United States Patent

Lewis

[15] **3,683,656**

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[54] HEAT EXCHANGER APPARATUS AND METHOD OF MAKING THE SAME

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[52] **U.S. Cl.** .....**72/98,** 72/100, 29/157.3 AH

[51] **Int. Cl.** **B21d 53/06**

[58] **Field of Search** ....29/157.3, 157.3 A, 157.3 AH; 72/100, 98

[56] **References Cited**

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[57] **ABSTRACT**

A shell-and-tube heat exchanger is shown having a bundle of tubes each of which is provided with external helical fins except in land portions adjacent tube sheets and supports. The tubes are constructed by first rolling grooves into the tube and reducing the tube diameter, then roll extruding fins up from the surface of decreased diameter to a diameter larger than the land portions of the tube and larger than the tube apertures in the tube sheets and supports of the heat exchanger, and finally rolling portions of the fins partially over toward an adjacent fin in a common axial direction to reduce the outer diameter of the fins so that the tube can be passed through the tube apertures of the tube sheets and supports. The rolling over of the fins is accomplished by applying lateral pressure on the fins through the use of a trailing roll-over die. Means is provided for radially withdrawing the groove forming and fin extruding dies from the surface of the tube without an equal withdrawal of the trailing roll-over die whereby all fins exceeding the desired diameter may be bent over to establish the desired fin diameter.

4 Claims, 3 Drawing Figures

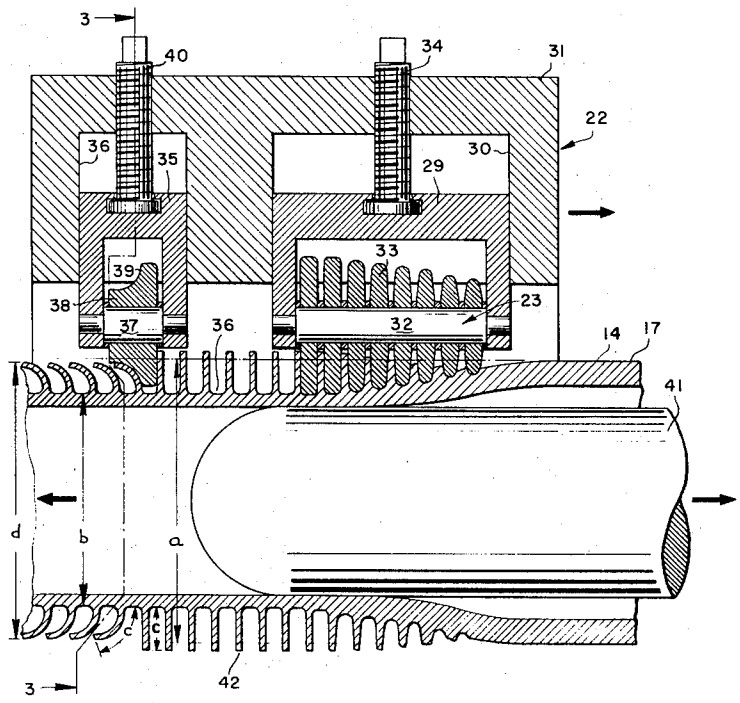
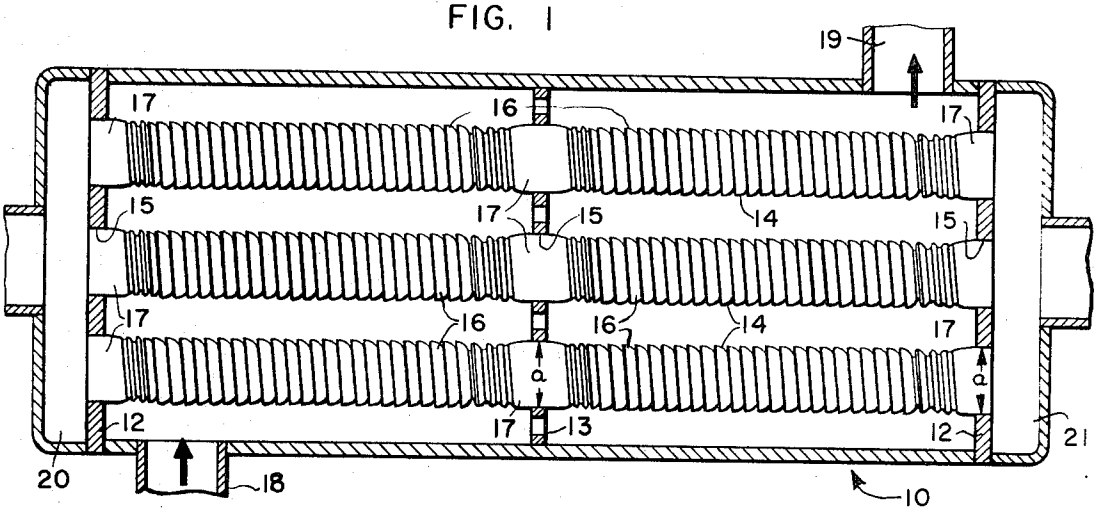


FIG. 1



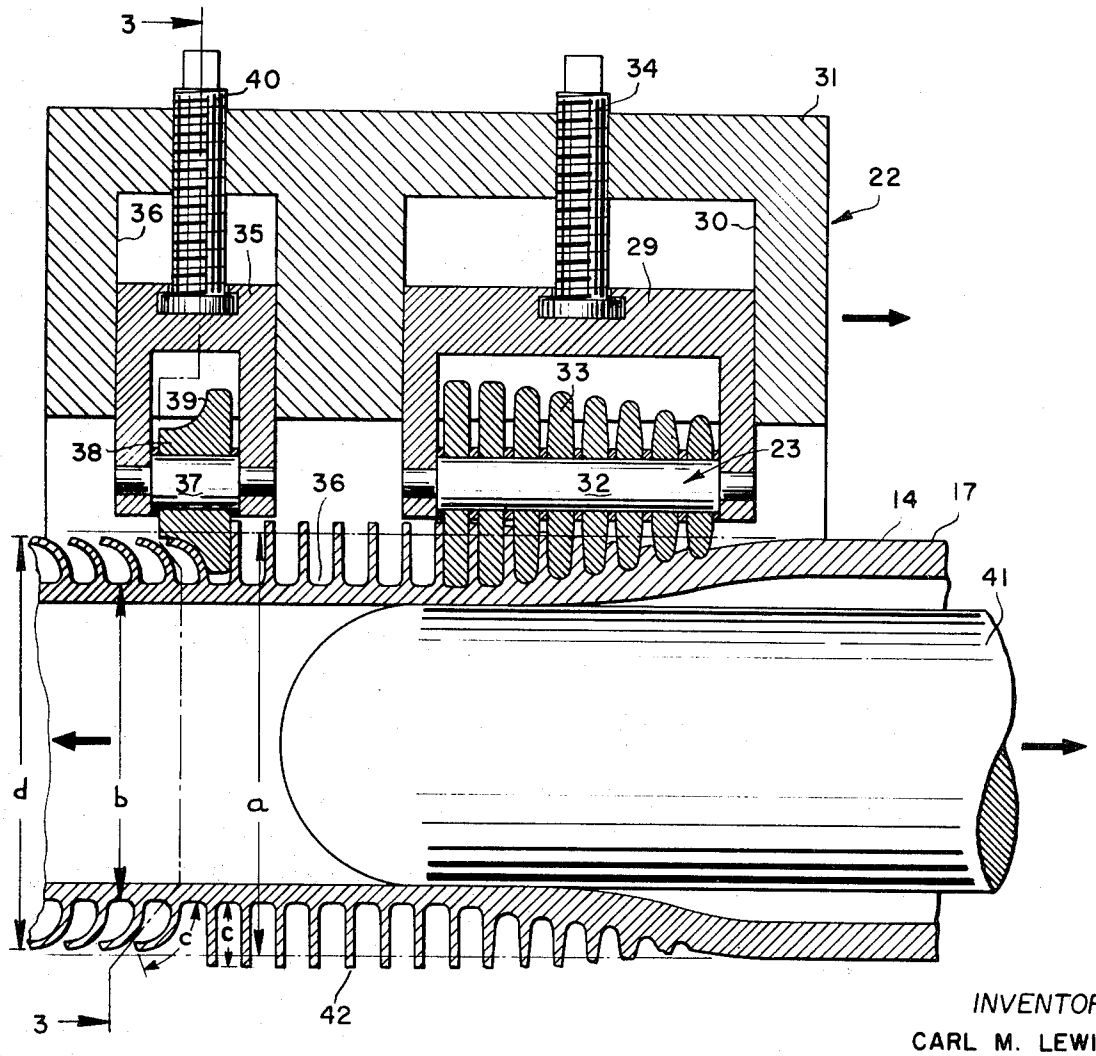


FIG. 2

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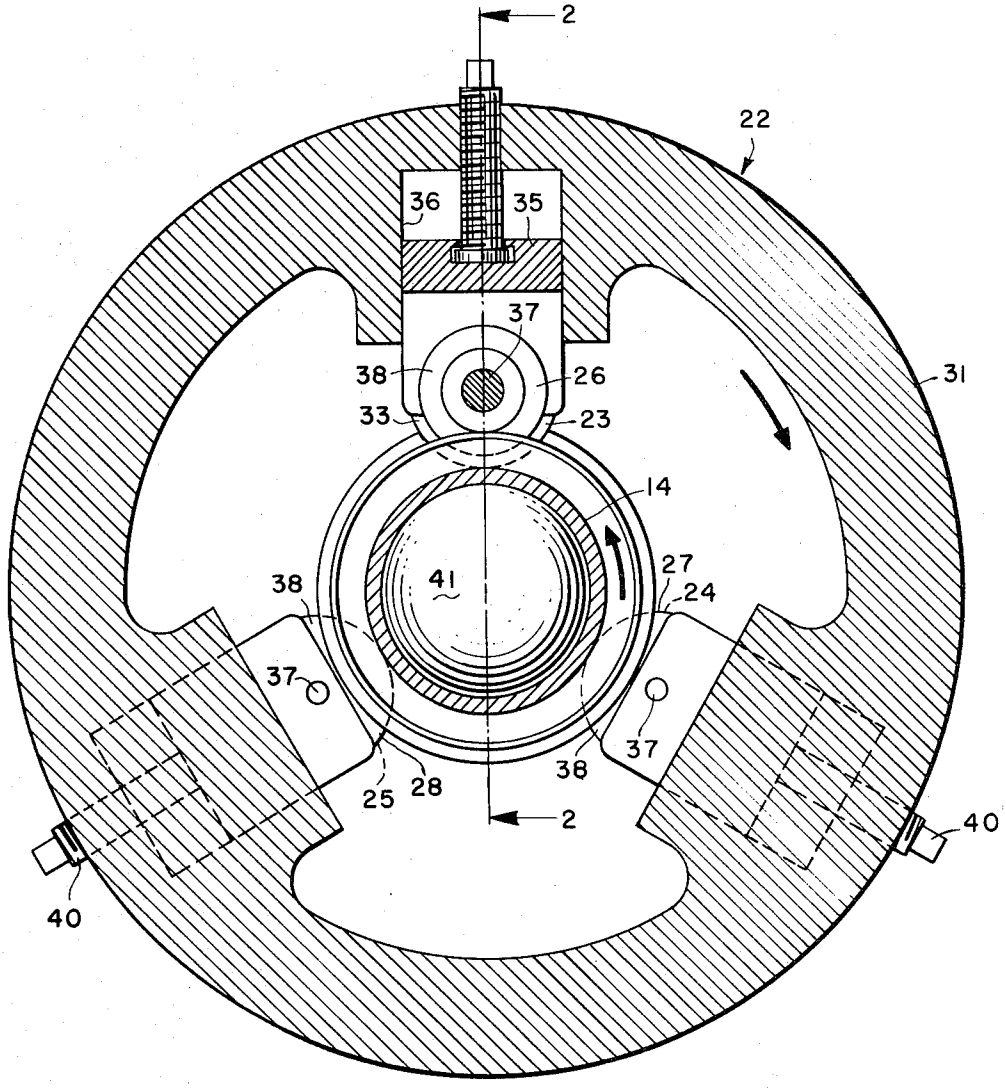


FIG. 3

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HEAT EXCHANGER APPARATUS AND METHOD OF MAKING THE SAME

This invention relates to heat exchanger apparatus and the method of making the same. More particularly this invention relates to shell-and-tube type heat exchangers and specifically the tubes thereof and the method of making them.

It is now common practice to provide integral helical fins on heat exchanger tubes which are installed in shell-and-tube type heat exchangers. The tube sheets and tube supports in such heat exchangers have apertures through which the heat exchanger tubes are inserted during installation. In certain types of heat exchangers, such as refrigerant evaporators, it is common practice to provide the tubes with an integral external helical fin in those areas intermediate the tube sheets and tube supports. A land or unfinned portion is generally left in the area of contact with the tube sheets and tube supports. Because the tubes are normally finned prior to installation within such a heat exchanger, it is common practice to form fins which have a diameter substantially no greater than the diameter of the land portions or diameter of the tube apertures within the tube sheets and supports. This is accomplished by forming the fins substantially entirely into the tube rather than by extruding the fins out from the original surface of the tube. However, it must be recognized that in forming the fins substantially entirely into the tube, the tube internal diameter is materially reduced thereby increasing its resistance to fluid flow therethrough.

It has been recognized, such as in U.S. Pat. No. 3,383,892, that in forming helical fins in this manner on the external surface of heat exchanger tubes, a transition condition may exist wherein the fins may extend radially beyond the land portions of the tube in those areas where the finning dies are first engaged with the tube surface. By providing a fin sizing die on the fin forming roller assembly it is possible to shorten the fins in this transition area thereby permitting the tube to be inserted through the apertures within the tube sheets and tube supports of a shell-and-tube type heat exchanger. The device as disclosed in this patent has the disadvantage of shortening the heat exchanger fins. Furthermore, it is only useful in those transition areas where the finning dies are first engaged with the heat exchanger tube. Thus note that as the finning dies are disengaged from the tube, the sizing die is simultaneously disengaged from the tube thereby yielding an area which is not sized. Therefore, the finning dies must be of such configuration as to form fins of a diameter no greater than the land portions except in those transition areas where the finning dies are first engaged with the heat exchanger tube surface.

The instant invention contemplates a different method of reducing the diameter of the finned portions. In the instant invention the fins are reduced in diameter without materially shortening their protruding extent. Furthermore, the reduction in fin diameter may be accomplished entirely along the finned portions of the tube rather than just in the transition areas heretofore described. Thus it is possible to reduce the diameter of integral helical fins which generally throughout their longitudinal extend along a heat exchanger tube protrude beyond the profile of the land portions of said tube. This is accomplished in the instant invention by rolling grooves into the tube and reducing the tube diameter, then roll extruding the fins up from the surface of decreased diameter to a diameter larger than that of the land portions of the tube and larger than that of the tube apertures in the tube sheets and supports, and finally bending over the outer portions of the fins toward an adjacent fin in a common axial direction to reduce the outer diameter of the fins so that the tube can be passed through the tube apertures of the tube sheets and tube supports..

It is thus an object of this invention to provide a method of reducing the diameter of an external integral helical fin on a heat exchanger tube to or less than the diameter of the unfinned portions of the heat exchanger tube or to or less than the diameter of the apertures in tube sheets or tube supports through which the tube must be inserted.

It is a further object of this invention to provide a method of increasing the internal diameter of a tube without increasing the diameter of the external helical fins thereon beyond the diameter of the land portions thereof or the diameter of the apertures within the tube sheets or tube supports through which the tube must be inserted.

It is a further object of this invention to provide a heat exchanger tube of increased internal diameter.

And it is still a further object of this invention to provide a heat exchanger tube with increased fin surface for a given fin density and height and a given land diameter.

Other objects and advantages will become apparent as this specification proceeds to describe the invention with reference to the drawings in which:

FIG. 1 is a vertical section through a shell and tube type heat exchanger having tubes therein constructed in accordance with the teachings of this invention, and

FIG. 2 is a section taken at line 2—2 of FIG. 3 which illustrates the apparatus and method for forming heat exchanger tubes in accordance with the teachings of this invention, and

FIG. 3 is a section taken at line 3—3 of FIG. 2.

Now referring to FIG. 1 of the drawings it will be seen that shell and tube type heat exchanger **10** has a cylindrical shell with tube sheets **12** at each end thereof. An appropriate tube support **13** may be located intermediate tube sheets **12** for supporting heat exchanger tubes **14** therebetween. Tube sheets **12** and tube support **13** are provided with apertures **15** in which the tubes **14** are received.

Each tube **14** has a plurality of integrally helically finned portions **16** axially nonextensive with the land portions **17**. The land portions **17** are positioned to be axially coextensive with the tube sheets and tube supports for the purpose of establishing a good support at tube sheet **13** and a good seal at tube sheets **12**. If desired the tubes **14** may be roll expanded slightly within the tube sheets to provide the desired seal.

The shell-and-tube heat exchanger **10** is provided with inlet **18** such as for the ingress of a liquid refrigerant and an outlet **19** such as for the egress of a gaseous refrigerant. The heat exchanger also has inlet and outlet headers **20** and **21** communicating with the interior of tubes **14** for passing a second heat exchange fluid such as water therethrough in heat exchange relationship with the heat exchange fluid passing external to heat exchanger tubes **14**.

The specific details of the heat exchanger tubes **14** and their method of construction will be more clearly understood by reference to FIGS. **2** and **3**.

The fins may be formed on heat exchanger tubes **14** by a fin forming head **22** shown in FIGS. **2** and **3**. Head **22** is comprised of an annular member **31** having provision for supporting a set of three circumferentially spaced leading roll assemblies **23**, **24** and **25** and a set of three circumferentially spaced trailing roller assemblies **26**, **27** and **28**. The roller assemblies **23**, **24** and **25** are generally similar in construction. Roller assembly **23** has a U-shaped frame **29** which is mounted for radial adjustment with respect to tube **14** in a groove **30** of annular member **31**. An arbor **32** extends between and is journaled at the ends of the legs of U-shape frame **29**. Arbor **32** carries a set of roller dies **33** for grooving tube **14** and roll extruding fins **42** up from the surface of tube **14**. Arbor **32** is disposed at a slight skew so that the dies **33** thread themselves and advance along tube **14**. A screw adjustment **34** is provided for moving frame **29** and thus dies **33** radially inwardly and outwardly with respect to tube **14**.

Each trailing roller assembly also has a U-shaped frame **35** supported in a groove **36** in annular member **31**. An arbor **37** is journaled at the ends of the legs of U-shaped member **35** and supports a training roller **38**. The roller **38** of trailing roller assembly **26** is somewhat smaller in diameter and is provided with a curved surface **39** adapted to contact and apply pressure to the lateral side of the fins **42** thereby bending them over in a common direction toward one end of the tube **14**. A screw adjustment **40** is provided to adjust the position of U-shaped members **35** and thus each roller **38** radially inwardly and outwardly with respect to tube **14** in grooves **36**. It should be appreciated that in the case of a single lead fin, only one of rollers **38** need have a curve surface **39** although more than one of rollers **38** could have a curved surface **39**. In the case of a multiple lead fin, it may be necessary that the complete bend-over operation for a single fin be performed by a single roller. The screw adjustments **34** and **40** are independent whereby U-shaped frame **29** and thus roller dies **33** may be withdrawn from the surface of tube **14** without affecting the operation of rollers **38**. This enables all the fins **42** of tube **14** to be bent over despite their location on the tube **14**.

In order to operate the fin forming head a mandrel **41** may be disposed within tube **14** or may be disposed in axially fixed relationship with fin forming head **22**. In any event, a tubular blank **14** is inserted into annular member **31** a distance beyond roller dies **33** sufficient to provide for the land portions of the tube adjacent one end of the tube. The tube then is advanced axially with respect to the fin forming head in the direction shown by the vectors in FIG. **2** and rotated with respect to the fin forming head **22** in the direction shown by the vectors in FIG. **3**. Simultaneously the roller dies **33** are brought into engagement with the surface of tube **14** by adjustment of screws **34** whereby an erect fin **42** is formed which extends substantially beyond the diameter or profile *a* of the unfinned or land portions of tube **14**. When the fins have advanced to rollers **38**, rollers **38** are adjusted radially inwardly to engagement with the sides of fins **42** by adjustment screws **40**. The roller **38** of roller assembly **26** which is provided with the curved surface **39** applies lateral pressure on the erect fin **42** thereby causing it to be bent over and reduced to a diameter *d* which is equal to or less than diameter *a*. As the roller dies **33** approach an intended land portion **17**, roller dies **33** are adjusted radially outwardly with respect to tube **14** by means of screw adjustments **34** until roller dies **33** no longer engage the surface of tube **14**. However, rollers **38** continue to bend over the remaining fins until rollers **38** approach the land area at which point rollers **38** are adjusted radially outwardly by means of screw adjustments **40** so that rollers **38** also clear the surface **17** of tube **14**. The same procedure may be used in forming the second finned portion of tube **14**.

There will be seen in FIG. **2** that in the process just described, roller dies **33** form slight grooves in the surface of tube **14** and reduce its diameter sufficiently so that the internal surface of tube **14** contacts mandrel **41**. Further advancement of tube **14** through dies **33** causes the material between the grooves to be extruded outwardly substantially beyond the original diameter of the tube whereby a relatively erect and high fin is produced. This fin, upon coming in contact with surface **39** of a roller **38** is bent over by application of lateral pressure at the side of the fins thereby reducing the diameter of the fins to less than about the original outer tube diameter *a*. Thus it will be seen that the original tube diameter, the land diameter or tube sheet or support aperture diameter *a* is substantially greater than the sum of the fin root diameter *b* and twice the fin height or protrusion curvilinear length *c* and equal to or greater than the bent fin outer diameter. On an exemplary evaporator tube of approximately 0.750 inch diameter and having about 0.035 inch high fins with a fin density of about 35 fins per inch it is possible by the use of the invention disclosed herein to either increase the fin height by about 25 percent or increase the tube internal cross-sectional area by about 6 percent without increases in the original tube diameter, the land diameter or tube sheet or support aperture diameter. Variations will, of course, exist for tubes of different diameter, fin height, fin density etc.

Having now described the preferred method and apparatus for practicing my invention, I contemplate that many changes may be made without departing from the scope or spirit of my invention and I accordingly desire to be limited only by the claims.

I claim:

1. A method of making a heat exchanger tube adapted to be supported in a tube support aperture of predetermined diameter comprising the steps of: providing a tubular blank having a generally circular cross-section of a predetermined outer diameter which is no greater than said aperture predetermined diameter; forming an extended heat transfer surface by extruding a fully developed helical fin up from the outer surface of said tubular blank to a diameter greater than said predetermined outer diameter and greater than said aperture predetermined diameter; reducing the diameter of said fully developed helical fin to a diameter less than the outer diameter of said fully developed helical fin existing immediately following the extruding step and to a diameter less than said aperture predetermined diameter by applying lateral force to one side of the helix of said helical fin axially of said tubular blank to cause said helical fin to bend over and thereby be reduced in diameter.

2. A method of making a heat exchanger tube adapted to be supported in a tube support aperture of predetermined diameter comprising the steps of: providing a tubular blank of generally circular cross-section of predetermined outer diameter which is no greater than said aperture predetermined diameter; forming an extended heat transfer surface by extruding a fully developed helical fin up from the outer surface of only a portion of said tubular blank to a diameter greater than said predetermined outer diameter and greater than said aperture predetermined diameter and leaving at least one unfinned land portion; reducing the diameter of the fully developed finned portion to a diameter less than the outer diameter of said fully developed helical fin existing immediately following the extruding step, to less than said aperture predetermined diameter, and to about the diameter of said land portion by bending said helical fin over; and from the step of extruding the helical fin to the step of bending the fin over, maintaining the inner diameter of the span of tubular blank with the extruded bent over fin at substantially the inner diameter of said span existing immediately following the extruding step.

3. A method of making a heat exchanger tube adapted to be supported in a tube support aperture of predetermined diameter comprising the steps of: providing a tubular blank of generally circular cross-section of predetermined outer diameter which is no greater than said aperture predetermined diameter; forming an extended heat transfer surface by extruding a fully developed helical fin up from the outer surface of only a portion of said tubular blank to a diameter greater than said predetermined outer diameter and greater than said aperture predetermined diameter and leaving at least one unfinned land portion; reducing the diameter of the finned portion to a diameter less than the outer diameter of said fully developed helical fin existing immediately following the extruding step, to less than said aperture predetermined diameter, and to about the diameter of said land portion by applying sufficient lateral force to one side of the helix of said helical fin axially of said tubular blank to cause said helical fin to bend over and thereby be reduced in diameter to about the diameter of said land portion; and from the step of extruding the helical fin to the step of bending the fin over, maintaining the inner diameter of the span of tubular blank with the extruded bent over fin at substantially the inner diameter of said span existing immediately following the extruding step.

4. A method of providing a tubular blank of a predetermined outer diameter with an extended heat transfer surface in the form of integral helical fins and adapted to be supported in a tube support aperture of predetermined diameter including the steps of: applying radially inward pressure on the outer surfaceof said tubular blank along a helicoidal path to thereby displace the material of said tubular blank causing a general reducing in outer diameter of the tubular blank and a helicoidal groove to be formed in the surface thereof; applying sufficient laterial pressure to the sides of said groove to displace the material between convolutions of said groove radially outward substantially beyond said predetermined diameter thereby forming a fully developed helicoidal fin having a diameter larger than said predetermined outer diameter and greater than said aperture predetermined diameter; and applying sufficient lateral pressure to one side of said groove to cause said helicoidal fin to be bent over sufficiently to reduce the diameter of said fin to a diameter less than the outer diameter of said fully developed helical fin existing immediately following the step of fully developing the helical fin, to less than said aperture predetermined diameter, to about said predetermined outer diameter; and from the step of fully developing the helical fin to the step of bending the fin over, maintaining the inner diameter of the span of tubular blank with the fully developed and bent over fin at substantially the inner diameter of said span existing immediately following the step of fully developing the helical fin.

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