March 15, 1966 E. P. HABDAS 3,240,177

METHOD FOR MAKING FINNED TUBING

Filed June 11, 1962 2 Sheets-Sheet 1

FIG.4.

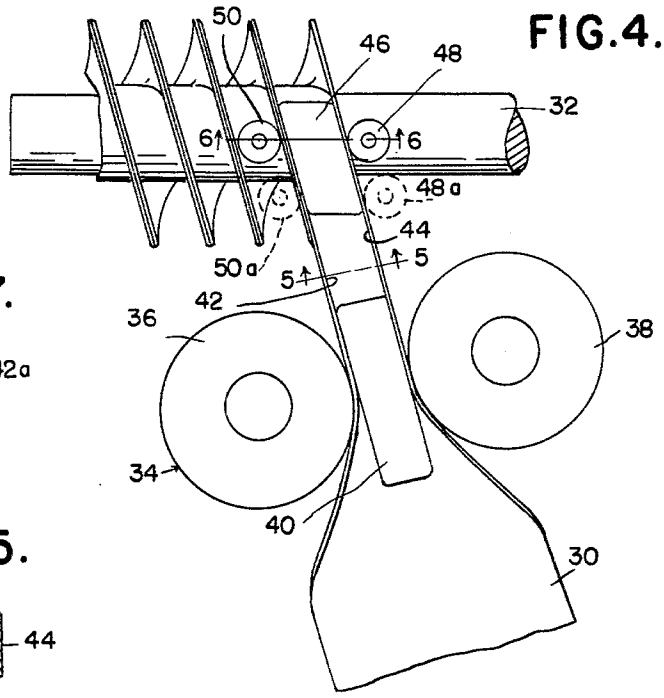


FIG.7.

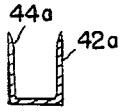


FIG.5.

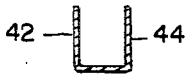


FIG.1.

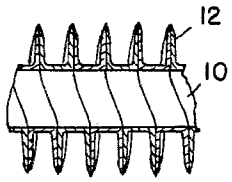


FIG.2.

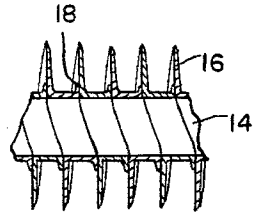
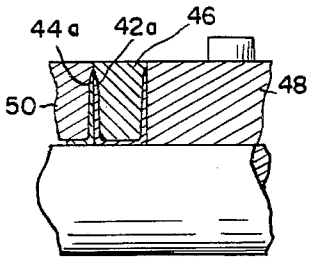


FIG.6.



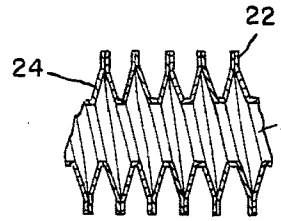


FIG.3.

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March 15, 1966 E. P. HABDAS 3,240,177

METHOD FOR MAKING FINNED TUBING

Filed June 11, 1962 2 Sheets-Sheet 2

FIG.8.

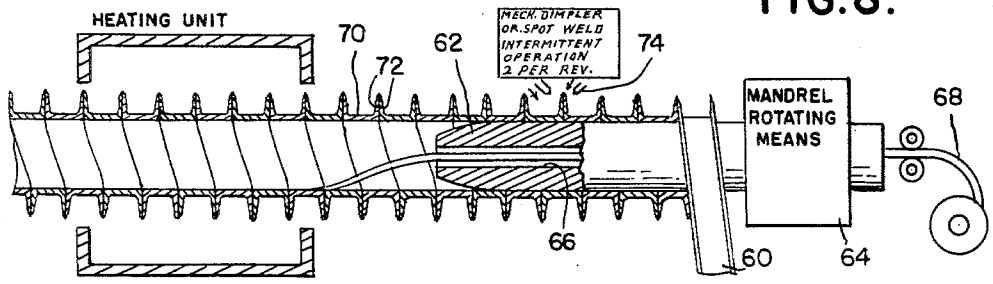


FIG.9.

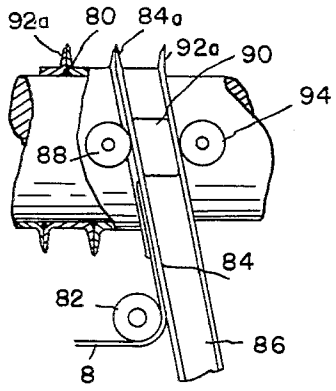


FIG.10.

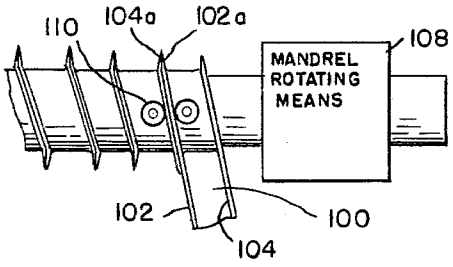
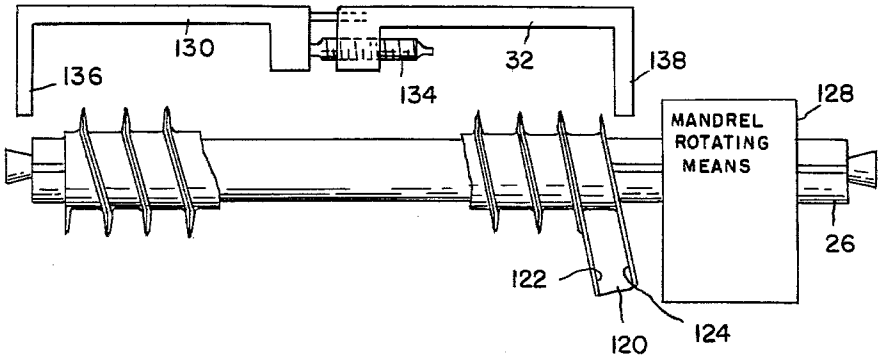


FIG.11.



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METHOD FOR MAKING FINNED TUBING

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Filed June 11, 1962, Ser. No. 201,511
7 Claims. (Cl. 113—118)

The present invention relates to fabricated finned tubing and method and apparatus for making the same.

It is an object of the present invention to provide a fabricated finned tubing characterized by the provision of fins of effective height formed from continuous strip stock which is first bent to U-shaped or channel cross-section, after which its edge flanges are thinned or tapered to provide a helical configuration to the channel strip in which the outer surfaces of the flanges of adjacent convolutions are in contact and are bonded together.

It is a further object of the present invention to provide finned tubing as described in the preceding paragraph in which the continuous U-shaped strip has a flange at one edge thereof of a width sufficient to produce a fin of effective height and a flange at the other side thereof of substantially less height in which the flange of lesser height is bonded throughout substantially its entire outer side surface to the base portion of the outer surface of the flange on the adjacent convolution of the strip.

It is a further object of the present invention to provide tubing of the character described in which the flanges at opposite edges of the continuous strip are of substantionally equal height sufficient to produce effective fins, and in which the flanges of adjacent convolutions are bonded together throughout substantially their entire outer surfaces.

It is a further object of the present invention to provide tubing of the character described in which the strip is provided at opposite edges with flanges of substantial height, and in which only the outer peripheral side portions of the flanges of adjacent convolutions are bonded together, leaving the inner portions of the flanges of adjacent convolutions in spaced relation to provide flexibility to the tubing.

It is a further object of the present invention to provide a method and apparatus for producing tubing in which continuous strip material has edge portions bent to form flanges, the flanges are thinner or tapered to produce a helical configuration of the strip in which the outer surfaces of the flanges of adjacent convolutions are in abutment, and bonding between the contacting surfaces of the flanges of adjacent convolutions is accomplished by resistance welding.

It is a further object of the present invention to provide a method and apparatus for producing tubing in which continuous strip material has edge portions bent to form flanges, the flanges are thinned or tapered to produce a helical configuration of the strip in which the outer surfaces of the flanges of adjacent convolutions are in abutment, and bonding between the contacting surfaces of the flanges of adjacent convolutions is accomplished by advancing the tightly coiled helical strip through a furnace or induction coil and supplying soldering or brazing material to the surfaces to be bonded.

It is a further object of the present invention to provide method and apparatus as described in the preceding paragraph in which the soldering or brazing material is supplied continuously through a mandrel on which the strip is wound and is melted in the furnace or induction coil and distributed to the surfaces to be bonded by continuous rotation of the tubing produced by helical winding of the strip.

It is a further object of the present invention to provide a method and apparatus as described in the second paragraph preceding in which the soldering or brazing material is supplied in strip or wire form interposed directly between the surfaces to be bonded during coiling of the strip into a tube.

It is a further object of the present invention to provide method and apparatus for making tubing as described in the three preceding paragraphs in which the adjacent fin-forming flanges are mechanically bonded at spaced intervals by mechanically dimpling or by spot welding prior to completion of the bonded joint.

It is a further object of the present invention to provide method and apparatus for producing short lengths of tubing which comprises forming flat strip into U-shaped configuration, tapering the edge flanges of the strip, winding the strip on an expanding mandrel, applying endwise clamping pressure to the ends of a helically wound section of strip, contracting the mandrel and removing it from the helically wound strip, introducing brazing or soldering rod to the interior of the helically wound strip, positioning the assembly in a brazing or induction furnace to provide a permanent bond between abutting outer surfaces of the flanges of adjacent convolutions.

Other objects and features of the invention will become apparent as the description proceeds, especially when taken in conjunction with the accompanying drawings, illustrating preferred embodiments of the invention, wherein:

FIGURE 1 is a fragmentary sectional view through a fabricated finned tube constructed in accordance with the present invention.

FIGURE 2 is a view similar to FIGURE 1 showing a modified form of fabricated finned tubing.

FIGURE 3 is a view similar to FIGURE 1, showing yet another modification of the fabricated finned tubing.

FIGURE 4 is a schematic view illustrating a method and apparatus for producing the fabricated finned tubing.

FIGURE 5 is a fragmentary section on the line 5—5, FIGURE 4.

FIGURE 6 is a fragmentary enlarged section on the line 6—6, FIGURE 4.

FIGURE 7 is a fragmentary enlarged sectional view similar to FIGURE 5, showing a modified edge thinned section.

FIGURE 8 is a schematic view illustrating the continuous forming and brazing or soldering operation.

FIGURE 9 is a fragmentary view similar to FIGURE 8, illustrating a different method of handling the soldering or brazing material.

FIGURE 10 is a fragmentary schematic view illustrating the use of welding electrodes.

FIGURE 11 is a schematic view illustrating method and apparatus for producing relatively short lengths of fabricated finned tubing.

In accordance with the present invention tubing of any reasonable size and wall thickness is produced in a continuous operation from flat strip material. The strip material may of course be furnished on a coil of indefinite length, and the method and apparatus as disclosed herein used to produce continuously elongated tubing having fins of any desired reasonable height in a continuous process.

Referring first to FIGURE 1 there is illustrated a fabricated finned tube **10** having relatively high fins **12** formed of double thickness of material bonded together as by welding, soldering, brazing or the like. In this operation the tubing is produced from flat strip which, as subsequently will be described in detail, has edge portions bent to extend laterally in the same direction from the plane of the strip so as to form flanges,

and these flanges are then tapered in such a way as to produce a helical configuration in the flanged strip of U-shaped cross-section in which the outer surfaces of the flanges of adjacent convolutions are brought into surface contact and are bonded together.

Referring to FIGURE 2 there is shown a tube **14** which differs from the tube **10** of FIGURE 1 primarily in that the fins **16** are throughout their major portion of single thickness, and the base portions of these fins **16** are bonded to relatively short flanges **18** provided at the opposite edge of the flanged strip material. Obviously, with this construction there is a substantial savings in material over that shown in FIGURE 1, while the bonding of the flange **18** to the base of the fins **16** provides adequate strength in the tubing.

Referring now to FIGURE 3 there is shown tubing **20** characterized by relatively high fins **22** formed of double-walled thickness but in which only the radially outer portions of the walls of the fins are bonded together, the inner portions as indicated at **24** being separated and preferably diverging so as to provide for flexibility of the fabricated tubing.

The tubing shown in FIGURES 1–3 may be formed of metal such for example as aluminum, copper, steel, or other suitable material. However, it is also contemplated that the tubing illustrated in these figures may be produced from suitable plastic compounds, in which case the bonding operation is preferably a heat and pressure bonding operation the values of which are controlled by the particular plastic compound employed.

Referring now to FIGURE 4 there is illustrated the method of forming and winding the strip material which may be employed to produce any of the tubes shown in FIGURES 1–3. In this operation flat strip material **30** may be advanced from a reel generally in a plane tangent to the rotating mandrel **32** but in a direction which makes an oblique angle therewith. The angle is selected such as to produce a tight helical winding of the channel resulting from subsequent operations on the strip so that outer flanges thereof are in surface to surface contact.

The flat strip advances to a channel forming roll assembly indicated generally at **34** where rolls **36** and **38** shape outer edge portions of the strip **30** against anvil **40**, thus producing a U-shaped section as shown in FIGURE 5. In this figure it will be observed that the flanges **42** and **44** are of uniform thickness and the construction results from an operation in which the edge portions of the strip are bent to the required shape without further change in configuration.

An edge thinning roll assembly is provided directly adjacent the rotating mandrel **32** and this assembly comprises a stationary anvil **46**, an outer thinning or tapering roll **48**, and an inner thinning or tapering roll **50**.

The tapering rolls **48** and **50** in conjunction with the anvil **46**, taper the flanges **42** and **44** to the tapered configuration best illustrated in FIGURE 6 in which the flanges are tapered outwardly. This outward tapering of the flanges produces a helical configuration of the channel strip conforming to the diameter of the rotating mandrel. Inasmuch as the tapering of each strip causes it to assume a curved shape it is desirable for the zone of action of rolls **48** and **50** to be close to the zone of tangency of the advancing web portion of the strip and the surface of the mandrel **32**. This relationship is illustrated in full lines in FIGURE 4 and results in an arrangement in which the roll **50** simultaneously thins and tapers the flange **42** of the advancing strip and presses it against the previously formed flange **44***a* of the next adjacent convolution. Thereafter, the abutting surfaces of the tapered flanges **42***a* and **44***a* may be bonded together by one of several different methods as will subsequently be described.

Instead of positioning the tapering roll **50** in position to engage the previously tapered flange **44***a* of a previously formed convolution and then advancing flange **32** of the channel shaped strip, the roll **50** may be positioned slightly in advance of the full line position illustrated in FIGURE 4, this alternative position being designated at **50***a*. In this case the flange **50** will press only the advancing flange **42** against the anvil **46** and after it has been thinned and tapered as required, it moves into engagement with the previously formed and tapered flange **44***a* of the next convolution. In the latter case the advancing channel shaped strip has the section illustrated in FIGURE 7 in which the thinned and tapered flanges **42***a* and **44***a* are both shaped in advance of engagement with the first completely formed helical convolution. It will be appreciated that if after thinning and tapering the flange is advanced in a straight line, the extra length at the outer or free edge of the flange may result in temporary buckling of the flange, but upon winding the U-shaped channel onto the rotating mandrel, this buckling is of course eliminated. If desired, suitable means may be provided for ironing the flanges into smooth helically extending configuration.

Referring now to FIGURE 8 there is illustrated a method and apparatus for completing the fabricated finned tubing. In accordance with this embodiment of the invention the advancing U-shaped strip here designated **60**, is wound on the rotating mandrel **62**, the mandrel being driven in rotation by means indicated diagrammatically at **64**. In this case the mandrel is hollow having an elongated opening **66** extending completely therethrough, and a supply of solder or brazing rod indicated at **68** is advanced through the mandrel into the interior of the helically wound strip here designated **70**.

In order to maintain the helically wound strip in properly wound condition means are provided for effecting a temporary connection between fins **72** at spaced intervals. This means, for example, may take the form of a dimpling device including tools **74** movable in the direction of the arrows to engage and to dimple the engaging fins of the helically wound tubing. It is found that sufficient rigidity is imparted to the construction until soldering or brazing is completed by mechanically dimpling the flanges together at about 180 degree intervals.

Instead of providing the temporary interconnection between the flanges by dimpling or staking, spot welding may be employed, in which case the tools or elements **74** may be considered as electrodes periodically advanced into engagement with opposed sides of the flanges **72** to effect spot welding.

With the helically wound tubing thus temporarily retained in proper helically wound relationship, it is continuously rotated and advanced, as occurs automatically by guiding advance of the channel strip **60** obliquely onto the rotating mandrel, into a heating zone where the material is brought to soldering or brazing temperature, and in which the soldering or brazing rod is melted and flows by capillary action between the abutting surfaces of adjacent convolutions of tubing. This capillary flow is of course substantially facilitated by the continuous rotation of the tubing.

The rate of operation is of course selected so that the bonding operation, either soldering or brazing, is completed during the continuous advance of the fabricated tubing through the heating station. The heating station may be a furnace of any suitable type or an induction coil.

It will of course be apparent that the tubing may be fabricated in any length and if desired, the continuous strip material from which the tube is formed may have additional lengths of material soldered, brazed, welded, or otherwise bonded to the preceding strips so that the length of the finished tubing may be exactly as desired.

Referring now to FIGURE 9 there is illustrated a variation of the method illustrated in FIGURE 8 in which continuous solder or brazing rod, strip or wire is mechanically fed into the space between confronting surfaces

of the flanges of adjacent convolutions of the U-shaped strip as it is wound upon the mandrel. In this case the solder or brazing rod is indicated at **80** and is guided around a roll **82** so as to be advanced with the flange **84** of the U-shaped strip **86** into the space between the roll **88** and the anvil **90** where the flange **84** is tapered to the configuration illustrated at **84***a*, and is also pressed into firm solid engagement with the adjacent surface of the previously tapered flange **92***a* formed from the advancing flange **92** by the roll **94** and the anvil **90**.

Otherwise, the method and apparatus is the same as illustrated in FIGURE 8, and the assembled convolutions of the U-shaped channel may be temporarily attached at spaced points as above described and advanced into the heating zone where the solder or brazing rod **80** melts and flows by capillary action to all points throughout the overlapped areas of the tapered flanges **84***a* and **92***a*.

Referring now to FIGURE 10 there is illustrated a somewhat different apparatus in which a U-shaped strip **100** having flanges **102** and **104** is advanced to a mandrel **106** by means indicated diagrammatically at **108**. In this figure an illustration of the thinning or tapering rolls is omitted but they may be of the type illustrated in FIGURE 8 or 9. In this case the bonding between the tapered flanges **102***a* and **104***a* formed from the flanges **102** and **104** respectively, is accomplished by passing the flanges while in surface-to-surface abutment between welding electrodes **110** so that welding current flows through the intervening flange portions between the electrodes. This operation, like those previously described, may be fully continuous so that tubing of any desired length may be produced.

Referring now to FIGURE 11 there is illustrated a simplified apparatus useful in forming relatively short lengths by a brazing operation. In this case the U-shaped tubing is illustrated at **120** having flanges **122** and **124**. This U-shaped tubing is advanced to the rotating mandrel **126**, which in this instance is of the expanding type and is being rotated by rotating means indicated diagrammatically at **128**. Again, in this figure the thinning rolls which thin the flanges **122** and **124** to the appropriate tapered configuration have been omitted for clarity but may be of the type previously described in conjunction with FIGURES 8 and 9.

In this case the U-shaped material **124** is wound tightly upon the mandrel **126** while the mandrel is in expanded condition. When the required length of material has been wound onto the mandrel to produce tubing of the required length, the advancing strip material is cut off and the helically wound tubing on the mandrel is rigidly clamped between clamp means diagrammatically illustrated as comprising relatively movable clamp members **130** and **132**, a screw **134** being provided effective to draw the clamping members **130** and **132** towards each other so that jaws **136** and **138** engage opposite ends of the assembled tubing. At this time the mandrel may be contracted and withdrawn from the wound tubing and suitable brazing or soldering material placed in the hollow interior. After this the assembly of tubing held in assembled relation by the clamp members **130**, **132** is simply placed in a furnace or other heating zone for completion of the soldering or brazing operation. If desired of course, and if necessary, the assembly may be turned about its axis so as to facilitate flow of the soldering or brazing material.

The drawings and the foregoing specification constitute a description of the improved fabricated finned tubing and method and apparatus for making the same in such full, clear, concise and exact terms as to enable any person skilled in the art to practice the invention, the scope of which is indicated by the appended claims.

What I claim as my invention is:

1. The method which comprises helically coiling a flanged strip having edge flanges defining a generally U-shaped cross-section on a rotating mandrel having a longitudinal opening therethrough into a closed helix with outer flange surfaces of adjacent convolutions in contact, rotating and sliding the helical coil continuously longitudinally of the mandrel and off one end thereof, advancing flowable bonding material through the opening in the mandrel into the open interior of the helical coil, and advancing the helical coil while rotating through a heating zone to melt the bonding material and causing it to flow by capillary action across the contacting flange surfaces.

2. The method of claim **1**, which comprises advancing the bonding material in the form of a continuous elongated element.

3. The method of claim **1** which comprises temporarily securing adjacent flange portions together at spaced points while the portion of the strip bearing said flange portions remains on the mandrel.

4. The method of claim **1** which comprises the step of pressing the flanges of coiled helical strip together after advancing the bonding material therebetween.

5. The method of making finned tubing which comprises winding a predetermined length of a continuous strip having edge flanges onto an expanded mandrel in a helical coil having outer flange surfaces of adjacent convolutions in surface contact, applying endwise clamping pressure to opposite ends of said coil, contracting and removing said mandrel, applying bonding material to the interior of said coil, and heating said coil and bonding material to melt the bonding material and to cause it to flow by capillary action across the contacting flange surfaces.

6. The method of making finned tubing which comprises bending opposite edges of a flat strip to form flanges extending in the same direction from the intermediate portion of the strip and generally perpendicular thereto to form the strip into U-shaped cross-section, one of said flanges being of a width sufficient to form an effective heat transfer fin, the other flange being of substantially less width, rolling both of said flanges progressively longitudinally thereof to tapered cross-section such that the free edges of said flanges are of reduced thickness, coiling the strip into a closed helix such that the portions of the strip intermediate said flanges constitutes a closed tubular construction and the outer surface of said flange of lesser width contacts the portions of the outer surface of said wider flange only adjacent the junction between said wider flange and the portion of said strip intermediate said flanges, and bonding the contacting outer surface portions of said flanges together.

7. The method of making finned tubing which comprises bending opposite edges of a flat strip to form flanges extending in the same direction from the intermediate portion of the strip and diverging slightly outwardly therefrom, said flanges both being of a width sufficient to act as an effective heat transfer fin, rolling both of said flanges progressively longitudinally thereof to tapered cross-section such that the free edges of said flanges are of reduced thickness, coiling the strip into a closed helix such that the outer surface portions of said flanges adjacent the free edges of said flanges are in contact and the outer surface portions of said flanges from the edges thereof connected to the intermediate portion of said strip to the contacting free edge portions thereof are in converging relation, and bonding the contacting free edge portions of the outer surfaces of said flanges together.

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