The present invention relates to heat exchange devices for cooling or heating liquids, such as, for example, as liquid dairy products. More particularly it is related to the method of making a heat exchange element which may be a multi-sectioned, sanitary, heat absorbing or refrigerant expanding unit for the compressor type of cooling machine adapted to be used in the top feed, trickle type of film cooler, employing multi-unit, compact constructions. The present application is a division of our application Serial No. 243,130 entitled “Heat exchange device” and filed November 30, 1938, which fully discloses and describes the heat exchange section and the process of making the section, which process is specifically claimed in this application. The heat exchange section as an article of manufacture is described and claimed in our co-pending divisional application.

The heat exchange section disclosed herein is described and claimed as an article of manufacture in our co-pending application Serial No. 442,750 entitled “Heat exchange element” and filed May 13, 1942.

In heat exchange elements of the type referred to, such as are used for the handling of food products, it is essential that the heat exchange sections be easily cleaned and of a sanitary construction providing smooth, unbroken surfaces free from cracks, crevices and shoulders for the flow of the milk or liquid to be treated and also to provide smooth passages for the flow of the heat exchange medium. The accompanying drawings illustrate the invention.

The principal objects of the present invention are to provide a simple method of constructing a heat exchange element which may be made in one or more joined sections with equal facility; in which embossed or corrugated sheets of metal are arranged face to face in opposed relation and sealed along predetermined lines, thus providing sealed liquid passages intermediate the plates; in which the bracing elements are substantially insulated from the heat exchange medium and so formed as to prevent the sections from freezing together, as well as to act as fluid control and distributing elements and spacing means when a plurality of elements is operated in close side-by-side position; and in which the embossings of the sections are so constructed and arranged as to cause turbulence in the liquids flowing through the interior of the sections and over the outer surface of the sections.

A further object of this invention is to provide an improved method of fabricating the improved heat exchange element whereby the side walls are formed integrally with the end bracing elements and are provided with oppositely disposed protuberances along the flow passages of the refrigerant or heating liquid, which flow passages are angularly disposed to the direction of flow of the liquid being treated and are formed by the application of internal pressure after the various parts of the unit have been assembled. Such construction not only results in the marked efficiency of the operation of the element but also results in a marked saving in the assembly and fabrication thereof.

With the foregoing and other objects and important features in view, the invention consists of certain novel features in the method of construction of a heat exchange section as will be readily apparent upon the examination of the details of construction and arrangement and various combinations as disclosed in the figures and following description, all of which will be first fully described and then specifically pointed out in the appended claims, references being made to the accompanying drawings in which:

Figure 1 is a side elevation of a multi-sectioned heat exchange element embodying our invention.

Figure 2 is a plan view of the heat exchange element shown in Figure 1.

Figure 3 is a fragmentary end view of the heat exchange element shown in Figure 1 and particularly emphasizing the inlet and outlet connections for the liquid to be circulated through the interior of the sections of the element.

Figure 4 is an elevational view of a portion of the liquid distributing and heat exchange element reinforcing bar or bracing mounted at the upper edge of the section, showing the novel surface of the liquid distributing element and schematically illustrating the dispersion of the liquid as it travels over the uniquely surfaced reinforcing or bracing portion of the element before it reaches the upper portion of the uppermost sections of the heat exchange element.

Figure 5 is a side elevation of a portion of a heat exchange section provided with novel surfacing at spaced positions intermediate the treating liquid flow passages and along the path of travel of the liquid being treated to disperse the same and more uniformly distribute the liquid on the heat exchange surfaces.

Figure 6 is a transverse sectional elevation, partially in broken away fragmentary section, of a heat exchange element embodying our invention taken along line 6–6 of Figure 1.
Figure 7 is a transverse sectional elevation of the heat exchange element embodying our invention, taken along the line 7-7 of Figure 1. Figure 8 is a transverse sectional elevation taken along the line 8-8 of Figure 1. Figure 9 is a longitudinal sectional plan taken along the line 9-9 of Figure 1. Figure 10 is a longitudinal elevational view of the juxtapositioned metal stampings used in the construction of the heat exchange sections before assembly and before joining the same to form a multi-sectioned element, which figure shows the line of welding defining the liquid passages before the same have been shaped or the ends of the sections flared. Figure 11 is a transverse sectional elevation taken along line 11-11 of Figure 10. Figure 12 is a transverse sectional plan taken along line 12-12 of Figure 10. Figure 13 is a sectional plan of an end portion of a partially fabricated section showing the various elements of the structure including the end plates for sealing the ends of the sections in separated position in relative order of assembly. Figure 14 is a fragmentary perspective view, partially in broken-away section of a portion of a heat exchange section, embodying our invention. Figure 15 is a longitudinal elevation of a modification of the heat exchange section embodying our invention. Figure 16 is a transverse sectional elevation taken along line 16-16 of Figure 15. Figure 17 is a transverse sectional elevation taken along line 17-17 of Figure 15. Referring to the illustrations, the invention in its preferred form as illustrated in Figure 1, comprises a plurality of joined sections C. Each heat exchange element as illustrated may, when a multi-zoned element is desired, include several zones or sections C provided with independent flow passages 20. These independent sections of the elements or units are all identical with the exception of the topmost section 21 of each unit, which topmost section 21 is provided with its top edge with a cylindrical bracing and liquid dispersing element 22 substantially devoid of heat exchange relation with the rest of the section to which it is affixed. The flow passages in the various sections or zones of the multiple-sectioned element or unit consist of outwardly bulged cooperative portions of two rectangular sheet metal stampings 23 and 24 intermediate a series of two sets of continuously welded lines to form the stampings and defining the flow passages in between the two stampings 23 and 24. In the illustrations, as clearly shown in Figure 10, the various adjacent horizontal reaches of the flow passages are formed in the joined stampings by certain portions of each of the two sets of continuous weld lines. It is desired at this point to indicate that the various sections of the two sets of continuous weld lines intermediate the adjacent reaches of the flow passage as shown in Figure 10 may also be of spot welding or "skp welding" construction. By such a "skp welding" construction, it would be possible to provide bypass intermediate adjacent reaches of the zigzag flow passage 20 to facilitate the discharge of refrigerant gas from the flow passage by reducing the distance through which the gas must travel to reach the discharge outlet. The two ends of the continuous flow passage 20 intermediate the opposed stampings constituting the section walls are located, in the preferred embodiment of the invention, at the lower and upper lefthand corners of each section of the unit of the heat exchange element and are respectively the inlet port 28 and the outlet port 29. However, it should be evident that the flow passage 20 could be so arranged and constructed that the ends thereof would be located at opposite ends of the sections. The zigzag passage 20 consists of a series of horizontal lengths of reaches of passage formed between outwardly bulged portions of the stampings 23 and 24, with appropriate bulged vertical passage segments so joined to the ends of the horizontal reaches of the passage 20 as to constitute a zigzag line of travel for the liquid circulating therethrough. The stampings 23 and 24 consist of a substantially co-planar metal sheet (preferably non-corrosive metal such as stainless steel) provided with a series of horizontal tiers of staggered rows 27 of outwardly directed, hollow, preferably semi-spherical protuberances 28 extending substantially across the face of the stampings 23 and 24 and leaving only vertical margins 29 at each end of the flat stamping. The rows of protuberances are preferably three deep and the site of the protuberances 28 is such as to effectively block the space intermediate two adjoining protuberances in an adjacent row 27, thereby effectively diverting any liquid which may flow through between the protuberances in the adjoining row. The vertical margins at the ends of the stampings 23 and 24 are flared outwardly, forming flanges 30. End plates 31 with inwardly directed flanges 32 are affixed to the free ends of flanges 30 as by weldings 33 between the end of the outwardly turned flange 30 of the stampings and the inwardly turned flange 32 of the end plates 31, with the exception of that portion of the flanges 30 immediately adjacent the inlet and outlet ports 25 and 26 for the passages 20. Triangular webs or partition elements 34 are affixed intermediate the flanges 30 at each end of each end plate 31, thereby sealing the vertical space intermediate the flanges 30 and the end plates 31, which space and its defining flange 30, 34 and 31 are substantially devoid of heat exchange relation with the passages 20 and the refrigerant or cooling medium or liquids which may flow through the passages. Each section or zone C of the heat exchange elements provided with an inlet and outlet hinge arm 35 and 36 respectively for establishing communication between the liquid passages 20 and for supporting the weight of the multiple-sectioned heat exchange element when mounted in a frame or machine, and these hinge arms are joined to the sections at the inlet and outlet ports 25 and 26 respectively and in communication with passage 20. The inlet and outlet ports 25 and 26 are defined by portions of the flange 30 intermediate two triangular partition elements 34 adjacent the two ends of the passage 20 of the unit. The ends of the hinge arms 35 and 36 are welded to or otherwise satisfactorily affixed to the outer edges of the flange 30 and partition 34 which define the inlet and outlet ports 25 and 26, and the two rectangular stampings 23 and 24 are in face to face contact with each other and the oppositely directed corresponding protuberances 28 are in exact transverse alignment. It should, however, also be remembered that satisfactory heat exchange sections and multiple-sectioned elements may be made by arranging the trans-
versely opposed protuberances in staggered or ther satisfactory relation one to another whereby turbulence of the liquids may be secured. On the interior of each stamping the inner surface spherical protuberances presents cavities which have an agitating effect in the refrigerant or cooling liquid as it is speedily passed through the flow passage 20 when the sections are placed in operation as heat exchange elements.

In the construction of a multi-zoned or multi-sectioned heat exchange element several separate individual units or zones 38 and 21 with a separate liquid passage 20 for each are welded together along their adjoining edges in superposed order as shown in Figure 1. Each zone or section is provided with separate liquid inlet and outlet connections in the form of hollow hinge arms 35 and 36 respectively. The spacing of the horizontal lengths of the flow passage 20 in each of the zones or sections of the compound units or elements which are combined to form an operative unit, is such that when two sections are joined in superposed order, the separate adjacent horizontal elements of the flow passage 20 of the adjoining sections are spaced from each other equal to the spacing intermediate any two adjacent horizontal elements or reaches of a flow passage in a separate section. Such construction facilitates the fabrication of a multi-zoned unit from single individual zones or sections.

The multiple-sectioned unit is also easily adapted to the use of a plurality of heat exchange media in that any one or more of the zones of the unit can be supplied with any desired type of heat exchange medium while the remaining sections or zones of the unit may be supplied with one or more other types of heat exchange media depending on the results to be accomplished and the liquid being treated on the outer surface of the unit.

In each unit consisting of a plurality of joined sections or zones, the uppermost section which is passed on to the upper surface of the element 22, in small rivulets, passes off of the lower portion of the element 22 onto the inner surface of the upper zone 21 of the heat exchange unit.

A similar finish with horizontal grains is provided on the outer surface of the walls or stampings 23 and 24 of the sections C intermediate the horizontally extending reaches of the flow passages 20 as shown in Figure 5. After the liquid once passes onto the surfaces provided with the staggered rows of protuberances 28, it is maintained in substantially uniform distribution and active turbulence as it passes downwardly over the surface of the sections C. This is true even when the sections are not especially grained.

In the fabrication of each section or zone 38 of the heat exchange unit, it is preferable to use two sheet metal stampings 23 and 24 provided with rows of rows 21 of protuberances 28. The stampings are identical as to constitute the reverse counterpart of each other when they are assembled face to face in reverse relation as shown by Figures 11 and 12. The stampings 23 and 24 have in substance the plane of the sheet of metal from which they were stamped, and peripheral unstamped vertical marginal edges 29 of the juxtapositioned plates are planar as shown by Figures 10 and 12. The sheets are then welded together at their upper and lower edges along the weld lines 40 and 41 as shown in Figure 10, which weld lines extend along these edges over to the vertical unstamped portions of the end margins. The internal horizontal flow spaces of the sections C are then laid out and their edges sealed by seam-welding of the stampings along the horizontal lines 42, 43 and 44 intermediate the tiers of superposed staggered rows of the protuberances 28. It may be well to repeat at this point that the seam weldings 42, 43 and 44, which in the preferred embodiment of this invention are continuous, may also take the form of interrupted weld lines which may be appropriately described by the term "skip welding," whereby a modified flow passage 20 provided with bypasses intermediate the horizontal reaches of adjacent sections would be provided to facilitate a more ready escape of the evaporated refrigerant from the various elements 20 toward the outlet port 26. The joining of the corresponding ends of one of the group of alternate horizontal weld lines including the lines 40 and 41 along their righthand end as shown in Figure 10 by vertical line 45 and joining the remaining horizontal weld lines at their corresponding opposite ends by vertical weld line 46, as clearly shown in Figure 10, defines the flow passage 20. In each instance the horizontal weld lines and the vertical joining lines are no closer to the remaining horizontal weld lines and their joining lines than the width of a tier of rows 27 of the protuberances or baffles 28. This arrangement of vertical and horizontal weld lines defines a zigzag flow passage 29 with its open ends or ports 25 and 26 at the left and upper lefthand corners respectively of the stampings 23 and 24 forming the sections C of the heat exchange unit or element.

Having thus joined the stampings 23 and 24 along the weld lines just referred to, the vertical unstamped portion or edges 29 of each stamping are then flared outwardly to become flanges 30 as clearly shown in Figure 13. Triangular web or partition elements 34 are provided at the ends of the vertical spaces intermediate the outwardly
4. turned flanges 30 at the opposite ends of the sections C as shown in Figure 14, and also at vertical sections intermediate the flanges 30 at the left end of the sections C immediately above and below the inlet passage 25 and outlet passage 26, and communicating with the opposite ends of the zigzag liquid flow passage 20 as is also clearly shown in Figures 1 and 14. Each section or zone is then provided at its inlet and outlet openings 25 and 26 with inlet and outlet hollow hinge arms 35 and 36 respectively, which are welded or otherwise satisfactorily affixed to the free edges of the flanges 30 at the lower and upper lefthand corners of the sections C, respectively. The hinge arms 35 and 36 are each welded to the free edges of the adjacent triangular partitions 34 defining the upper and lower boundaries, respectively, of the inlet and outlet ports 25 and 26 to the liquid passage 20. End plates 31 with inwardly turned flanges 32 are then provided to enclose the vertical space intermediate the outwardly turned flanges 30 at either end of the section or zone C and between the triangular partitions 34, which space is not already taken up by the hinge arms 35 and 36. The end plates 31 are fixed to the flanges 30 by welding 33 or other satisfactory means between the flange 32 and the outer free edge of the flange 30 as is clearly shown in Figure 9.

Each of the topmost sections 21 of the heat exchange unit comprised of a plurality of sections C is also provided with a cylindrical, horizontally grained section and unit bracing element 22 extending across the uppermost edge of the section 21 intermediate the outwardly turned flanges 30. The horizontal grain lines 39 of the element 22 constitute liquid distributing and dispersing means to act on the liquid supplied to the element 22 in rivulet for uniform distribution throughout the entire length of the upper portion of the sections 21. Similar grain lines 39 are provided on the surface of the stampings 23 and 24 intermediate the horizontally extending tiers of rows of protruberances 28. To complete each of these respective sections C, provided at their ends with end plates 31, and only in the instance of the uppermost sections 21, the end plate 31 is provided near its upper extremity with a latch or catch 41. Such a latch facilitates the proper mounting and positioning of the heat exchange unit when assembled in compact order in an enclosed heat exchanger of the swinging section type for which the unit is particularly adaptable as is clearly shown in our copending application Serial No. 243,130.

To provide the individual zones or sections C of the multizoned units or heat exchange device with internal flow passages 20, the outlet hinge arms 35 of the completed multi-sectioned elements are each sealed and the inlet hinge arms 35 are each connected to a source of fluid pressure, such as hydraulic pressure. The pressure is adjusted until the portions of the plates or stampings 23 and 24 intermediate the weld lines defining the flow passages 20 have been bulged out to the desired shape as shown by the said drawings, Figures 7, 8, 9 and 14, depicting internal views of the sections, and Figures 6 and 14 depicting the bulged effect on the liquid passage boundary partitions of the stampings 23 and 24.

However, the stampings 23 and 24 may be stamped originally with the bulged portions to form the flow passages 20, and in such instances hydraulic pressure would not be required to form the internal flow passage 20.

In Figure 15 is shown a modified form of heat exchange section C, which differs only from the previously described sections by using horizontal spacing elements 48 and 49 intermediate the stampings 23 and 24 along the position occupied by the weld lines in the preferred embodiment shown in Figure 1 and Figure 10, which weld lines define the liquid flow passage 20. The spacing elements 48 along the horizontal weld lines comprise straight, narrow metallic strips of a thickness equal to the desired thickness of the heat exchange medium passage 20. The vertical spacing elements 49 along the position occupied by the vertical weld lines in the preferred form and defining liquid passage 20 are straight along their outer edges 50, but are curved along their inner edges 51 to facilitate the passage of liquid through the liquid passage 20. The spacer elements 48 are also of a thickness equal to the desired thickness of the liquid passage 20. The only other difference in the modified form of section shown in Figures 15, 16 and 17, when compared to the preferred embodiment of the invention as previously described and shown in the preceding figures, is the final shaping or bulging operation performed on the preferred embodiment of the invention, which shaping or bulging of the section employing fluid pressure is not necessary in the modified embodiment of my invention as illustrated in Figures 15, 16 and 17 which employs the use of the spacing elements 48 and 49. In this later described modified type of section the bulging operation is not required in that the flow passages 20 are formed by and defined by the spacing strips or elements 48 and 49.

It will of course be evident that the heat exchange device and the unique elements incorporated therein are particularly adapted for use in the treatment of foodstuffs, such as milk, requiring sanitary treatment, and the entire device is so constructed as to incorporate only sanitary features to make it acceptable for such use. However, the heat exchange element is also well adapted for use in the heating or cooling of other liquids which do not necessarily require sanitary handling, but in which heating or cooling operation it is desired to secure a high rate of heat transfer. An apparatus in which use it may also be desired to assemble the individual elements in close side-by-side compact relation as illustrated in a heat exchange machine fully described in our copending application Serial No. 243,130 of which this application is a division.

Each of the heat exchange sections is provided at either end with a transverse bracing element or end plate affixed to the outwardly flared vertical ends of the stampings constituting the walls of the individual heat exchange sections. The outwardly flared ends of the stampings, as well as the end plates, are united in sealed relation one to another and are substantially devoid of heat exchange relation with the heat exchange medium passing through the liquid flow passages on the interior of the respective sections. Being thus substantially devoid of heat exchange relation, there will not be a tendency of crystallization of spilled liquid to form on the outer surface of the outwardly flared flanges at the end of the sections of the multi-sectioned heat exchange element, or on the bracing end plate affixed thereto, thereby hindering the satisfactory operation of the heat exchange element.

Various changes in the heat exchange devices as shown and described to explain the invention in
the improved method of making the heat exchange section may be made in accordance with the common knowledge of those skilled in the art and yet come within the scope of the invention as set forth in the appended claims.

We claim as our invention:

1. The process of making a sheet metal heat exchange section which consists in forming a substantially flat sheet metal stamping provided with longitudinally extending superposed tiers of staggered rows of semi-spherical protuberances, superposing two or said stampings one upon another with corresponding protuberances in opposed relation, welding the stampings together along certain contiguous lines which form continuous weld lines defining a zigzag flow passage between the two stampings, sealing one end of said zigzag flow passage, and then separating said sheets at all points except said weld lines by introducing a fluid under pressure between said plates through said remaining open end of said zigzag flow passage.

2. The method of making a heat exchange element for liquids which comprises stamping superposed tiers of staggered rows of outwardly extending protuberances in a rectangular sheet of metal, placing a second sheet of metal of the same size and stampings face to face with the first sheet, sealing the top and bottom edges of the two sheets substantially throughout their entire length, welding the faces of the sheets together at separate intervals, flaring the vertical edges of each sheet outwardly away from the corresponding edge of the adjacent sheet, securing inlet and outlet fittings to the two ends of a flow passage between the two sheets defined by the lines of welding between said sheets, closing one of said fittings, and introducing a fluid under relatively high pressure between the sheets through the other fitting to force the sheets apart at all points except at points of welding to form a series of outwardly bulged flow passages with adjacent passages communicating one with another at their ends only, thereby forming a continuous zigzag flow passage intermediate said inlet and outlet fittings.

3. The method of making a multi-zoned heat exchange section for liquids which comprises stamping superposed tiers of staggered rows of outwardly extending protuberances in a rectangular sheet of metal of the size of a single zone, placing another sheet of metal of the same size and stampings face to face with the first sheet, sealing the top and bottom edges of the two sheets together substantially throughout the entire length of the sheets, welding the faces of the sheets together at separate intervals, flaring the vertical margins of each of the joined sheets outwardly away from each other, securing partition elements to said flared margins intermediate the same at the extreme ends of the free vertical space intermediate said margins, sealing inlet and outlet fittings to the two ends of the flow passage between the two joined sheets which flow passage is defined by the lines of welding between the sheets, securing end plates to the free edges of the said margins spanning the free space intermediate the flared margins, superposing one or more zones and joining them together at the adjacent edge, securing a bracing element to the top edge of the top zone, sealing all the outlet fittings of the several zones, and then separating the sheets of the several zones of the section by introducing a fluid under pressure between the several sheets through said inlet openings.

4. The method of making a sheet metal heat exchange section which consists in superimposing sheet-like stampings having fluid baffles means on their outer surfaces, securing said stampings together along continuous lines intermediate the same to define fluid flow space therebetween and to provide a unitary double walled plate-like structure having an inlet and outlet openings, applying bracing elements at either end of said stampings substantially devoid of heat exchange relation with the fluid flow space intermediate said stampings, sealing the outlet opening, and separating said stampings at all points except said lines securing the same together by introducing fluid under pressure between said stampings through said inlet opening.

5. The method of making a sheet metal heat exchange section which comprises superimposing two sheets of metal, both of said sheets being provided with staggered rows of fluid baffles on their respective faces, welding the joining faces of said sheets together along lines intermediate said rows of baffles and about the margins of the same providing inlet and outlet passages intermediate said plates which when into the space therebetween, applying high pressure between the faces through said passages to separate them between the welds, and applying bracing elements to the ends of said sheets of metal, said bracing elements being substantially devoid of heat exchange relation with the space intermediate the plates.

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