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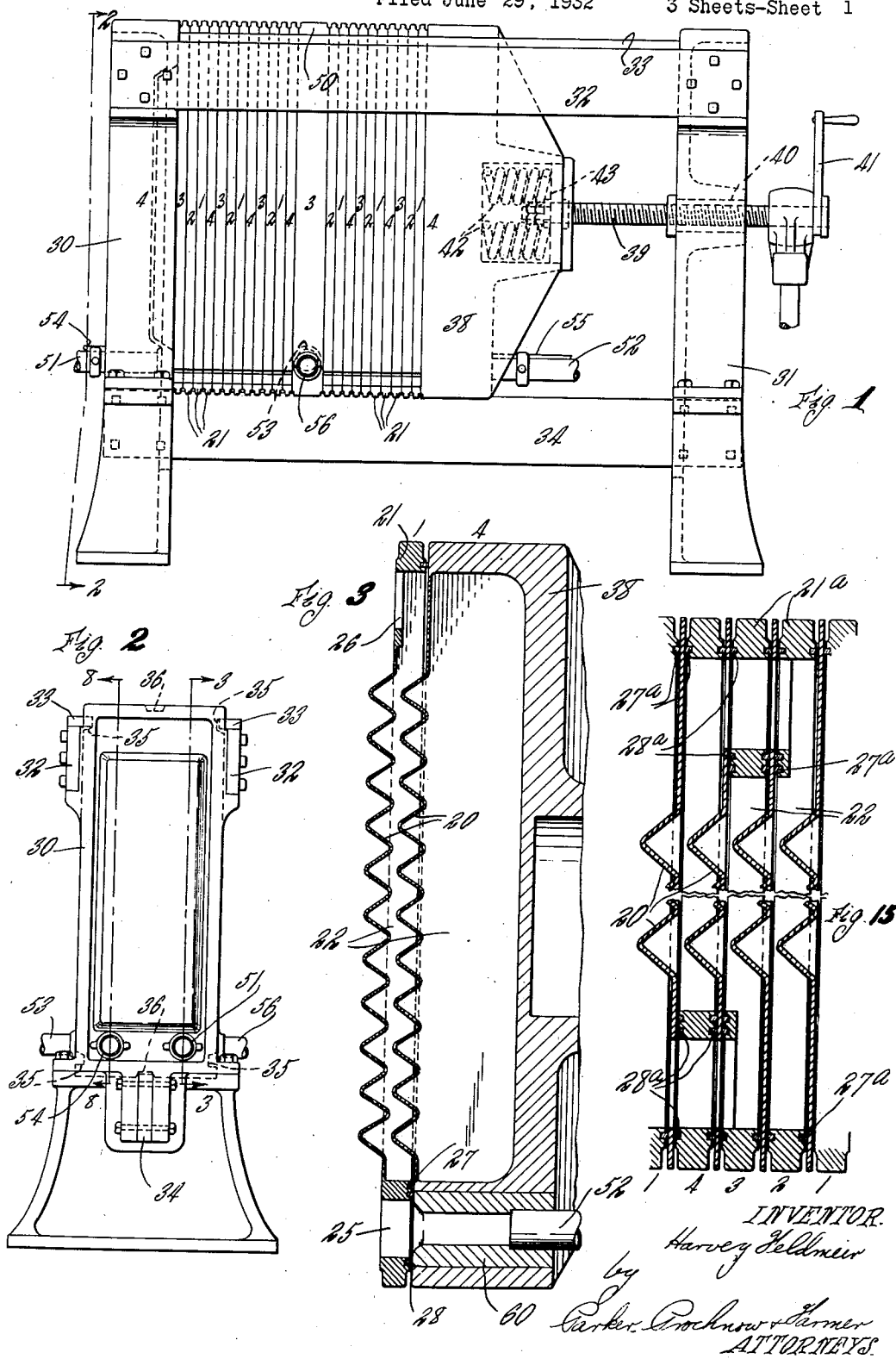
H. FELDMEIER

1,972,379

PLATE HEAT EXCHANGER

Filed June 29, 1932

3 Sheets-Sheet 1



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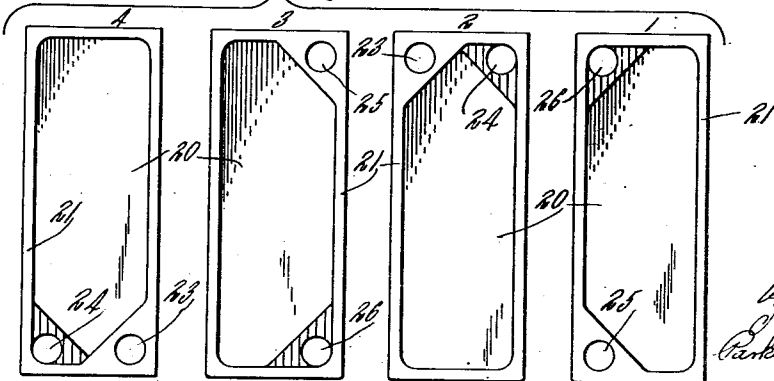
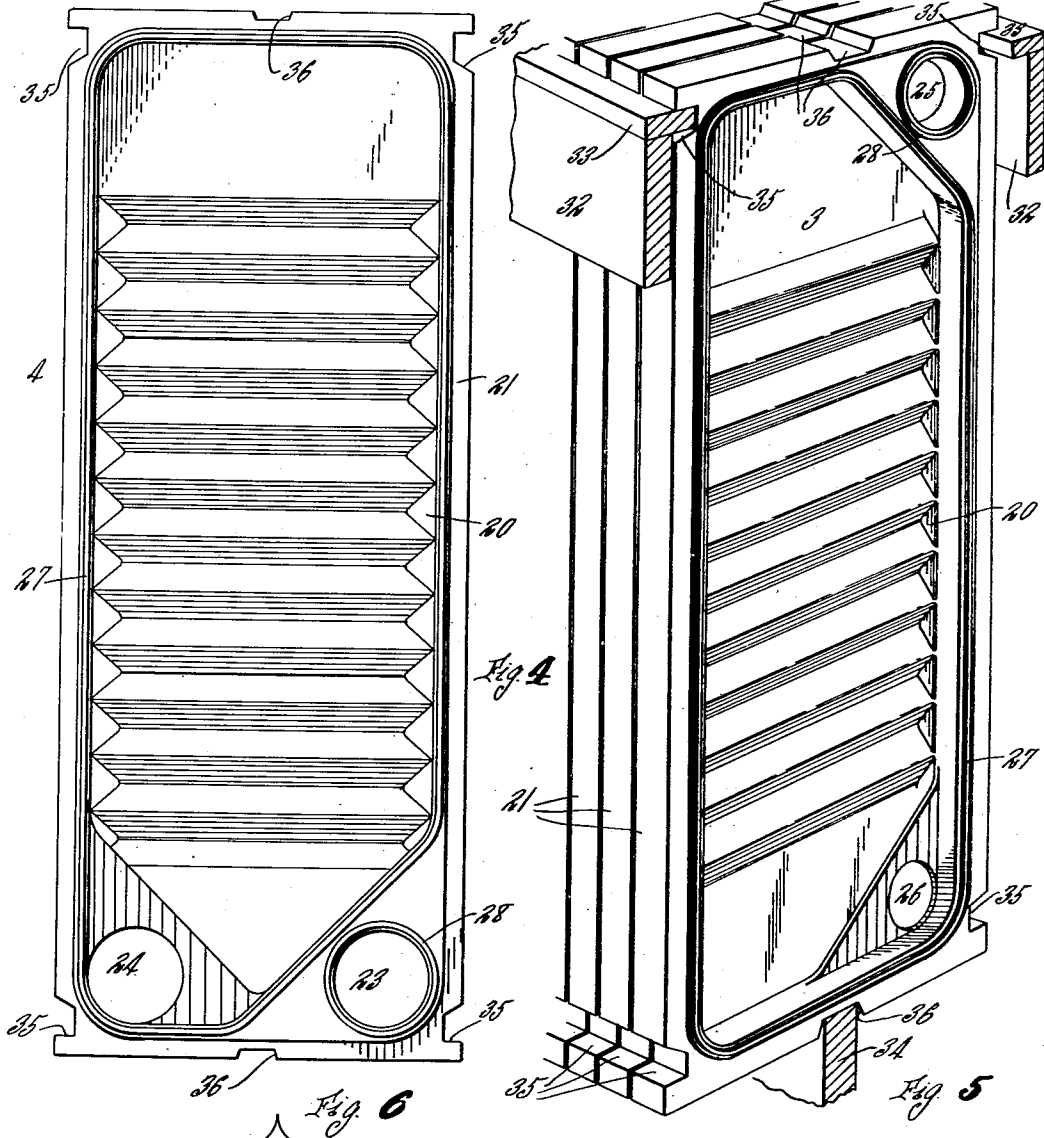
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PLATE HEAT EXCHANGER

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3 Sheets-Sheet 2



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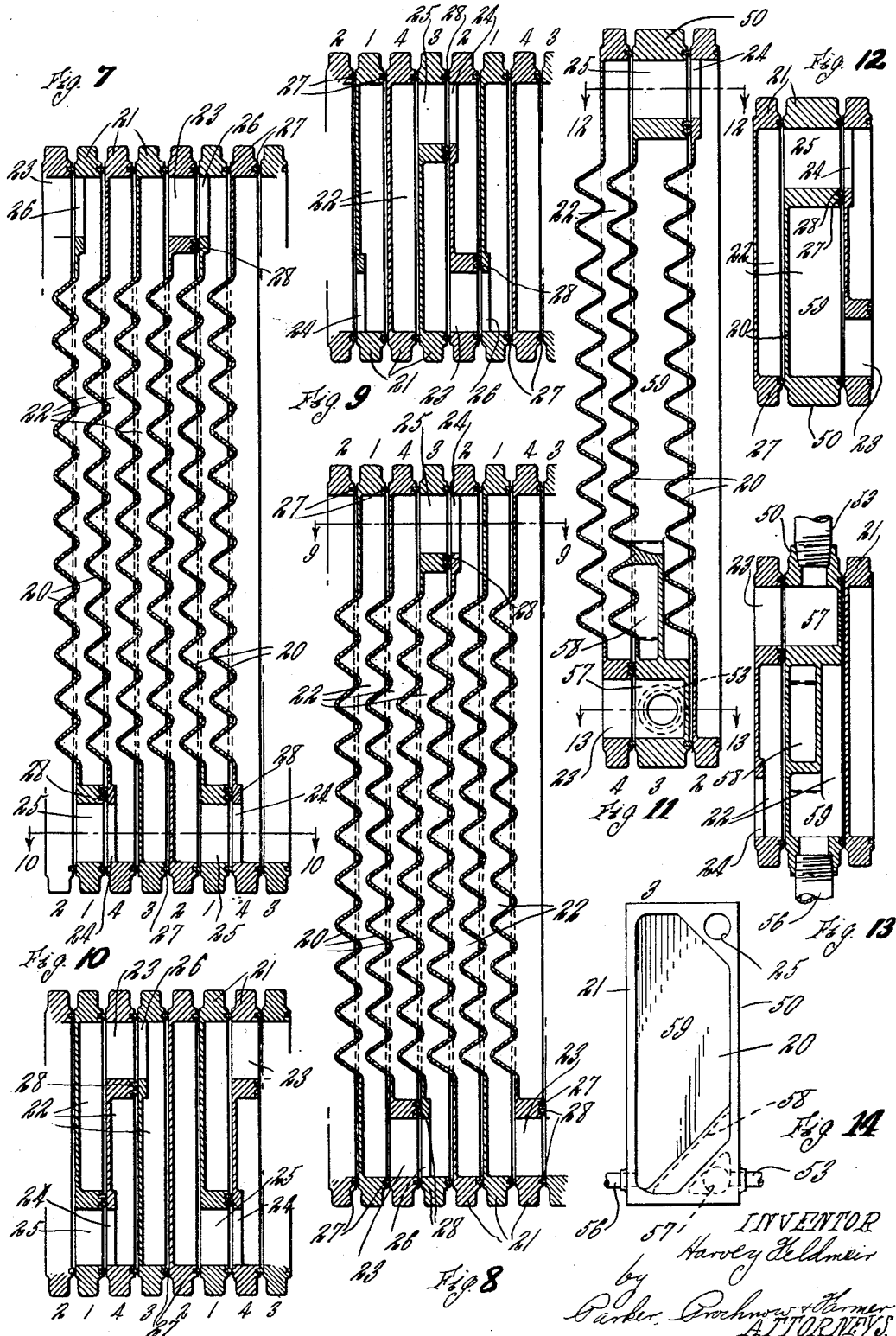
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PLATE HEAT EXCHANGER

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3 Sheets-Sheet 3



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PLATE HEAT EXCHANGER

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6 Claims. (Cl. 257—245)

This invention relates to that type of heat exchangers for fluids in which a plurality of plates or elements are removably secured in spaced face to face relation so as to provide fluid flow spaces which are separated by thin heat conducting walls and are interconnected in such a way that separate streams of fluid of different temperatures flow in contact with opposite faces of each heat conducting wall for the exchange of temperature from one fluid to the other, the elements of said device being adapted to be quickly and easily assembled for use and disconnected to facilitate the cleaning of the surfaces with which the fluids contact. Such devices are adapted, for example, for heating or cooling liquids such as milk by exchange of heat between the milk and one or more heating or cooling mediums.

One object of the invention is to provide a heat exchange device of this sort which is of large capacity but relatively small compact form, and will have high efficiency in operation. Other objects of the invention are to provide a heat exchange device which is constructed so as to enable a rapid flow of the fluids in considerable volume with a maximum heat exchange; in which the heat exchange elements and fluid flow spaces are of such form as to give the maximum area of heat exchange surface with the minimum resistance to flow and pressure in the fluids; which is constructed to cause the fluids to flow in relatively wide shallow streams or layers so as to give the device large capacity and efficiency of heat exchange with the minimum of pressure in the fluids; which provides a multiplicity of fluid flow spaces which are relatively long, compared with their width, and shallow; in which the heat conducting walls are corrugated so as to increase the length of the heat exchange or conducting surfaces and increase the turbulence of the fluids; in which the heat exchange walls are arranged so as to form shallow fluid flow spaces between the walls while, nevertheless, the walls are separated by relatively thick, rigid spacing frames or elements; and which embodies the other features of improvement and advantage hereinafter described and set forth in the claims.

The heat exchange device, as herein described, is of a construction adapting it for cooling milk, and for the sake of brevity and clarity of description, the fluids between which the exchange of heat occurs will be hereinafter referred to as "milk" and "water" or "brine" but it is to be understood that the invention is not restricted to use with these fluids but is adapted for use with other fluids either for cooling or heating purposes.

In the accompanying drawings:

Fig. 1 is a side elevation of a heat exchange device embodying the invention and illustrating an arrangement adapted for cooling milk in two

stages, in which the milk flows counter-current to cool water in the first stage and then to refrigerated brine in the second stage.

Fig. 2 is a transverse elevation thereof on line 2—2, Fig. 1.

Fig. 3 is an enlarged, fragmentary longitudinal sectional elevation thereof on line 3—3, Fig. 2.

Fig. 4 is a face view of one of the heat exchange elements, detached.

Fig. 5 is a perspective view of several of the elements arranged face to face.

Fig. 6 is a diagrammatic view of four of the plates or elements showing the two different forms of the elements and the four different positions in which they are assembled.

Fig. 7 is a longitudinal, sectional elevation through a group of the plates or elements taken on line 3—3, Fig. 2.

Fig. 8 is a similar view on line 8—8, Fig. 2.

Fig. 9 is a horizontal, transverse section thereof on line 9—9, Fig. 8.

Fig. 10 is a similar transverse, horizontal section on line 10—10, Fig. 7.

Fig. 11 is a longitudinal sectional elevation through the intermediate header and two elements on opposite sides thereof.

Figs. 12 and 13 are transverse, horizontal sections on lines 12—12 and 13—13, respectively, Fig. 11.

Fig. 14 is a face elevation on a reduced scale of the intermediate header.

Fig. 15 is a fragmentary longitudinal section showing a slightly modified construction.

The heat exchange device comprises a plurality of separate thin wall or plate elements 20 of metal or other suitable heat conducting material arranged face to face parallel with each other and separated by interposed spacing frames or elements 21 which may be formed either by means of a thick integral marginal portion projecting from one face of each plate 20, or by means of separate open frames interposed between the marginal portions of the plates 20. Preferably, the plates are of rectangular form, being relatively long compared with their width, and formed with corrugations which are preferably of V-shape and extend crosswise of the length or greater dimension of the plates, the plates being arranged so that the ridges of the corrugations of one plate register with or enter the furrows of the next plate whereby a flow space 22 is formed between each two adjacent plates extending in a zig-zag course lengthwise of the plates and bounded by the spacing frame between said plates.

As illustrated in the drawings, the plate elements are made in two slightly different forms. In the first form, as best shown in Fig. 4 and by the diagram numbered 4 in Fig. 6, the element, which is here shown with the marginal spacing

frame 21 integral with and projecting from one face of the plate 20, is provided at one of its narrow ends with two transverse, through passages 23 and 24. The first passage 23 extends through one corner portion of the plate and spacing frame 21 while the other passage passes through the other corner of the same narrow end of the plate within the area bounded by the spacing frame. In the element of the second form, best shown in Fig. 5, and by the diagram numbered 3 in Fig. 6, the element is provided with two transverse, through passages 25 and 26, one at each of the opposite narrow ends of the element and adjacent the same long edge of the element. The passage 25 extends through the plate and a corner portion of the spacing frame while the passage 26 passes through the plate within the area bounded by the spacing frame. The elements of these two different forms alternate when assembled in the apparatus and may be arranged with four successive elements placed in the four different positions indicated in the four diagrams in Fig. 6, that is, with two like elements, numbers 4 and 2 in Fig. 6, turned at an angle of 180° with reference to each other and the other two like elements, numbers 3 and 1, similarly turned at an angle of 180° to each other. The relative positions of the assembled elements are indicated by the numbers 1, 2, 3, and 4 thereon in Fig. 1, each element being of the form and positioned as represented by the correspondingly numbered diagram in Fig. 6. With the elements thus arranged face to face with their marginal frames all facing in the same direction the passage 24 of element number 4 communicates with the lower end of the flow space 22 between this element and the adjacent element number 3, on the right, so that a fluid entering through passage 24 will pass through said space and through the passage 25 in the diagonally opposite corner of element number 3 and the registering passage 24 of the element number 2 into the flow space between the elements numbers 2 and 1, and thence diagonally through this space and out through passage 25 of element number 1 so that this fluid will pass through the alternate flow spaces 22. At the same time, if another fluid is admitted to the lower right hand corner of the flow space between element number 1 and the next element or other space-closing member on the right, it will flow diagonally through this space and through the passage 26 of element number 1 and the registering passage 23 of element number 2 into the upper left hand corner of the flow space between elements numbers 3 and 4 and thence diagonally through this space and out through the passage 23 at the lower right hand corner of the number 4 element. Thus, the two fluids will flow counter-current to each other lengthwise through the apparatus, that is, one fluid entering at the left end of the apparatus and discharging at the right end while the other fluid enters at the right and discharges at the left end.

The elements are clamped or secured together face to face in the order mentioned with suitable provision for sealing the joints between them around the flow spaces 22 and connecting passages so as to prevent escape of the fluids therefrom between the face of the elements. For this purpose, in the construction shown, each spacing frame is provided with a compressible packing or gasket 27 confined with a groove in one face of the spacing frame surrounding the flow space 22 of this element and with a packing or gasket

28 confined in a groove surrounding the transverse passage 23 or 25, as the case may be, in the corner portion of the frame. When the plates are clamped together, these gaskets will be compressed between a face of each plate 20 and the opposing face of the next spacing frame and effectually seal the joints between these parts.

The several elements can be movably mounted to enable them to be clamped together to seal the flow spaces and passages and to be separated, on a suitable supporting frame provided with means for forcing the elements together. The frame shown for this purpose comprises opposite upright, end frames 30 and 31 connected at their upper portions by parallel, longitudinal guide bars 32 having inwardly extending flanges 33 at their upper edges, and a lower longitudinal guide bar 34 connecting the lower central portions of the end frames. The flanges 33 of the upper guide bars 32 project into registering notches 35 in the opposite long edges of the several elements near their upper ends and the upper edge of the lower guide bar 34 projects into registering notches 36 in the bottom edges of the several elements so that the elements are thus supported by and adapted to slide toward and from each other on said guide bars. Since, as before explained, different elements are arranged in different positions with one or another narrow end thereof uppermost, the several elements are preferably provided with the guide notches 35 and 36 at both ends of the elements so that the elements will be similarly supported and guided on the frame whether placed with one or the other end thereof uppermost. A movable clamping head 38 is also slidably mounted on the guide bars 32 and 34 and is adapted to be forced toward the end frame 30 for clamping the heat exchange elements between said end frame and the clamping head, by suitable means, such as a screw shaft 39 arranged to turn in a screw threaded opening or nut 40 in the end frame 31. The screw may be turned by a crank 41 at its outer end, or other suitable means for pressing the heat exchange elements together between the clamping head and the end frame 30. Preferably, suitable springs 42 are arranged between the movable head 38 and a block 43 swivelled on the inner end of the screw shaft to provide a yielding pressure between the screw shaft and the movable head.

Suitable connections are provided for the admission and discharge of the milk and the cooling liquid to the opposite ends of the group or groups of heat exchange elements. As before mentioned, in the apparatus illustrated in the drawings, the heat exchange elements are arranged in two sets or series through which the milk flows in succession for cooling it in two stages, first by means of cool water in one stage and then by means of brine in the second stage. To enable this two stage action the apparatus shown is provided with an intermediate head 50 which is disposed between the two series of elements and may be slidably mounted on the stationary frame in the same manner as the heat exchange elements, and the supply pipe for one cooling liquid and the discharge pipe for the other are connected with this intermediate head.

If the end and intermediate clamping heads are made of metal suitable for contact with milk, they and the heat exchange elements may be arranged in the relative order indicated in Fig. 1 in which the numbers 1, 2, 3 and 4 indicate the elements corresponding respectively with the like numbered four diagrams in Fig. 6. In such ar-

rangement, the end frame or clamping head 30 at the left end of the apparatus may have its right hand side formed like the corresponding side of a number 4 element, while its opposite or exposed side may be plain or of other suitable form. The right hand clamping head 38, see Fig. 4, may have its left side similar to the corresponding side of a number 4 element while its opposite or exposed side could be plain or of other suitable form. The intermediate head 50, which takes the place of a number 3 element, may be similar to such an element except that its spacing frame, see Fig. 11, is made thicker and is provided at its lower end, at opposite edges, respectively with water or brine inlet and outlet passages or connections. Assuming that the milk enters at the left end of the apparatus, it may enter through a suitable inlet 51 at the lower front corner of the head 30 and, after passing through alternate flow spaces and connecting passages of the heat exchange elements, as explained, discharge through a suitable outlet 52 at the lower front corner of the right hand head 38. Water may enter the rear lower corner of the intermediate head 50 through a suitable inlet 53 and, after passing through the other flow spaces of the elements of the first stage, discharge through a suitable outlet 54 at the lower, rear corner of the left head 30. The brine for the second stage may enter through a suitable brine inlet 55 at the lower rear corner of the right hand head 38 and, after passing through the heat exchange elements of the second stage, discharge through a suitable outlet 56 at the lower, front corner of the intermediate head. In this described arrangement, the water inlet 53 of the intermediate head connects with a passage 57 which extends through the left hand face of this head and connects with the transverse passage 23 of the adjacent element number 4, and preferably the head 50 is chambered to provide an air chamber 58 between the water passage 57 and the brine chamber 59 of this head to reduce exchange of temperature from the water to the brine in this head.

If it is desired to make the end and intermediate heads of material not suitable for contact with milk, they can be made of any construction suitable for pressing the heat exchange elements together, and the liquid passages can extend directly through each of the heads for connection with the passages or flow space of the heat exchange element next to each head, and the passage in each head through which the milk flows could be lined with a bushing 60, see Fig. 3, of material suitable for contact with the milk. With such an arrangement, the heat exchange elements would preferably be arranged in one or more groups of four between each two heads with a number 1 element in contact with the left hand face of the right hand head or intermediate head and a number 4 element in contact with the right hand face of the left hand or intermediate head.

As hereinbefore explained, the marginal spacing frames for the heat conducting plates 20 can be formed integrally with or permanently attached to the plates 20, or the spacing frames can be formed as open frames separate from the plates and interposed between adjacent plates. The latter construction is illustrated in Fig. 15. In this case, each spacing frame 21a is provided on its opposite faces with gaskets or packing means for forming liquid tight joints between the same and the conducting plates when the

plates and frames are clamped together. For instance, gaskets 27a and 28a may be provided in similar grooves or on opposite faces of each spacing frame or element.

By constructing the heat exchanger as described, the fluid flow spaces provided between the conducting walls are relatively long in proportion to their width, but are nevertheless very wide in proportion to their thickness so as to produce wide but shallow or thin streams which have a long travel in contact with the heat transfer surfaces. This favors the use of a large number of plates in series and enables a rapid flow and great turbulence with a low pressure for the liquids, thus giving high efficiency and a large capacity in an apparatus of moderate dimensions. The high pressures on the fluids required in apparatus in which the fluid flows through long, narrow channels or grooves is not necessary, and the plates are much easier to clean and keep in a sanitary condition which is of especial importance in milk treating apparatus.

I claim:

1. A heat exchanger for fluids comprising a plurality of thin, elongated, substantially rectangular conducting walls separably arranged face to face and spaced apart by spacing frames of substantially corresponding dimensions at the marginal portions of the conducting walls and in conjunction with said walls forming elongated shallow fluid flow spaces corresponding in dimensions with the internal dimensions of said spacing frames, said walls and spacing frames each being of two different forms alternating with each other and the alternate walls and frames being reversed end for end, each wall having a transverse passage through one narrow end thereof within the area bounded by the adjacent spacing frame and another transverse passage through one narrow end outside of said area, and each spacing frame having a transverse passage through one narrow end thereof registering with said second passage of the adjacent wall, said walls and spacing frames being arranged with the passage through each frame registering with the first mentioned passage through an adjacent wall and the corresponding passages of alternate walls located at opposite narrow ends of the walls, whereby separate fluid streams caused to flow through adjacent flow spaces at opposite sides of a conducting wall are kept separated and one stream caused to flow in series lengthwise through one after another of the alternate flow spaces and another stream caused to flow in series lengthwise through one after another of the remaining flow spaces.

2. A heat exchanger for fluids comprising a plurality of thin, elongated, substantially rectangular conducting walls separably arranged face to face and spaced apart by spacing frames of substantially corresponding dimensions at the marginal portions of the conducting walls and in conjunction with said walls forming shallow fluid flow spaces corresponding in dimensions with the internal dimensions of said spacing frames, said walls having corrugations extending transversely to their longer dimensions, said walls and spacing frames each being of two different forms alternating with each other and the alternate walls and frames being reversed end for end, each wall having a transverse passage through one narrow end thereof within the area bounded by the adjacent spacing frame and another transverse passage through one nar-

row end outside of said area, and each spacing frame having a transverse passage through one narrow end thereof registering with said second passage of the adjacent wall, said walls and spacing frames being arranged with the passage through each frame registering with the first mentioned passage through an adjacent wall and the corresponding passages of alternate walls located at opposite narrow ends of the walls, whereby separate fluid streams caused to flow through adjacent flow spaces at opposite sides of a conducting wall are kept separated and one stream caused to flow in series lengthwise through one after another of the alternate flow spaces and another stream caused to flow in series lengthwise through one after another of their remaining flow spaces.

3. A heat exchanger for fluids comprising a plurality of thin, elongated, substantially rectangular conducting walls arranged face to face and separated by spacing frames of substantially corresponding dimensions arranged between the marginal portions of the conducting walls and in conjunction with said walls forming elongated and relatively wide but shallow fluid flow spaces corresponding in dimensions with the internal dimensions of said spacing frames, said walls being separate from said spacing frames and said walls and frames being separably clamped together with each spacing frame clamped between two of said walls with interposed joint packings, said walls and spacing frames each being of two different forms alternating with each other and the alternate walls and frames being reversed end for end, each wall having a transverse passage through one narrow end thereof within the area bounded by the adjacent spacing frame and another transverse passage through one narrow end outside of said area, and each spacing frame having a transverse passage through one narrow end thereof registering with said second passage of the adjacent wall, said walls and spacing frames being arranged with the passage through each frame registering with the first mentioned passage through an adjacent wall and the corresponding passages of alternate walls located at opposite narrow ends of the walls, whereby separate fluid streams caused to flow through adjacent flow spaces at opposite sides of a conducting wall are kept separated and one stream caused to flow in series lengthwise through one after another of the alternate flow spaces and another stream caused to flow in series lengthwise through one after another of the remaining flow spaces.

4. A heat exchanger for liquids comprising a plurality of thin elongated substantially rectangular conducting walls separably arranged face to face and having thick marginal portions which space apart the thin portions of the walls thereby forming shallow elongated flow spaces between the walls bounded by said marginal portions, said walls being of two different forms only alternating with each other and the alternate walls being reversed end for end, each wall having a transverse passage through one narrow end thereof within the area bounded by said marginal portion and a second transverse passage through its thick marginal portion at one narrow end of the wall, said walls being ar-

ranged with the passage in the marginal portion of each wall registering with the first mentioned passage of an adjacent wall and the corresponding passages of alternate walls located at opposite narrow ends of the walls, whereby separate fluid streams caused to flow through adjacent flow spaces at opposite sides of a conducting wall are kept separated and one stream caused to flow in series lengthwise through one after another of the alternate flow spaces and another stream caused to flow in series lengthwise through one after another of the remaining flow spaces.

5. A heat exchanger for liquids comprising a plurality of thin elongated substantially rectangular conducting walls separably arranged face to face and having thick marginal portions which space apart the thin portions of the walls thereby forming shallow elongated flow spaces between the walls bounded by said marginal portions, said walls being of two different forms only alternating with each other and the alternate walls being reversed end for end, each wall of one form having two transverse passages through one narrow end thereof, one through its thin portion and the second through its marginal portion, and each wall of the other form having two transverse passages one through its thin portion at one narrow end of the wall and the second through the opposite narrow end of its marginal portion, said walls being arranged with the passage in the marginal portion of each wall registering with the first mentioned passage of an adjacent wall and the corresponding passages of alternate walls located at opposite narrow ends of the walls, whereby separate fluid streams caused to flow through adjacent flow spaces at opposite sides of a conducting wall are kept separated and one stream caused to flow in series lengthwise through one after another of the alternate flow spaces and another stream caused to flow in series lengthwise through one after another of the remaining flow spaces.

6. A heat exchanger for fluids comprising a plurality of elongated thin heat-conducting walls separably secured together, and frames for separating the walls to form elongated fluid flow spaces which are relatively wide and shallow and materially longer than their width, said walls and spacing frames each being of two different forms alternating with each other and the alternate walls and frames being reversed end for end, and connections arranged to cause a fluid stream to flow in series through one after another of the alternate flow spaces lengthwise thereof and another fluid stream to flow in series through one after another of the remaining flow spaces lengthwise thereof, whereby separated shallow fluid streams of substantially the effective width of said walls flow in heat exchange relation over opposite faces of one after another of said walls lengthwise thereof, and means separably supporting said walls for movement of the walls toward and from each other, each of said walls having parts arranged to cooperate with said supporting means to support the wall in either of two positions which are reversed end for end relatively to each other.