United States Patent [19]

DeCicco

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[54] **METHOD OF MAKING HEAT EXCHANGER**

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[52] **U.S. Cl.** ...... **29/157.3 A,** 29/157.3 B, 29/471.3, 29/482, 29/497.5, 29/503

[51] **Int. Cl.**.. **B21d 53/00,** B21k 29/00, B23p 15/26

[58] **Field of Search** .... 29/503, 471.3, 482, 471.1, 29/474.3, 474.4, 497.5, 470.5, 475, 157.3 R, 157.3 A, 157.3 B; 228/1, 36, 40

[56] **References Cited**

UNITED STATES PATENTS

3,107,421	10/1963	Turnbull	29/474.4 X
3,605,255	9/1971	Metzger et al.	29/498 X
3,633,266	1/1972	Taylor	29/497.5 X
3,680,200	8/1972	Terril et al.	29/503 X
3,760,481	9/1973	Greever	29/503 X
3,793,704	2/1974	Antonevich	29/470.5 X

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[57] **ABSTRACT**

A method of making fluid-tight telescopic joints in serpentine aluminum tubing for heat exchangers with a plurality of relatively long U-shaped aluminum tubing sections for supporting aluminum fins stacked in spaced relation thereon and a plurality of short U-shaped aluminum tubing sections each having opposite ends adapted to telescopically fit in the ends of the long sections of tubing to connect adjacent ends of the long sections, including the steps of providing an aperture in at least one of the long tubing sections for venting the tubing during soldering, assembling the short tubing sections with the ends thereof telescopically positioned in the ends of the long tubing sections and spaced therefrom to permit the flow of solder into the telescopic joints, dipping the assembly in the fluid solder to immerse the short tubing sections and the lower ends of the upper tubing sections to a depth just below the upper ends of the lower tubing sections to flow solder into the telescopic joints while venting the tubing through the aperture in the long tubing section, introducing ultrasonic vibrations into the solder while the assembly is dipped, and closing the aperture in the long tubing section by brazing.

11 Claims, 5 Drawing Figures

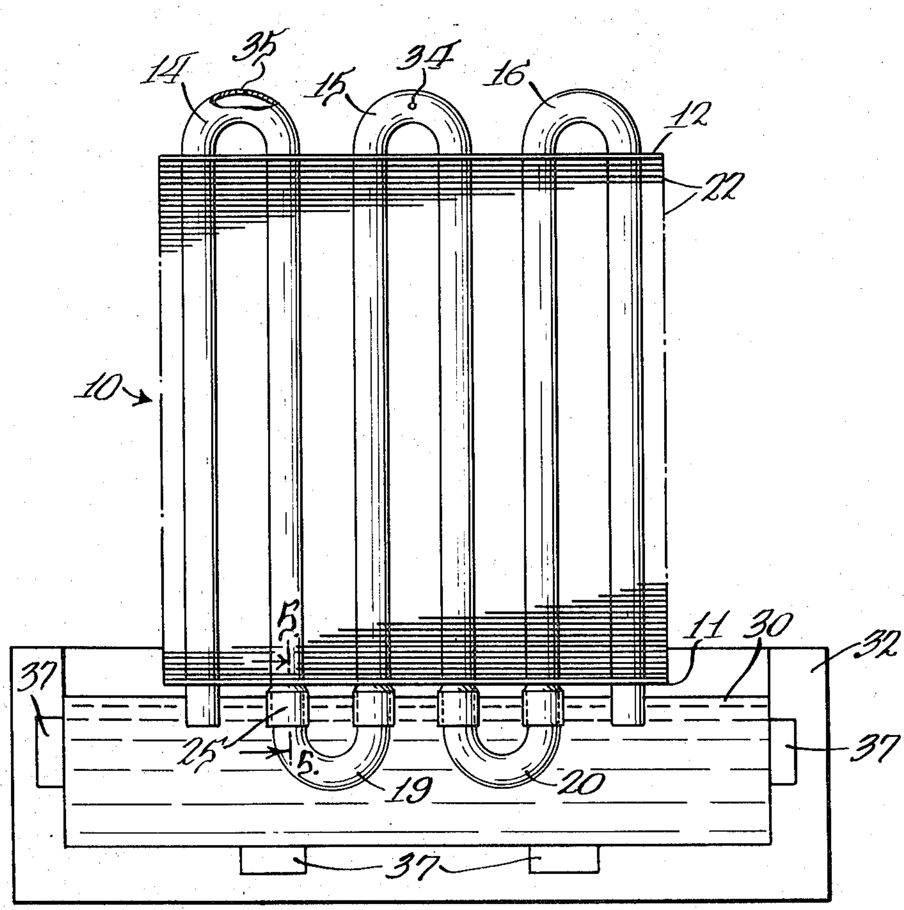


Fig. 1.

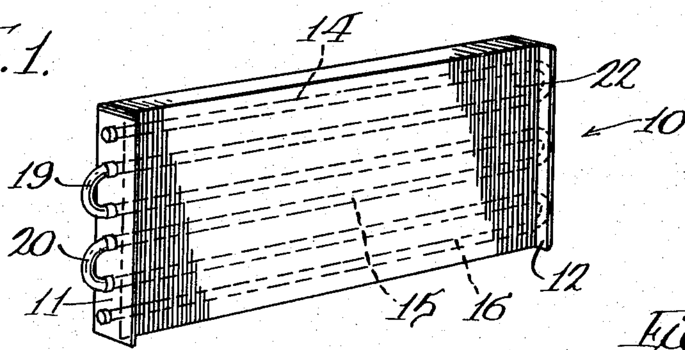


Fig. 2.

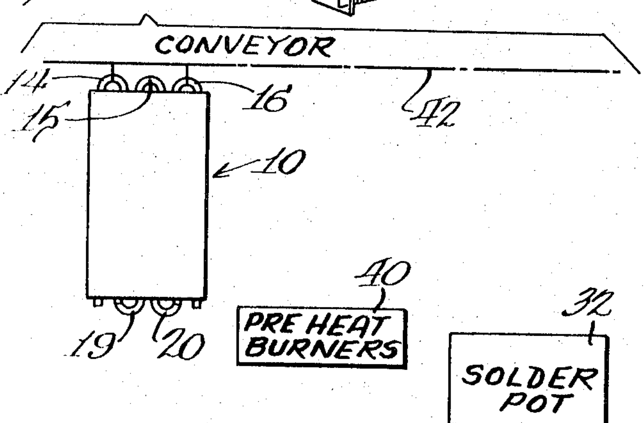


Fig. 3.

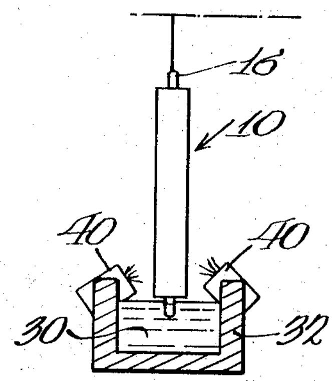


Fig. 4.

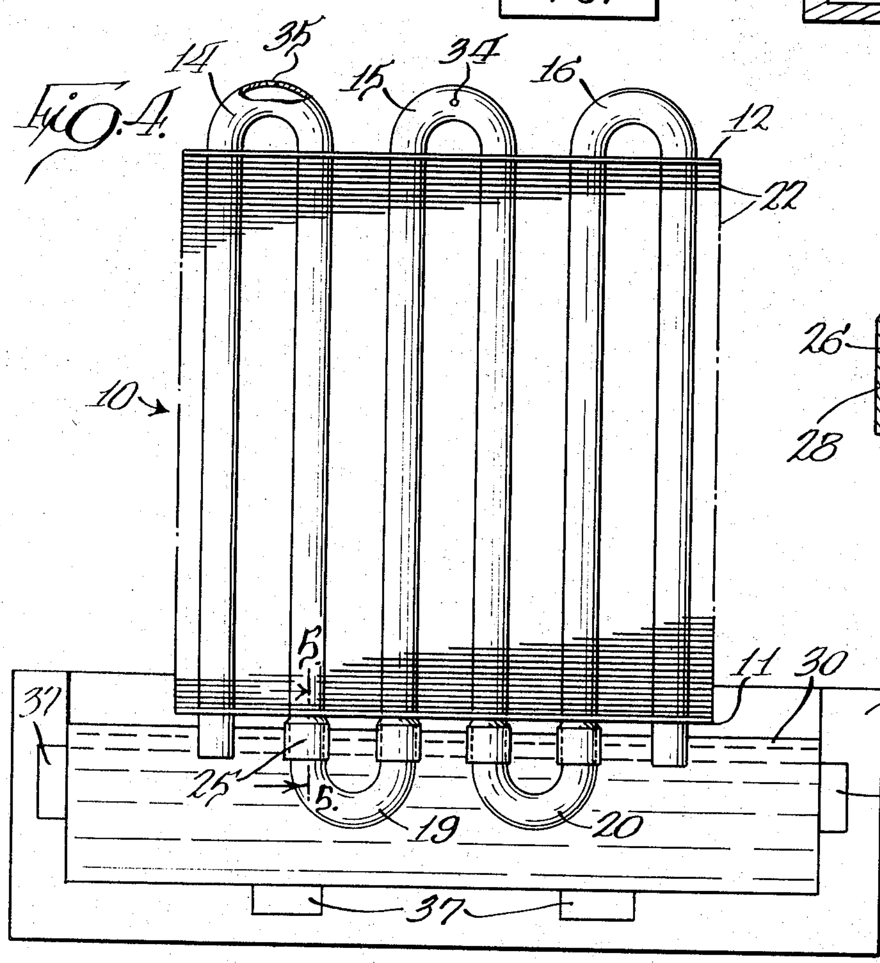
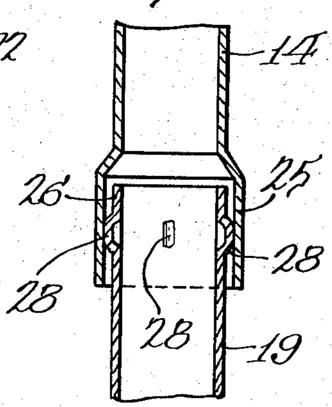


Fig. 5.



METHOD OF MAKING HEAT EXCHANGER

BACKGROUND OF THE INVENTION

The invention relates to the manufacture of fluid-tight joints in metal tubing for heat exchangers such as condensers and evaporators for air conditioning and refrigeration equipment.

In the past, heat exchangers of the type described have been made with refrigerant coils arranged in serpentine fashion in an assembly of spaced metal heat transfer fins. Often, the coils have been made of copper tubing. The fins have been made of various materials. Recently, it has been common to utilize aluminum tubing and aluminum heat transfer fins.

In the manufacture of heat exchangers utilizing serpentine aluminum tubing and aluminum fins, several methods have been utilized. In a preferred method, the serpentine arrangement of tubing has been constructed by utilizing a plurality of rather long U-shaped or hairpin-shaped tubes which are open at one end. Open ends of the tubes are connected by relatively short U-shaped tubes or return bends soldered to the ends of the hairpin tubes in a manner to provide the desired serpentine refrigeration circuit. During the assembly, the hairpin tubes are inserted into fins, following which the tubes are mechanically expanded so that the bends are tightly fitted on the tubes before the return bends are added. The fins may be spaced in various ways, as by collars integral with the fins and fitted on the tubes.

The above described method of assembly is utilized in the construction of various types of heat exchangers, such as those utilized in home refrigerators and freezers, room air conditioners and automobile air conditioners. Perhaps, the most troublesome problem in assembly is experienced in connecting the return bends to the hairpin tubes. In many constructions, connections of this type have been soldered, utilizing a zinc chloride flux with a zinc aluminum solder. Such a process has provided a relatively secure joint, but involves the necessity of removing flux residue from the inside and the outside of the tubing after the soldering process has been completed. Because the flux is highly corrosive, it is important that it be completely removed on the inside to avoid contamination of the refrigerant and on the outside to avoid corrosion. Adequate cleaning has involved significant expense.

In view of the difficulty and expense of removing flux residue from soldered joints, it is desirable to provide a method of connecting the tube ends without the requirement of utilizing a flux.

Prior U.S. Pat. No. 3,633,266 relates to a method of fluxless soldering of telescopic joints in aluminum tubing in which solder is applied to one or both of the tubular members in the form of a thin coating in the area of the telescopic joint. After assembly, the joint is heated while the tubes are moved relative to each other. My prior application Ser. No. 258,840 filed June 1, 1972, now abandoned, relates to a method of fluxless brazing of telescopic joints in aluminum tubing in which a ring of brazing alloy is inserted in one of the tubes adjacent each telescopic joint, and brazing is effected by heating the tubing to in turn heat the brazing alloy to a temperature at which it flows into the telescopic joint. U.S. Pat. No. 3,107,421 shows a sleeve soldered on abutting tube ends while vented.

Another method of soldering telescopic joints in serpentine tubing has involved assembly of the tubing in a manner to frictionally hold the joints together while immersing the joints in molten solder and introducing ultrasonic vibrations into the molten solder to adhere the solder to the telescoped tubing ends. In such process, solder is expected to flow into the telescopic joints, and in order for such flow to occur, it is necessary that the serpentine tubing be vented to atmosphere. Often, however, the free ends of the tubing are also immersed in solder at the time the joints are immersed in solder, and the serpentine tubing is thereby sealed from atmosphere such that the solder will not flow into the joints. As a result, a practice was utilized by which special vent tubes were inserted into the free ends of the serpentine tubing and shaped with angularly turned remote ends projecting out of the solder bath, like snorkel tubes, to communicate the interior of the serpentine tubing with atmosphere so that solder would flow into the telescopic joints. A difficulty arises with such process in that the special vent tubes become soldered into the free ends of the serpentine tubing, but are not necessary or not usable in connection with the desired refrigerant circuit. As a result, it was necessary to reform or remove the special tubes, and this involves a considerable time and expense.

SUMMARY OF THE PRESENT INVENTION

The present invention relates to a method of making fluid-tight telescopic joints in serpentine tubing for heat exchangers or the like by providing an aperture in one of the upper tubing sections adjacent the bend therein for venting the tubing while dipping the telescopic joints into molten solder to flow the solder into the telescopic joints.

The invention preferably includes the steps of providing upper inverted U-shaped tubing sections, providing lower U-shaped tubing sections each having opposite ends adapted to telescopically fit in the ends of the upper sections to connect adjacent ends of the upper sections, assembling the lower tubing sections with the upper ends thereof telescopically positioned in the lower ends of the upper tubing sections and spaced therefrom to permit the flow of solder into the telescopic joint, dipping the assembly into solder while venting the tubing through an aperture in one of the upper tubing sections adjacent the bend therein.

As described herein, the telescopic joints are dipped in molten solder, while introducing ultrasonic vibrations into the solder. Preferably, the tubing is preheated before introduction into the molten solder. In one example, the solder bath is maintained at a temperature of about 800°F., and the tubing is preheated to a temperature on the order of 900°F. before insertion into the solder bath.

As described herein, the method involves the provision of angularly spaced radial projections on one of the tubing sections in each telescopic joint for frictionally retaining the sections assembled together while permitting the flow of solder into the joints.

After the telescopic joints are retained in the solder bath for a limited period of time on the order of 2 to 4 seconds during approximately half of which time the bath is subjected to ultrasonic vibration, the assembly is withdrawn from the bath and the vent aperture is closed as by brazing in order to provide a fluid-tight circuit from one end of the serpentine tubing to the other.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a view of a typical heat exchanger utilizing telescopic tubular joints made according to the present invention;

FIG. **2** is a diagrammatic illustration of a production line for practicing the method of the present invention;

FIG. **3** is an end elevation of the structure shown in FIG. **2**, with the heat exchanger assembly lowered to dip the telescopic joints into the solder bath;

FIG. **4** is an enlarged cross-sectional view taken through solder pot with the heat exchanger assembly lowered to dip the telescopic joints into the solder bath; and

FIG. **5** is an enlarged sectional view through a typical telescopic joint, taken at about the line **5—5** of FIG. **4**.

DESCRIPTION OF PREFERRED METHOD

The invention is illustrated in connection with an aluminum tube-aluminum fin condensor **10** adapted for use in room air conditioners. The condensor includes end plates **11** and **12** for supporting tubing which has been traditionally described as refrigerant coils and which is illustrated in a serpentine arrangement. The serpentine arrangement is provided by a plurality of relatively long U-shaped tubular members as at **14, 15,** and **16**, which are sometimes referred to as hairpin-shaped. Open ends of the adjacent tubular hairpin-shaped members are connected by shorter U-shaped tubular members as at **19** and **20**, the first of which connects one end of tubular member **14** with one end of tubular member **15**, and the second of which connects the other end of tubular member **15** to one end of tubular member **16**. The members **19** and **20** are sometimes referred to as return bends.

The longer tubular members as at **14, 15** and **16** are supported on the end plates **11** and **12**. The shorter return bends **19** and **20** are secured to the longer tubular members. Mounted on the longer tubular members **14, 15** and **16** are a plurality of relatively thin fins **22** which function as heat transfer members. The fins are closely spaced from each other as by collars on the fins tightly fitted on the tubular members **14, 15** and **16**. In a typical manufacturing process, the end plates and fins are stacked, and the tubes **14, 15** and **16** are inserted in the plates **11** and **12** and the fins **22**, following which the tubes are expanded sufficiently to form a tight fit in the stack. Afterward, the return bends **19** and **20** are secured in place.

In order to appropriately join the short return bends **19** and **20** to the longer tubing sections **14, 15** and **16** in fluid-tight telescopic joints, the lower ends of each of the tubing sections **14, 15** and **16** which are to be joined to the return bends **19** and **20** are formed as best illustrated in FIGS. **4** and **5** with an enlarged end portion as at **25** adapted to telescopically receive therein an end portion **26** at the upper terminus of each return bend. As illustrated in FIG. **5**, each of the upper end portions of the return bends as at **26** is formed with a plurality of angularly spaced projections as at **28.** The end portion **26** is thus adapted to be frictionally retained in the end portion **25** while still leaving a substantial portion of the periphery of the end portion **26** spaced from the end portion **25** for permitting the flow of solder into the joint.

Soldering of the telescopic joints is effected in a bath of molten solder **30** maintained at a temperature on the order of 800°F. in a solder pot or vat **32.** The tubing sections **14, 15, 16, 19** and **20** are preferably aluminum or an aluminum alloy. The solder is on the order of 95 percent zinc and 5 percent aluminum, though the aluminum content may be as little as 3 percent.

In order to flow the solder into the telescopic joints, the heat exchanger assembly **10** is lowered to a position over the solder pot **32** where the telescopic joints are immersed in the solder **30** to a depth slightly below the upper ends of the return bends **19** and **20.** It is important that the assembly not be lowered to a depth where the solder can flow into the open upper ends of the return bends **19** and **20.** When the telescopic joints are immersed as described, it will be noted that the lower open ends of the tubing sections **14** and **16** are also immersed in the solder **30.** Under these conditions, in the absence of provision for venting the serpentine tubing, the air locked inside the tubing would prevent the free flow of solder into the telescopic joints. Thus, in order to vent the serpentine tubing in a manner to let the solder flow into the telescopic joints and displace air from the tubing, the tubing is vented by providing an aperture as at **34** adjacent the bend in the tubing section **15.** In a typical construction, the aperture may be on the order of 1/8 inch in diameter. If desired, the aperture may be located differently or an additional aperture may be provided as indicated at **35** in the tubing section **14.**

In a preferred process, the telescopic joints are dipped in the molten solder **30** for a relatively short period of time on the order of 4 seconds, and during at least a portion of such time period, such as the last 2 seconds, for example, ultrasonic vibrations are introduced into the solder bath while the telescopic joints are immersed. As illustrated herein, the solder pot or vat **32** is constructed of dual inner and outer walls, and conventional commercially available vibrators are mounted on the inner walls as illustrated at **37.** As shown herein, two such vibrators **37** are provided in the bottom portion of the pot and one on each of two side walls of the pot. The vibrators **37** may be of conventional types commercially available from Blackstone Corp. (Jamestown, N.Y.), or from Branson Sonic Power Co. (Danbury, Conn.). As is understood in the art, the ultrasonic vibrations, in conjunction with the heat and solder, have the effect of breaking up oxides on the surfaces immersed in the solder bath to enable formation of fluid-tight joints.

It is desirable to maintain the solder bath **30** at a fairly even temperature, and toward this end, the telescopic joints are preferably preheated before immersion into the solder bath. In a typical manufacturing installation, the telescopic joints at the lower end of the heat exchanger assembly may be heated by preheat burners as illustrated at **40** which direct flame toward the joints as the assembly is carried by a conveyor **42** between the preheat burners toward the solder pot **32.** When the assembly **10** is disposed over the solder pot, the conveyor is stopped, and at this time, the solder pot may be elevated, or the assembly may be lowered so that the telescopic joints are immersed. Usually, the solder pot with molten solder is relatively heavy, while the assembly **10** is relatively light, and it is thus usually preferable to lower the assembly **10** into the solder. The telescopic joints are preferably heated to a temperature on the order of 975°F. at the burners **40** to ensure that they remain at least as hot as the solder bath at the time of dipping.

After immersing the telescopic joints for about 4 seconds, and subjecting the solder bath to ultrasonic vibrations for about the last half of such time, the assembly may be elevated to withdraw the tubing from the solder bath. After cooling, any vent apertures as at **34** or **35** are completely closed as by soldering or brazing so that the tubing is fluid-tight.

I claim:

1. A method of making fluid-tight serpentine tubing for a heat exchanger comprising the steps of

a. providing at least two upper inverted U-shaped tubing sections,

b. providing at least one lower U-shaped tubing section having opposite ends adapted to telescopically fit into the ends of the upper sections,

c. providing angularly spaced radial projections on the upper tubing sections or the lower tubing section adjacent the ends thereof for frictionally retaining the sections assembled together in telescopic joints while permitting the flow of solder into the joints,

d. providing an aperture in at least one of the upper tubing sections above the lower ends thereof,

e. assembling the lower tubing section with the ends thereof frictionally retained in the adjacent ends of the upper tubing sections, and

f. dipping the lower end of the assembly into solder to immerse the lower ends of the upper tubes to a depth just below the upper ends of the lower tubing section to flow solder into the telescopic joints while venting the tubing through the aperture in the upper tube.

2. A method as defined in claim **2**, including the steps of removing the assembly from the solder and closing the aperture in the upper tubing section.

3. A method as defined in claim **3**, wherein the aperture is closed by soldering.

4. A method of making a heat exchanger with fluid-tight serpentine aluminum tubing for liquid refrigerant and aluminum heat transfer fins on the tubing, comprising the steps of;

a. providing long U-shaped aluminum tubing sections for supporting aluminum fins,

b. providing apertured aluminum fins and stacking the fins in spaced relation on the long sections with the legs of the long sections in the apertures in the fins,

c. providing short U-shaped aluminum tubing sections each having opposite ends adapted to telescopically fit in the ends of the long sections of tubing to connect adjacent ends of the long sections,

d. providing angularly spaced radial projections on the upper tubing sections or the lower tubing sections adjacent the ends thereof for frictionally retaining the sections assembled together in telescopic joints while permitting the flow of solder into the joints,

e. providing an aperture in at least one of the upper tubing sections adjacent the bend therein,

f. assembling the lower tubing section with the ends thereof frictionally retained in the adjacent ends of the upper tubing sections,

g. dipping the lower end of the assembly into solder to immerse the lower ends of the upper tubes to a depth just below the upper ends of the lower tubing section to flow solder into the telescopic joints while venting the tubing through the aperture in the upper tube, and

h. introducing ultrasonic vibrations into the solder while the assembly is dipped.

5. A method as defined in claim **4**, including the step of closing the aperture in the long tubing section.

6. A method as defined in claim **4**, including the step of preheating the assembly to a temperature on the order of that of the molten solder before dipping.

7. A method of making a heat exchanger with fluid-tight serpentine aluminum tubing for liquid refrigerant and aluminum heat transfer fins on the tubing, comprising the steps of

a. providing long U-shaped aluminum tubing sections for supporting aluminum fins,

b. providing apertured aluminum fins and stacking the fins in spaced relation on the long sections with the legs of the long sections in the apertures in the fins,

c. providing short U-shaped aluminum tubing sections each having opposite ends adapted to telescopically fit in the ends of the long section of tubing to connect adjacent ends of the long sections,

d. providing an aperture in at least one of the upper tubing sections adjacent the bend therein,

e. assembling the lower tubing section with the ends thereof telescopically positioned in the lower ends of the upper tubing sections and spaced therefrom to permit the flow of solder into the telescopic joint, and

f. dipping the lower end of the assembly into solder to immerse the lower ends of the upper tubes to a depth just below the upper ends of the lower tubing section to flow solder into the telescopic joints while venting the tubing through the aperture in the upper tube.

8. A method as defined in claim **7** including the step of vibrating the solder to effect adherence of the solder to both tubing sections in each joint.

9. A method of making a heat exchanger with fluid-tight serpentine aluminum tubing for liquid refrigerant and aluminum heat transfer fins on the tubing, comprising the steps of

a. providing long U-shaped aluminum tubing sections for supporting aluminum fins,

b. providing apertured aluminum fins and stacking the fins in spaced relation on the long sections with the legs of the long sections in the apertures in the fins,

c. expanding the tubing in the legs of the long sections to hold the fins in place,

d. providing short U-shaped aluminum tubing sections each having opposite ends adapted to telescopically fit in the ends of the long sections of tubing to connect adjacent ends of the long sections,

e. providing angularly spaced radial projections on the upper tubing sections or the lower tubing section adjacent the ends thereof for frictionally retaining the sections assembled together in telescopic joints while permitting the flow of solder into the joints,

f. providing an aperture in at least one of the upper tubing sections adjacent the bend therein,

g. assembling the lower tubing section with the ends thereof frictionally retained in the adjacent ends of the upper tubing sections,

h. dipping the lower end of the assembly into solder to immerse the lower ends of the upper tubes to a depth just below the upper ends of the lower tubing section to flow solder into the telescopic joints while venting the tubing through the aperture in the upper tube, and

i. introducing ultrasonic vibrations into the solder while the assembly is dipped.

10. A method as defined in claim **9,** including the step of closing the aperture in the upper tubing section by brazing.

11. A method as defined in claim **9,** including the step of maintaining the solder at a temperature on the order of 800° F. and the step of preheating the assembled telescopic joints to a temperature on the order of 975° F. before immersing the joints in the solder.

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