

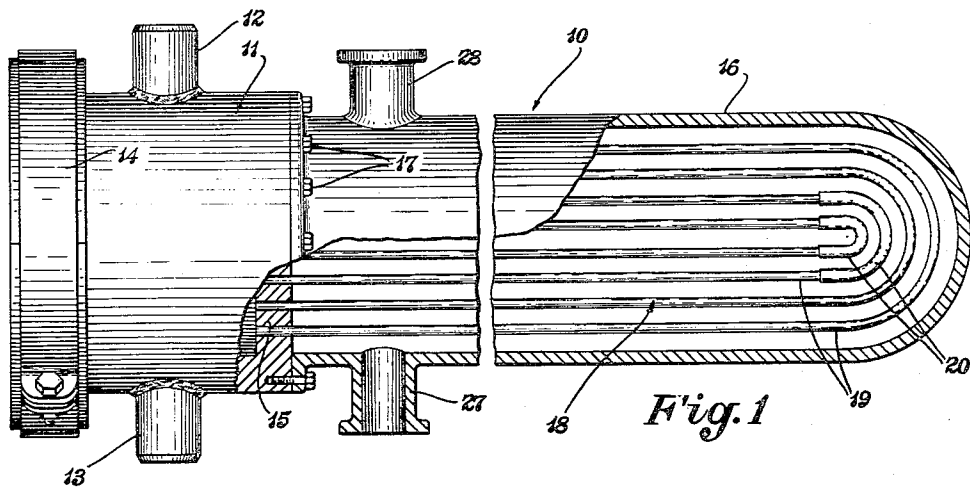
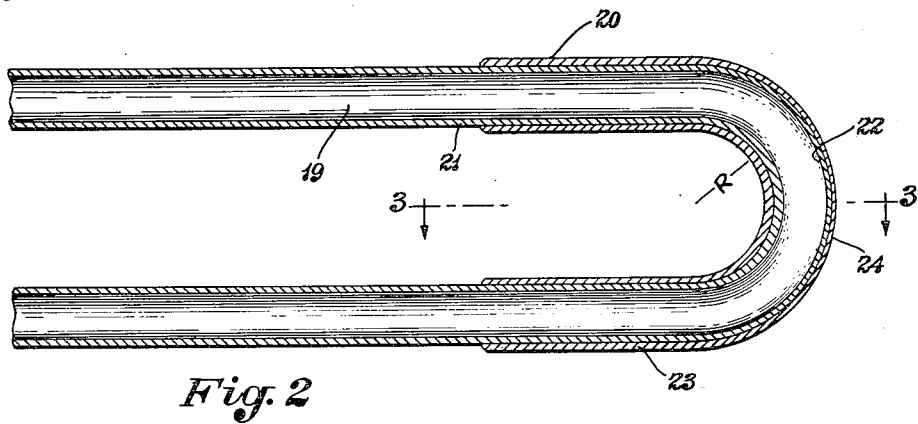
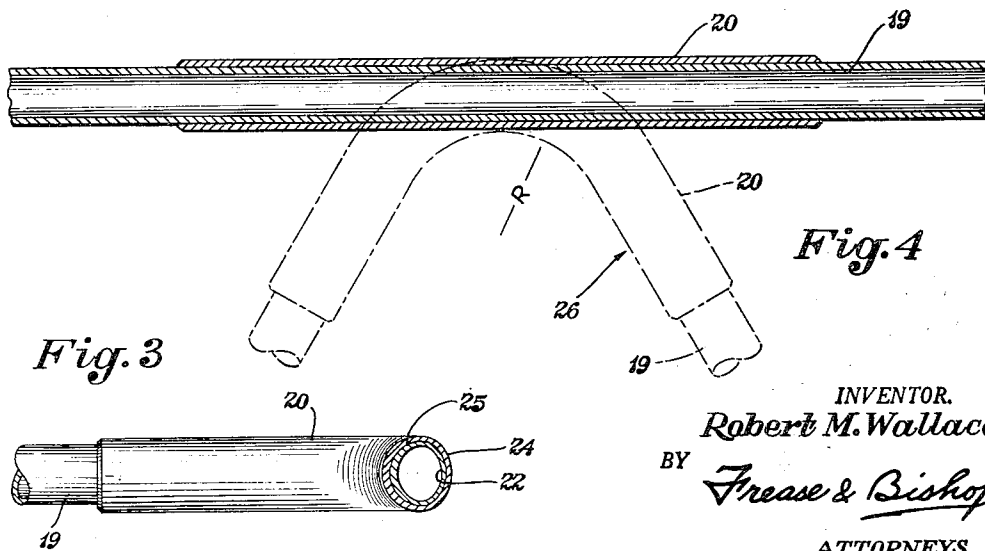
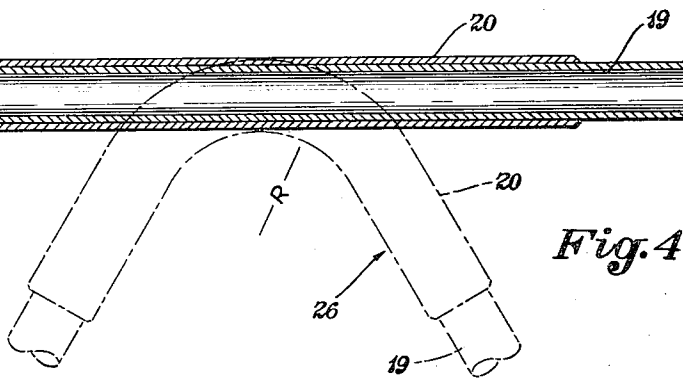
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HEAT EXCHANGER U-TUBES

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HEAT EXCHANGER U-TUBES

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The invention relates to heat exchanger tubes and more particularly and specifically to heat exchanger U-tubes having reinforced bends and to a method of making such U-tubes.

In the production and assembly of heat exchangers of the type designed for and equipped with U-bent tubes, numerous problems and difficulties arise relative to the manufacture of the U-bent tubes involved.

It has been discovered that the bending operation necessary for producing U-tubes, particularly those tubes destined for the innermost positions in the tube bundle which are bent about a relatively small radius, causes a substantial thinning down of the tube wall thicknesses in the regions of the outermost or outside radius of the bend.

This thinning down of portions of the tube wall thickness, which is the result of stretching or elongation of metal in the tube wall at the outer portion of the bend, causes a development of weak points in the tube. If the initial wall thickness of the tube before bending is closely calculated for the strength required in the finished product, a reduction of wall thickness resulting from the bending operation will reduce the strength factor of the bent portion of the tube to below the minimum strength required.

Several solutions of this problem have been used in an effort to offset this reduction of strength in the production of U-tubes, but these solutions have, in themselves, created additional problems and disadvantages.

One of the prior expedients has been to determine the amount a specific tube wall thickness will thin down when bent on the required radius, and to calculate the wall thickness that would be required before bending which, after bending, will provide a resultant thickness in the thinned portions sufficient to satisfy the strength requirements.

This solution, while providing the necessary strength in the regions of the bend, results in a wall thickness throughout the unbent portions of the tube far in excess of the necessary strength requirements.

Such excessive tube wall thickness creates an undesirable increase in tube weight and bulk which unnecessarily complicates the design and construction of the pressure vessels in which the U-tubes are contained.

The use of tubes having excessive wall thickness in the unbent portions of the tubes not only greatly increases the costs of manufacture of the pressure vessel itself in adapting it to accommodate such tubing, but, it also substantially increases the tube costs.

Another expedient has been to use dual gauge tubes. Dual gauge tubes are tubes having a prescribed wall thickness for a portion of the length thereof and an increased wall thickness portion is provided for the necessary interval in the length of the tube where the tube may be bent without a reduction of wall thickness below the strength requirements for the bent portion of the tube.

Dual gauge tubes usually must be purchased or made on special order so that the interval of increased thickness in each tube is properly spaced and located to co-

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incide with the required bend location necessary to produce tubes to meet the specifications for each particular heat exchanger tube bundle, and each tube in the bundle.

One disadvantage inherent in the use of dual gauge tubes is, the extremely high cost of manufacture of such tubes.

Secondly, the use of dual gauge tubes having permanently fixed intervals of increased thickness in the tube wall reduces variations in their use which might become desirable or necessary in assembly of tube bundles, and it also results in a high rate of tube scrap loss from end cropping when cutting the tubes to the required lengths with the thick wall portions properly located.

It is therefore a general object of the present invention to provide a heat exchanger U-tube construction with a reinforced U-bend and methods for making such a construction which eliminate substantially all of the disadvantages inherent in prior constructions.

A primary object of the present invention resides in the provision of a heat exchanger U-tube construction wherein the bent portions of the tube are as strong as or stronger than the straight walled sections of the tubing.

Another object of the present invention lies in the provision of a heat exchanger U-tube construction which includes a reinforced bent portion of a character which permits the utilization of tubes having a uniform wall thickness throughout, which uniform thickness is consistent with the strength requirements of the finished tube.

It is an object of the instant invention to provide a heat-exchanger U-tube construction which permits the use of tubes of a minimum, uniform wall thickness so that the initial costs of the tubes and the costs of manufacture of those parts of the heat exchanger needed to accommodate and support the tubes will be maintained at minimum figures.

Still a further object of the present invention is in the provision of a heat exchanger U-tube construction wherein a separate reinforcing sleeve or secondary tube is telescoped over the primary tube at the predetermined bend location to provide a thickness and strength in the resultant bent portion equal to or greater than minimum requirements.

It is another important object of this invention to provide a heat exchanger U-tube construction including a primary metal tube of uniform thickness throughout to which a reinforcing sleeve is applied at the predetermined bend location, wherein the reinforcing sleeve may be made of a metal having a greater tensile strength than the primary tube metal, permitting utilization of a sleeve of minimum weight and thickness while achieving maximum strength in the resultant bend.

Still another object of the present invention resides in the provision of a heat exchanger U-tube having a reinforcing sleeve applied thereabout throughout the length of the bent portions thereof, wherein the walls of the sleeve are maintained in intimate metal to metal contact with the walls of the tube insuring a strong, rupture proof construction, and producing a thickened tube wall at the bend having efficient heat transfer characteristics.

Additionally, an important object of this invention resides in the provision of a method by which a reinforcing sleeve may be quickly and easily applied in tight engagement to a heat exchanger tube at a preselected location thereon, which method enables the selective application of the reinforcing sleeve to the tube at the time the heat exchanger is being fabricated. This permits unlimited variation in tube lengths and sleeve positions without incurring scrap losses which are inherent in the use of certain prior constructions and methods.

Still further objects and advantages of the present construction and methods of construction reside in the

simplicity of design and the simplified procedures involved both of which factors result in low manufacturing costs with the minimum of scrap losses.

These and other objects apparent to those skilled in the art may be accomplished by the parts, constructions, arrangements, elements, combinations, methods, steps and procedures which comprise the present invention, the nature of which is set forth in the following general statement, and a preferred embodiment of which—illustrative of the best mode in which applicant has contemplated applying the principles—is set forth in the following description and illustrated in the accompanying drawing, and which are particularly and distinctly pointed out and set forth in the appended claims forming a part hereof.

In general terms the present invention may be stated as including in a heat exchanger, a primary metal tube, which may be Monel or copper-nickel metal, bent about a radius to provide straight tube sections the open ends of which are adapted to be secured in a heat exchanger tube sheet, a tubular metal sleeve or secondary tube formed of the same or a different metal, and which may have a greater tensile strength or a lower coefficient of expansion than the metal constituting the primary tube, said tubular sleeve being tightly, telescopically affixed on said tube in intimate metal to metal heat transfer contact therewith throughout the bent portion thereof; and wherein, in the production of U-tubes for heat exchangers of the character noted, a tubular metal sleeve having a preselected coefficient of expansion is telescopically positioned at a predetermined location on a tube, followed by expanding said tube within the sleeve to tightly engage the tube walls against the sleeve with the sleeve walls in intimate metal to metal heat transfer contact with the tube walls, and bending the tube about a radius so that the sleeve extends throughout the bend and reinforces the bent portion of the tube.

In the accompanying drawing, in which like numerals designate similar parts throughout the several views;

Figure 1 is a general schematic view of a heat exchanger, partially in section for purposes of clearer illustration;

Fig. 2 is a fragmentary vertical section of the bent portion of a U-tube;

Fig. 3 is a sectional view taken on line 3—3, Fig. 2, as indicated; and

Fig. 4 is a sectional view of a length of tubing prior to bending, with the bending operation generally indicated in dotted line.

There is illustrated in Fig. 1 of the drawing a heat exchanger, generally designated at 10, which includes a head section 11 provided with the usual inlet and discharge connections 12 and 13, and which head section is closed at one end by a removable head closure assembly 14, and which head section includes the usual tube sheet 15. A cylindrical body or shell 16 is secured, as at 17, to the head section 11 to extend from and enclose the tube sheet 15; and a U-tube bundle, generally designated at 18, is interconnected with the tube sheet 15 in a conventional manner. The shell may be provided with inlet and outlet connections 27 and 28.

The U-tube bundle 18 consists of a plurality of U-bent heat exchanger tubes 19, generally referred to in the art as U-tubes. In accordance with usual practice, the tubes 19 of the bundle 18 are arranged in a substantially nested relationship wherein the tubes 19 form a plurality of concentrically arranged U-shaped members from the central region of the bundle outwardly toward the wall of cylindrical shell 16.

The size and spacing of the individual tubes 19 constituting the bundle 18 are exaggerated in the schematic showing of Fig. 1 in order to more clearly illustrate the present invention.

Referring to Fig. 1, the innermost, centrally located U-tubes 19 in the tube bundle 18 are bent on a relatively small radius while the radius of the bend in those tubes

in the outer regions of the bundle is substantially larger.

It has been discovered that bending of U-tubes about a small radius to form tubes for use in the inner regions of a bundle produces substantial, weakened areas about the outer wall portions of the tube bends due to elongation and thinning of the metal at such locations.

In accordance with the present invention, a tubular reinforcing sleeve 20 is applied about a tube at the predetermined bend location—prior to the bending operation—in order that a wall thickness is maintained throughout the bend—after bending—which will equal or exceed the original wall thickness of the tube before bending.

In Fig. 2, there is illustrated in enlarged, fragmentary section a typical U-tube 19 constructed in accordance with the present invention wherein a tubular sleeve 20 is affixed to the tube, and the tube is bent about a radius R at a location substantially centrally of length of the sleeve 20. As shown, those portions of the tube wall 21 in the bent area which are thinned down, as at 22, due to elongation produced by the bending are reinforced by the thickness of the sleeve walls 23, which are likewise thinned down, as at 24, by the bending.

It has additionally been discovered that when an outer reinforcing sleeve 20 is affixed on the tube in accordance with the methods to be hereinafter described, that the subsequent bending of the tube and sleeve will maintain the tube and sleeve walls in intimate metal to metal heat transfer contact throughout the bend producing a substantially composite tube wall (as seen at 25, Fig. 3) having the necessary thickness to meet the strength requirements of the finished tube.

For the purposes of insuring a bent tube wall of required strength, to reduce weight in and cost of the end product and to maintain intimate metal to metal contact between the sleeve and tube, it is contemplated that the sleeve members 20 in the present construction may be formed from a metal having a greater tensile strength than the metal from which the tube walls are formed.

By constructing U-tubes for heat exchangers in accordance with the present invention, as described above, U-tubes may be provided which are of a minimum weight and mass, and which may be manufactured, by methods to be hereinafter described, at costs substantially below those involved in the production of prior constructions.

Further, the U-tube construction constituting the present invention permits greater variation and maintenance for less stringent tolerances than in the use of prior constructions; and provides a substantial reduction in scrap losses in the fabrication of the heat exchanger.

The method, comprising a part of the present invention, by which the aforescribed heat exchanger U-tube construction may be made involves the provision of a tube having a uniform wall thickness throughout, and of a tubular sleeve having an inside diameter the same as or sufficiently greater than the outside diameter of the tube to be conveniently telescoped thereover.

In the practice of this method, it may be desirable that the metal from which the tube is formed has a greater coefficient of expansion than the metal from which the sleeve is formed. Likewise, for advantages produced in the end product it may be desirable that the sleeve metal have as great if not a greater tensile strength than the tube metal.

Accordingly, Inconel, carbon steel or stainless steel sleeves may be used with copper-nickel, admiralty metal and Monel tubes, while at the same time, copper-nickel sleeves could be suitably applied to admiralty metal tubes, and Monel sleeves to copper-nickel tubes.

In assembly, the sleeve is telescoped over the tube and passed therealong to the predetermined location of bend. The tube is then expanded into the sleeve to bring the interface surfaces of the sleeve and tube walls into tight,

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intimate metal to metal heat transfer contact. (See Fig. 4.)

Once the sleeve is secured to the tube in tight metal to metal engagement, the tube is subjected to a bending operation, as generally illustrated by dotted lines (Fig. 4), about a radius substantially centrally of the length of the sleeve.

By reason of the tight, intimate fit between the tube and sleeve walls, the outermost portions of the sleeve walls in the bent portion will tend, upon elongation, to thin coincidentally with the thinning of the tube walls in the same location producing an even closer and more intimate contact between their interface surfaces, and result in a substantially composite wall throughout the bent portion.

By providing a U-tube construction by the above method, a bi-metallic tube bend is obtained in which the tube wall in the bend—normally thinned by bending—is reinforced to provide a tube bend of a thickness and strength equal to or greater than that in the unbent portions of the tube walls.

Accordingly, a U-tube construction, and a method of producing the same, is provided which encompasses all those objects and advantages over prior constructions heretofore denoted.

In the foregoing description, certain terms have been used for brevity, clearness and understanding, but no unnecessary limitations are to be implied therefrom beyond the requirements of the prior art, because such words are used for descriptive purposes herein and are intended to be broadly construed.

Moreover, the embodiments of the improved construction and method illustrated and described herein are by way of example, and the scope of the present invention is not limited to the exact details of construction.

Having now described the invention, the construction, operation and use of a preferred embodiment thereof, the new method steps contemplated, and the advantageous new and useful results obtained thereby; the new and useful constructions, arrangements and methods, and reasonable mechanical equivalents thereof obvious to those skilled in the art, are set forth in the appended claims.

I claim:

1. Heat exchanger U-tube construction including, a primary metallic tube having a substantially U-bend portion intermediate the ends thereof, the U-bend being formed on a relatively small radius such as to cause thinning of the tube wall at the bend, said primary tube having walls of uniform thickness throughout the unbent portions thereof sufficient to withstand the pressure to which those portions are subjected and a thinner wall at the U-bend portion insufficient in thickness to withstand the pressure to which the parallel portions are subjected, a secondary metallic tube section telescoped over the U-bend portion

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of said primary tube, the secondary tube having a thinned wall in the U-bend portion thereof, the combined thickness of the thinned walls of the primary and secondary tubes in the U-bend portions thereof providing sufficient metal thickness to withstand the pressure to which the parallel primary tube portions are subjected, the metal constituting the secondary tube section having a smaller coefficient of expansion than the metal constituting the primary tube, the metal constituting the secondary tube section having a greater tensile strength than the metal constituting the primary tube, and the primary tube being expanded into the secondary tube section to bring the interface surfaces of said two tubes into intimate metal-to-metal heat transfer contact.

2. Heat exchanger U-tube construction including, a primary metallic tube having a substantially U-bend portion intermediate the ends thereof, the U-bend being formed on a relatively small radius such as to cause thinning of the tube wall at the bend, said primary tube having walls of uniform thickness throughout the unbent portions thereof sufficient to withstand the pressure to which those portions are subjected and a thinner wall at the U-bend portion insufficient in thickness to withstand the pressure to which the parallel portions are subjected, a secondary metallic tube section telescoped over the U-bend portion of said primary tube, the secondary tube having a thinned wall in the U-bend portion thereof, the combined thickness of the thinned walls of the primary and secondary tubes in the U-bend portions thereof providing sufficient metal thickness to withstand the pressure to which the parallel primary tube portions are subjected, the metal constituting the secondary tube section having a smaller coefficient of expansion than the metal constituting the primary tube, the primary tube being expanded into the secondary tube section to bring the interface surfaces of said two tubes into intimate metal-to-metal heat transfer contact, and the combined thicknesses of the walls of said two tubes in the U-bend portion being at least as great as the uniform wall thickness of the unbent portions of the primary tube.

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