United States Patent [19]

Bullard et al.

[11] **3,815,672**

[45] **June 11, 1974**

[54] **SPLIT FIN HEAT EXCHANGE UNIT**

[75] Inventors: **Russell H. Bullard; Robert M. Lloyd; David B. Zipser,** all of Wilmington, Del.

[73] Assignee: **The Singer Company,** New York, N.Y.

[22] Filed: **Nov. 17, 1972**

[21] Appl. No.: **307,695**

[52] **U.S. Cl.** ..... **165/151,** 165/171, 29/157.3 B

[51] **Int. Cl.** **F28f 1/32**

[58] **Field of Search** ..... 29/157.3 B; 165/149–152, 171, 172, 177, 178, 175, 174; 62/515

[56] **References Cited**

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Primary Examiner—Manuel A. Antonakas
Assistant Examiner—Theophil W. Streule, Jr.
Attorney, Agent, or Firm—Marshall J. Breen; Chester A. Williams, Jr.; Joel Halpern

[57] **ABSTRACT**

A heat exchange unit comprises a series of parallel tubular finned leg portions connected with U-shaped bends to form a continuous path for the circulation of a heat exchange fluid. The unit is formed of two joined sections, each of which is provided with an offset portion. In the construction of the unit, hairpin tubing is employed in each section; however, straight tubes extend through at least the longitudinally aligned offset portion of each section. The method of constructing the unit comprises expanding the hairpin tubes of each section into heat conducting engagement with the fins thereon by a single stroke multitube expander device, juxtapositioning both sections in side-by-side relationship, inserting the straight tubes through at least the offset portions of the sections, separately expanding the straight tubes into heat conducting engagement with the fins thereon, and providing return bends on the open ends of the straight tubes and on selected open ends of the hairpin tubing to provide the desired circulation path for the heat exchange fluid.

5 Claims, 4 Drawing Figures

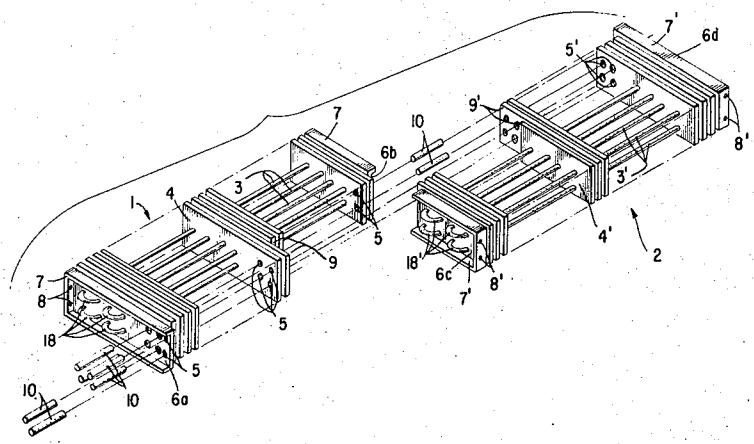


Fig. 1

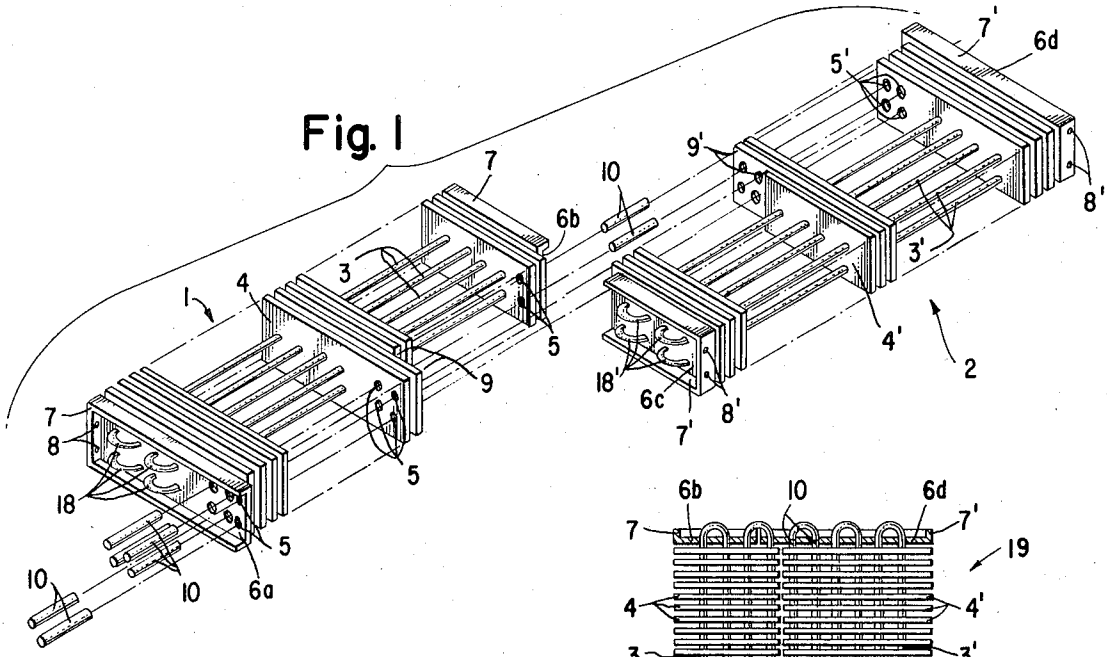
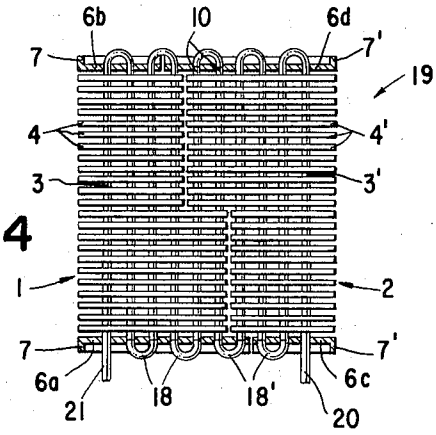


Fig. 4



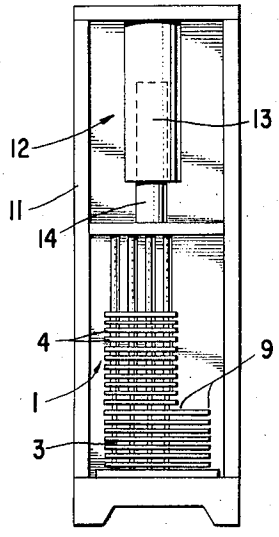


Fig. 2

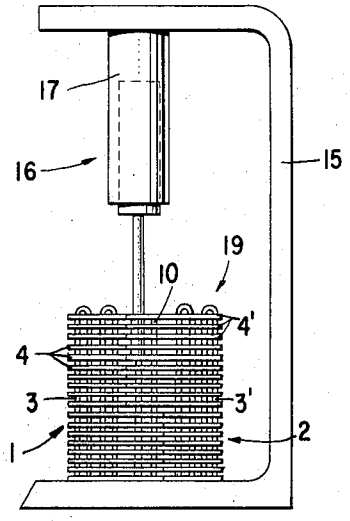


Fig. 3

SPLIT FIN HEAT EXCHANGE UNIT

BACKGROUND OF THE INVENTION

The present invention relates to heat exchange units of the type in which a coil of finned thermally-conductive tubing is mounted between end plates and is adapted to circulate a heat exchange fluid therethrough. More particularly, the invention is concerned with the provision of a heat exchange unit of the character described in which the coil is oversize and in which the tubes are expanded into heat-conducting engagement with the fins thereon and with the end plates so as to form a unitary rigid structure. The invention also provides a method for constructing such a heat exchange unit utilizing an oversize coil.

It has heretofore been conventional, in the construction of heat exchange units of the type to which the present invention relates, particularly when the coil is oversize, to expand the tubes of the coil into heat-conducting engagement with the fins carried by such tubes by one of two coil expansion methods. The first method employs the use of straight tubes throughout the coil core and of single piece end plates. Each straight tube is individually expanded, or groups of such tubes are expanded, and the core tubing is subsequently serpentine circuited by the use of tube type return bends at each coil end. The second method employs tube type configued hair pins and split end plates, two equal or substantially equal coil sections being each multitube expanded followed by split end plate fastening. The core tubing is subsequently circuited by the use of tube type return bends at only one coil end. The tube expansion process is not described in detail herein since the use of single-stroke multitube and multi-stroke single tube expanders is well known. Reference is thus made to U.S. Pat. No. 2,658,358 to Boling, and U.S. Pat. No. 3,457,620 to Ares, for a detailed description of the methodology of such prior art practices employed in connection with tube expansion into heat-conducting engagement with a plurality of apertured fins.

The need for employing either of the aforesaid two conventional techniques stems primarily from the fact that the core tube assembly is oversize, i.e., comprises a number of tubes which in aggregate width exceeds the capacity of the available hairpin tube expander.

In actual field use, inherent disadvantages of each of the conventional construction techniques become evident. For example, straight tube core coils have twice the tubing serpentine connections and are, therefore, more susceptible to core leaks. An oversized coil made in this manner also involves greater labor costs. Spliced hairpin core coils have centermost bowing tendencies. Such bowing also adversely affects the aesthetic appearance of an apparatus containing spliced section coils. Also, but of greater significance, is the phenomenon of center coil and/or end plate area tube chafing which ultimately results in coil tube failure. This chafing of the coil tubes is a result of the vibrational stresses produced in an operating apparatus containing such coils, such stresses and motions being produced by rotating machinery vibrations or the like. Therefore, it will become readily apparent that there is need for a technique of constructing oversize coils which overcomes the disadvantages of the aforesaid conventional methods of construction.

SUMMARY OF THE INVENTION

It is one object of the present invention to provide a heat exchange unit which can be constructed at relatively low cost and which is sufficiently rigid to withstand both the handling/lifting stresses during its incorporation within a unit, and the vibrational stress developed when the unit is placed in operation.

It is another object of this invention to provide an oversized heat exchange coil assembly which can be constructed at relatively low cost and which has an increased service life.

It is yet another object of this invention to provide a relatively low cost oversized heat exchange coil of the finned type in which the core tubes have been expanded into heat conducting engagement with the fins, the coil assembly having improved rigidity and service life.

It is a further object of this invention to provide a method for constructing a relatively low cost heat exchange coil possessing improved rigidity and service life.

According to the present invention, there is provided in a heat exchange unit comprising a coil of thermally-conductive tubing adapted to permit the continuous passage therethrough of a heat exchange fluid, said coil being formed by a plurality of parallel and substantially planar straight portions and end loops and in which said tubing has been expanded into heat conducting engagement with thermally conductive fins carried thereon, the improvement comprising a first section which includes hairpin tubing extending between and mounted in a first pair of end plates, a portion of said fins closer to one of said end plates than the other having a greater width than that of the remaining fins whereby a first offset portion is formed, a second section which includes hairpin tubing extending between and mounted in a second pair of end plates, a portion of said fins closer to one end plate than the other of said second pair having a greater width than that of the remaining fins in said second section whereby a second offset portion is formed, and a plurality of single straight tubes mounted in said end plates of the first and second pairs extending through and carrying at least those portions of said fins within said first and second offset portions.

According to the present invention, there is also provided a method of constructing a rigid heat exchange unit having a finned coil of thermally-conductive tubing adapted to permit the circulation therethrough of a heat exchange fluid, comprising arranging a first section of open-ended tubing which includes hairpin configured U-shaped bends and carrying a plurality of spaced fins thereon between a first pair of end plates, a portion of the fins closer to one of said end plates than the other having a uniform and greater width than that of the remaining fins such that a first offset portion is formed, arranging a second section of open-ended tubing which includes hairpin configured U-shaped bends and carrying a plurality of spaced fins thereon between a second pair of end plates, a portion of the fins closer to one end plate than the other of said second pair having a uniform and greater width than the remaining fins in said second section such that a second offset portion is formed, simultaneously expanding the hairpin tubes of said first section into heat conducting engagment with the fins thereon and with the end

plates, simultaneously expanding the hairpin tubes of said second section into heat conducting engagement with the fins thereon, and with the end plates, juxtaposing said first and second sections in side-by-side relationship to form a generally rectilinear structure, positioning single straight tubes through the fins and end plates of at least said offset portions, expanding said straight tubes into heat-conducting engagement with the fins thereon and with the end plates through which said straight tubes extend, and providing interconnections for the open ends of said straight and U-bent tubes to permit circulation of said heat exchange fluid through all of said tubes in the desired circulation path.

BRIEF DESCRIPTION OF THE DRAWINGS

In order that the invention may be more fully comprehended it will now be described, by way of example, with reference to the accompanying drawings in which:

FIG. **1** is a perspective view of the heat exchange unit of this invention in an intermediate stage of construction;

FIG. **2** is an elevational view of a section of the heat exchange unit in position to have certain of the core tubes expanded;

FIG. **3** is an elevational view similar to FIG. **2** in which the assembled sections of the heat exchange unit are in position to have the straight tubes expanded; and

FIG. **4** is a plan view of the assembled heat exchange unit of the invention.

DESCRIPTION OF THE INVENTION

Referring to FIG. **1** of the drawings, there is shown two sections **1** and **2** of a heat exchange unit prior to their being assembled to form a unitary structure **19.** The sections are similarly constructed; therefore, the fabrication of section **1** will be described, and it will be understood that the same procedure of fabrication will be employed to produce section **2.** Various corresponding parts of the coil sections **1** and **2** have been designated with the same reference character except for the addition of a prime mark (') to such reference characters on section **2.**

Section **1** is constructed by first forming at least one hairpin or U-shaped bend of tubing **3** having parallel legs and open ends. The tubing is formed of a material having good thermal conductivity such as copper or aluminum. It will be understood, of course, that various materials having the required properties of thermal conductivity and workability are available and may be utilized. Cooper and aluminum, however, have proven to be eminently satisfactory.

A plurality of plates or fins **4,** likewise formed of a material having good thermal conductivity, and having apertures **5** therethrough are positioned along the straight or leg portions of the tubing in spaced parallel relation to each other. The function of such fins is, of course, to increase the effective surface area available for heat transfer.

In the condition illustrated in FIG. **1,** the plates or fins are still relatively loosely positioned on the legs of the tubing. As will be described hereinafter, expansion of the tubing effectuates a fixed positioning of the fins on the tubing in thermalconducting engagement therewith.

As shown in FIG. **1,** a consecutively arranged portion of the fins closest to end plate **6***a* have a greater width than that of the remaining fins. Preferably half the fins in each section have the increased width which define an offset portion for the coil, whereas the other half of the fins of each section have a lesser width. Offset portions **9** and **9'** defined by the increased widths of fins in coil sections **1** and **2** respectively include apertures **5** and **5'**, as shown, permitting the insertion therethrough of single straight tubes. Insertion of such straight tubes through the fins within the offset portions of sections **1** and **2** when such sections are positioned in side-by-side relationship with the offset portions in longitudinal alignment serves to produce a unitary assembly.

It will be noted that end plate **6**a of section **1** extends beyond the edges of the fins in the offset portion. On the other hand, end plate **6**c of section **2** does not extend as far as the edge of the fin arranged closest thereto. This is likewise true of end plates **6**d and **6**b also shown in FIG. **1.** It is to be further noted that end plates **6** are provided with apertures **5** therein. By utilizing the overlapping end plates **6***a* and **6***d*, certain of the straight tubes extend through the overlap portions of such end plates. It has been found that by providing an overlapping end plate construction the need for end plate inter-fastening with bolts and nuts or the like has been obviated. One or more coil sections may be juxtaposed in side-by-side relation and can each utilize the foregoing overlapping technique. This overlapping end plate construction imparts improved rigidity to the assembled unit. However, it is within the concept of this invention to provide end plates at each end of the coil sections having widths which are coextensive with the fins arranged closest thereto so that when assembled there is no overlap by the end plate. In such an end plate arrangement suitable fastening means, such as bolts and nuts or the like, are desirably utilized.

Referring to FIG. **2** of the drawings, section **1** is depicted as being positioned within a jig or support frame **11** associated with a single stroke multi-tube expander device. The expander, as is well known in the art, essentially includes a source of hydraulic fluid and a compressor (not shown), a hydraulic cylinder assembly **13** which includes a main piston **14** and bullet heads positionable respectively within the several core tubes to be expanded. A single stroke of the main piston effectuates simultaneous expansion of all of the tubes containing bulleted rodheads. Such expansion, as previously stated, serves to fixedly position fins **4** on the tubes in thermal-conducting engagement therewith. The expansion also serves to secure the tubes within the end plates.

Sections **1** and **2** are independently subjected to core tube expansion by the same or a plurality of expander devices. The sections are then positioned in side-by-side juxtaposition such that the offset portions of the sections are in longitudinal alignment. Straight tubes **10** are inserted through the apertures of the fins located within such offset portions as well as through those other fins whose apertures are not occupied by hairpin tubes and the resulting loose assembly of sections **1** and **2** is then positioned within jig or support frame **15** as depicted in FIG. **3.** An expander device **16** capable of expanding a single, core tube at a time, and including a hydraulic cylinder assembly **17,** is then operatively connected sequentially with each of the straight tubes

10 not already expanded. Each such tube is then independently expanded into thermal conducting engagement with the fins thereon and with the end plates through which the tubes extend. Return bends **18** are provided at the open ends of the straight tubes **10** and at selected open ends of the U-shaped tubes **3**, so as to provide for the desired circulation path of the heat exchange fluid through the coil. The return bends may be joined to the tubing such as by soldering. It will be observed, from FIG. **4**, that the tubing at each end of the assembled heat exchange coil or unit **19** is preferably open as at **20, 21** for the introduction of a heat exchange fluid thereto and for the discharge of the fluid subsequent to passage through the coil. As will be appreciated by persons versed in the art, pumping means, associated temperature sensing means and temperature controlling means (not shown) may be connected with the coil, so as to regulate the temperature as desired.

It will be understood that various changes in the details, materials, arrangements of parts, and operating conditions which have been herein described and illustrated in order to explain the nature of the invention, may be made by those skilled in the art within the principles and scope of the invention.

Having thus set forth the nature of the invention, what is claimed herein is:

1. In a heat exchange unit comprising a coil of thermally-conductive tubing adapted to permit the continuous passage therethrough of a heat exchange fluid, said coil being formed by a plurality of parallel and substantially planar straight portions and end loops connecting said parallel portions to form a continuous tube circuit and in which said tubing has been expanded into heat conducting engagement with thermally conductive fins carried thereon, the improvement comprising a first section which includes hairpin tubing extending between and mounted in a first pair of end plates, a portion of said fins closer to one of said end plates than the other having a greater width than that of the remaining fins whereby a first offset portion is formed, a second section which includes hairpin tubing extending between and mounted in a second pair of end plates, a portion of said fins closer to one end plate of said second pair than the other having a greater width than that of the remaining fins in said second section whereby a second offset portion is formed, and a plurality of single straight tubes mounted in said end plates of the first and second pairs extending through and carrying at least those portions of said fins within said first and second offset portions.

2. A heat exchange unit according to claim **1**, wherein the width of the fins within the offset portions of said first and second sections are substantially equal.

3. A heat exchange unit according to claim **1**, wherein the combined width of said first and second sections renders the unit too wide for use with standard single stroke multi-core tube expander devices.

4. A heat exchange unit according to claim **1**, wherein the said straight tubes and selected open ends of said hairpin tubing are provided with return bends and are interconnected so as to permit continuous passage of said heat exchange fluid therethrough in the desired circulation path.

5. A heat exchange unit according to claim **1**, wherein one of the end plates of each said pair extends beyond the edge of the fins arranged closest thereto and the other end plate of each pair terminates short of the edge of the fins arranged closest thereto to provide for an overlapping end plate construction, apertures being provided in said extended portions of said end plates and straight tubes extending therethrough.

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