July 18, 1950

H. D. WHITE ET AL
REFRIGERATION EVAPORATOR AND
METHOD OF MAKING THE SAME

2,515,972

Filed June 25, 1946

3 Sheets-Sheet 1

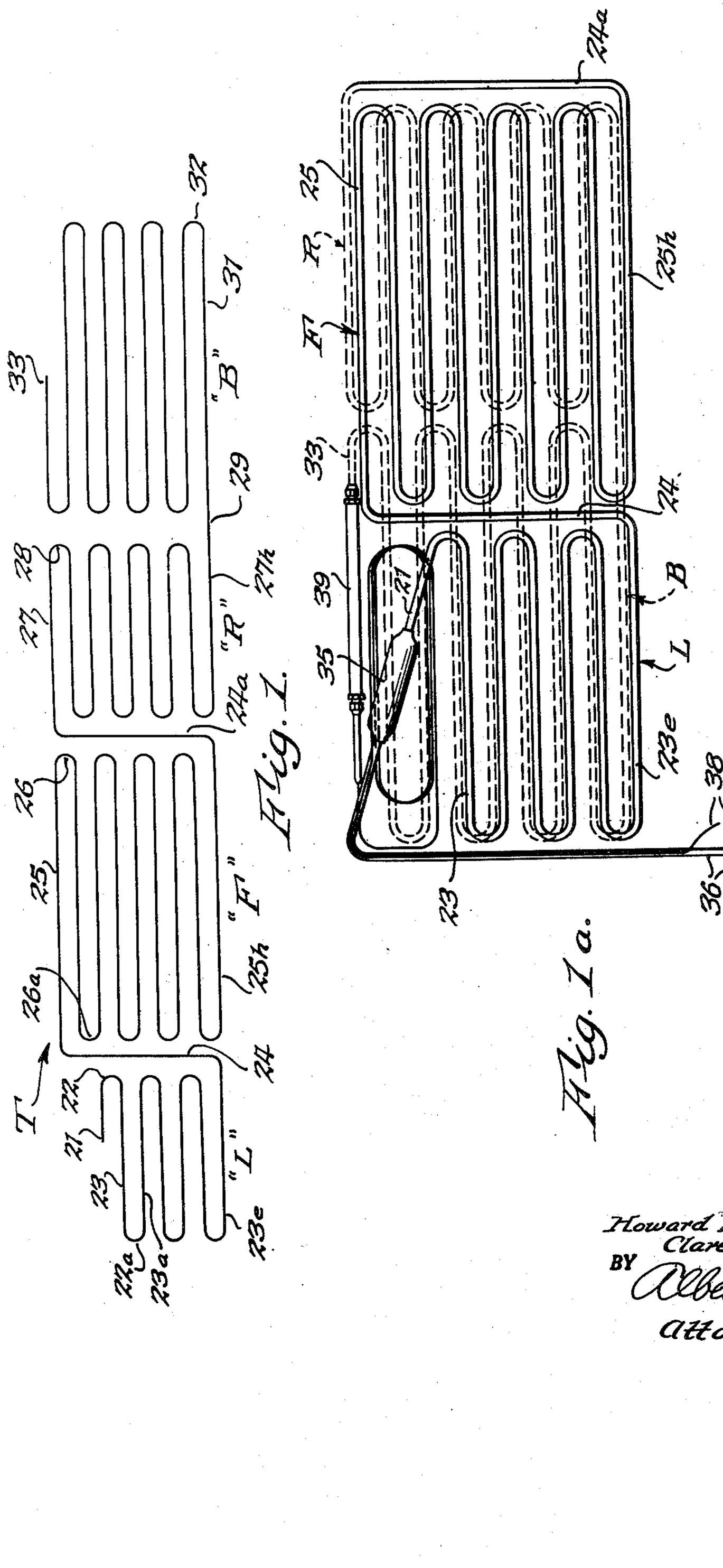

Fig. 1.

Fig. 1a.

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3 Sheets-Sheet 2

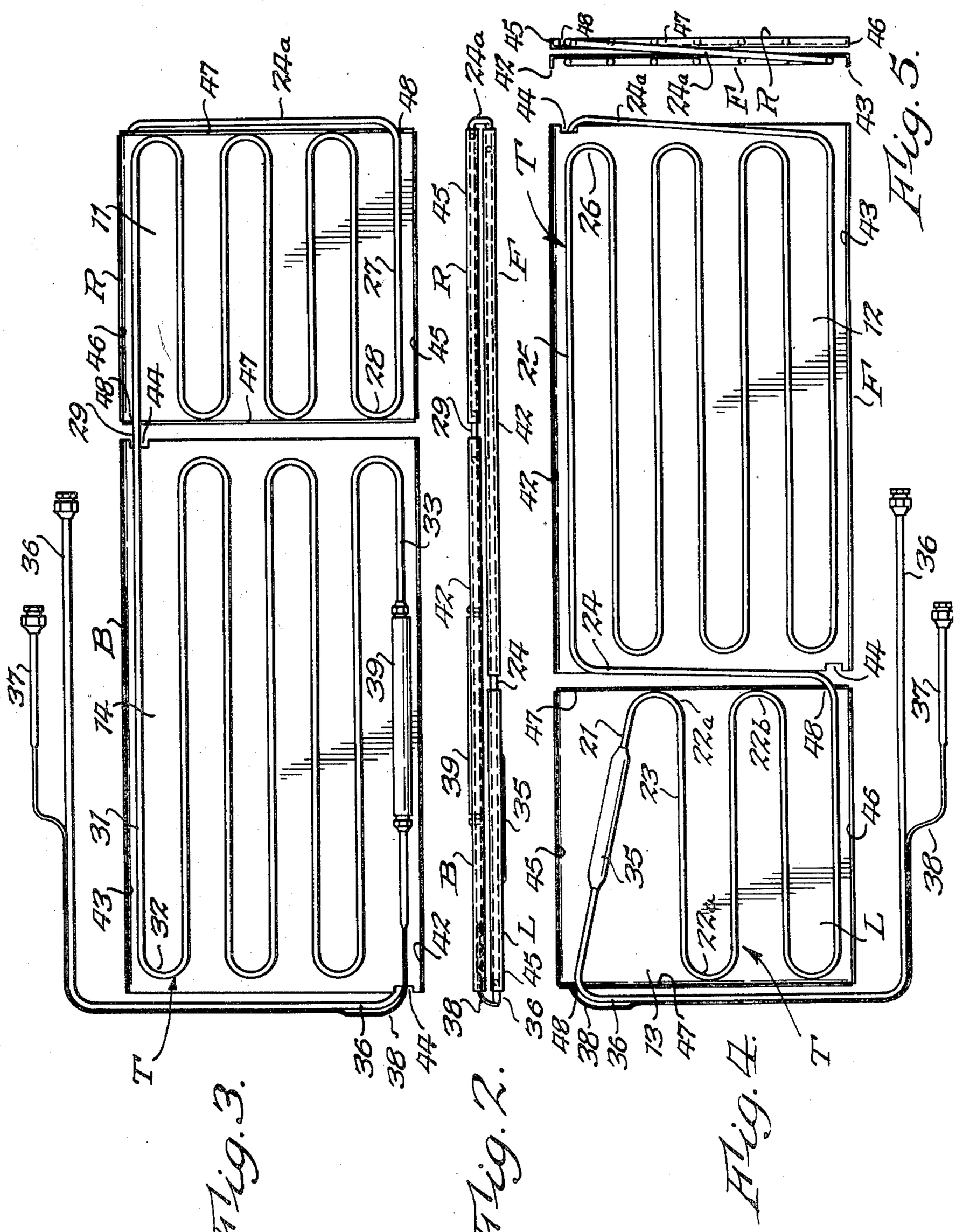

Fig. 3.

Fig. 2.

Fig. 4.

Fig. 5.

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Fig. 7.

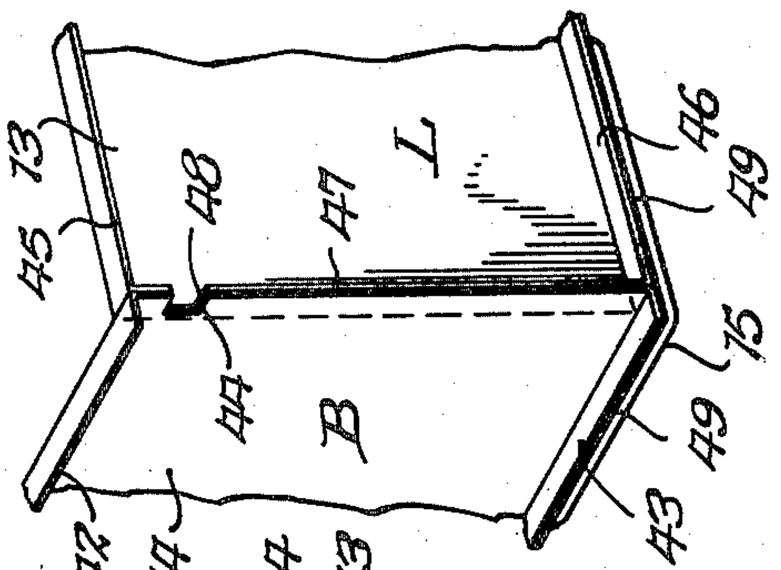
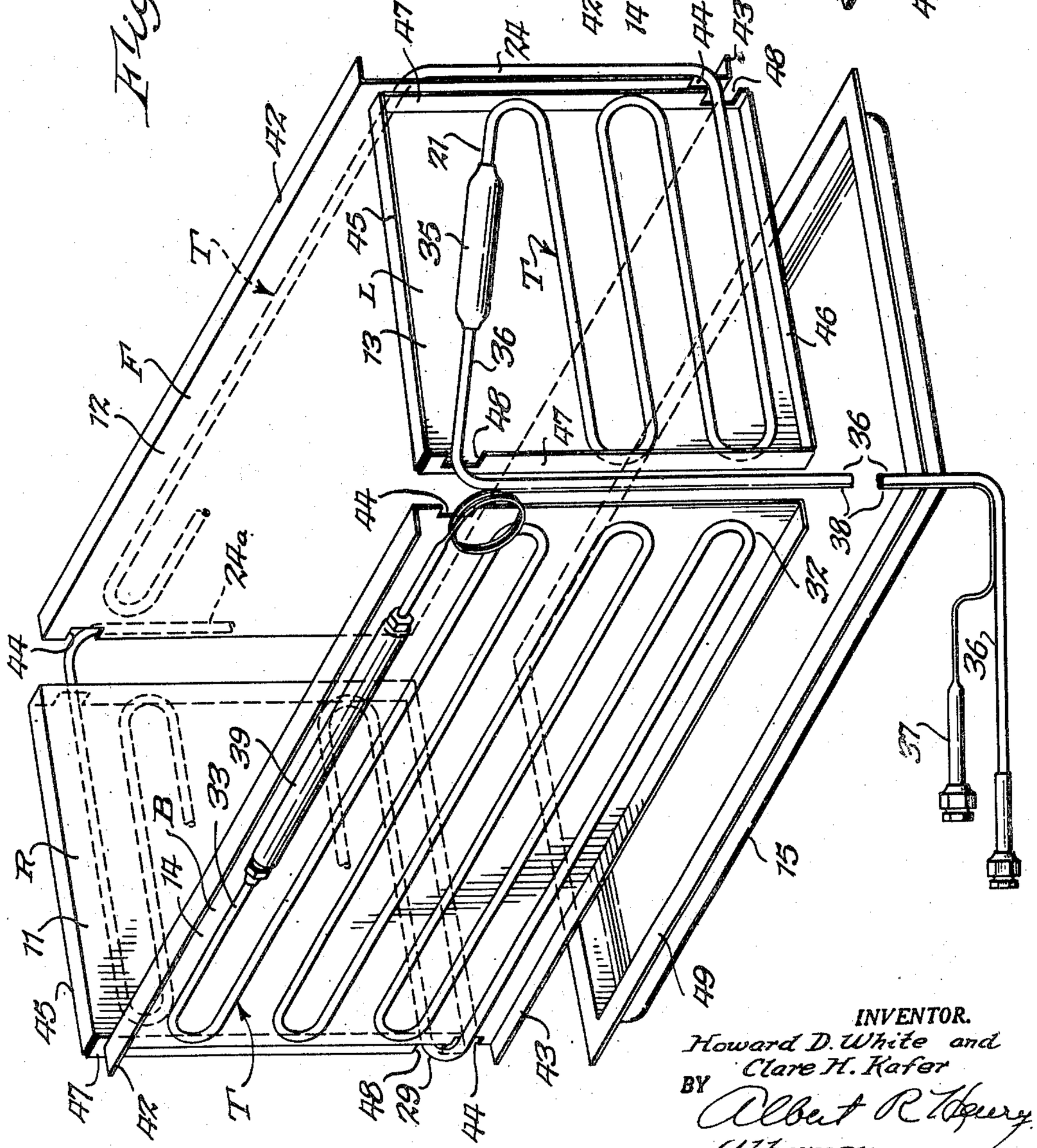


Fig. 6.



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UNITED STATES PATENT OFFICE

2,515,972

REFRIGERATION EVAPORATOR AND METHOD OF MAKING THE SAME

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6 Claims. (Cl. 62—126)

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This invention relates to a refrigeration evaporator and to a method of making the same, and it has particular reference to an evaporator of the continuous coil type, which, while being initially formed in a plane or flat condition, may be extended into box-like configuration to encase the side walls of a refrigerated container.

It has heretofore been customary to bend a length of tubing into various configurations around or within the walls of a storage compartment, and to connect the bent tubing in series with a condenser and compressor of a refrigeration circuit, the tubing then constituting the evaporator of the system. Insofar as we are advised, however, such evaporators have been formed by bending the tubing directly into the final intended shape. For example, if three sides of the compartment are to be covered with the coil, the tubing has simply been bent back and forth in more or less serpentine fashion to form a three-sided frame work which could be inserted in or around the storage space. Similarly, if four sides of a tank are to be encased, the practice has been to bend the tubing into regular prismatic form of a size suited to the tank dimensions.

It is essential to the proper functioning of a refrigerating machine and its components that the internal passages for the refrigerant be adequately dehydrated before the refrigerant fluid is introduced. The common practice of the art has been to place the parts, such as condensers and evaporators, in a drying oven, and to bake the parts until all moisture has been expelled. Inasmuch as the oven temperature must be kept below a value which would adversely affect the physical properties of the metals employed, the drying time is necessarily prolonged. When treating large coils, such as those employed for frozen food cabinets, beverage containers, and the like, the bulk of the prismatic coils necessitates the installation of enormous oven capacity if production speed is to be attained. Also, because of the dimensions of such coils, increased costs are encountered, despite relatively low weight, when they are shipped from a fabricating to an assembly point.

We have discovered that three dimensional, or prismatic, evaporator coils may be laid out initially in a plane form, and may be folded compactly so as to occupy a minimum of space while being dehydrated or transported. Coils made according to our invention may also be assembled with the other components required to form a complete "low side" for a refrigeration

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machine, and be dehydrated and treated as a unit to protect the assembly from the entrance of moisture. They may also be bent or extended into the desired final form after such treatment without injury to the tubing. The final article may thus be made with economies in manufacture and protection against faulty operation.

The principles of the invention will be fully understood by reference to the following detailed description of certain embodiments and practices, illustrated in the accompanying drawings, wherein:

Fig. 1 is a line diagram of a length of tubing bent into convolutions all initially disposed in the same plane;

Fig. 1*a* is a plan of a coil such as is indicated in Fig. 1, wherein two sections have been folded over flat against the other two sections.

Fig. 2 is an edge view of a four section coil of modified construction wherein two sections have been folded on two other sections;

Figs. 3 and 4 are plans taken from the opposite sides of the coil shown in Fig. 2;

Fig. 5 is an end elevation of the coil shown in Fig. 2;

Fig. 6 is an exploded view of the coil shown in Fig. 2 as the same is extended to prismatic form; and,

Fig. 7 is a detail of a corner of a tank showing how the edges may be joined.

Referring first to Fig. 6, there is shown side plates 11, 12, 13, and 14 respectively adapted to form the walls of a tank, and to be connected to a bottom pan 15. The side walls are encased with refrigerant tubing, generally designated by the letter T, which constitutes an expansion coil adapted to be connected in the usual refrigeration circuit. It will be seen that the structure as shown in Fig. 6 constitutes a hollow prismatic body defining a storage compartment, to which access may be had through the open top. The total volume of the body is, obviously, large compared to the volume of the tubing T and the side plates considered alone.

For convenience of description, the side walls 11, 12, 13, and 14 are also designated with the letters R, F, L, and B, arbitrarily designating the left, front, right, and back of rear sides of the tank structure, although the prism may of course be viewed from any direction. Similar designations are applied to the various sections of the coil T throughout the remaining figures.

In order to form the tubing T so that it may ultimately assume the configuration illustrated in Fig. 6, and in accordance with the principles

of the invention, a suitable length of tubing is first laid up in the flat by bending it back and forth as shown in Fig. 1. Beginning, for example, at the left of the figure, the tubing end 21 merges into a return bend 22 which runs through a straight stretch 23 to another return bend 22*a*, which enters a parallel stretch 23*a* to another return bend, and so on until the final stretch 23*e* is reached. These successive stretches and bends are all disposed in the same plane, that is, the plane of the paper, and they are here designated with the section letter "L," or left hand section, for the purpose previously noted.

Having thus formed one coil section, the tubing is bent at right angles, also in the plane of the paper, to form a riser 24, which, at a suitable height, is again bent at right angles to provide the first stretch 25 of the adjacent coil section "F." By means of return bends 26, 26*a*, etc., the section F is then formed in the same plane to include a series of parallel stretches, of which the last is designated 25*h*. The tubing is then again bent upwardly to form a second riser 24*a*, similar to the riser 24, and in the manner just described the tubing is again turned into stretches 27 and return bends 28 to provide the next coil section "R."

It will be noted that as the coil finishes the final stretch 27*h* for the section R, it is not given a bend to form another riser before entering the final section "B," although it may here be pointed out that such additional riser can be utilized if desired. The connection between the sections R and B is made with a straight length of tubing 29 in this particular instance, and the final section B is then formed with stretches 31 and bends 32, rising from the bottom to the top. The coil end 33 is thus brought out on the same side as the end 21, and the overall length of tubing T required for the laying up is shortened somewhat. Another reason for utilizing the straight connection 29 at this point will be apparent later.

Referring next to Fig. 1*a*, the tubing utilized in forming the plane coil just described is herein illustrated pictorially and the sections have been given the same symbols. To the end 21 of the left section is now attached an accumulator 35 and a return or suction conduit 36 adapted to be connected to the inlet side of a refrigerant compressor. Sections R and B, which were originally at the right as shown in Fig. 1, are then bent or folded bodily under sections F and L, by twisting the riser 24*a* between its ends or right angle bends through an arc of 180°. The materials of which evaporators are customarily formed are quite workable, and they lend themselves to the imposition of such torsional strain without liability of failure. In one aspect, the riser, which is disposed transversely of the section, becomes a hinge or pivot member about which the sections may be relatively rotated. Section B therefore now underlies section L, while section R underlies section F, and the overall length of the convoluted tubing, as laid out in Fig. 1, has accordingly been reduced to substantially half its original value, while the thickness has of course been slightly more than doubled. For clarity of illustration, the underlying R and B sections are shown in dash lines, while the upper L and F sections appear in solid lines, this draftsman's convention being utilized to permit the reader to follow the tubing from one end to the other.

It will be noted that the coil end 33 of Fig. 1 now points in the same direction as the opposite end 21. A supply conduit 37 and capillary tube 38 is now soldered or otherwise connected to the return line 36 for the well known heat exchange function, and the outlet end of the capillary is connected through an adapter 39 to the coil end 33, which now of course becomes the refrigerant inlet end.

With reference to this specific example, it may be observed that it would be possible to twist the riser 24 in the opposite direction from the riser 24*a*, thereby placing the section L over the section F, and if a riser were interposed between the sections R and B, the same step could be repeated, thereby to foreshorten the compacted assembly to approximately one quarter of its length indicated in Fig. 1. Within the broad principles of the invention, such a modification may be resorted to, and its utilization ought to depend upon practical considerations of overall coil dimension and packing space. For example, the coil as laid up in Fig. 1 for a storage cabinet of six cubic feet capacity may have an overall length of nearly ten feet, which is too long for the average size drying oven, but by bending it once on itself, the length is less than six feet, which will fit nicely in such equipment, or stack readily in a shipping truck. If different dimensions are encountered, the folding operations may be varied accordingly. It should moreover be noted that the straight section 29 cannot readily be bent 180° to superimpose the sections B and R, unless it be made so long as to space these sections a considerable distance. This is because a full return bend requires a certain "radius" to prevent collapsing of the tubing wall, and accordingly sections so connected cannot be folded and compacted into the smallest space.

After the coil is formed, folded, and finished as just described, it may be stacked with others of like nature in the drying oven for dehydration, or crated and shipped to another processing point. It has been discovered that such compacted coils occupy only about one-twelfth of the space required for the prismatic coil, such as is shown in Fig. 6, and accordingly it will be seen that the present invention provides for great space saving and handling economies during manufacture.

The coil shown in Figs. 2 to 5 inclusive is, insofar as the actual laying up is concerned, substantially the same as that just described. Accordingly, the same reference characters have been employed to avoid mere repetition of explanation. The assembly of these figures differs primarily in that the tubing T has been laid up, in the flat, directly on the side walls 11, 12, 13 and 14, which are positioned on the bending table in spaced relation under the tubing sections associated with each of them.

The front and back walls 12 and 14 may be of the same shape, and formed with top and bottom flanges 42 and 43 and with notches 44 located at diagonally opposed corners. The end plates 11 and 13 are also formed with top and bottom flanges 45 and 46, and with side flanges 47 which are provided with notches 48 adapted to register with the notches 44 when the parts are positioned in prismatic order. The wall plates are laid in the flat alongside of each other and in such manner that a notch 44 on the front or back plate is juxtaposed to a notch 48 on the adjacent end plate. Clearance spaces are thereby provided for the portions of tubing connecting the sections, and for the conduit 36 connected to the suction end 21 of the evaporator. While the tubing and plates are in the flat, they may be interconnected by soldering or by means of a so-called cold

solder, or they may be temporarily attached and then brazed or welded in an oven after the sections have been superimposed by folding about the riser 24*a* as an axis.

When it is desired to convert the flat and compacted evaporator into space-enclosing prismatic form, the tubing sections either with or without the plates attached, are simply pulled out until the rectilinear dimensions are obtained. Sections L and F are accordingly displaced through an angle of 90°, and riser 24 is thereby given a twist of 90°. Sections F and R are similarly displaced through a right angle, but in the opposite direction from sections L and F, which accordingly removes half the twist originally placed in riser 24*a* to superimpose the coil sections, as shown in Figs. 1*a* and 2. Sections R and B are likewise turned at right angles, and the connecting section 29 is thereby given a 90° bend, which can be formed without collapsing the tubing. The corner between the sections B and L, which accommodates the interconnected supply and suction lines 38 and 36, adjusts itself to the new configuration, and the riser portions of these conduits may also be twisted about their own axes 90° if necessary.

The evaporator then assumes the general form shown in Fig. 6, and when the side walls are secured to the coil sections in the flat, the flanges 47 of the end plates are brought up against the marginal portions of the front and back plates, as shown in Fig. 7, with the notches 44 and 48 in registry with each other. The plates may then be secured in any suitable manner, as by riveting or welding, or by means of clamps such as are described and claimed in our copending application Serial No. 625,798, filed October 31, 1945. The bottom 15 may then be positioned, and, by forming the bottom with a drawn flange 49 adapted to register with the flanges 43 and 46, the assembly may be rapidly completed. The completed evaporator is then ready for installation in a cabinet and connection to the remaining components of the refrigerating system.

It may be pointed out, in connection with the attached plate form of coil just described, that the stretches and return bends may be defined by die-pressing a sheet of material to delineate the evaporator section, then covering it with a second sheet, and welding the two together, as has been done heretofore in the so-called pressed or sheet metal domestic evaporators. Instead of folding the assembled sheets, however, they are interconnected by riser sections, such as 24 or 24*a*, so as to admit of the described twisting action along their longitudinal axes, and thereby enable the flat or compacted sections to be brought into three-dimensional form without injury to the tubing. It will also be apparent without additional illustration or description that the torsional displacement of the risers may also be effected when the tubing stretches are disposed vertically, rather than horizontally as shown in Fig. 6.

It was previously noted that the accumulator 35, and suction and supply conduits 36 and 37, could be incorporated into the assembly while the coil is in the plane or compact state. When this is done, the entire unit, which now constitutes a substantially complete "low side" for a refrigeration machine, can be dehydrated after the assembly is made. Heat is simultaneously applied to all of the parts, and a drying medium may be passed through the unit, or the passageways may be subjected to a vacuum to exhaust the moisture.

When this operation has been completed, some refrigerant gas is admitted through the end of the conduit 36 or 37 until all the passageways are flooded, and some positive pressure developed. The ends of the conduits 36 and 37 are then plugged, and the unit is then ready to be extended and connected between the condenser receiver and compressor inlet. The entrance of moisture accordingly is forestalled, as well as errors of mislocation of parts, and the service troubles heretofore arising from such causes are materially minimized.

While the invention has been described with reference to certain specific embodiments and practices which have been found to be advantageous, it will be apparent to those skilled in the art that the invention is susceptible of numerous modifications and variations without departure from its principles. It is accordingly intended that the invention be deemed to have a scope commensurate with that of the following claims.

We claim:

1. A continuous tube type evaporator comprising a plurality of plates adapted to define angularly disposed walls of a storage space, each of said plates having connected thereto series connected stretches of tubing and return bends positioned in the plane of said plates, riser members disposed transversely of the tubing stretches of said plates and integrally connecting the last stretch of one section to the first stretch of an adjacent section, said risers being free from the adjacent plates between which they extend, flanges formed on said plates whereby they may be connected to each other when angularly disposed, and notches cut in said flanges to accommodate said risers in a line common to the planes of adjacent plates when said plates are angularly disposed, said risers being adapted to be twisted along their own axes through arcs of at least ninety degrees, whereby said sections may be positioned in the same plane or in superimposed planes or at right angles to each other.

2. The method of making a prismatic evaporator comprising the steps of laying up a plurality of sections of tubing by bending the same back and forth in a common plane, positioning the end of one section of tubing transversely of such section and in the plane thereof, continuing the bending of such tubing to form an adjacent section, relatively rotating the sections about the axis of said transverse tubing thereby to superimpose said sections from a common plane to closely adjacent parallel planes, subjecting said sections in said superimposed condition to further processing, and thereafter rotating said sections about said axis in a reverse direction to position said sections at angles with respect to each other and thereby delimit a prismatic space.

3. The method of making a prismatic evaporator which comprises disposing a plurality of wall plates in the same plane and in closely spaced relation with adjacent edges substantially parallel, forming a serpentine refrigerant passage on the surface of each plate defined by a series of stretches and interconnecting return bends, connecting the last stretch of the passage on one plate to the first stretch of the passage on the adjoining plate by means of a length of tubing extending substantially parallel to said adjacent edges, folding said plates on each other and simultaneously torsionally distorting said tubing length through an arc of substantially one hundred and eighty degrees, subjecting said plates and passages to heat treatment, thereafter re-

versely rotating said plates through an angle of substantially ninety degrees and simultaneously removing substantially half the torsional strain in said tubing length, and interconnecting the adjacent substantially parallel edges of said plates.

4. The method of making a four-sided evaporator coil of the continuous tube type which comprises forming a series of four refrigerant passage sections, each of said sections including a series of stretches connected by return bends lying in the same plane, interconnecting at least some of said sections by lengths of riser tubing extending transversely of said sections and substantially in the planes thereof, superimposing two adjacent sections on the remaining sections in compact order, the connection between each pair of sections being formed by one of said lengths of riser tubing, subjecting the compacted assembly to heat treatment, and thereafter bending each section at right angles to its adjacent section to form a four-sided prismatic evaporator, the bends at said riser connected sections being along the axes of said risers whereby they are subjected to a torsional displacement of substantially ninety degrees.

5. The method of making a three dimensional refrigeration evaporator assembly which comprises laying up a series of connected coil sections in a plane form, superimposing certain of said sections upon other of said sections, said sections being interconnected by a riser about which said sections may be pivoted by twisting said riser, connecting a refrigerant supply line to the end of one of said sections and a refrigerant return line to the end of another of said sections, subjecting the assembly to a dehydrating operation to expel moisture from all of said sections and said supply and return line, closing the ends of the supply and return lines to exclude moisture from the assembly, thereafter angularly disposing said sections by torsionally distorting said riser to form a space defining evaporator assembly, opening the ends of the supply and return lines and connecting them respectively to a source of refrigerant and a withdrawal means therefor.

6. A collapsible refrigeration evaporator comprising a continuous one piece tube apportioned into a plurality of sections, each of said sections including a series of substantially parallel stretches interconnected by return bends, the stretches and bends in each section all lying in a common plane, the sections adjacent each other being angularly disposed with respect to each other to define a dihedral angle therebetween, a riser constituting a portion of said continuous tube extending from the last stretch of one section transversely of the stretches thereof and in the plane of said section, said riser member being bent at the end opposite said last stretch to form the first stretch of said adjacent section, said riser thereby being disposed in the planes of both sections and along said dihedral angle, whereby said adjacent sections may be selectively positioned in a common plane or at an angle to each other, or in substantial parallel superimposed relationship, by torsionally straining said riser along its longitudinal axis as a hinge member.

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