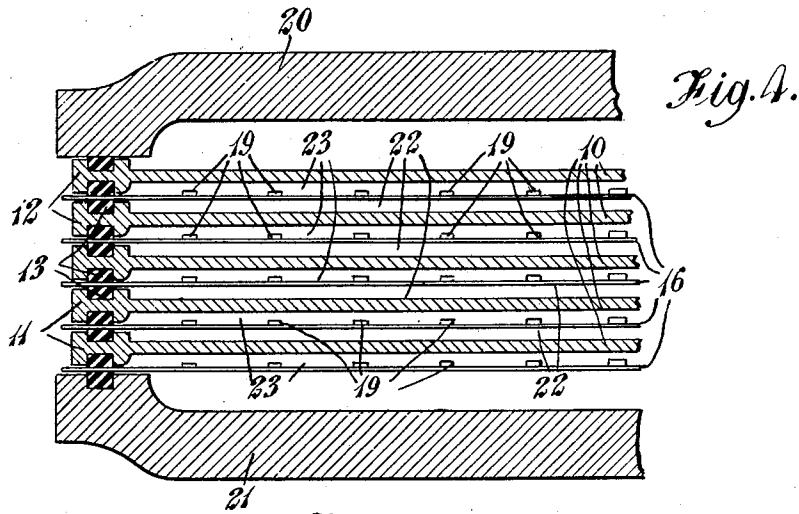
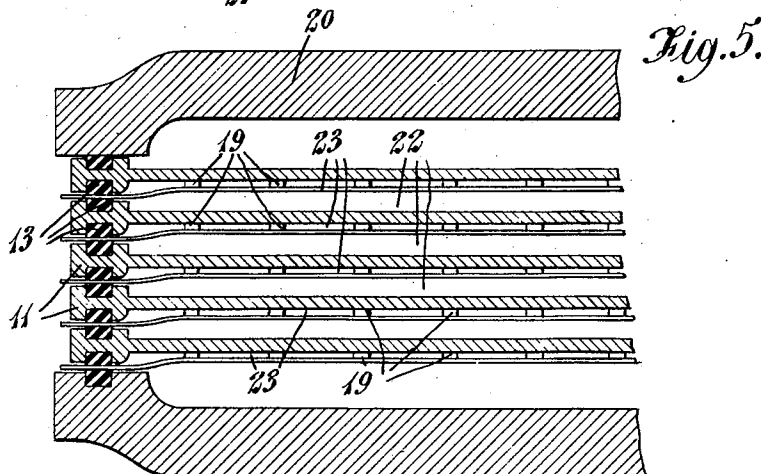
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PLATE-TYPE HEAT-EXCHANGE APPARATUS

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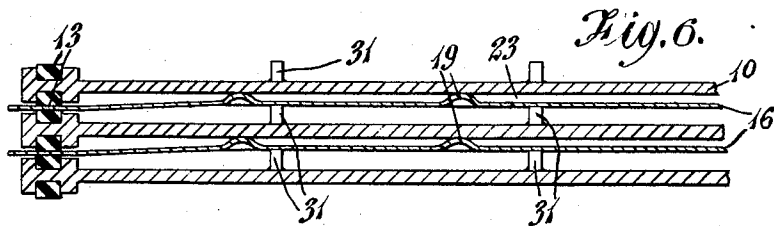
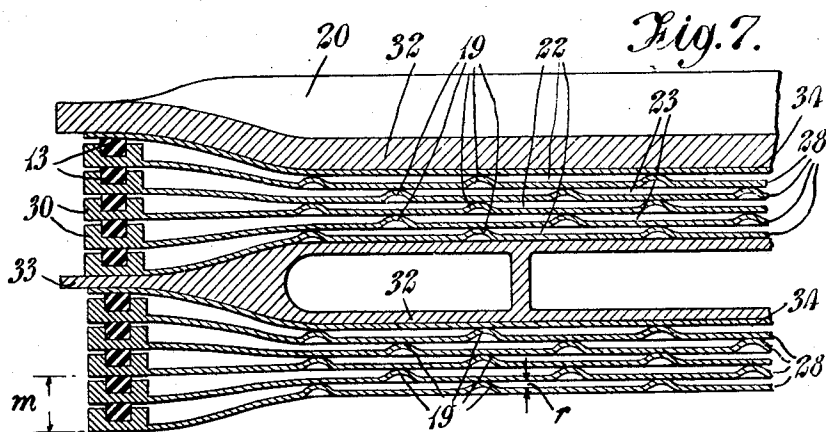
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PLATE-TYPE HEAT-EXCHANGE APPARATUS

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PLATE-TYPE HEAT-EXCHANGE APPARATUS

Edwin Prestage, London, England

Application August 4, 1938, Serial No. 223,080
In Great Britain August 5, 1937

9 Claims. (Cl. 257—245)

This invention relates to plate-type heat-exchange units of the kind comprising a series of plates which are held together in a pack by clamping means, said plates having packing means interposed between the marginal parts of adjacent plates so that the inner parts of the plates are spaced to produce a plurality of thin, substantially flat chambers for the liquid to be treated, said liquid being caused to flow in a film substantially straight across each chamber from an inlet opening disposed adjacent one portion of the periphery of the chamber to an outlet opening adjacent the opposite portion of the periphery.

It is the object of the present invention to provide means in the construction and operation of heat-exchange units whereby their thermal efficiency may be increased, and by which such units are rendered more suitable for the heat treatment of milk and other liquids requiring a precise sequence and duration of the heat treatment conditions. The present invention seeks to provide a form of apparatus which, for its size, is capable of treating a relatively large quantity of liquid owing to the improved heat-exchange conditions existing therein.

It has been found that with liquids, such as milk, the property of giving up heat to, or receiving heat from, the surface of a heat-exchange plate is largely dependent upon the velocity with which the liquid is flowing relative to the said surface. Moreover, there is a decided advantage in making the film of liquid between the plates relatively thin, i. e. of the order of 0.03" to 0.10", but this leads to practical difficulties in the manufacture of the heat-exchange plates, mainly on account of the means which must be used to seal the marginal parts of the plates for preventing leakage. It will be observed that it is usual to form the seal by soft rubber washers set in relatively deep grooves. Also, there is considerable commercial merit in using rolled sheet metal for the plates, mainly on account of the saving in weight and cost as compared with cast metal plates, and the perfectly smooth and sound condition in which sheet metal is now produced. Thermal conductivity of rolled sheet metal is also greater than that of cast metal and this again improves the heat transference.

According to the invention, regarded broadly, in a heat-exchange unit of the kind above referred to, the distance separating the inner parts of a pair of adjacent plates when the unit is in operation is substantially less than the dis-

tance separating their marginal parts. In all forms of heat-exchange unit according to the invention the reduced separation between the plates is measured in a direction at right angles to the general plane of the chamber bounded by said plates. The reduction in the separation can be produced in many ways, such as by causing the plates to be deflected by the pressure of the fluid used during operation, and by causing the clamping pressure to deform the plates and thus reduce their separation.

Heat-exchange units are already known in which the effective thickness of the chambers between the consecutive plates is made smaller than the thickness of the marginal packing means by making the plates conical in form, but such plates are not only relatively difficult to manufacture accurately, but require careful use and handling. Further, in a plate-type heat-exchange unit wherein the liquids to be treated are caused to flow as a film through thin chambers bounded by adjacent plates, it has been proposed to form said plates with corrugations extending substantially transversely with respect to the direction of liquid flow, corresponding corrugations of consecutive plates being arranged to extend one into the other, causing the liquids to follow sinuous paths through the chambers, and also producing a sequence of constrictions the thickness of which is smaller than the distance by which the plates are separated at their marginal parts. The total area of the constrictions in each chamber amounts however, to only a fraction of the area of said chamber, and it will be noted that in these two forms of heat-exchange unit having conical and corrugated plates respectively, the separation of the plates at their inner parts, when measured at right angles to the general plane containing the marginal packing, i. e. the general plane of the plate in the case of the corrugated variety, is substantially equal to the thickness of said marginal packing means.

In a heat-exchange unit of the kind referred to, according to the invention the inner part of a plate is deflected or offset around its marginal part and just within the latter so that the thickness of the chamber between the said plate and the next adjacent plate, towards which the offsetting is directed, is substantially less than the thickness of the packing means between said plates. Thus, alternate plates may be dish-shaped so as to cause the inner part of each to lie substantially closer to one of the adjacent plates than the distance separating the mar-

ginal parts of the said adjacent plates. Alternatively, the thickness of the pack of plates forming the heat-exchange unit may be substantially less at the inner part than around the margin in order to make the thickness of each of the chambers less than the distance separating the distance of the marginal parts of the two plates bounding the chamber.

If desired, the pressure of cooling or heating fluid may be utilised to deflect the inner parts of the plates and thereby reduce the thickness of the film of liquid to be treated.

The invention is illustrated in the accompanying drawings in which

Figures 1 and 2 are front elevations of a pair of plates to show the form of heat-exchange unit to which the invention relates;

Figure 3 is a diagram to indicate the paths followed by the working fluids when the heat-exchange unit is in operation;

Figure 4 is a fragmentary sectional plan of one form of heat-exchange unit according to the invention, the plates being shown in the positions they occupy when the unit is inoperative;

Figure 5 is a similar view showing the thin plates pressed over by the heating or cooling fluid;

Figure 6 is a similar view of an arrangement in which the reduced separation between certain pairs of plates is obtained by the action of clamping the pack;

Figure 7 is a fragmentary sectional plan of another form of heat-exchange unit in which all of the chambers are reduced in thickness by the action of the clamping means.

Figures 1, 2 and 3, which are taken from my co-pending application Serial No. 153,304, filed July 13, 1937, are included herein to exemplify the form of heat-exchange unit to which the present invention relates. Such a unit comprises a plurality of substantially flat plates having marginal packing means and adapted to be superimposed so that when they are clamped together they form a series of thin fluid-tight flat chambers across which the working fluids pass in the form of thin rapidly-moving films. In this example the plates are alternately thick and thin, a thick plate 10 being shown in Figure 1 and being provided around its front margin with a thickening rib 11 and at its rear with a similar rib which is indicated at 12. Both of these ribs are grooved for the accommodation of flexible rubber packing rings 13, while each of the thick plates 10 has a pair of slots 14 and 15 serving to conduct the working fluids in the manner indicated in Figure 3. The thick plates 10 are arranged alternately with thin plates 16 disposed between them. The form of the thin plates is shown in Figure 2, and it will be seen that slots 17 and 18 are provided for the passage of the working fluids and that spacing members 19 which may be in the form of corrugations or applied strips are arranged longitudinally so that they do not interfere with the flow of the working fluid from one end of the plate to the other. The arrangement of ports shown is intended to connect alternate chambers in series, but of course they may be placed if desired so that alternate chambers are connected in parallel, as both of these methods are quite well known. The views shown in Figures 4 to 7 are all fragmentary sectional plans to show various forms of improved heat-exchange plate, and are those which would be obtained by taking sections on a line such as that shown at A-A in Figure 1.

Referring to Figures 4 and 5 a series of thick plates 10 and thin plates 16 are arranged alternately, and their marginal parts are clamped together between a pair of massive end covers indicated at 20 and 21, clamping means (not shown) such as screws or a hydraulic press being utilised to supply the requisite force. The thin plates 16 are relatively flexible by nature, and it will be seen that the spacing members 19 which are provided upon their inner parts project only slightly so that they do not contact with the thick plates 10 as the heat-exchange unit is clamped up. The arrangement shown in Figures 4 and 5 is intended primarily for use where milk or an equivalent liquid is to be heated or cooled by a relatively inexpensive working fluid, such as hot water or brine respectively, and when the plates are assembled the usual inlet and outlet connections are arranged so that the chambers indicated at 22 are used to pass this hot water or brine, the pressure being so adjusted that the thin plates 16 are pressed over to the position shown in Figure 5, thus bringing the spacing members 19 into contact with the adjacent plates 10. This, of course, reduces the thickness of intervening chambers 23 which are used to carry the milk of equivalent liquid to be heat treated. The main object of reducing the thickness of the chambers in this way is to increase the velocity with which the milk or equivalent liquid sweeps past the surfaces of the chamber, thus improving the rate of heat transfer, while it also tends to make the temperature of the milk or equivalent liquid more uniform during its passage through the heat-exchange unit.

The arrangement shown in Figure 6 is substantially the same as that in Figures 4 and 5, the main difference being the provision of deflecting ribs or projections 31 which are attached to the thick plates 10 and are arranged to distort the relatively thin flexible plates 16 as the clamping pressure is applied by the end covers 20 and 21. The thickness of the chambers 23 for the milk or equivalent is primarily determined by spacing members 19 in the form of pressed-up ribs, and these are preferably arranged to be out of register with the deflecting ribs 31 so that the flexibility of the thin plates 16 permits a certain amount of latitude in the degree to which the plates can be clamped together, thus allowing for the reduction in the thickness and resilience of the rubber packing rings 13 as these become old.

Another form of heat-exchange unit in which the desired reduction in the thickness of the chambers is obtained by the action of the clamping means is shown in Figure 7, and is particularly suitable for processes where a heat-exchange is to be effected between hot milk or equivalent and cold milk or equivalent. Such heat-exchange units are employed primarily for economising heat, for example in the pasteurisation process, by causing a heat-interchange between the hot milk leaving a holding-tank during emptying of the latter and the cold milk on its way towards another such tank which is being filled. During the high-temperature short-time process the same stream of milk can of course be passed through both sets of chambers, said milk being held at the desired high temperature for the prescribed time after leaving one set of chambers and before entering the other set. In this example the plates are indicated at 28 and are all relatively thin so as to be substantially flexible, each of said plates being formed at its marginal part with a grooved bead 30 for the accommodation of

a soft rubber packing washer 13. The projection or height of the spacing members 19 is again somewhat less than that of the marginal rib 30, and in order to reduce the thickness of all of the chambers 22 and 23 the end cover 20 is bulged as indicated at 32 so as to distort the plates 28 in the manner shown. Obviously, the outermost plates of the pack are deflected most, thus tending to limit the number of plates which can be used together. In the example shown however, an intermediate member 33 having both of its sides bulged at 32 is interposed within the pack so as to enable the number of plates 28 to be increased. Unribbed plates 34 are provided against the cover 20 and the appropriate side of the intermediate member so as to prevent the milk or equivalent liquid from coming into contact with said cover or intermediate member. The plates themselves are of course made from non-corrosive sheet metal, preferably stainless steel, although any suitable metal, such as nickel alloy or tinned copper, may be used. It will be understood that the sectional plan views in the drawings show only that part of the heat-exchange unit adjacent one side thereof, and therefore in the arrangements shown in Figures 5, 6 and 7 those parts of the chambers 22 and 23 which lie immediately adjacent the marginal parts of the plates and which as a consequence are only partly reduced in thickness, constitute a relatively small portion of the total area of the chambers.

It will be appreciated that by adopting the present invention the separation of the plates in a heat-exchange unit can be reduced to any desired extent, thus producing liquid films of $\frac{1}{16}$ " or $\frac{1}{32}$ " or even thinner, despite the fact that the provision of a robust liquid tight rubber joint around the margins of the plates necessitates a relatively wide spacing at the margins of the plates.

What I claim is:

1. A heat-exchange unit for liquids comprising a plurality of substantially flat plates, clamping means for holding said plates together in a pack, resilient packing rings extending between the peripheral parts of adjacent plates to produce substantially flat chambers, straight across which the liquids flow in flat streams, said rings serving to seal the edges of said chambers, and at least some of said plates being flexible and adapted to be deflected by liquid pressure in the said chambers during operation of said unit, whereby to produce a thickness of the chamber between a pair of plates, for the major part of the area of said chamber, substantially less than the thickness of the packing ring between said pair of plates.

2. A heat-exchange unit comprising a plurality of metal plates, clamping means adapted to hold said plates in a pack, marginal packing rings separating the edges of adjacent plates to define substantially flat liquid chambers, spacing members distributed over the area of the plates, said spacing members being substantially less in height than the thickness of the corresponding packing ring, so that when the heat exchange unit is in operation the pressure of the liquid therein will cause at least alternate plates to be deflected, whereby the thickness of the liquid chamber between said plates is made substantially less than the thickness of the corresponding packing ring between said plates.

3. A heat-exchange unit comprising a plurality of thin metal plates, clamping means arranged

to hold said plates in a pack, marginal packing rings interposed between said plates to define liquid chambers, and means for squeezing said plates together at their center parts so that at least some of the chambers have for the major part of their area a thickness which is substantially less than the thickness of the packing ring serving to define said chamber.

4. A heat-exchange unit comprising a plurality of plates, clamping means adapted to hold said plates, marginal packing rings installed between the edges of adjacent plates to define liquid chambers, across which the liquids flow in substantially flat thin films, spacing projections distributed across the area of the plates and adapted to prevent adjacent plates from being brought into complete contact with one another, the clamping means being arranged to compress the center parts of the plates to a greater extent than the peripheral portions thereof, whereby the thickness of each of the chambers is reduced to a value which is less than the thickness of the packing ring defining the margin of said chamber.

5. A heat-exchange unit comprising a series of thin sheet metal plates, clamping means securing said plates in a pack, marginal packing means serving to hold said plates apart and defining thin substantially flat chambers for the liquids to be treated, all of said plates having their marginal parts offset so that when the heat-exchange unit is in operation the thickness of the chamber between a pair of contiguous plates is substantially less than the thickness of the packing ring disposed between said two plates.

6. A heat-exchange unit comprising a plurality of thin metal plates, clamping means arranged to hold said plates in a pack, marginal packing rings interposed between said plates defining liquid chambers, means for squeezing said plates together at their center parts so that at least some of the chambers have for the major part of their area a thickness which is substantially less than the thickness of the packing ring serving to define said chamber, and a separating member dividing the pack of plates into sections, and which is thinner at its peripheral part than at its center so as to squeeze the heat-exchange plates for reducing their separation.

7. A heat-exchange unit comprising a plurality of plates at least some of which are flexible, clamping means adapted to hold said plates in a pack, marginal packing means being interposed between the edges of adjacent plates defining substantially flat liquid spaces, separating means distributed over the area of the flexible plates, the thickness of said separating means being such that when the plates are clamped together, said means will cause deflection of the flexible plates to reduce the thickness of the adjacent liquid chamber to a value which is less than the thickness of the packing ring defining the margin of the said adjacent liquid chamber.

8. A heat-exchange unit for liquids comprising a plurality of substantially flat plates, clamping means for holding said plates together in a pack, resilient packing rings extending between the peripheral parts of adjacent plates to produce substantially flat chambers permitting liquid to flow thereacross in thin flat streams, said rings serving to seal the edges of said chambers, and at least some of the plates being flexible and adapted to be deflected towards the next adjacent plate when the unit is assembled and put into opera-

tion, whereby to produce a thickness of chamber between a pair of plates for the major part of the area of said chamber substantially less than the thickness of the packing ring between said pair of plates.

- 5 9. A heat-exchange unit comprising a plurality of flexible metal plates, clamping means adapted to hold said plates in a pack, marginal packing rings separating the edges of adjacent
10 plates to define substantially flat liquid chambers, spacing members distributed over the area

of the plates, said spacing members being substantially less in height than the thickness of the corresponding packing ring, and means for deflecting at least alternate plates when the heat-exchange unit is assembled and placed in operation, whereby the thickness of the liquid chamber between said plates is made substantially less than the thickness of the corresponding packing ring between said plates.

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