

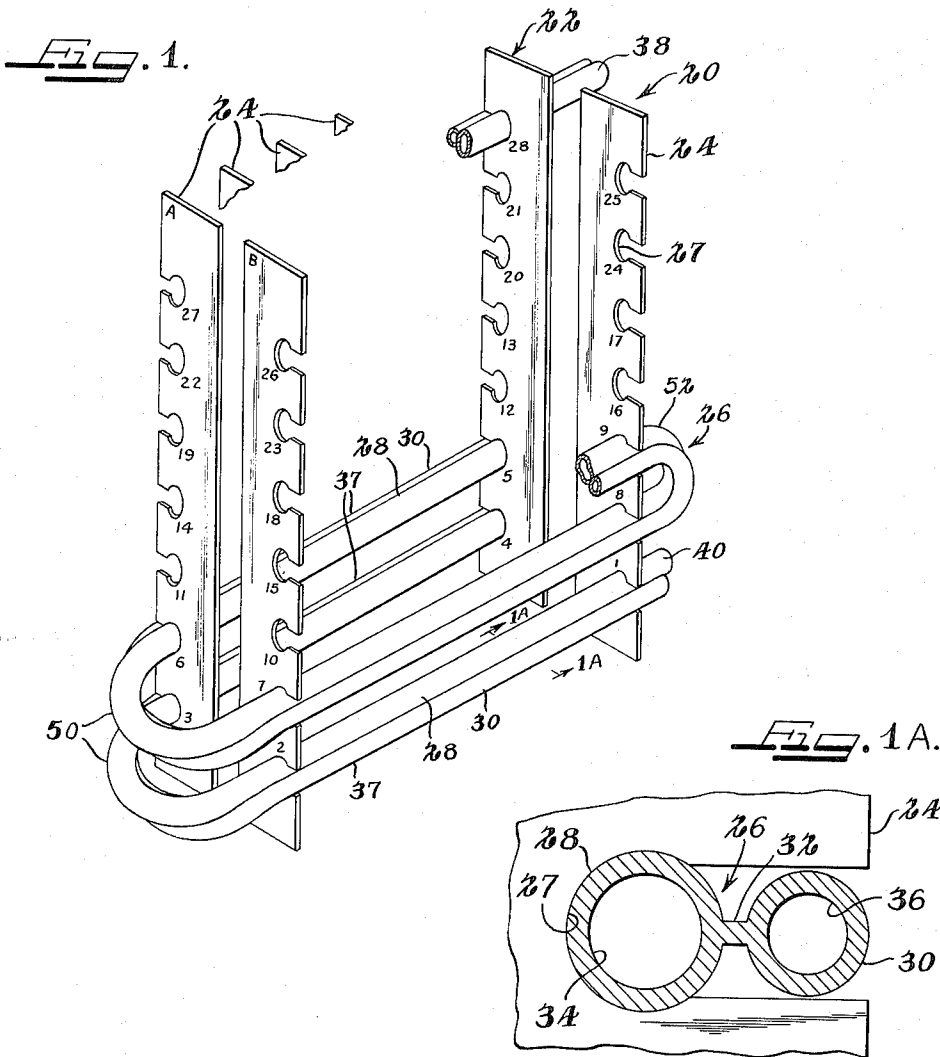
Sept. 28, 1965

S. F. PASTERNAK
METHOD OF FORMING REVERSE BENDS IN EXTRUDED INTEGRAL
DUAL-PASSAGE HEAT EXCHANGE TUBING

3,208,261

Filed Dec. 11, 1961

5 Sheets-Sheet 1



A	3	6	11	14	19	22	27	30	35
B	2	7	10	15	18	23	26	31	34
C	4	5	12	13	20	21	28	29	36
D	1	8	9	16	17	24	25	32	33

Fig. 2.

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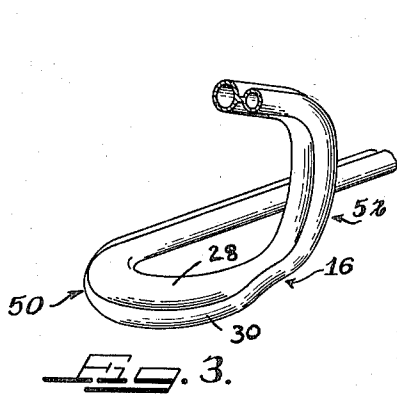
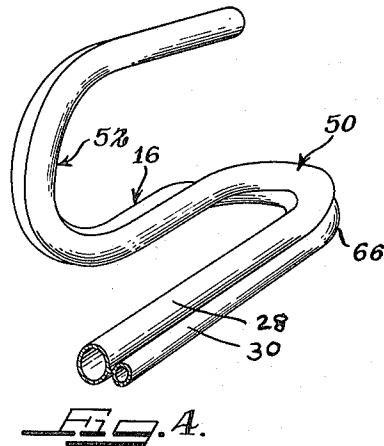
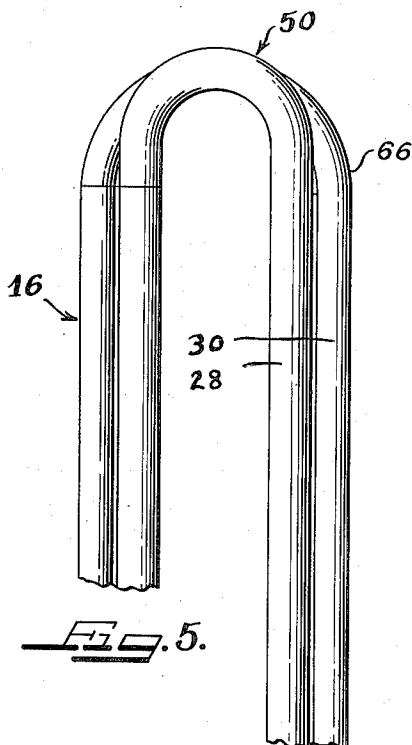
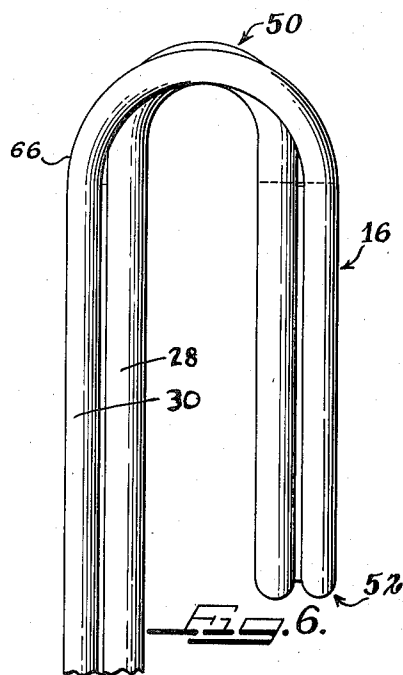
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5 Sheets-Sheet 2



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3,208,261

5 Sheets-Sheet 3

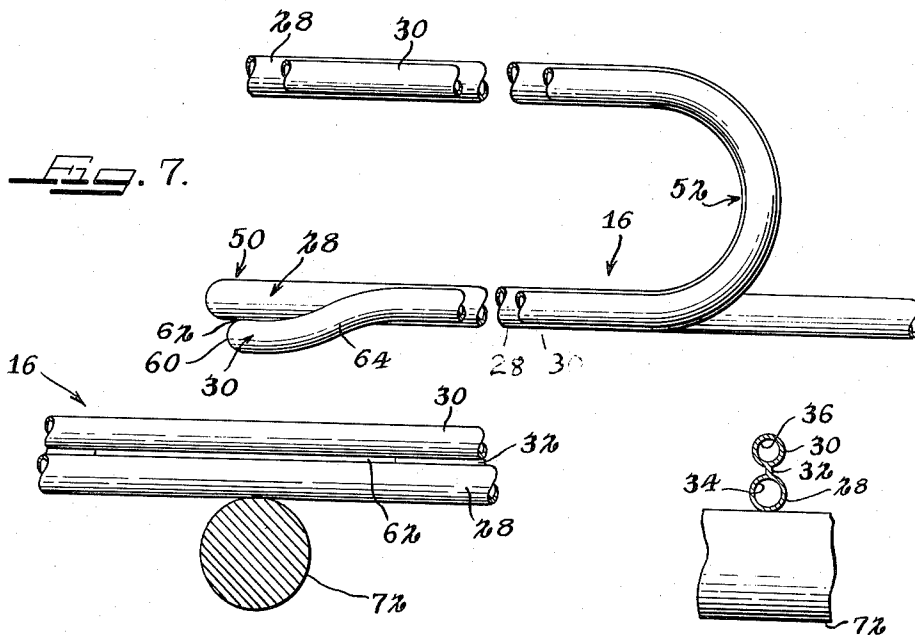


Figure 8

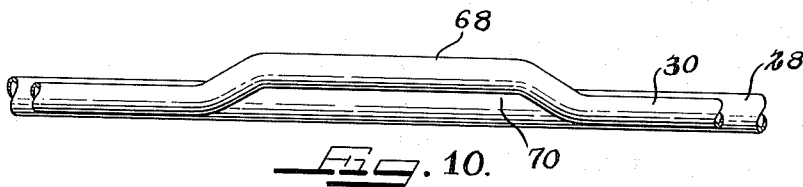
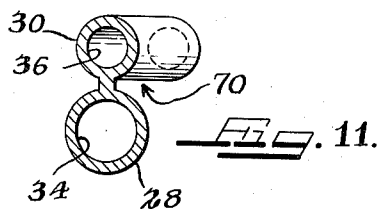


Figure 9

Figure 10



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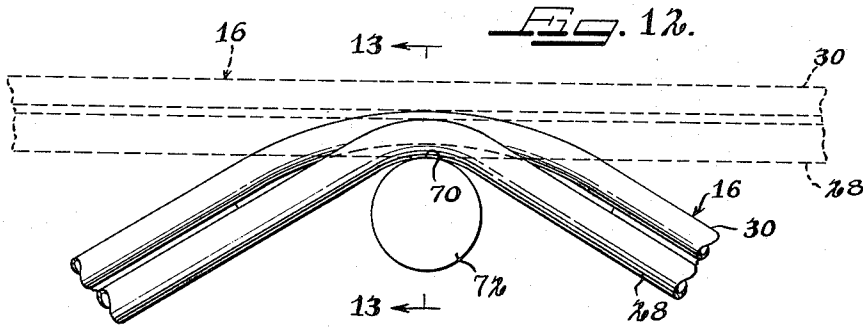
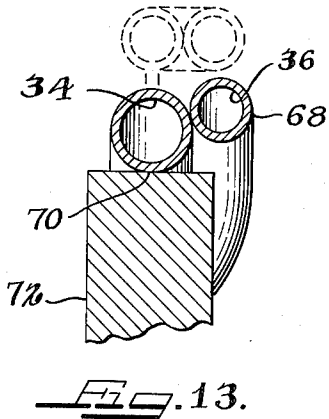
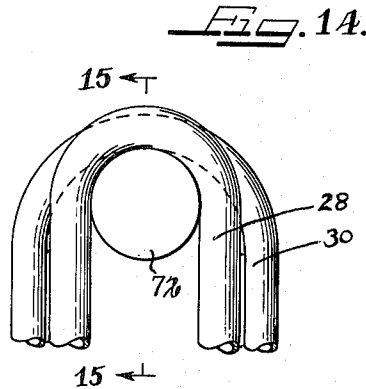
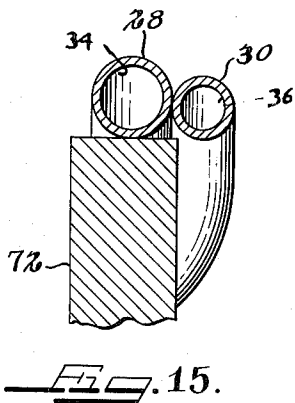
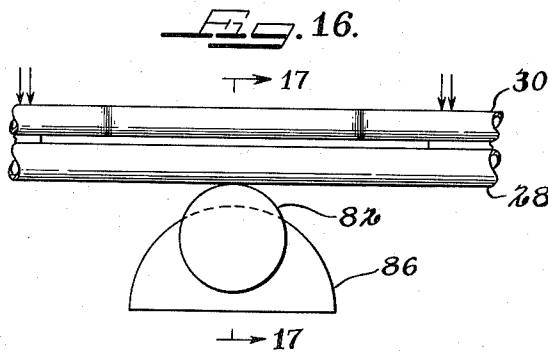
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METHOD OF FORMING REVERSE BENDS IN EXTRUDED INTEGRAL
DUAL-PASSAGE HEAT EXCHANGE TUBING

Filed Dec. 11, 1961

5 Sheets-Sheet 4



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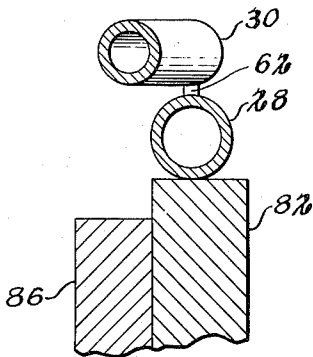
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METHOD OF FORMING REVERSE BENDS IN EXTRUDED INTEGRAL
DUAL-PASSAGE HEAT EXCHANGE TUBING

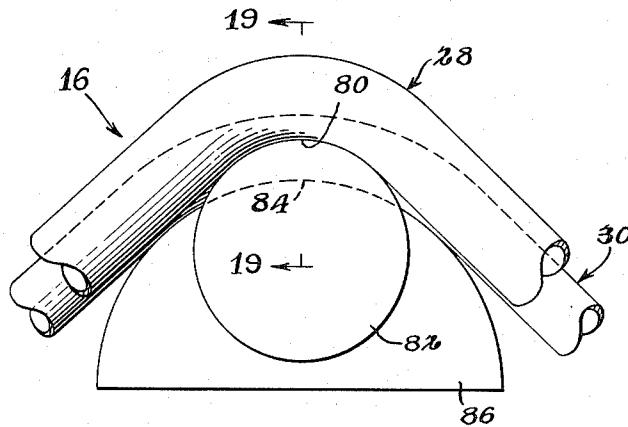
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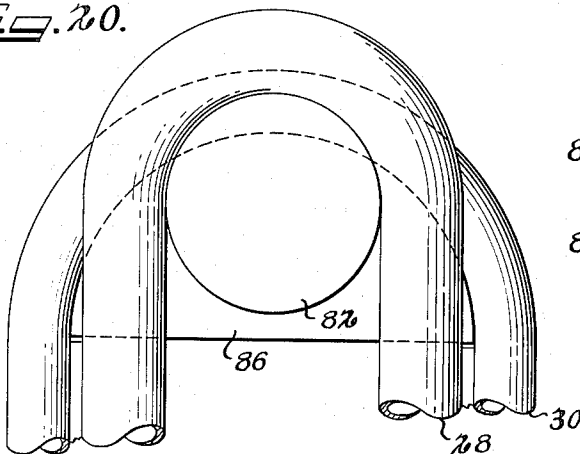
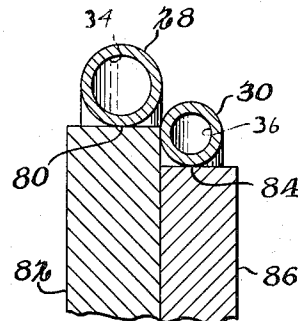
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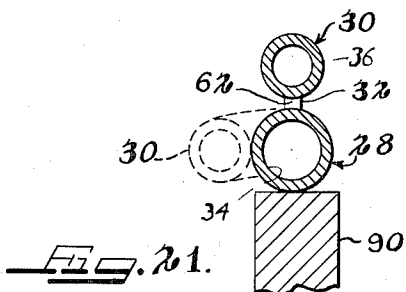
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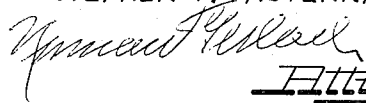


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3,208,261

METHOD OF FORMING REVERSE BENDS IN EXTRUDED INTEGRAL DUAL-PASSAGE HEAT EXCHANGE TUBING

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Filed Dec. 11, 1961, Ser. No. 158,274
8 Claims. (Cl. 72—335)

The present invention relates to heat exchange tubing and has particular reference to integral dual-passage heat exchange tubing which, in the extrusion process by means of which it is formed, emerges from the extruding dies as a continuous length of tube stock having two parallel, axially extending, closely spaced fluid passages therein.

A comparatively recent development in the air conditioning industry which in its broadest aspect is inclusive of refrigeration equipment is the provision of such extruded heat exchange tubing wherein the passages through the tube stock are cylindrical and the stock assumes the form of a pair of cylindrical tubes which are joined together in Siamese joint fashion coextensively throughout the length of the tubing and in substantial tangential relationship so that, in transverse cross section at any region therealong, the tubing roughly assumes the form of the figure 8. There is no appreciable separation between tubes and, in fact, the cylinders which comprise the outer sides of the two tubes respectively intersect each other geometrically so that the thickness of metal between adjacent passages is somewhat less than the sum or total of the thicknesses of the tube walls.

Tubing of the type under consideration lends itself well to use as tubing stock for the formation of refrigeration coils or other dual-passage conduits in that one of the two passages may be used to conduct the coolant fluid while the other passage may be intermittently employed to conduct a heating fluid for defrosting purposes. When put to such use, usually the diameter of one of the two tubes is made appreciably greater than the diameter of the other tube, the larger diameter tube serving to conduct the coolant fluid and the smaller diameter tube serving to conduct the heating fluid. Due to the intimate coextensive contact between the two tubes, heat is transferred from the smaller tube to the larger tube almost instantaneously when a flow of the heating fluid is induced through the smaller tube so that the defrosting operation takes place quite rapidly.

The use of such dual-passage heat exchange tubing is, however, limited to installations where the bends which are created in the tubing are either unidirectional, or where they take place on a large radius. While such tubing may readily be bent in a direction which maintains corresponding longitudinal regions of the two tubes equidistant from the bending center, it cannot be bent on a short radius in any other direction, and especially in a direction where the curved axial lines of the tubes remain in the same plane but at different radial distances from the bending center. Attempts thus to bend the tubing have invariably resulted in either rupture of one or both tubes, or in buckling of the tube which lies on the inside of the bend, such buckling nearly always closing off the tube passage, especially if the bend is sharp.

Since dual-passage heat exchange tubing of this character is wider in one direction than in the other, the difficulty involved in bending such tubing may be expressed differently by stating that the tubing is more susceptible to bending in its flat direction than it is in an on-edge direction.

For the reasons outlined above, dual passage heat exchange tubing has not been used in connection with heat

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exchange units of the type where closely spaced strips of flat fin stock are applied to the tubing and the tubing is obliged to pass through the fin strips and make reverse bends in two directions. For example, the tubing may readily be bent in a vertical plane to carry the tubing from one level to the next, but it cannot be bent in a horizontal plane in reentrant fashion to provide the required serpentine configuration on each tubing level.

Heretofore, the sharpest bend which can be attained in dual-passage tubing to provide a serpentine structure with all of the tube sections in the straight reach portions lying in a common plane, is a bend which is obtained when the tubing is twisted, either 180° through the bend, or when it is twisted 90° in one direction near one end of the bend and 90° in the other direction near the other end of the bend. In either event, to produce a close bend of small radius, the extent of twisting required to accommodate the bend is such as to place a considerable stress upon the metal of the tubing, resulting in a strain which may subject one or both tubes to rupture or buckling. In other words, the proposed remedy is almost as great an evil as the condition which it is designed to overcome, and in any event, the sharpest bend obtainable by this method is but slightly smaller than the wide bend which is permissible without twisting of the tubing.

The above-noted limitations that are attendant upon efforts satisfactorily to bend dual-passage heat exchange tubing in its flat direction are present whether the bending operations are attempted cold or whether heat is applied to the tubing, the application of heat merely hastening the time at which buckling or pinching off of one or the other tube takes place.

According to the present invention, a novel method has been provided whereby integral extruded dual-passage heat exchange tubing of the general type set forth above may be bent in an on-edge direction so that, for example, serpentine tubing may be provided with reverse bends at the ends of the straight reach sections which will bring the various tube lengths of such reach sections into coplanar existence. Because such a method has been provided, according to the invention, it is possible to produce heat exchange tubing of the dual-passage type and to fashion it into such serpentine configuration and apply fin stock to the straight reach sections of the tubing as to produce heat exchange units of a character which it heretofore has been impracticable, if not impossible, to manufacture in the absence of such method.

Briefly, in carrying out the method of the present invention, and as exemplified by a specific disclosure herein representing a preferred form of the method and of the article produced thereby, the tube stock is extruded from extruding dies which give to the stock continuously issuing therefrom the form of a pair of cylindrical tubes which may be of equal diameter or of different diameters or shapes. These tubes assume positions of parallelism and they are closely spaced from each other by a narrow web which is of such small width that the tubes are practically tangential coextensively therealong. Actually, the thickness of the metal between the adjacent tube passages is slightly greater than the sum of the thicknesses of the two tube walls. Although the width of the web is small, the thickness thereof is sufficiently great as to afford a large metal expanse for heat exchange purposes between the walls of the two tubes so that little heat exchange efficiency is lost by thus slightly separating the tubes.

The purpose of the web is solely to facilitate separation of the two tubes by slitting of the web along a limited extent in the region where the bend is to be effected. The width of the web is just sufficient to permit entry of a slicing tool between the two tubes. If the bend is to

be a reentrant 180° semi-circular bend, the length of the slit which is effected in the web is preferably equal to or slightly greater than the arcuate extent of the bend. After the slit has been made, the outer tube in relation to the bend, and which is usually of smaller diameter, is displaced laterally in a medial region thereof along the slit, the displacement carrying the metal of the smaller tube outwardly beyond the vertical confines of the larger tube, assuming the bend is to be made in a vertical plane.

Thereafter, with the flat direction of the tubing extending in a vertical plane, the section of the larger tube, from which the smaller tube has been separated, is positioned against a bending anvil and bending force is applied to the tubing so that a positive bending of the larger tube is effected in the usual manner of conventional tube bending operations. Because of the separation of the smaller tube from the larger tube in the region of bending, normal bending of the larger tube to produce the desired reentrant 180° bend is not in any way inhibited, retarded, restricted or modified by its connection at the ends of the section undergoing bending to the smaller tube, and bending force may be applied until the desired 180° bend has been completed in the larger tube.

During such bending of the larger tube, the detached section of the smaller tube will, without engaging the anvil, have its ends carried downwardly and, in addition, have such directional force applied thereto as to cause this detached section to assume the form of a bight substantially parallel and close to the reverse bend formed in the detached section of the larger tube. No appreciable amount of stretching of the smaller tube will take place, and after the bend in both tubes has been effected, the smaller tube will be disposed alongside of the larger tube and closely hug the same so that little loss of heat exchange efficiency will take place in the region where the web of the tubing has been slitted.

As an alternative step in the method of the present invention, both detached sections of the tubes are formed about a bending anvil and thus, the detached section of the smaller tube is caused to assume a definite curvature instead of following a floating course during the bending thereof.

The provision of a method of bending dual-passage heat exchange tubing in an on-edge direction as briefly outlined above being among the principal objects of the invention, it is a further object to provide such a method wherein bending is accomplished without requiring the use of heat.

Numerous other objects and advantages of the invention not at this time enumerated will become more readily apparent as the nature of the invention is better understood.

In the accompanying five sheets of drawings forming a part of this specification, a heat exchange unit embodying the principles of the present invention has been illustrated, together with alternative methods by means of which such heat exchange unit may be made.

In these drawings:

FIG. 1 is a fragmentary perspective view of an exemplary form of heat exchange unit constructed and assembled according to the principles of the present invention and embodying dual-passage heat exchange tubing having two kinds of reverse bends therein for reentry of the tubing into the fin stock cluster;

FIG. 1A is an enlarged sectional view taken on the line 1A—1A of FIG. 1 in the direction indicated by the arrows;

FIG. 2 is a table giving the order of reentry of the tubing into the fin stock cluster;

FIG. 3 is a fragmentary front perspective view of a limited section of the dual-passage heat exchange tubing shown in FIG. 1;

FIG. 4 is a rear perspective view of the section of tubing shown in FIG. 3;

FIG. 5 is a top plan view of the section of tubing shown in FIG. 3;

FIG. 6 is a bottom plan view of the section of tubing shown in FIG. 3;

FIG. 7 is a side elevational view of the section of tubing shown in FIG. 3;

FIG. 8 is a schematic side elevational view of a straight length of dual-passage heat exchange tubing and illustrating a slitting operation which is performed upon the tubing as the first step in the bending method of the present invention;

FIG. 9 is an end elevational view of the structure shown in FIG. 8;

FIG. 10 is a side elevational view similar to FIG. 8 but illustrating schematically a tube-displacement operation which constitutes the second step in the method of the present invention;

FIG. 11 is an end elevational view of the structure shown in FIG. 10;

FIG. 12 is a side elevational view similar to FIGS. 8 and 10 but illustrating the commencement of the tube-bending operation;

FIG. 13 is a sectional view taken on the line 13—13 of FIG. 12;

FIG. 14 is a side elevational view similar to FIG. 12 but illustrating the completion of the tube-bending operation;

FIG. 15 is a sectional view taken on the line 15—15 of FIG. 14;

FIG. 16 is a side elevational view similar to the dotted line disclosure of FIG. 12 and illustrating an initial tube-bending operation according to an alternative method;

FIG. 17 is a sectional view taken on the line 17—17 of FIG. 16;

FIG. 18 is a side elevational view similar to the full line disclosure of FIG. 12 but illustrating the partially completed tube-bending operation according to the alternative method;

FIG. 19 is a sectional view taken on the line 19—19 of FIG. 18;

FIG. 20 is a side elevational view similar to FIG. 14 but illustrating the completion of the tube-bending operation according to the alternative method; and

FIG. 21 is a sectional view similar to FIG. 19 but illustrating another alternative method of tube-bending.

Referring now to the drawings in detail and in particular to FIGS. 1, 1A and 2, an exemplary form of heat exchange unit or assembly assembled according to the method of the invention has been designated in its entirety by the reference numeral 20. The unit 20 consists of a cluster 22 of closely spaced, parallel strips of fin stock, the individual strips being designated by the reference numeral 24. A single length of dual-passage heat exchange tubing 26 is threaded in serpentine fashion through a series of marginal notches 27 provided in the edge regions of the strips 24.

The length of tubing 26 is of special construction and, as shown in FIG. 1A, the tube stock from which the length is formed is comprised of two parallel tubes 28 and 30, the former tube being of relatively large mean diameter and the latter being of relatively small mean diameter. The tubing 26 is formed by an extrusion process from a metal such as aluminum or an aluminum alloy having high heat conducting properties. The two tubes 28 and 30 are connected together in heat-exchange relationship by means of a narrow web 32 which, although narrow, is of sufficient transverse thickness as to afford an appreciably wide path for the flow of heat from the tube 30 to the tube 28 when a heating fluid is passed through the tube 30. The tube 28 presents an internal passage 34 through which there is adapted to be passed a suitable coolant fluid which may be either a gas or a liquid, while the tube 30 presents an internal passage 36 through which there is adapted to be passed a gaseous or a liquid heating fluid

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media such as steam or hot water for defrosting purposes.

Heat exchange tubing of the same general character briefly described above but differing slightly in structure from that specifically illustrated is known in the art and is currently superseding ordinary single-passage tubing in the manufacture of refrigeration coils since defrosting problems are greatly simplified by the use of such dual passage tubing. Such conventional tubing differs from the tubing of the present invention in that no spacing web is provided between the two tubes and the tubes are approximately tangentially disposed with the distance between the adjacent tube passages being slightly less than the combined sum of the thickness of the two tube walls. The present tubing 26 is so constructed that the distance between the two passages 34 and 36 is slightly greater than the combined thickness of the walls of the two tubes 28 and 30, the excess distance being, of course, equal to the width or thickness of the web 32.

Returning now to the description of the heat exchange unit 20 and to the manner in which the tubing 26 and the fin stock cluster 22 are assembled with respect to each other, the tubing 26 is bent to serpentine form and is threaded through the notches 27 in the individual fin strips 24 so that the latter establish a series of cooling fins which extend across and bridge the straight reach sections 37 of the serpentine tubing 26. The notches 27 have enlarged bottom regions 39 to accommodate the tube 28 and a narrow entrance throat region 41 to accommodate the tube 30.

In assembling the fin stock strips 24 and tubing 26, the sides of the tube 28 in the straight reach sections 37 are flattened as shown in dotted lines in FIG. 1A so as to reduce the over-all transverse width thereof, and, after the reach sections 37 have been positioned in the notches 27, internal air pressure is applied to the tubes 28 to expand the same back to its original cylindrical shape and thus cause the wall of the tube 28 frictionally to engage the edges of the enlarged bottom regions 39 of the notches 27.

The assembled tubing and fin stock cluster 22 constitute a basic heat exchange unit or assembly which may be operatively installed or mounted in a wide variety of installations by means of a suitable supporting framework, such as specially spaced mounting brackets (not shown) which may fit over the reverse bends or arcuate end sections at the ends of the straight reach sections of the serpentine tubing 26. The free ends 38 and 40 of the tubing 26 terminate at the same end of the unit 20. Obviously when the serpentine tubing possesses an even number of reach sections, the ends thereof will terminate at the same end region of the unit 20, and when the tubing possesses an odd number of reach sections 37, the ends 38 and 40 will terminate at opposite ends of the unit.

The unit 20 selected for illustration herein is not necessarily a commercial embodiment of a heat exchange device. Rather, it is a unit which illustrates the use of dual-passage heat exchange tubing 26 having at one end of the unit reverse bends 50 which lie in a horizontal plane, terminate in certain of the reach sections 37 and result in the tubes 28 and 30 of such certain reach sections lying in a common horizontal plane, and also having at the other end of the unit reverse bends 52 which terminate in other of the reach sections 37 and result in the tubes 28 of such other reach sections lying in a common vertical plane while the tubes 30 of said other reach sections lying in another common vertical plane. The various fin strips 24 are arranged in two tiers or rows. The outside strips 24 of one of the rows have been labelled A and B, respectively, and the outside strips 24 of the other row have been labelled C and D, respectively, for tabulation purposes in connection with the table of FIG. 2 in order to illustrate the manner in which the discontinued or broken-away portions of the tubing are continued through the fin stock.

Commencing with the tubing end 40, the tubing passes

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through the strip D at the point labelled 1 and from that point the straight reach section of the tubing passes through all of the strips between the strip D and the strip B and then passes outwardly of the cluster 22 through the strip B at the point labelled 2. From the point 2 the tubing 26 makes a reverse bend in approximately a horizontal plane and reenters the cluster 22 through the strip A at the point 3, from whence it passes through the cluster and emerges from the strip C at the point 4. From the point 4 the tubing 26 makes a reverse bend in a vertical plane, and then it reenters the cluster through the strip C at the point 5. The tubing 26 then traverses the cluster 22 and emerges from the strip A at the point 6 directly above the point 3 and then it makes a reverse bend in a horizontal plane, progressing in a direction opposite to the progressive direction of the reverse bend between the points 2 and 3. The tubing then enters the cluster through the strip B at the point 7, traverses the cluster to the point 8 from whence it emerges through the strip B and makes a reverse bend in a vertical plane before reentering the strip D at the point 9. The progression of the tubing from the point 9 to the point 17 is similar to the progression of the tubing from the point 1 to the point 9, as is the progression of the tubing from the point 17 to the point 25 and, therefore, need not be described herein in detail, especially in view of the table of FIG. 2, which gives the points of entry in numerical order of the tubing as it progresses from the end 40 to the end 38 through the individual fin strips A, B, C and D. The end 38 of the tubing 26 emerges from the strip C at the point 29 on the same side or end of the cluster as the end 40 of the tubing.

It is to be noted at this point that the arithmetical progression of the points of entry and emergence of the tubing 26 through the strips A and B may be expressed by the progressive or additive algebraic expression $(X+3, +5, +3, +5, \text{etc.})$. Similarly, the arithmetical progression of the points of entry and emergence of the tubing 26 through the strips C and D may be expressed by the progressive or additive algebraic expression $(X+7, +1, +7, +1, \text{etc.})$, these expressions being valid for any desired height of unit.

It is also to be noted that the character of the reverse bends 50 which are at the near end of the unit 20, as viewed in FIG. 1 and lie in respective horizontal planes, is different from the character of the reverse bends 52 which are at the far end of the unit and lie in respective vertical planes. Reverse bends such as the bends 52 are comparatively easy to form by conventional bending methods inasmuch as the two tubes 28 and 30 are bent upon the same radius and about a common center. It is merely necessary to place the larger tube 28 against a bending anvil and apply bending force to the tube on opposite sides of the anvil and the tube 28 will assume the desired arcuate shape while the tube 30, being intimately and coextensively attached to the tube 28, will follow the arcuate contour of the tube 28 and similarly become bent. The forming of a reverse bend which will bring the straight reach sections of the tubing at the opposite ends of the bend into coplanar relationship is a different and a difficult matter. Such a bend can, according to conventional bending methods, only be accomplished when the bend is made on a relatively large radius. Whether the bend be undertaken in such a manner as to place the larger tube 28 on the outside of the bend, or to place the smaller tube 30 on the outside of the bend, or whether the tubes be of equal diameter, any attempt to bend both tubes simultaneously while maintaining their coplanar relationship will result in either buckling and pinching-off of the inside tube, in undue stretching and consequent rupture of the outside tube, or both of these damaging influences. Furthermore, it is impractical to twist the tubing 26 in the regions of the desired reverse bend since the amount or degree of twisting necessary will require that torsional stresses be applied to the tubing to such a degree that rupture of one or both

tubes will result. For these reasons, dual-passge tubing has been employed in connection with refrigeration coils, finned heat exchange units and the like, only when bends such as the bends 52 are made so as to bring the reach sections of the larger tube into coplanar relationship in one common plane and the reach sections of the smaller tube into coplanar relationship in another common plane, or in other words, only when the bends can be made about a common center and on a common radius in the flat direction of the tubing.

The character of the bends 50 and the manner in which these bends are made in the tubing 26 constitute the essential features of the present invention. These bends are illustrated in detail in FIGS. 3 to 7, inclusive, and the manner in which they are formed is schematically shown in FIGS. 8 to 19, inclusive.

Referring now to FIGS. 3 to 7, inclusive, the tubing fragment which is illustrated in these views may be regarded as being a section of the serpentine tubing 26 of the heat exchange unit 20 of FIG. 1, extending from the point 5 through points 6, 7, and 8, to the point 9. It is similarly applicable to a section of the tubing extending from the point 13 to the point 17, or from the point 21 to the point 25.

A bend of the nature shown at 52 in FIGS. 3 to 7 is conventional and is effected by conventional bending procedures on tubing wherein the tubes 28 and 30 are joined to each other in Siamese fashion and with no intervening web such as the web 32 of the tubing 26. The bending procedure is equally applicable to the webbed tubing 26 and, therefore, no claim is made herein to tubing so bent, nor to the method of so bending it except insofar as this character of bend, in combination with the special bends 50, cooperate to make up the novel heat exchange unit 20. The bends 52 are made simply by passing the tubing 26 around a bending anvil by the application of bending force to the tubing on opposite sides of the point of contact with the anvil and so that the tubes 28 and 30 become bent on the same radius about a common bending center.

Referring now to FIGS. 3 to 7, inclusive, in the bend 50, the larger tube 28 remains in the general plane of the reach sections which extend away from the bend at the opposite ends of the latter, and the bend is a normal coplanar 180° reentrant bend such as would take place in the absence of the attached tube 30. The smaller tube 30, however, in the region of the bend 50, is displaced laterally or downwardly as at 60 and underlies the tube 28, as clearly shown in the lower left-hand corner of FIG. 7. This displacement of the smaller tube 30 is made possible by the provision of an elongated slit 62 in the web 32 which exists between the two tubes 28 and 30, the slit having an extent at least as great as the extent of the proposed bend. In its underlying position, the tube 30 is in substantial coextensive intimate contact with the tube 28 so that there is negligible loss of heat exchange characteristics between the tubes 28 and 30 by reason of the destruction or discontinuance of the web 32 at this region. Stated in other terms, and referring additionally to FIG. 1, it may be considered that in its progression from the point 2 of the fin strip B to the point 3 of the fin strip A, the tube 30 leaves the plane of the tube 28 and slopes downwardly as shown at 64, then traverses the apex region of the bend below the tube 28 in the region 60, and rises on the other side of the bend as shown at 66 on FIG. 4, and finally moves into coplanar relationship with the tube 28 at the point 3 of FIG. 1. The various bends 50 between the points 6 and 7, 10 and 11, 14 and 15, 18 and 19, etc., are the same in form as the bend which extends between the points 2 and 3 and they all are made according to the novel method of the present invention which will now be described in detail.

Referring now to FIGS. 8 to 15, inclusive, there has been disclosed in these views one method by means of which the bends 50 may be created in the extruded heat exchange tubing 26. Initially, the tubing 26 is caused to

be operated upon by a suitable searing tool such as a shearing knife or disk and a slit 62 is formed in the web 32 at the region of the bend which is to be effected. The length of the slit 62 is substantially equal to the extent of the bend although, is desired, it may be slightly longer than the extent of the bend. The slitting of the web 32 has been illustrated in FIGS. 8 and 9. This slitting preferably takes place without actual removal of metal from the web 32.

After the slitting operation which is illustrated in FIGS. 8 and 9, the slit 62 is widened as shown in FIGS. 10 and 11 by displacing the medial region 68 of the severed section of the tube 30 laterally and thus providing an elongated opening 70 between the two tubes. This displacing operation may conveniently be effected by the utilization of suitable displacement dies or by a suitable wedging tool or a prying tool. During the displacement of the medial region 68 of the tube 30, the straight linear extent of the tube 28 is not disturbed.

At this point in the method, the tubing 26, thus slitted, is ready for the actual bending operation. To bend the same, the center point 71 of the desired bend is selected and placed against a bending anvil such as the anvil 72 of FIGS. 12 and 13, the tube being so disposed with respect to the anvil that the offset medial region 68 of the tube 30 lies outside the vertical confines of the tube 28 and is out of vertical register with the anvil 72 as shown in dotted lines in FIG. 12. Thereafter, bending pressure is applied to the straight length of tubing 26 on opposite sides of the anvil, as indicated by the arrows in FIG. 10, and the bend takes place with the various tubing parts moving from the dotted line position through the full line position thereof to the position in which they appear in FIGS. 14 and 15 where the completed bend 50 is shown as having been effected.

The bend which takes place in the tube 28 is more or less a conventional bend of the warp-around type wherein the inner side of the tube closely hugs the outer curved or cylindrical surface of the anvil 72 throughout an arcuate extent of 180°. During the time that the tube 28 is thus undergoing bending, the offset medial region 68 of the smaller tube 30, having its ends attached to the larger tube 28, generally follows the movement of this latter tube and also assumes a curved condition. During such bending movement of both tubes 28 and 30, the offset medial region 68 of the smaller tube 30 is drawn against the side of the larger tube 28 as shown in FIGS. 12 and 13, so that at the completion of the bend, the sides of the two tubes throughout substantially the entire bend are in coextensive tangential contact (see FIGS. 14 and 15).

It is to be noted that, in effecting a bend such as the bend 50, the offset medial region 68 of the smaller tube 30 is drawn inwardly of the bend contour a slight distance, this being due to the amount of metal that is consumed in effecting the cross-over at the regions 64 and 66, as previously described. A portion of the tube 30 thus moves below the uppermost level of the bending anvil 72, as shown in FIG. 15, and since the tube 30 is not obliged to touch any portion of the anvil 72, no appreciable stretching of the metal of the smaller tube 30 takes place during the bending operation.

It will be understood, of course, that in applying bending pressure to the tubing 26 as indicated by the arrows in FIG. 12, means must be provided for preventing the tubing from twisting or rotating. When such means are provided, and when the bend has been completed, the longitudinal axes of the two tubes 28 and 30 in the adjacent or adjoining reach sections lie in a common plane, i.e., a common horizontal plane in the case of the tubing when it has been installed in the completed heat exchange unit 20 as shown in FIG. 1.

To accommodate the specific form of heat exchange unit 20 of FIG. 1, the bend is made so that the smaller tube 30 lies beneath the larger tube 28 in the region

of each bend 50 but passes around the tube 28 near the ends of the bend and assumes an outside position with respect to the adjacent reach sections adjoining the bend. It is within the scope of the present method to effect the slitting of the tubing 16, as heretofore described, and then to apply the slitted tubing to the anvil 72, and finally apply bending pressure to the tubing on opposite sides of the anvil in such a manner that when the bend has been completed throughout an angle of 180°, the smaller tube 30 will lie on the inside of adjacent reach sections. To effect such a bend, it is merely necessary to invert the tubing 26 from the position it is shown in FIG. 12 in dotted lines and apply the same to the anvil 72 in its inverted position. When such a bend has been effected, the apex of the bend in the smaller tube 30 will protrude outwardly a slight distance beyond the apex of the bend in the larger tube 28.

It is to be finally noted that in connection with the various bends 50, when each bend has been completed, the radius of the bend in the larger tube 28 is shorter than the radius of the bend in the smaller tube 30. This is to be distinguished from the formation of the various bends 52 where the two radii are not only equal but were the bends in the two tubes are concentric.

In FIGS. 16 to 21, inclusive, a slightly modified bending procedure has been illustrated. In preparing the tubing 26 for bending according to this modified procedure, the web 32 is slitted as at 62 in FIG. 8 and the center point 80 of the desired bend in the larger tube 28 is applied to the cylindrical surface of an anvil section 82 of small radius. At the same time, the center point 84 of the desired bend in the smaller tube 30 overlies and is spaced upwardly from the cylindrical surface of an anvil section 86 of larger radius, as shown in FIGS. 16 and 17. Thereafter, bending pressure is applied to the tubing 26, as indicated by the arrows in FIG. 16, on opposite sides of the anvil sections 82 and 86 and the bend in the larger tube 28 takes place with this tube section becoming wrapped around the anvil section 82 as a guide. During movement of the tube 28 from the position wherein it is shown in FIGS. 16 and 17 to the position wherein it is shown in FIGS. 18 and 19, the smaller tube 30 follows the movement of the tube 28 until such time as the center point 84 of the desired bend in the tube 30 engages the cylindrical surface of the anvil section 86. Thereafter, during continuance of the bending operation, the tube 28 continues to become wrapped around the anvil section 82 while the tube 30 commences a wrap-around operation against the anvil section 86, both wrap-around operations being completed when the parts assume the positions in which they are shown in FIGS. 20 and 21.

The character of the bend which is produced when the two anvil sections 82 and 86 are employed is similar to the character of the bend 50 which is produced by utilizing the single bending anvil 72. The tubes 28 and 30 in both instances are in substantial coextensive tangential contact throughout the region of the bend, but in the case where two anvil sections are employed, the bend which is produced in the smaller tube 30 is of a precision nature and its curvature is more accurately semi-circular than in the case of the use of but a single anvil.

In FIG. 23 yet another modified bending procedure has been illustrated. It has been found that under certain circumstances it is not necessary to effect lateral displacement of the smaller tube section 30 after the slitting operation has been performed and prior to the actual bending operation. The tubing 26 may be positioned against the anvil 90 as shown in FIG. 22 with the axes of the two tubes 28 and 30 lying in substantially a vertical plane, after which bending pressure may be applied to the portions of the tubing 26 on opposite sides of the anvil as previously described in connection with the previously outlined method steps. The application of such bending pressure will cause the portion of the tube 30 which has become physically disassociated from the tube

28 by reason of the slit 62 to slide or effect a camming action against the latter tube so that upon completion of the bending operation, it will assume the dotted line position in which it is illustrated.

It is to be distinctly understood that the heat exchange unit 20 which is illustrated in the accompanying drawings and described herein is only exemplary of one form of unit requiring the use of the present bending methods for producing the reverse reentrant bends 50. Numerous other forms of heat exchange units or assemblies are made possible by the use of the present method. It also is to be understood that the method of the present invention is not limited to use in connection with the specific form of extruded, integral, dual-passage tubing 26 which is illustrated in the drawings. For example, the method is applicable to the bending of dual-passage tubing regardless of the relative size of the two tubes or of their specific shapes. The tubes need not be cylindrical in configuration, nor need the web which joins them be flat. In fact, under certain circumstances, there need be no web. It is merely necessary that the distance between the two passages provided by the tubes be sufficiently great that the tubes are capable of being separated along a limited longitudinal extent by a slitting or other separating operation. Finally, the method of the present invention is applicable to the bending of dual-passage tubing whether the bends be of greater or lesser extent than the 180° selected for illustration herein. Irrespective, however, of the particular use to which the present method may be put, the essential features thereof are at all times preserved.

The invention, therefore, is not to be limited to the exact arrangement of parts shown in the accompanying drawings or described in this specification, nor is it to be limited to the exact performance of the steps described herein for carrying out the method involved. Only insofar as the invention has particularly been pointed out in the accompanying claims is the same to be limited.

Having thus described the invention what I claim as new and desire to secure by Letters Patent is:

1. The method of creating an arcuate bend in a straight length of dual-passage heat exchange tubing having two separate internal parallel fluid passages extending coextensively therealong and separated by a thickness of the material from which the tubing is formed, said method comprising the steps of cutting through the material of the tubing between said fluid passages in the region of the tubing where the bend is to be effected in order thus physically to disassociate the bodies of material surrounding the two passages respectively, and thereafter applying bending force to the straight sections of the tubing on opposite sides of said region and causing said sections to be swung angularly toward each other while maintaining the passages through said sections in substantially coplanar relationship, such application of bending force to the straight sections of the tubing serving to effect a sliding movement of one of said bodies of material in the bending region against the other body in the bending region whereby said one body of material becomes laterally displaced from the other body of material.

2. The method of creating an arcuate bend in a straight length of dual-passage heat exchange tubing having two separate internal parallel fluid passages extending coextensively therealong and separated by a thickness of the material from which the tubing is formed, said method comprising the steps of cutting through the material of the tubing between said fluid passages in the region of the tubing where the bend is to be effected in order thus physically to disassociate the bodies of material surrounding the two passages respectively, displacing one of said disassociated bodies of material laterally from the other body of material, and thereafter applying bending force to the straight sections of the tubing on opposite sides of said region and causing said sections to be swung angularly toward each other while maintaining the passages through the sections in substantially coplanar relationship.

3. The method of creating an arcuate bend in a straight length of dual-passage metallic heat exchange tubing which is comprised of two closely-positioned parallel tubes connected together throughout their entire length by a narrow integral web, said method including the steps of longitudinally slitting the metal of the web in the region of the tubing where the bend is to be effected in order thus physically to disassociate the tube bodies in such region, displacing one of the physically disassociated tube bodies laterally from the other disassociated tube body, and thereafter applying bending force to the straight sections of the tubing on opposite sides of said region and causing said sections to be swung angularly toward each other while maintaining the portions of the tubes in said sections in substantially coplanar relationship, said application of bending force to the straight sections of the tubing serving to effect individual bending of the physically disassociated tube bodies about substantially the same bending center but on different radii.

4. The method of creating an arcuate bend in a straight length of dual-passage heat exchange tubing which is comprised of two closely positioned parallel tubes connected together throughout their entire length by a narrow integral web, said method comprising the steps of longitudinally slitting the material of the web in the region of the tubing where the bend is to be effected and throughout the entire region in order thus physically to disassociate the tube bodies in such region, displacing the outer of the physically disassociated tube bodies with respect to the bend laterally from the inner disassociated tube body, and thereafter applying bending force to the straight sections of the tubing on opposite sides of said region and causing said sections to be swung angularly toward each other while maintaining the portions of the tubes in said sections in substantially coplanar relationship, said application of bending force to the straight sections of the tubing serving to effect individual bending of the physically disassociated tube bodies about substantially the same bending center but on different radii.

5. The method of creating an arcuate bend in a straight length of dual-passage heat exchange tubing which is comprised of two closely positioned parallel tubes connected together throughout their entire length by a narrow integral web, said method comprising the steps of longitudinally slitting the material of the web in the region of the tubing where the bend is to be effected in order thus physically to disassociate the tube bodies laterally from each other in such region, displacing one of the physically disassociated tube bodies laterally from the other disassociated tube body in a direction normal to a plane passing through the axes of the two tube bodies, and thereafter applying bending force to the straight sections of the tubing on opposite sides of said region and causing said sections to be swung angularly toward each other in said plane to positions of substantial parallelism, and in such directions that upon termination of the swinging movement the tube bodies at the opposite ends of the displaced and disassociated tube body will assume positions on the far sides of the substantially parallel straight sections.

6. The method of creating an arcuate bend in a straight length of dual-passage metallic heat exchange tubing which is comprised of two closely-positioned parallel tubes connected together throughout their entire length by a narrow integral web, said method including the steps of longitudinally slitting the metal of the web in the region of the tubing where the bend is to be effected in order

thus physically to disassociate the tube bodies in such region, displacing one of the physically disassociated tube bodies laterally from the other disassociated tube body, positioning the central region of said other disassociated tube body against a bending anvil, and applying bending force to the straight sections of the tubing on opposite sides of the anvil and causing said sections to be swung angularly toward each other while maintaining the portions of the tubes in said sections in substantially coplanar relationship.

7. The method of creating an arcuate bend in a straight length of dual-passage metallic heat exchange tubing which is comprised of two closely-positioned parallel tubes connected together throughout their entire length by a narrow integral web, said method including the steps of longitudinally slitting the metal of the web in the region of the tubing where the bend is to be effected in order thus physically to disassociate the tube bodies in such region, displacing one of the physically disassociated tube bodies laterally from the other disassociated tube body, positioning the central region of said other disassociated tube body against a first bending anvil, positioning a second anvil adjacent the center point of said one disassociated tube body, and applying bending force to the straight sections of the tubing on opposite sides of the first bending anvil and causing said straight sections to be swung angularly toward each other to effect wrapping of said disassociated tube bodies about the first and second anvils respectively.

8. The method of creating an arcuate bend in a straight length of dual-passage heat exchange tubing which is comprised of two closely-positioned parallel tubes connected together by a narrow integral web which extends radially outwardly of each tube and lies in the common plane of the tube axes, one of said tubes being of smaller diameter than the other tube, said method including the steps of longitudinally slitting the material of the web in the region of the tubing where the bend is to be effected in order thus physically to disassociate the tube bodies in such region, displacing the physically disassociated tube body of smaller diameter laterally from the physically disassociated tube body of larger diameter, thereafter applying bending force to the straight sections of the tubing on opposite sides of said region and causing said sections to be swung angularly toward each other while maintaining the portions of the tubes in said sections in substantially coplanar relationship, and continuing the application of such bending force until such time as said straight sections assume positions of parallelism, the direction of application of such bending force being such that upon completion of the bending operation the tube bodies of smaller diameter in said straight sections will assume positions on the far sides of the substantially parallel straight sections.

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