

May 28, 1968

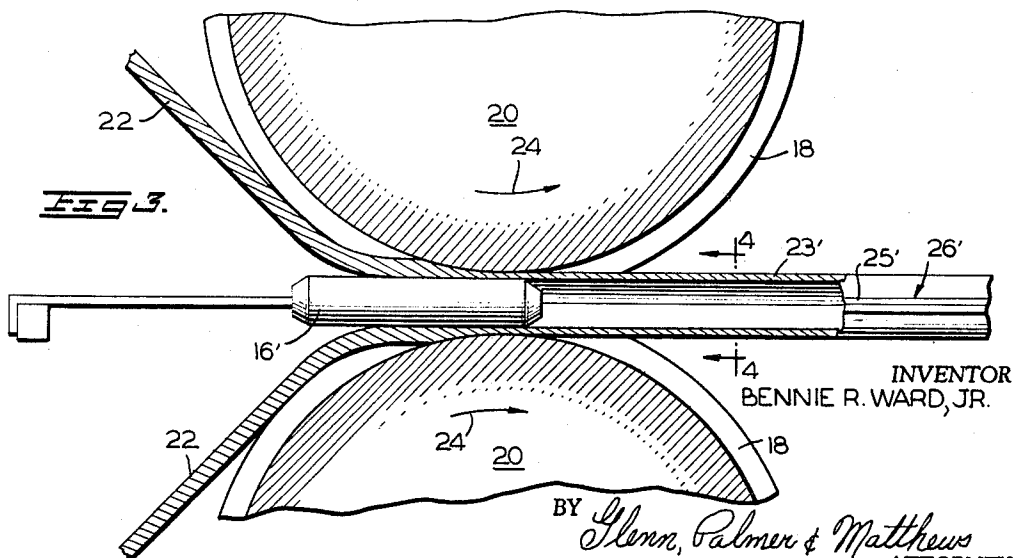
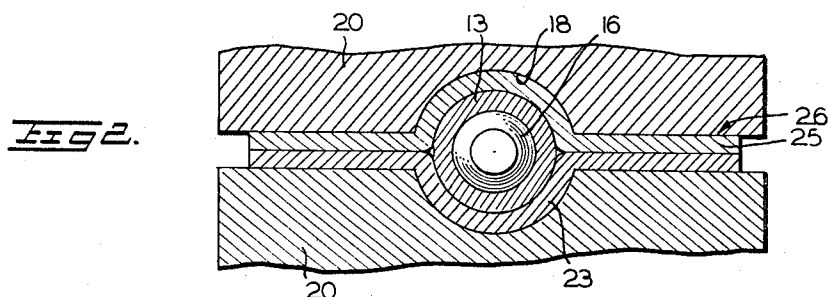
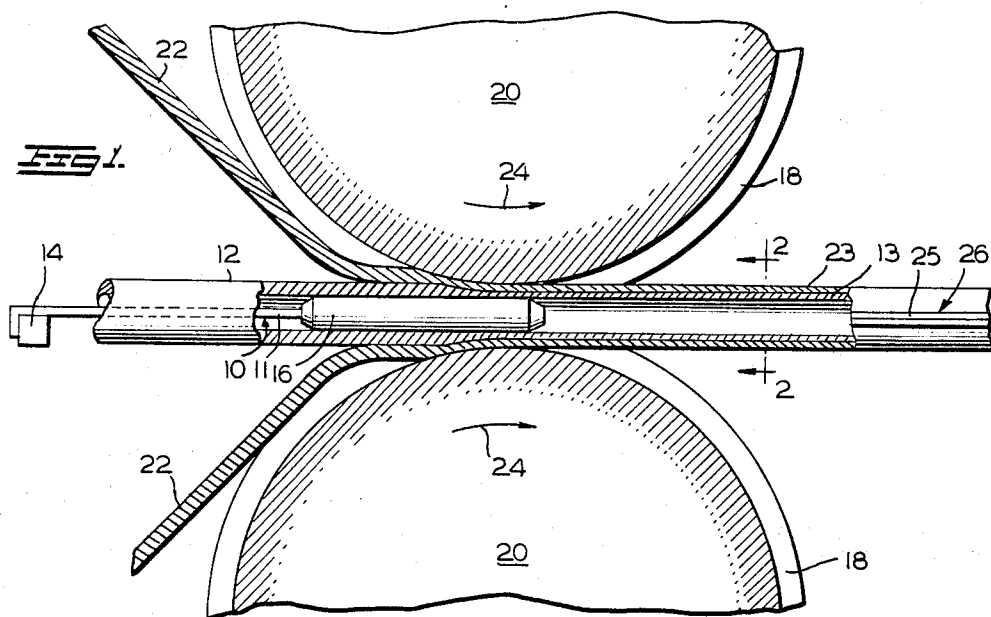
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3,384,946

METHOD OF MAKING INTEGRALLY FINNED METAL TUBING

Filed April 27, 1965

2 Sheets-Sheet 1



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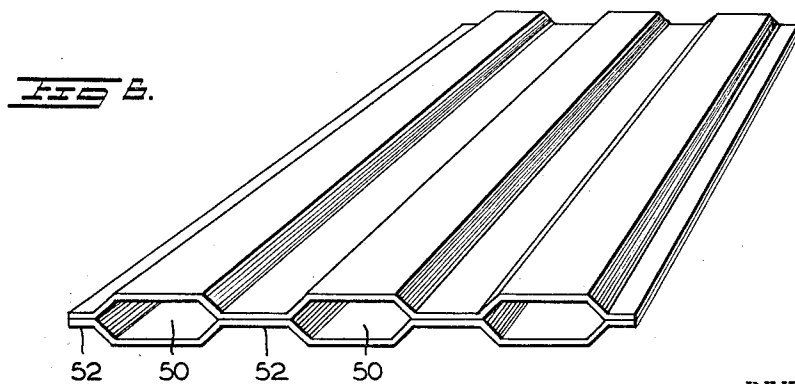
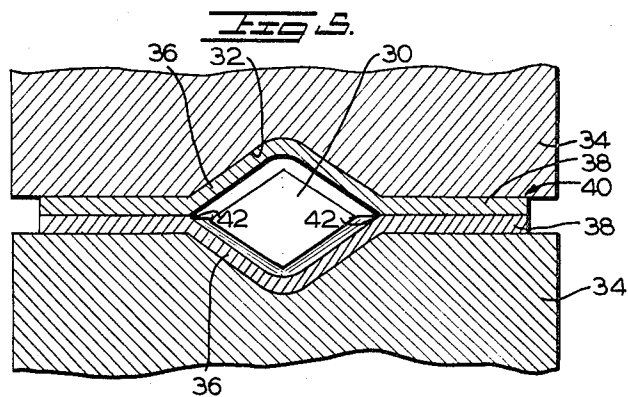
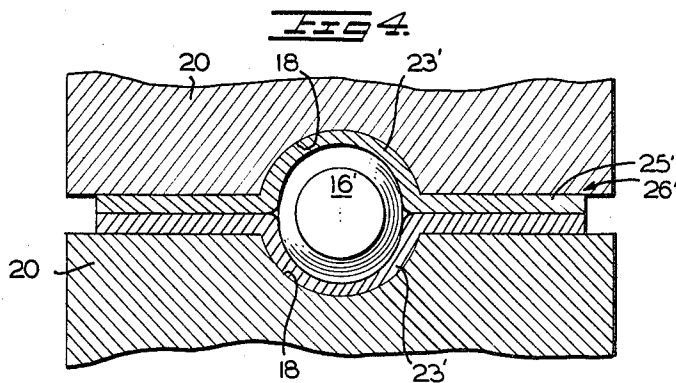
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2 Sheets-Sheet 2



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METHOD OF MAKING INTEGRALLY FINNED METAL TUBING

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ABSTRACT OF THE DISCLOSURE

Integrally finned metal tubing is made by a process of roll-welding metal sheets by passing them between rollers which act against a mandrel to deform, elongate and bond the sheets together in the configuration desired for said tubing.

This invention relates to integrally finned metal tubes and the like and to methods of making the same.

It is well known that many different types of heat exchangers utilize hollow tubes through which a cooling or heating medium is circulated, whereby the outer peripheral wall of the hollow member forms the primary heat exchange surface for heat transfer purposes. Examples of such heat exchangers are automobile radiators and convectors for space heating.

In order to increase the heat transfer between the primary and secondary heat exchange mediums, various manufacturers increase heat transfer area by providing fins in contact with the outer surface of the tubes. Such contact must be intimate if the fins are to serve their purpose efficiently. Various systems have been devised for mechanically connecting the fins to the tubes. Other systems connect the two by an intermediate material, as by tinning, welding, soldering, brazing, and the like. Still other systems utilize fins which are integral with the tubes, thereby efficiently providing continuous and uninterrupted heat flow paths.

The present invention concerns tubes of this latter type, and, moreover, methods for economically and conveniently producing the same. The tubes according to the invention have external radial fins integral with the body of the tube, and may be conveniently produced directly for flat metal strip or sheet in a single operation. For some applications, for example where a relatively corrosive heat exchange fluid will pass through the interior of the tube, it may be desirable to provide a tube lining of a different material. In accordance with the invention, such composite tubes may be conveniently produced directly from flat metal strip or sheet, and metal tubing, in a single operation.

The heat transfer characteristics of the tube according to the invention may be enhanced by deforming the integral fins in accordance with the assignee's copending application Ser. No. 332,818 by Loehlein and Curran.

For a better understanding of the invention, and of its other details, objects, and advantages, reference is now made to the accompanying drawings, which show, for purposes of illustration only, a preferred embodiment of the invention. In the drawings:

FIG. 1 is a semi-diagrammatic sectional elevation view of suitable apparatus carrying out and producing the invention;

FIG. 2 is a sectional view taken at II—II in FIG. 1;

FIG. 3 is a semi-diagrammatic sectional elevation view of suitable apparatus carrying out and producing an alternate form of the invention;

FIG. 4 is a sectional view taken at IV—IV in FIG. 3;

FIG. 5 is a sectional view of another alternate form of the invention; and

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FIG. 6 is a traverse view of still another alternate form of the invention.

Referring now more particularly to the drawing, when composite finned tube is to be produced, mandrel 10 having a tip 16 of circular cross-section is inserted through pre-heated copper or aluminum tube 12. The rearward end of mandrel 10 is anchored to stationary member 14 so that tip 16 extends into circular, circumferential grooves 18 in rolls 20. Aluminum sheets or strips 22 are wound off storage coils (not shown) thru a pre-heating station (not shown) and are inserted between the nips of rolls 20 at opposite sides of mandrel tip 16 and tube 12. Rolls 20 then rotate in direction 24, thereby: pulling tube 12 and strips 22 through the roll pass; deforming and elongating tube 12 into tube 13 of reduced thickness; deforming and elongating strips 22 into configurations of reduced thickness having grooved portions 23 and flat portions 25; bonding grooved portions 23 to tube 13; and bonding flat portions 25 together to form fins 26. The inner diameter of tube 12 is unchanged.

It can be seen that the circumference of the roll surface varies across groove 18, so that for each revolution of roll 20 the metal contacting the deepest portion of groove 18 tends to move forward (in the direction of rolling) at a lower speed than the metal in fins 26 and the metal in the shallower portions of groove 18. This effect tends to cause the bonded sheets 23 to tear apart instead of normally leaving the area of contact with rolls 20, or at least to slip with respect to the surfaces of grooves 18. In the embodiment described above, however, this has not been found a problem, probably because of the strong bond between grooved portions 23 and tube 13, as well as between flat portions 25.

The composite finned tube is not necessary for a large number of applications. In the alternate form of the invention shown in FIGURES 3 and 4, inner tube 12 has been omitted, so that strips 22 directly contact and deform around mandrel tip 16'. In the resultant product, grooved portions 23' define the internal passage and flat portions 25' are bonded together to form fins 26'. By omitting tube 12, this form of the invention is suitable for a continuous operation.

In contrast to mandrel tip 16 of circular cross-section, mandrel tip 16' is of oval or elliptical cross-section, being oriented with its major diameter perpendicular to the axes of rotation of rolls 20. Grooves 18 continue to have a cross-section defined by an arc of a circle. This design, by causing the thickness of grooved portion 23' to be a minimum at the plane perpendicular to fins 26' and a maximum adjacent fins 26', eliminates the tendency of the bonded sheets to tear apart or slip with respect to the surfaces of grooves 18. Instead, the variation in metal thickness equalizes the variation of the linearly translated speeds of the surfaces of groove 18, thereby promoting uniform metal flow in the direction of rolling throughout grooved portion 23'.

In another alternate form of the invention shown in FIGURE 5, mandrel tip 30 and grooves 32 in rolls 34 are of a partially rounded rhombic cross-section, so that in the resultant product, grooved portions 36 define the internal passage and flat portions 38 are bonded together to form fins 40. The thickness of the grooved portions 36 and flat portions 38 is uniform in the direction perpendicular to the axis of rotation of rolls 34. The walls of grooved portions 36 meet at an angle along lines 42 where the bond between flat portions 38 is exposed to the tube passage. Like the finned tube shown in FIGURES 3 and 4, this finned tube is suitable for a continuous operation. Where ultimate heat exchange and fluid flow considerations permit, there are certain advantages to the modified rhombic cross-section. First, the bonds along lines 42

are smooth and complete. Further, the same mandrel tip 30 and rolls 34 can be used for different roll settings and sheet thicknesses.

It will be clear that by providing a roll with a number of spaced circumferential grooves and using with each such groove a mandrel having a complementary shape, relatively wide sheets can be deformed, elongated, and bonded into a heat exchange panel having multiple passages and fins. Each such panel will constitute, in effect, a plurality of finned tubes sharing common integral fins. In this connection, FIGURE 6 shows an exemplary heat exchange panel having a plurality of partially flattened rhombic passages 50 and fins 52.

The invention is further illustrated in the following examples:

Example 1

Two directly-driven rolls were set .025 inch apart. Each roll had an 8 inch width, a 5 inch diameter, and a $\frac{3}{8}$ inch substantially semi-circular, circumferential groove at the center of its width. The $\frac{1}{4}$ inch diameter mandrel was coated with graphite grease. Two annealed 5457 aluminum alloy sheets having a thickness of .040 inch and a width of 6 inches were wire brushed on one surface. An annealed 6063 aluminum alloy tube having a $\frac{1}{4}$ inch I.D. and a $\frac{3}{8}$ inch O.D. was belt sanded to remove the layer of surface oxide. The tube was disposed between the wire-brushed surfaces of the two sheets and the sandwich preheated at 1000° F. for five minutes. The forward end of the mandrel was inserted through the tube of the preheated sandwich. The rear end of the mandrel was secured to the mill support so that the mandrel tip was placed at the center of the grooves and at the bite axis. The sandwich was then passed through the mill at an entrance speed of 120 feet per minute. The final product exhibited a good bond between the tube and the sheet and between the portions of sheet forming the fins. The fin thickness was .045 inch. The thicknesses of the inner tube and of the tubular portions of the sheet were reduced in approximately the same proportion.

Example 2

The process of Example 1 was carried out with the inner tube being made of copper rather than 6063 aluminum alloy. The substitution of materials did not significantly alter the process or the resultant product.

Example 3

The process of Example 1 was carried out with two 1100 aluminum alloy sheets of .060 inch thickness being substituted for each .040 inch thick aluminum sheet. The resultant composite product exhibited good bonds between the tube and sheet and between the sheet itself. The fin thickness was .063 inch.

It will be apparent that in practicing the invention various modifications can be made in the embodiments described above: The roll surfaces can be lubricated by

spraying the inner surfaces of the flat sheet. Instead of the two cylindrical rolls shown, three or more Turks-head rolls can be employed, thereby to form a corresponding number of fins. Initially the inside edges of the metal strips can be coated with a stop-weld material, so that following the deforming and bonding operation the tips of the fins can be deformed away from the plane of the bonded portions of the fins, thereby to provide increased heat transfer area. When a composite tube is desired, a plurality of metal sheets can be passed on each side of the mandrel in the operation shown in FIGURE 3. The shape of the grooves in the rolls and the shape of the mandrel can be changed to produce tubes of various cross-sectional shapes other than circular, oval, or modified rhombic.

While present preferred embodiments of the invention, and methods of producing the same, have been illustrated and described, it will be recognized that the invention may be otherwise variously embodied and practiced within the scope of the following claims.

What is claimed is:

1. A process of roll welding to form a composite finned tube, comprising preheating a plurality of malleable metal sheets, passing said sheets simultaneously into contact with a mandrel positioned therebetween and through rolls adjacent said mandrel, said rolls having a circumferential groove aligned with said mandrel and of a shape generally complementing said mandrel, so that first portions of the sheets contact said mandrel and deform into said grooves so as to enclose a generally tubular space, said deformation causing substantial elongation and reduction in thickness across the entire said first portions, and so that second portions are urged together by said rolls and are thereby reduced in thickness, elongated to substantially the same extent as said first portions, and roll-welded to form fins extending radially outward from said first portions.

2. The process of claim 1 wherein an inner surface of a said metal sheet is coated adjacent its edge with a stop-weld material, and following said deforming and said welding of said sheets the edges thereof are separated and deformed to increase the heat transfer area of said fins.

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