

Jan. 15, 1957

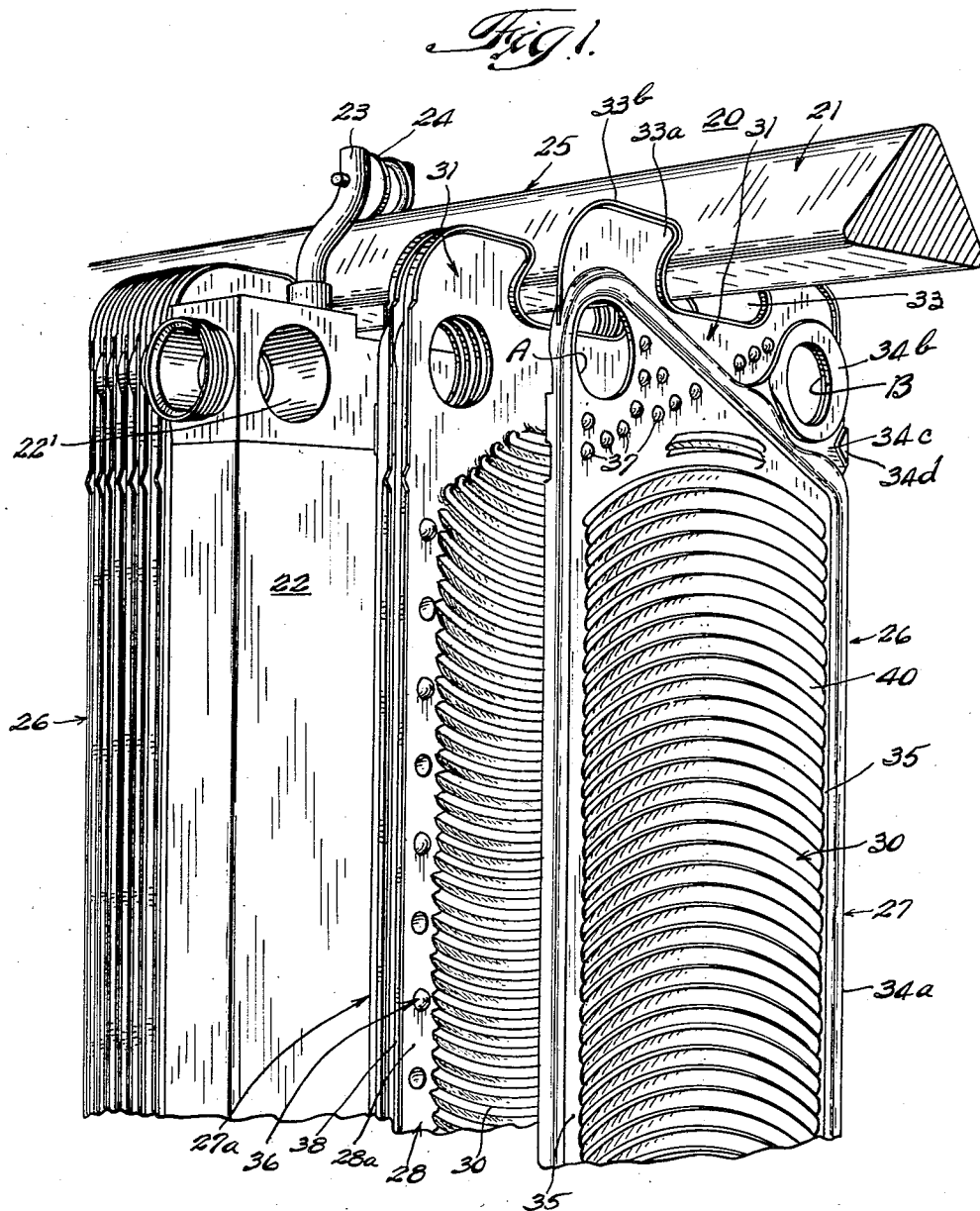
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2,777,674

PLATE TYPE HEAT EXCHANGER

Filed May 29, 1953

5 Sheets-Sheet 1



INVENTOR.

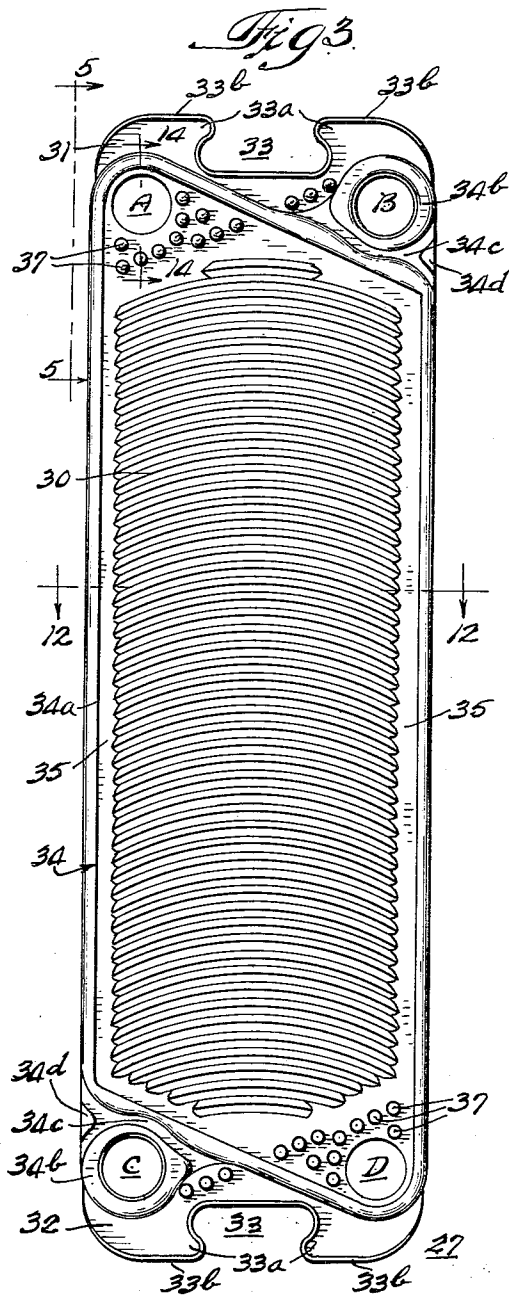
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5 Sheets-Sheet 2



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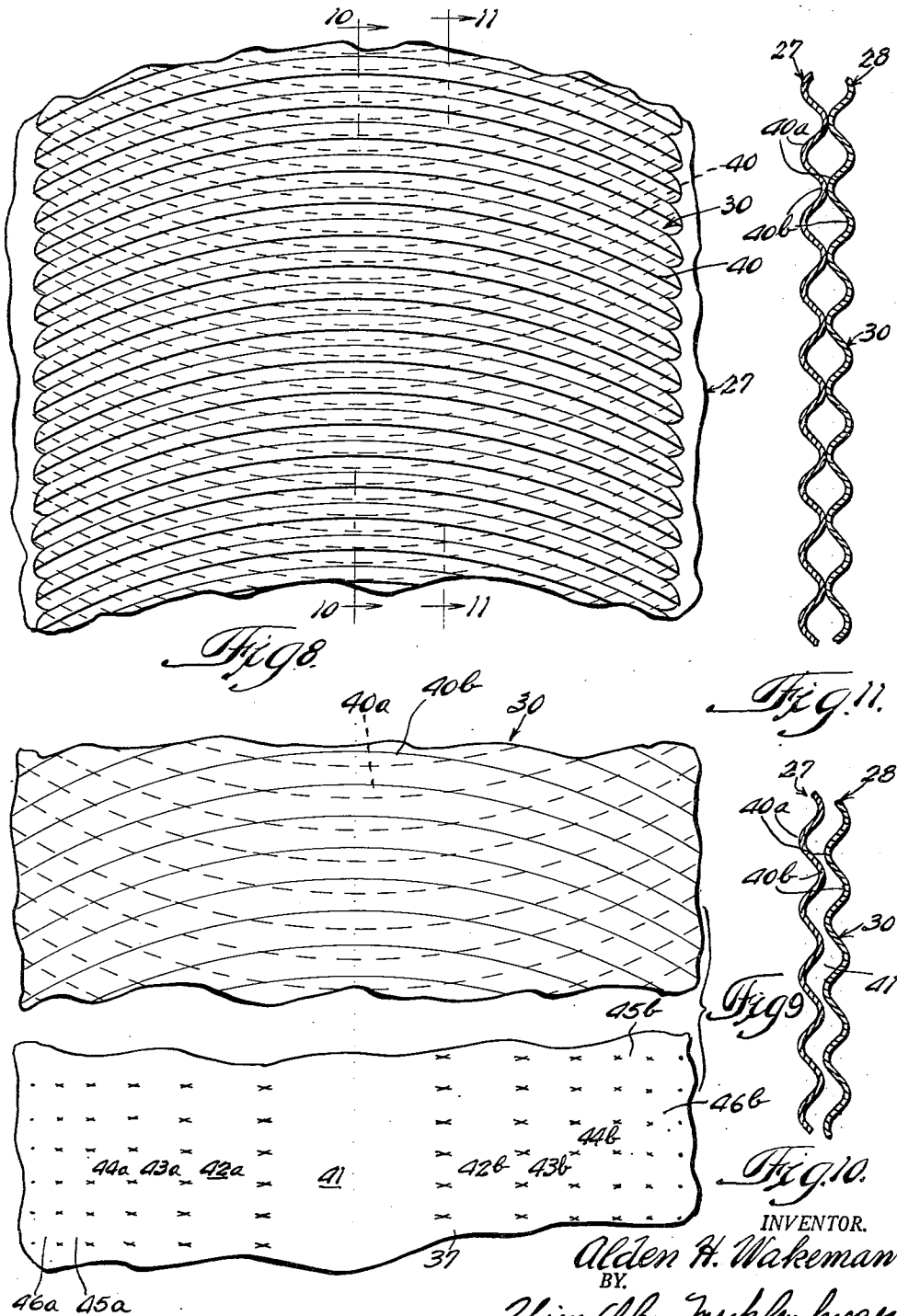
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PLATE TYPE HEAT EXCHANGER

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5 Sheets-Sheet 4



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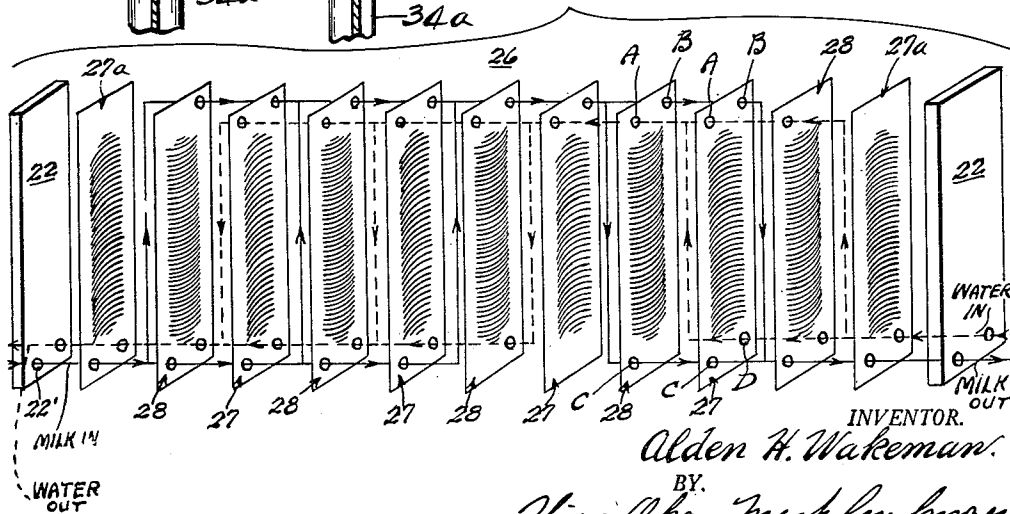
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PLATE TYPE HEAT EXCHANGER

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PLATE TYPE HEAT EXCHANGER

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7 Claims. (Cl. 257—245)

This invention relates to heat exchangers and more particularly to a plate heat exchanger of a type adapted primarily for use in commercial dairies, breweries and other food and beverage processing plants.

Because of the inherent nature of most dairy products to be readily susceptible to numerous harmful bacteria and also due to the fact that one or more of such dairy products are normally included within the daily diet of most individuals, the dairy industry, as a whole, has been most conscientious in its efforts to protect the public health and meet the needs of the public by striving to produce dairy products which are more wholesome, healthful, and delectable in character and which readily meet the standards regarding purity as set forth by municipal, State, and Federal agencies. By reason, therefore, of the scrutinized activities of the dairy industry in producing and processing its products, the costs of dairy operation and the equipment required therefor are generally well above the average for comparable industries.

In a plate heat exchanger, for example, which in the dairy industry is utilized in the heating, cooling and pasteurization of milk and milk products, and which apparatus is the subject matter of this invention, it is essential that the apparatus may be readily disassembled for thorough cleaning, usually once a day or after each run, be durable and effective in operation, and be of compact and simple construction requiring only a minimum floor area for proper operation.

It is one of the objects, therefore, of this invention to provide a plate heat exchanger which successfully meets the most rigid of municipal, State, and/or Federal public health regulations, is durable and highly efficient in operation, compact and simple in construction, and is easy to service and maintain.

It is a further object of this invention to provide a plate heat exchanger whose capacity may be varied over a wide range to accommodate variations in the fluidity and quantity of the products being circulated there-through.

It is a still further object of this invention to provide a plate heat exchanger which is capable of producing a greater heat exchange under given conditions of plate area, temperature difference, and pressure drop than had heretofore been attained in apparatus of this type, thereby requiring fewer number of plates to produce a given result which in turn reduces the cost of the equipment.

It is a still further object of this invention to provide a plate heat exchanger wherein the flow of the product and/or the heat transfer medium between the various plates is at a uniform rate substantially across the entire face of the plates, thereby eliminating stagnant flow areas and minimizing the precipitation and deposit upon the plates of solids carried by the product and/or heat transfer medium which complicate the cleaning of such plates.

It is a still further object of this invention to provide a plate heat exchanger wherein the individual sheet metal plates are of such structural formation that their pressed fabrication does not set up any internal stresses

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which would cause buckling, warping, or deforming of the plates thereby assuring uniformly tight gasket pressure when the plates are in pressed assembled relation with respect to one another and facilitating the cleaning of the plates when disassembled.

It is a still further object of this invention to provide heat exchange plates wherein each of the plates is uniformly supported by the adjacent plates over a substantially large area, when the plates are assembled, thereby minimizing the possibility of the plates diaphragming with respect to one another and restricting certain of the flow passages when the heat transfer medium is circulated between the plates under a high pressure.

Further and additional objects will appear from the description, accompanying drawings and appended claims.

In accordance with the preferred embodiment of this invention as described herein, a plate heat exchanger is provided comprising a plurality of thermal conductive plates assembled in face-to-face relation with intermediate marginal gaskets, wherein each plate includes a center portion adapted for contact on one surface with a heat transfer medium flowing thereover, and on the opposite surface with a second heat transfer medium, and inlet and outlet portions for the circulating medium communicating with the center portion. The center portion carries on both surfaces thereof means protruding therefrom which extend in a curvilinear direction across said center portion to effect turbulence of the circulating heat transfer mediums.

For a more complete understanding of this invention reference should be made to the drawings wherein:

Figure 1 is a fragmentary perspective view of the improved plate heat exchanger shown in a partially disassembled relation.

Fig. 2 is a front elevational view of one of the ungasketed heat exchange plates shown in Fig. 1;

Fig. 3 is a front elevational view of one of the gasketed heat exchange plates shown in Fig. 1;

Fig. 4 is an enlarged fragmentary back elevational view of the heat exchange plate shown in Fig. 3;

Fig. 5 is an enlarged fragmentary side elevational view taken along line 5—5 of Fig. 3;

Fig. 6 is an enlarged fragmentary front elevational view of the gasketed heat exchange plate which contacts the terminal header seen in Fig. 1;

Fig. 7 is a left side elevational view of the heat exchange plate shown in Fig. 6;

Fig. 8 is a fragmentary enlarged front elevational view of the corrugated portion of the heat exchange plate, shown in Fig. 3, in overlying relation with respect to the corrugated portion of the heat exchange plate, shown in Fig. 2;

Fig. 9 is a diagrammatic view of the corrugated plate portions shown in Fig. 8; the upper portion of the diagrammatic view indicating only the contacting portions of the corrugations, and the lower portion of the diagrammatic view indicating only the flow ways defined by the points of contact between the corrugations of adjacent plates;

Figs. 10 and 11 are fragmentary sectional views taken along lines 10—10 and 11—11, respectively, of Fig. 8;

Fig. 12 is a sectional view taken along line 12—12 of Fig. 3;

Fig. 13 is an enlarged fragmentary sectional view of the marginal portions of a plurality of the heat exchange plates, shown in Figs. 2 and 3, arranged in assembled pressed relation;

Fig. 14 is an enlarged fragmentary sectional view taken along line 14—14 of Fig. 3;

Fig. 15 is similar to Fig. 14, taken along line 15—15 of Fig. 6; and

Fig. 16 is a diagrammatic view of a section of the heat exchange plates; solid and dotted lines indicating respectively the direction of flow of two heat transfer mediums between the heat exchange plates.

Referring now to the drawings and more particularly to Fig. 1, a portion of a plate heat exchanger 20, in partially disassembled relation, is shown which in this instance comprises an elongated support member 21, one or more terminal headers 22 mounted on said member 21 for slidable movement longitudinally thereof, and a plurality of heat exchange plates 27 and 28 mounted in face-to-face relation on member 21 and likewise slidable longitudinally thereof. Guide members, not shown, disposed in parallel relation with member 21, are provided for engaging the lower end of each of the plates 27 and 28. The support member 21 and guide members are supported at opposite ends by upright frame members, not shown, one of which is normally designated a stationary header. An adjustable presser plate, not shown, is mounted on the other frame member and cooperates with the stationary header to effect pressing of a plurality of terminal headers 22 and heat exchange plates 27 and 28 therebetween to form a plurality of heat exchange plate sections 26, one of which is shown diagrammatically in Fig. 16. In a heat exchanger 20 used for pasteurizing dairy products, three plate sections usually designated the regenerative, heating, and cooling sections are normally utilized.

The terminal header 22, as shown in Fig. 1, functions as a spacer between adjacent plate sections 26, and is provided at its upper end with a yoke or hanger 23 which embraces the opposite sides of the support member 21 and terminates in a roller 24, the latter engaging the upper edge 25 of member 21. The member 21, in this instance, is substantially triangular in cross section. The terminal header 22 is usually provided with one or more ports 22' formed therein which are adapted to communicate with certain of the passageways formed between the plates 27, 27a, and 28, when the latter are in assembled pressed relation. The function of the terminal headers will become more apparent in the discussion to follow hereinafter.

The heat exchange plates 27 and 28, shown more clearly in Figs. 3 and 2, respectively, are fabricated preferably from sheet metal material such as high grade stainless steel and each plate comprises a corrugated center portion 30 and end portions 31 and 32 which are separated by the center portion 30. The end portions 31 and 32 are each provided with a centrally disposed recess 33 which is adapted to accommodate a portion of supporting member 21 and the guide members, not shown, when the apparatus is assembled. The recess 33 forms a pair of talon-shaped fingers 33a which engage the sloping sides of supporting member 21. The edge of each end portion, adjacent the recess 33, is bent over a slight amount to form a stiffening flange 33b to compensate for the relatively thin gauge sheet material used in fabricating the plates. Plates 27 and 28, as shown in Figs. 3 and 2, respectively, each have four apertures, A, B, C and D, two of which are formed in each of the end portions 31 and 32. All of the apertures are of uniform size and when the plates 27 and 28 are in assembled relation, the corresponding apertures on the plates are adapted to align with respect to one another to form conduits through which the heat transfer mediums may flow. The number of apertures in the end portions 31 and 32 of each of the plates 27 and 28 may vary according to the location of the particular plate within the assembled plate section 26, as seen more clearly in Fig. 16. In the diagrammatically shown section 26, see Fig. 16, the direction of flow of the heat transfer mediums, in this instance designated milk and water, between the various plates of the section is shown in full and dotted lines respectively. It will be noted in Fig. 16 that plates 27 and 28 are alternately arranged within the section and that one of the heat transfer mediums flows on one side and the other heat

transfer medium flows on the opposite side of each of the plates of the section, with the exception of the end plates 27a in which case the heat transfer medium flows only on one side thereof.

Plate 27, shown in Fig. 3, carries a gasket 34 which is mounted on both sides thereof, namely, the front and back surfaces of the plate, and includes a portion 34a which delimits an area comprising the corrugated center portion 30 and a part of each of the apertured end portions 31 and 32. In this instance, gasket portion 34a includes, within the delimited area, apertures A and D and defines the area over which one of the heat transfer mediums is caused to circulate. Apertures B and C, in this instance, are completely encircled by gasket portions 34b which effect sealing off of these apertures with respect to the delimited area of gasket portion 34a and thereby permit one of the heat transfer mediums to bypass the area delimited by gasket portion 34a. A recessed trough 34c is formed in gasket 34 between gasket portions 34a and 34b and is adapted to prevent the heat transfer mediums from becoming mixed or contaminated by one another in case a part of gasket portions 34a and 34b should become ruptured. In the event that a rupture should occur in either end portion 31 or 32 of the plate, the heat transfer medium—milk or water—will flow into trough 34c and escape out along the elongated sides of the plate and be readily detected, thereby facilitating location of the ruptured gasket when the apparatus is assembled. A delta-shaped protuberance 34d is formed in the gasket at the mouth of the trough 34c adjacent the edge of the plate and is adapted to engage a portion of the adjacent plate 28, when the plates 27 and 28 are in assembled relation with respect to one another. The protuberance 34d gives added support to the assembled plates at a point near one of the apertures and thereby eliminates the possibility of the plates diaphragming with respect to one another when the heat transfer medium is circulated under high pressure through the apparatus.

Gasket portion 34a, as seen in Fig. 3, is spaced from the ends of the corrugations, formed in center portion 30, so as to provide a narrow marginal passage 35 which, when the plates are assembled, is adapted to accommodate protuberances 36 formed about the marginal portion 28a of plate 28, as seen more clearly in Fig. 13.

Disposed within the area of plate 27, delimited by gasket portion 34a, and adjacent apertures A and D are a plurality of protuberances 37 which, when the plates are assembled, are adapted to contact the corresponding portion on the adjacent plate 28 positioned in front thereof. The protuberances 37 have a dual function; first, they give added support to the plates adjacent the apertures, and secondly, form pockets or dimples on the back side of plate 27 which are adapted to accommodate a portion 34' of the gasket 34 in a manner, as seen in Fig. 14. The accommodated gasket portions 34', which take the form of lugs, are adapted to prevent the gasket, adjacent the apertures A through D, from spreading or moving relative to the metallic plate on which it is mounted when the heat transfer medium is flowing through the apertures under high pressure. The gasket 34 is formed preferably of a plastic material, such as rubber, which may be readily vulcanized directly on the sheet material during the fabrication of the latter and which will not be deleteriously affected by either of the heat transfer mediums. The portions of the gasket 34 disposed on the front and back surfaces of the plate 27 are preferably integral with one another.

It is to be noted that each of the gasketed plates 27a which, as heretofore mentioned, is the end plate of a section and contacts the adjacent surface of either the terminal header 22, presser plate, or stationary header—the latter two not shown—has all of the apertures A through D on the side of the plate which is in contact with one of said adjacent surfaces, completely gasketed with respect to one another by gasket portions 34b, as

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seen in Fig. 6. The reason for gasketing all of the apertures on this side of the plate 27a is to prevent any of the heat transfer medium becoming trapped between the plate 27a and the adjacent surface of the header 22, presser plate, or stationary header. It is also to be noted, in Fig. 7, that the portion of the gasket 34 disposed on this side of the plate 27a is not of the same thickness as the portion of the gasket disposed on the other side of the plate. The reason for this thickness differential between the portions of the gasket on either side of plate 27a is that the thinner gasket engages the adjacent uncorrugated surface of the header 22, presser plate, or stationary header and permits the corrugations formed in the center portion 30 of the plate to contact the adjacent surface, as well. The remaining gasketed plates 27 in a section 26 have the portions of the gasket 34 of uniform thickness on both sides of the plate 27, as seen in Fig. 14.

It is to be noted in Fig. 13 that, when the plates 27 and 28 are in assembled pressed relation, the protuberances 36 formed in the marginal portion of plate 28 do not contact the adjacent marginal space 35 of plates 27 disposed on either side of plate 28. Thus, the heat transfer medium may circulate over the protuberances as well as around them. The function of the protuberances 36 is to act as flow-retarders, thereby preventing the heat transfer medium from flowing at a more rapid rate along the sides of the center portion 30 than in the middle thereof. This flow-retarding action is caused by the great turbulence effected by the protuberances along the sides of the center portion. It will be noted that only every other one of the protuberances 36a or 36b project in the same direction from a particular side of the plate 28. As a result of the increased turbulence within the marginal space 35 of plate 27, no depositing or accumulating of particles of the heat transfer medium occurs on the plate adjacent the gasket portion 34a, as had generally occurred in prior heat exchangers. This depositing, particularly in the case of milk, is frequently referred to as milk stoning which materially increases the difficulty of cleaning the plates subsequent to disassembly of the apparatus.

The longitudinal edges of the center portion 30 of plate 28, as seen in Fig. 13, are bent in substantially the same direction to form a pair of flanges 38, between which a gasketed plate 27 nests, when the plates are in assembled relation. The flanges 38 prevent outward spreading of the gasket portion 34a when the plates are pressed together and thereby reduce the possibility of gasket failures. In addition, a further strengthening or stiffening effect for the plate 28 is obtained by reason of the flanges 38.

Both plates 27 and 28, when fabricated, have the corrugations 40 formed in center portions 30 thereof extending in a curvilinear direction across the plates. The incurvate corrugations 40 are formed in the sheet material by subjecting the latter to a high pressure between forming dies. By reason of the incurvate contour of the corrugations and the very high pressure required for their formation, it is believed that there is an actual flow of the metal throughout the corrugated portion of the plate which results in no internal stresses remaining within the plate subsequent to forming, which might cause the latter to buckle, warp, or deform when the plate has been released from an assembled pressed position with respect to other plates. Thus, the plate 27 or 28, because of its freedom of any locked-up internal stresses, will always assume a planar position, thereby facilitating cleaning, assembling, and disassembling of the apparatus 20.

While the corrugations 40 are shown in this instance to be continuous and to extend thwartwise of the plates 27 and 28, it is to be understood, of course, that these corrugations might be formed of interrupted segments and extend in a direction other than that shown without departing from the scope of this invention. In the plates 27 and 28 shown in Figs. 3 and 2, respectively, the corrugations thereof are arcuate in shape. When the plates are

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in assembled relation, as seen in Figs. 8 and 9, the direction of curvature of the corrugations of each succeeding plate is opposite from the one preceding it, thus the center portions 30 of adjacent plates contact one another at several points as seen in the lower half of Fig. 9. These points of contacts define flow ways 41, 42a and b, 43a and b, 44a and b, 45a and b, and 46a and b within the passageway formed between adjacent plates. The number of flow ways will vary depending upon the radius of curvature of the corrugations 40. The widths of the flow ways decrease uniformly from the longitudinal center of the center portion outwardly to the marginal space 35 of plate 27 or the corresponding point on plate 28. It will also be noted that the actual contacts between adjacent plates are mere points but because of the acute angles of crossing of the contacting protuberances at the middle of the center portions, wider restrictions to flow result, as indicated in Fig. 9. No point of contact between the plates occurs at the longitudinal centerline because of the fact that the ridges 40a and valleys 40b of the corrugations 40 of one plate are not superimposed with respect to one another as seen more clearly in Fig. 10, but instead are offset approximately one-third the distance between adjacent ridges 40a of a plate. Notwithstanding the fact that the flow ways 41, 42a and b, 43a and b, 44a and b, 45a and b, and 46a and b are not uniform in width, a uniform rate of flow of the heat transfer medium between the adjacent plates is obtained which is believed to be due to the fact that the ridges 40a and valleys 40b within flow ways 41 are disposed substantially at right angles to the direction of flow within the flow way 41, thus causing more resistance to flow than is caused by the ridges and valleys of the corrugations within outer flow ways 46a and b which are substantially less than a right angle with respect to the direction of flow. A further contributing factor to this uniformity of flow rate is due to the fact that the restricted areas about the points of contact defining flow way 41 are of greater size than those about the points of contact defining the other flow ways. Thus, by reason of the turbulence caused by the larger contact areas, the effective width of flow way 41 is reduced to a substantially greater extent than flow ways 46a and b.

By varying the number of apertures A, B, C, or D in each of the plates 27, 28, or 27a, the numbers of streams of water or milk flowing in one direction between adjacent plates to form a pass, as commonly referred to in this art, may be varied to suit a particular condition. In the plate section 26, shown in Fig. 16, the flow passages for the milk and water each constitute a two-stream pass and a three-stream pass system.

Thus, it will be seen that a plate heat exchanger has been provided which is simple and compact in construction, may be readily cleaned and serviced, requires less plates because of the greater heat transfer capacity of the novel plate design, and readily meets the rigid standards of cleanliness as set forth by various municipal, State, and Federal agencies.

While a particular plate heat exchanger has been shown above, it will be understood, of course, that the invention is not to be limited thereto, since many modifications may be made, and it is contemplated, therefore, by the appended claims, to cover any such modifications as fall within the true spirit and scope of this invention.

I claim:

1. In a plate heat exchanger capable of disassembly through which a heat transfer medium circulates, a pair of removable complementary thermal conductive plates, said plates being arranged in contacting face-to-face relation to form a plurality of elongated substantially parallel passageways therebetween for such medium, the widths of said passageways becoming progressively narrower from the center passageway outwardly toward the sidewise spaced passageways each plate comprising an elongated center portion having a plurality of elongated crescentic corrugations formed therein, said corrugations

being arranged in substantially coextensive relation and extending crosswise of said center portion and transverse to the direction of flow of such circulating medium to effect turbulence of the latter, the direction of curvature of the corrugations on one plate being opposite from the direction of curvature of the corrugations on the other plate whereby only segments of the corrugations of said plates are in contact with one another when said plates are in assembled relation, and define said passageways the portions of the corrugations of said complementary plates disposed between said contacting corrugation segments defining said center passageway being in staggered spaced relation with respect to one another, when said plates are assembled, to effect uniform rate of flow of such medium through all of said passageways, and means formed on each plate and disposed on opposite sides of said center portion and communicating with said passageways to effect circulation of such medium therethrough.

2. A plate heat exchanger capable of disassembly through which a heat transfer medium circulates, comprising a pair of removable thermal conductive plates arranged in contacting face-to-face relation to form a plurality of elongated substantially parallel passageways for the circulating medium, each plate having the contacting face thereof provided with a plurality of elongated crescentic corrugations extending crosswise of the plate face and substantially transverse to the direction of flow of the circulating medium to effect turbulence of the latter; the direction of curvature of the corrugations of one plate being substantially opposite from the direction of curvature of the corrugations of the other plate whereby only segments of the opposite corrugations are in contact with one another, the magnitude of the medium flow resistance effected by the contacting segments of said opposed corrugations becoming progressively smaller from the center passageway toward the sidewise spaced passageways formed between said pair of contacting plates.

3. A plate heat exchanger capable of disassembly through which a heat transfer medium circulates, comprising a pair of elongated thermal conductive plates arranged in contacting face-to-face relation to form a plurality of longitudinally extending passageways for the circulating medium, each plate having the contacting face thereof provided with a plurality of elongated crescentic substantially coextensive corrugations extending crosswise of the plate face and substantially transverse to the direction of flow of the circulating medium to effect turbulence of the circulating medium and to maintain said plate in substantially planar configuration when in disassembled relation; the direction of curvature of the corrugations of one plate being substantially opposite from the direction of curvature of the corrugations of the other plate whereby only segments of the opposed corrugations are in contact with one another, the widths of the passageways defined by said contacting segments becoming progressively narrower from the center passageway outwardly toward the sidewise spaced passageways.

4. The exchanger recited in claim 2 wherein one of said pair of contacting plates is provided with a marginal gasket delimiting the corrugated center portion thereof and a similar corrugated center portion on the other

of said pair of plates; said second plate having the contacting face thereof provided with a marginal flange adapted to accommodate and encompass portions of said marginal gasket.

5. The exchanger recited in claim 2 wherein one of said pair of contacting plates is provided with a one-piece marginal gasket having a first section thereof delimiting the contacting face on one side of said plate and having a second section thereof integral with said first section and delimiting the contacting face on the other side of said plate.

6. The exchanger recited in claim 2, wherein one of said pair of contacting plates is provided with a plurality of marginal protuberances spaced endwise from said crescentic corrugations, the projection of said marginal protuberances being less than the projection of said crescentic corrugations whereby said marginal protuberances are not in contact with the other of said pair of contacting plates.

7. In a plate heat exchanger capable of disassembly through which a heat transfer medium circulates, comprising a plurality of removable thermal conductive plates arranged in contacting face-to-face relation to form a plurality of elongated substantially parallel passageways for the circulating medium between adjacent plates, each plate having the contacting face thereof provided with a plurality of elongated crescentic corrugations extending crosswise of the plate face and substantially transverse to the direction of flow of the circulating medium to effect turbulence of the latter; the direction of curvature of the corrugations of one plate being substantially opposite from the direction of curvature of the corrugations of the adjacent plate whereby only segments of the opposite corrugations are in contact with one another, the magnitude of the medium flow resistance effected by the contacting segments of said opposed corrugations becoming progressively smaller from the center passageway outwardly toward the sidewise spaced passageways; only alternate plates of said plurality of plates being provided with a marginal gasket having one segment thereof affixed to one contacting face thereof and delimiting the corrugated area thereof and a similar area on the contacting surface of the adjacent plate, and a second section of said gasket integral with said first section and affixed to the opposite contacting face of said plate and delimiting the corrugated area thereof and a similar area on the contacting surface of the adjacent plate; the remaining alternate plate being provided with a marginal flange encompassing a portion of the gasket section of one of the adjacent gasket plates.

References Cited in the file of this patent

UNITED STATES PATENTS

1,747,115	Higgins	Feb. 11, 1930
2,248,933	Astle	July 15, 1941
2,550,339	Ehrmann	Apr. 24, 1951
2,594,008	Getz	Apr. 22, 1952
2,610,834	Dalzell	Sept. 16, 1952
2,676,000	Ekwall	Apr. 20, 1954

OTHER REFERENCES

60	Serial No. 402,669, Manz (A. P. C.), published May 25, 1943.
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