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METHOD OF PRODUCING DUPLEX INTERNALLY FINNED TUBE UNIT

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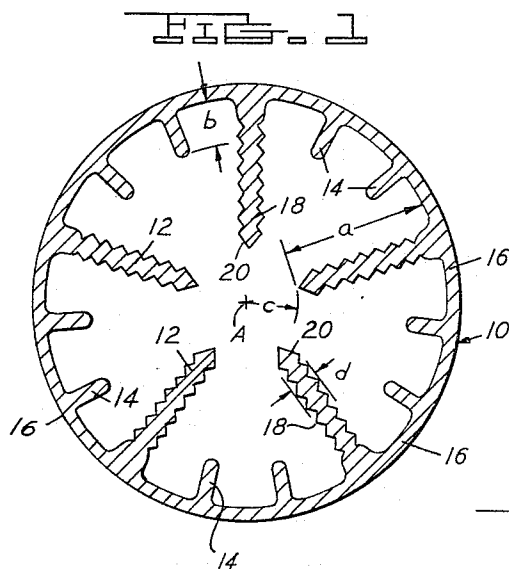


FIG. 2

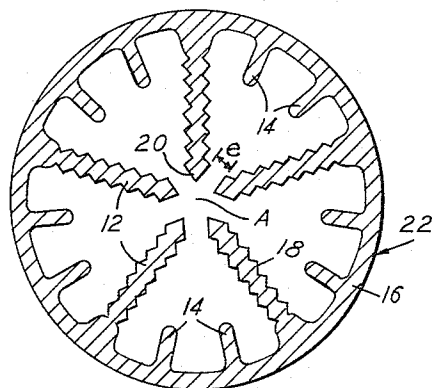
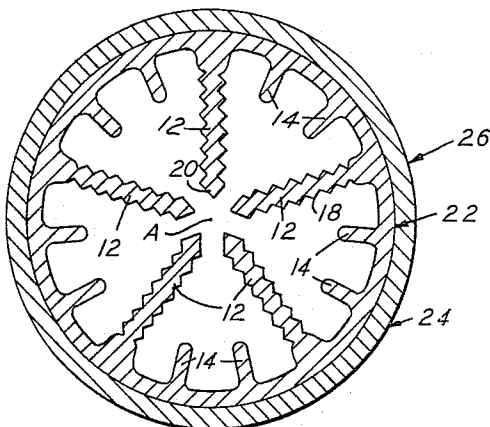


FIG. 3



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METHOD OF PRODUCING DUPLEX INTERNALLY FINNED TUBE UNIT

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The present invention relates to an improved method of producing duplex internally finned tube units for use in heat exchange installations. More particularly, the method deals with the production of a tube unit constituted by an external shroud tube of a metal impervious to deterioration in its surrounding environment, and an internal finned liner tube of a different metal which is also especially well suited for exposure to a fluid medium contained in or traversing the interior of the tube unit.

It is a general object of the present invention to provide a method which in particular enables the production of the liner tube of the unit, by initial extrusion and a subsequent drawing operation, in a very close spacing of its internal fin formations relative to one another, such as could not be accomplished by a single extruding operation using presently available equipment or tubing.

More specifically, the method of the invention contemplates the initial extrusion of the liner tube in an outer diameter substantially exceeding its ultimate O.D., and with its internal, longitudinally extending radial fins disposed in a circumferential and radially spacing of their inner ends which is substantially greater than in the final tube product, this operation being followed by a drawing of the initial tube to reduce its O.D. to the desired ultimate dimension, while at the same time bringing the ends of its radial fins toward one another, in both the radial and circumferential senses, to the desired spacing thereof.

A further object of the invention is to provide a method of producing a dual or duplex tube unit including an internally finned liner tube formed as just described, in which an outer shroud tube of a different material is drawn or sunk onto the liner tube in a manner to produce an extremely tight interface contact between the smooth outer surface of the liner tube and the smooth inner surface of the shroud tube, thus promoting very efficient heat transfer by the duplex tube unit.

Still more specifically, in accordance with the improved method the inner, internally finned liner tube is of a metal not only metallurgically suited to its environment of exposure but also possesses substantially greater yield strength than the different metal of the outer shroud tube. Thus, upon termination of the final drawing or sinking operation performed on the telescoped tubes, both thereof tend to spring back or outwardly; but because of its greater yield strength than the outer tube, this tendency is stronger in the inner tube, so that a strong and continuing pressure grip exists at the contacting interface of the tubes.

In yet another aspect, the invention contemplates the aging of the internal liner tube, which is preferably of aluminum, prior to its drawn or sunk union with the shroud tube, which is preferably of copper. In this connection, the initial drawing or sinking of the aluminum liner substantially increases its hardness and strength by work hardening, thus supplementing the age hardening effect.

The foregoing as well as other objects will become more apparent as this description proceeds, especially when con-

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sidered in connection with the accompanying drawing illustrating the invention, wherein:

FIG. 1 is an enlarged scale view, in section in a transverse radial plane at 90° to its axis, of a typical finned internal liner tube as extruded initially for the purposes of the invention;

FIG. 2 is a similar view showing a liner tube as preliminarily drawn to reduce its outer diameter and modify the relationship to one another of its internal fin formations; and

FIG. 3 is a further similar cross sectional view showing the modified liner of FIG. 2 as finally associated with the outer shroud tube of the tube unit.

In various heat transfer applications, such for example as one utilizing water chiller tubes of a relatively small O.D., it is desirable to employ a double or duplex tube unit, including an inner tube component able to resist corrosive deterioration and having circumferentially spaced, longitudinally extending fins radiating inwardly from its inner surface, and an outer tube component also suited for the environment to which it is exposed. The extrusion procedure is obviously best suited to the production of an internally finned inner or liner tube of the above general description, and an aluminum alloy having the desired metallurgical resistance to attack can be readily extruded. However, in the small diameter size involved, for example about 3/4 inch outer diameter, of the ultimate duplex tube unit, it is impossible, using presently available extrusion tooling, to produce such a tube size which still has the internal finning in the desired close central spacing, radius-and-circumference-wise, of the inner ends of the fin formations.

It is in the production of such tube unit sizes that the method of the present invention comes into play; as well as in the accomplishment of a very tight contact of interface surfaces of the liner and shroud tube components to insure highly efficient heat transfer capacity.

The reference numeral 10 in FIG. 1 generally designates a liner tube as inwardly extruded from an aluminum alloy, such as alloy 6063-T5. In a typical production of a final duplex tube unit of the approximate 3/4 inch outer diameter instanced above, liner tube 10 will, as extruded, have an O.D., say, of 0.805 inch, and a wall thickness of 0.025 inch. This tube may, utilizing existing extrusion tooling, be produced in the diameter and wall dimension indicated, and also may be provided with different types of integral, internal fin formations 12, 14, respectively, projecting radially inwardly toward the tube axis A and extending continuously along the length of the extrusion.

Thus, larger radial fins 12 of the initial liner extrusion 10 of FIG. 1 are shown to extend a radial distance "a" of 0.282 inch from the inner surface of the tube wall 16; and the smaller fin formations 14 will, for example, have a corresponding dimension "b" of 0.080 inch. The large fins 12 are shown as having corrugated or zig-zag sides 18 and 20, but this is of no particular significance in the present invention.

As also shown in FIG. 1, the pointed ends 20 of fins 12 terminate a radial distance "c" of 0.096 inch from the tube axis A; and the circumferential spacing of the termini 20 of successive fins 12 from one another is sufficiently great to permit extrusion by tooling equipment capable of successfully producing the relatively small dimensions mentioned. This circumferential spacing is later reduced substantially, as will be described.

The overall circumferential width "d" of the larger fins 12 amounts to 0.046 inch in the typical tube under

consideration. These fins are angularly spaced 72° from one another, with the smaller fins 14 intervening therebetween at intervals of 24°.

As thus produced, the tube extrusion 10 is next subjected to drawing in a die which will reduce its outer diameter to, say, 0.680 inch, as shown in FIG. 2 of the drawing. Dimensions of the tube other than its O.D. remain the same, but the result of the drawing just mentioned is to bring the ends 20 of the larger fins 12 substantially toward one another, to the extent that the circumferential spacing "e" between successive fin end means amounts to a desired value of 0.040 inch, a relationship incapable of accomplishment by the usually available extrusion equipment alone. The reduced tube is designated 22, and the reduction of its O.D. amounts to about 15%.

So reduced, the liner tube is telescoped within an outer shroud tube 24 (FIG. 3) of copper, for example, a DHP copper chosen in part for its suitability for exposure in the intended environment. The telescoped interfit is a fairly loose one in the interest of ease of assembly; and the assembled tubes 22, 24 are then submitted to a further drawing operation in an appropriately sized die. Assuming the thickness of the wall of shroud tube 22 to be, say, 0.036 inch, the die will be of a diameter, for example 0.750 inch or less, such as to sink the two tubes beneath their overall outer diameter amounting to 0.752 inch, to which dimension the tubes spring back following the final drawing.

In accordance with the invention, the method contemplates an intervening age hardening of the aluminum liner following its initial extrusion and preliminary drawing and prior to its sinking assembly to the copper tube 24, for the purpose of improving its pressure-stressed bond to tube 24 to complete the final duplex tube, which is generally designated in FIG. 3 by the reference numeral 26. Thus, a heat treat of liner tube 22 at 350° F. for eight hours produces a T5 hardness.

As indicated above, the choice of the metal for the respective tubes 22, 24, or other different metals otherwise suited for the intended purpose, is in part governed by their respective yield strengths; and in accordance with the invention the yield strength of the inner tube should be substantially greater than that of the outer. For the selected aluminum alloy liner 22, the yield strength approximates 16,000 p.s.i., while the yield strength of the copper of outer shroud 24 approximates 9,000 p.s.i. Thus, following the final drawing or sinking of the telescoped tubes 22, 24, the former, by reason of its much greater yield strength than the outer tube 24, has a substantially greater tendency to spring back outwardly than the copper shroud; and the greater spring-back force of liner 22 creates a continuing, strongly stress-pressurized contact of the mating smooth tube surfaces at their interface.

Non-ferrous alloys other than those referred to above may be employed, and particularly in the case of the outer shroud tube, for example, brass, a copper-nickel alloy, or the like.

The aging step of the operation is of significance in increasing the hardness of the pre-extruded and pre-drawn liner tube 22, to increase its hardness and ductile strength, which increase is also contributed to by the drawing of the extrusion to the form of FIG. 2. Thus, the drawing and aging steps are seen to be complementary to one another, and in certain cases the work hardening in the draw will suffice to produce adequate hardness and yield strength, so that aging need not be resorted to.

The method of the invention is rapidly and efficiently performed on standard extrusion and drawing equipment, extending the field of use to the production of integrally and internally finned tube units of small diameter incapable of present day production by extrusion tooling alone.

What I claim as my invention is:

1. A method of producing an internally finned tube unit, comprising extruding a first metal tube to provide fins predeterminedly spaced circumferentially about and projecting inwardly of the inner surface of said tube, drawing said tube to reduce the outer diameter thereof and bring the inner extremities of said spaced fins radially and circumferentially closer to one another than was practically possible in said extruding of said first tube, telescoping said first tube within a second tube of metal, and sinking said telescoped tubes to bring the same in tight contact with one another.

2. A method of producing an internally finned tube unit, comprising extruding a first metal tube to provide fins predeterminedly spaced circumferentially about and projecting inwardly of the inner surface of said tube, drawing said tube to reduce the outer diameter thereof and bring the inner extremities of said spaced fins radially and circumferentially closer to one another than was practically possible in said extruding of said first tube, the metal of said first tube having a given yield strength after the drawing, telescoping said first tube within a second tube of metal having a yield strength less than that of said extruded and drawn first tube, and sinking said telescoped tubes to bring the same in continuing tight pressure contact with one another.

3. A method of producing an internally finned tube unit, comprising extruding a first non-ferrous metal tube to provide fins predeterminedly spaced circumferentially about and projecting inwardly of the inner surface of said tube, drawing said tube to reduce the outer diameter thereof and bring the inner extremities of said spaced fins radially and circumferentially closer to one another than was practically possible in said extruding of said first tube, the metal of said first tube having a given yield strength after the drawing, telescoping said first tube within a second tube of a different non-ferrous metal having a yield strength less than that of said extruded and drawn first tube, and sinking said telescoped tubes to bring the same in continuing tight pressure contact with one another.

4. A method of producing an internally finned tube unit, comprising extruding a first, externally smooth surfaced non-ferrous metal tube to provide fins predeterminedly spaced circumferentially about and projecting inwardly of the inner surface of said tube, drawing said tube to reduce the outer diameter thereof and bring the inner extremities of said spaced fins radially and circumferentially closer to one another than was practically possible in said extruding of said first tube, the metal of said first tube having a given yield strength after the drawing, telescoping said first tube within a second, internally smooth surfaced tube of a different nonferrous metal having a yield strength less than that of said extruded and drawn first tube, and sinking said telescoped tubes to bring the same in continuing tight pressure contact with one another at the interface thereof.

5. A method of producing an internally finned tube unit, comprising extruding a first tube of aluminum to provide fins predeterminedly spaced circumferentially about and projecting inwardly of the inner surface of said tube, drawing said tube to reduce the outer diameter thereof and bring the inner extremities of said spaced fins radially and circumferentially closer to one another than was practically possible in said extruding of said first tube, telescoping said first tube within a second tube of copper, and sinking said telescoped tubes to bring the same in continuing tight pressure contact with one another due to the differential in the yield strength of the metals thereof.

6. A method of producing an internally finned tube unit, comprising extruding a first, externally smooth surfaced tube of aluminum to provide fins predeterminedly spaced circumferentially about and projecting inwardly of the inner surface of said tube, drawing said tube to re-

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duce the outer diameter thereof and bring the inner extremities of said spaced fins radially and circumferentially closer to one another than was practically possible in said extruding of said first tube, aging said first tube, telescoping said first tube within a second, internally smooth surfaced tube of copper, and sinking said telescoped tubes to bring the same in continuing tight pressure contact with one another at the interface thereof due to the differential in the yield strength of the metals thereof.

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10 CHARLIE T. MOON, *Primary Examiner.*