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3,568,288

APPARATUS AND METHOD FOR MAKING FINNED TUBING

Filed July 12, 1968

3 Sheets-Sheet 1

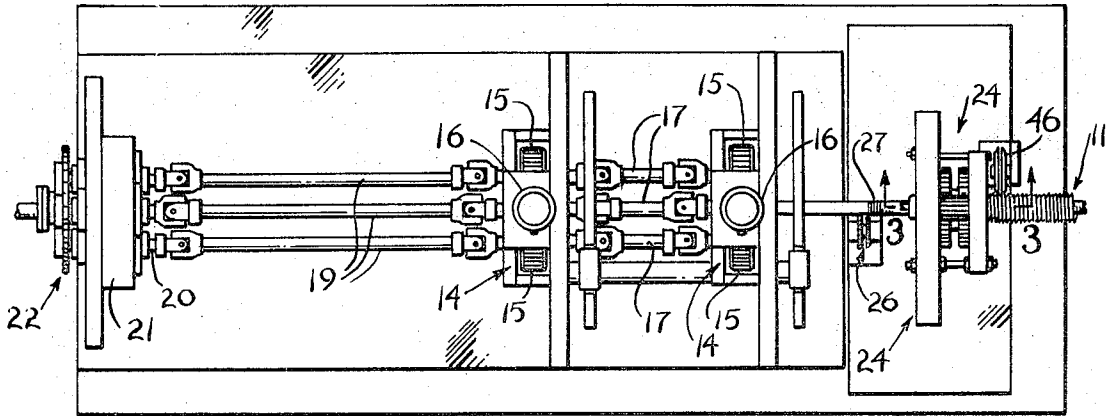


Fig. 1

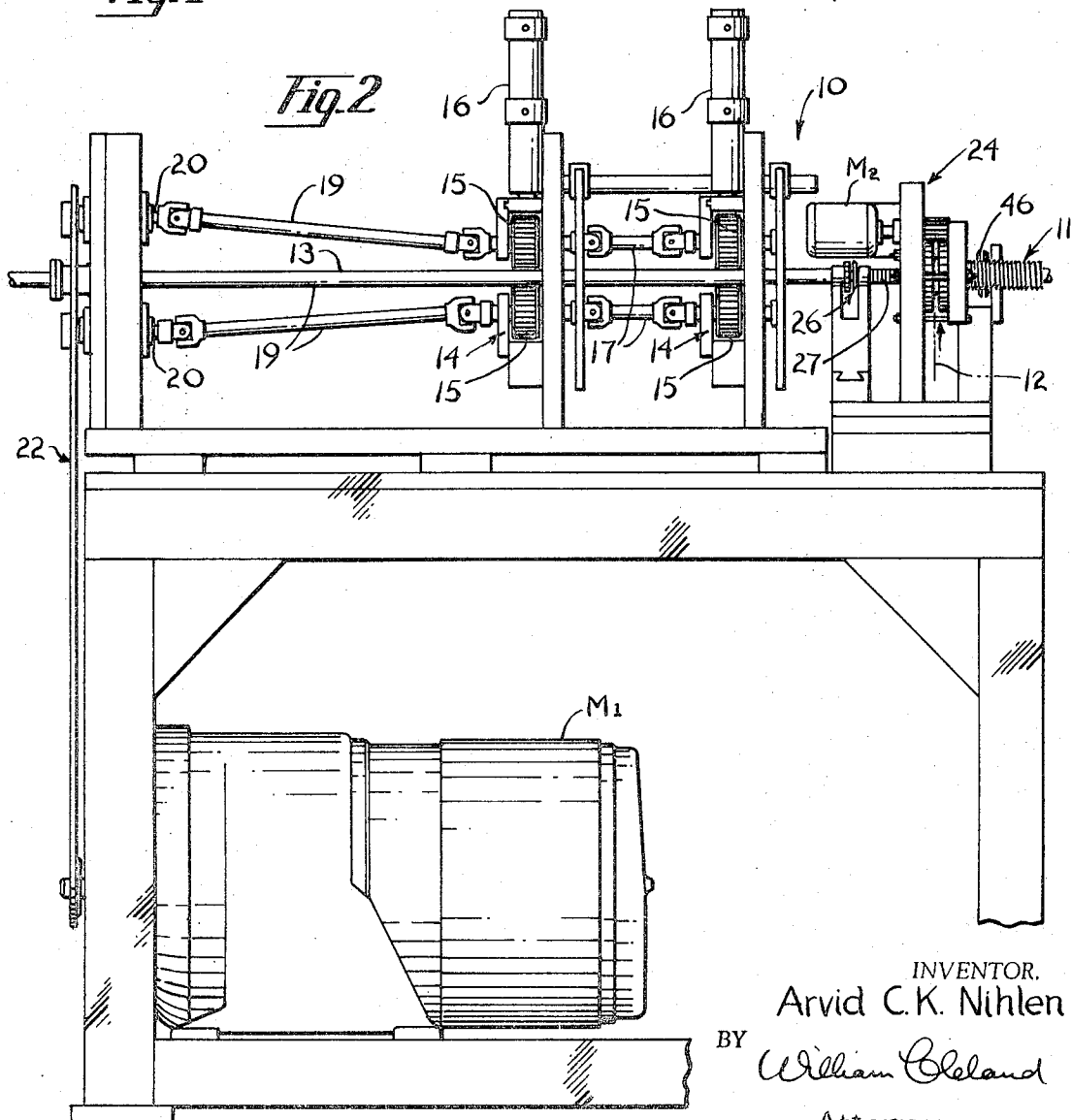


Fig. 2

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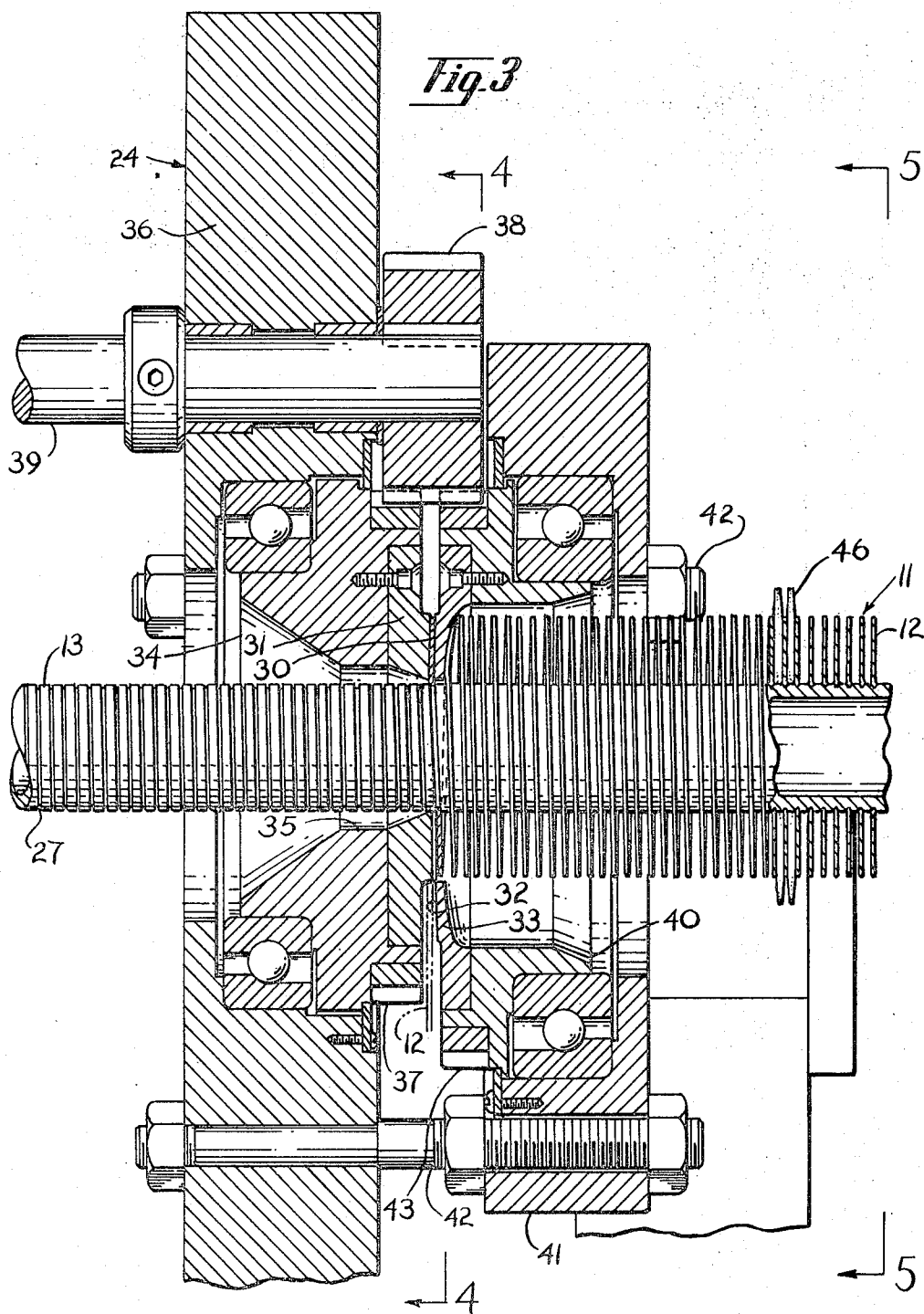
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Fig. 4

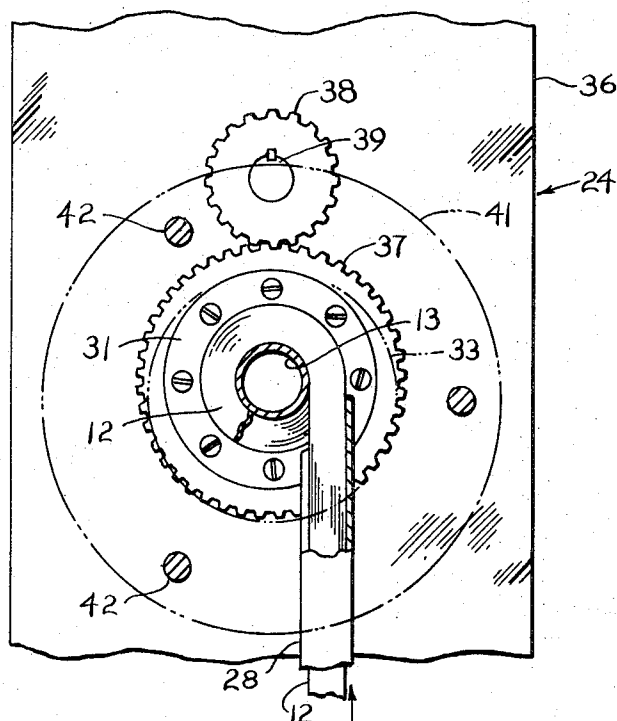


Fig. 5

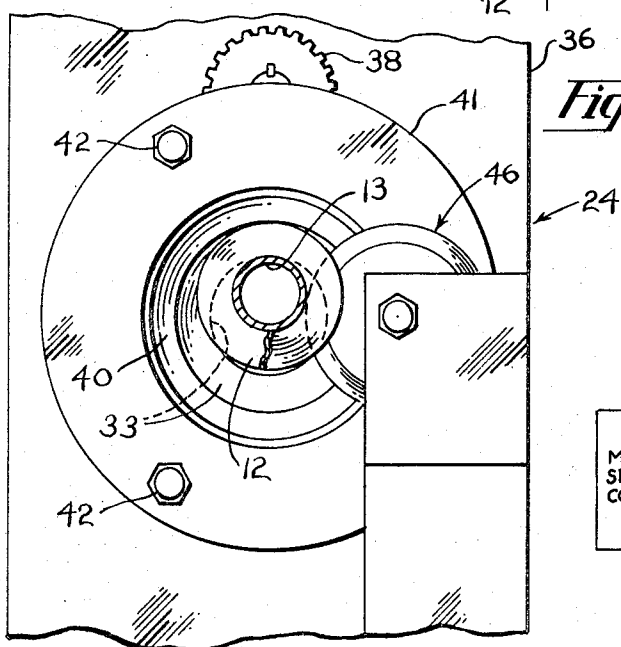
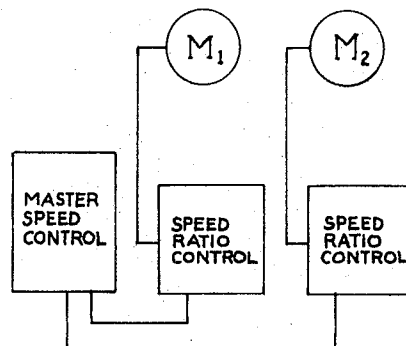


Fig. 6



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APPARATUS AND METHOD FOR MAKING FINNED TUBING

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18 Claims

ABSTRACT OF THE DISCLOSURE

Method and means helically winds metal fin ribbon edgewise about a rotating, axially advancing tube into tight pressure engagement of inner edge portion of ribbon, while simultaneously tapering and elongating ribbon to progressively outwardly increasing extents towards requisite maximum elongation at outer portion of fin ribbon. Helical fin secured to tube as by tensioned reception of inner fin edge and crimping tube stock against inner portions of fin ribbon, or otherwise attaching inner portions of fin ribbon tightly against tube.

BACKGROUND OF INVENTION

Prior methods and means for making finned heat exchange tubing have included, for example, feeding finning ribbon edgewise against the tube to anchor an inner edge of the ribbon within a helical groove provided in the tube. In one known method the tube is axially shifted, but was not rotated, and a pressure disc was rotated at a radius about the tube to press the fin ribbon against an annular anvil surface, and to draw the fin stock from a supply coil. That is, the fin ribbon was drawn through a throat with rolling movement of the pressure disc to squeeze the fin material predominately inwardly of the tube. This tended to cause the neutral line of the fin ribbon to be shifted radially inwardly of the axis of the tube. In another method the fin ribbon stock was drawn through a throat of triangular cross-section, while being helically wound without stretching the ribbon, whereby the inner half was said to retain its original cross-sectional shape. In any event, in the related prior art methods utilizing radially inward pressure on the ribbon, combined with a squeezing grip on the material, did not elongate the outer portions of the material to any substantial extent.

SUMMARY OF INVENTION

In the present invention the tube is rotated and axially shifted at predetermined speed past a cutting tool which provides a shallow groove helically around the tube. Finning ribbon or tape is simultaneously fed from a source of supply thereof through guide means to a finning head and edgewise toward pressure engagement with the tube and into the helical groove, where the ribbon is engaged between an annular pressure applying member and an anvil surface of an annulus which is constantly rotated about the axis of the tube, rotation of the pressure member being concentric with reference to said annulus. The rotative speeds of the annulus and the pressure-applying member are coordinated to apply a forcible, radially inward wiping action upon the fin ribbon, on the order of cold forging, with resultant uniform elongation of the outer edge portion of the ribbon without substantially changing the length of the ribbon stock along its original neutral line. Means is also provided for progressively crimping surface portions of the tube anchoringly against the inner portion of the fin ribbon.

One object of the invention is to provide an improved method and means for finning tubing of the character described at a higher surface speed with resultant in-

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creased production of finned tubing, as for use in heat exchange equipment.

Another object of the invention is to provide a method and means of the character described by which the length of the fin ribbon stock required for specific lengths of tubing can be calculated on the basis of the outside diameter of the tubing (i.e. length per turn equals pi multiplied by the O.D. rather than pi multiplied by the diameter of helically wound fin ribbon).

Other objects of the invention will be manifest from the following brief description and the accompanying drawings.

Of the accompanying drawings:

FIG. 1 is a top plan view of a finning machine embodying the features of the invention.

FIG. 2 is a front elevation of the machine shown in FIG. 1.

FIG. 3 is an enlarged fragmentary cross-section, taken substantially on the line 3—3 of FIG. 1, through the finning head of the finning machine.

FIGS. 4 and 5 are vertical cross-sections, taken substantially on the lines 4—4 and 5—5, respectively, of FIG. 3, on a reduced scale.

FIG. 6 is a schematic wiring diagram of a master speed control, utilized in the finning machine, to control the ratio of the movements of fin tubing through the finning head with respect to the rate at which fin ribbon is formed on the tubing.

Referring to the drawings generally, and to FIGS. 1 and 2 in particular, the numeral 10 designates a finning machine for producing finned heat exchange tubing 11, in which fin ribbon 12 of heat conductive metal (see FIGS. 4 and 5), suitable for cold forging the same in a manner to be described later, is to be helically wound and affixed to tubing 13 of the same or a different conductive material as the tubing is progressively rotated and axially fed through a finning head 24. For this purpose, the tubing 13 is supported to be fed along a fixed axis by two longitudinally spaced sets 14, 14 of three driven rollers 15, 15, two of which in each set rotate on fixed axes and the third being urged inwardly thereof, by suitable hydraulically actuated means 16, 16 to maintain the rollers in tight driving connection with the tubing. Axially aligned rollers 15 of the sets thereof are connected by swivelly jointed drive shafting 17, 17 intermediate the sets 14 to be driven by a master motor M₁, through swivelly jointed drive shafting 19, 19 from one set of rollers 15 to stub shafts 20, 20 in a relatively fixed driving head 21, driven by a suitable chain-drive 22 to motor M₁. The peripheral surfaces of the rollers may be of hard metal provided with parallel serrations for gripping the surface portions of tubing at a suitable angle, and under predetermined pressure, calculated simultaneously to rotate the tubing and move it axially toward a finning head 24 at predetermined, adjusted rotational and linear speeds of the tubing for purposes to be described, in accordance with controlled speeds of the motor M₁.

Before the rotated tubing 13 passes axially through the finning head 24, a grooving tool 26 progressively cuts therein a relatively shallow spiral groove 27 in known manner (see FIGS. 1 to 3).

Referring now to FIGS. 3 to 5, with continued axial movement of the grooved tubing 11 through the finning head 24, the metal fin ribbon 12 is fed from a supply thereof (not shown), through a suitable ribbon guide 28, and progressively toward tight engagement of the inner edge of the ribbon within the spiral groove 27. Simultaneously with this action the ribbon 12 may be, at a point immediately above the upper portion of the tubing, fed between an annular anvil surface 30 of an annulus 31 which is rotated about the longitudinal axis of the tubing, and an annular pressure surface 32 of annular

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pressure member 33 mounted in the finning head 24, for eccentric rotation thereof about an axis spaced below said axis of rotation of the annulus 31. That is, the edge-wise applied fin ribbon 12 is also progressively fed tangentially of and between opposed surface portions 30 and 32 of the annulus 31 and said pressure member 33, respectively. This localized pressure progressively cold forges the spirally wound fin ribbon 12 to have progressively outwardly decreased thickness effecting elongation of the outer edge portion of the fin ribbon, while otherwise maintaining the aforesaid spiral condition of the ribbon around the rotating tube.

The annulus 31 may comprise a disc which is interchangeably affixed in an apertured plate 34 centrally apertured at 35, rotatably mounted in a fixed upright 36. For rotating the plate 34, with annulus 31 affixed therein, the plate may have affixed thereon an eccentric gear 37 which meshes with a driving gear 38, keyed on a shaft 39 powered by the slave motor M_2 mounted on the upright 36, the shaft 39 being journaled through the upright. Pressure member 33 is similarly interchangeably affixed on an apertured plate 40 rotatably mounted in a housing 41 which is adjustably secured to the upright or main housing 36 as by means of a plurality of adjustment studs 42, 42 affixed to the upright. The plate 41 carries an eccentric gear 43 which meshes with driving gear 38, to be rotated thereby about an axis spaced substantially below the common axis of the smaller driven gear 37 and the tubing 13. As both gears 37 and 43 are driven by the same driving gear 38, gear 37 will rotate at higher r.p.m. than the larger gear 43. By the same token, the differing rotational speeds of the annular surface portions 30 and 32 applies a continuous wiping action to the fin ribbon at the aforesaid localized point of tangential engagement of the ribbon therebetween.

Upon passing through the finning mechanism 24, the finned tubing 11 is subjected to a crimping tool 46 of known type including spaced crimping rollers which extend at opposite sides of the spiral ribbon 12, progressively to crimp surface portions of the metal tubing against the inner edge portion of ribbon. This operation assures that the ribbon is tightly anchored in spiral groove 27 to assure maximum heat (or cold) transfer between the fin and the tubing.

In operation of the finning machine described above to produce heat exchange tubing, straight metal tubing 13 is fed through the finning machine 10, as shown in FIGS. 1 and 2, to rotate at predetermined rotational speed while being moved axially through finning head 24 at given linear speed. Before the tubing passes through the finning head, the spiral groove 27 is progressively provided in the cylindrical outer surface thereof (see FIG. 3).

In passing through the finning head 24, as shown in FIG. 3, the grooved tubing 13 has fin ribbon 12 tangentially fed between the forming surfaces 30 and 32 of the eccentrically rotating annulus 31 and annular pressure member 33. The resultant, pressurized wiping action concentrated on the ribbon, as it is spirally wound edgewise onto the tubing, has the effect of progressively cold forging the ribbon toward the outer portions thereof, thereby to elongate the same without substantially changing the location of the neutral line of the ribbon. This results in a substantial saving in fin ribbon used over that formerly required in use of prior methods by which the neutral line was shortened. The concentrated pressure against the ribbon, above the tubing 13, can be modified as required for maximum efficiency by appropriate adjustment of housing 41 with respect to the fixed housing 34, through the threaded adjustment of the nuts on the pins 42. Immediately upon leaving the finning head, the crimping tool progressively crimps tubing material against the inner edge portion of the spirally applied fin ribbon to anchor the same in the spiral groove 27.

Adjustment of the rotative and axial movements of the tubing with respect to the rotative speeds of the annulus

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31 and pressure member 33, is easily accomplished by the master control system shown in FIG. 6, to control the variable speed ratios of motors M_1 and M_2 .

With the method and means described, it is possible, with slight modification of parts of the finning mechanism, similarly to form flanged fin ribbon spirally about the tubing 13, in which case the spiral groove 27 would be omitted from the tubing, and the crimping tool would be modified to suit, or omitted.

Other modifications of the invention may be resorted to without departing from the spirit of the invention or the scope of the appended claims.

What is claimed is:

1. A method of tension-winding metal fin ribbon spirally about a rotating and axially advancing tube, comprising the steps of feeding the ribbon edgewise about the tube and into pressure engagement of the inner edge portion of the ribbon with the tube, while simultaneously elongating the ribbon to progressively outwardly increasing extents toward maximum elongation at the outer edge portion of the ribbon, said progressively increasing elongation of the ribbon being accomplished by frictional engagement of the ribbon between opposing annular surface portions of two annular members which are relatively rotated at different peripheral speeds around the tube as it is fed through the annular members.

2. A method as in claim 1, one said annular member being rotated about the tube eccentrically with respect to the other member, frictionally to engage the ribbon at a given point in the path of movement thereof radially outward from the tube.

3. A method as in claim 2, wherein one said relatively rotatable annular member is tiltable relatively of the other to apply said elongating pressure to the ribbon adjacent at the point of frictional engagement with the ribbon concentrated adjacent said outer edge portion of the ribbon.

4. A method as in claim 3, including the step of providing groove means spirally in said tube, and said inner edge of the ribbon being urged into said groove means by said edgewise feeding thereof.

5. A method as in claim 4, wherein the surface speed of the tube is higher than the surface speed of the fin ribbon to effect tight engagement of the fin ribbon within said groove means, thereby to improve heat transfer bond between the fin ribbon and the tube.

6. A method as in claim 5, wherein the inner edge portion of the fin ribbon is progressively gripped by crimping portions of the tube inwardly of said inner edge portion.

7. A method as in claim 1, wherein said inner edge portion of the fin ribbon is progressively gripped by crimping portions of the tube material inwardly of the said inner edge portion of the ribbon.

8. A method as in claim 1, wherein said progressively increasing elongation of the ribbon is accomplished by frictional engagement of the ribbon between opposing surfaces of two annular members which are relatively rotated at different peripheral speeds around the tube as it is fed through the annular members, and wherein said inner edge portion of the fin ribbon is progressively gripped by crimping portions of the tube material inwardly of said inner edge portion.

9. Apparatus for tension-winding metal fin ribbon from a supply source thereof spirally about a tube, comprising: a relatively fixed finning head; mounting means for supporting the tube to rotate about its longitudinal axis through said finning head; means for rotating said tube on said mounting means while progressively axially advancing the tube through said finning head; means for feeding the fin ribbon from the supply thereof in edgewise direction toward pressure engagement of the same with the axially advancing rotating tube progressively to form the fin ribbon spirally around the same; an annulus mounted on said finning head for rotation thereon about an axis of rotation of the annulus coextensive with said axis of said tube as it advances through the annulus, and the annulus

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having an axially presented annular anvil surface; and an annular pressure-applying member mounted on said finning head for rotation of said annular member about an axis thereof coextensive with said axis of the advancing tube, to accomplish pressure engagement of the edgewise fed fin ribbon between opposed surface portions of said pressure member and said anvil surface, thereby to cold forge the fin ribbon to progressively outwardly decreasing thickness thereof effecting elongation of the outer edge portion of the fin ribbon while otherwise maintaining said progressively formed spiral condition of the fin ribbon around the rotating tube.

10. Apparatus as in claim 9, said annular pressure applying member being eccentrically rotatably mounted with respect to the axis of rotation of said annulus.

11. Apparatus as in claim 10, the portion of said annular member at the point of said pressure engagement being sufficiently thin to be received between the flighting of said progressively formed spiral fin ribbon.

12. Apparatus as in claim 11, said annular member being angularly adjustably mounted with respect to said annulus, selectively to vary the cold forging effect attained by the pressure applying member.

13. Apparatus as in claim 12, including cutting means operable in timed relation to the progressive spiral formation of the fin ribbon for cutting a spiral groove for reception of the inner edge of the spirally formed fin ribbon therein.

14. Apparatus as in claim 13, wherein the tube is rotated at a faster surface speed rate than that of the fin ribbon,

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tending to draw the inner edge of the wound ribbon into said spiral groove.

15. Apparatus as in claim 14, said annular member and said annulus being rotated at different surface speeds generating frictional heat within the fin ribbon to facilitate said cold forging effect.

16. Apparatus as in claim 9, the portion of said annular member at the point of said pressure engagement being sufficiently thin to be received between the flighting of said progressively formed spiral fin ribbon.

17. Apparatus as in claim 9, said annular member and said annulus being rotated at different surface speeds generating frictional heat within the fin ribbon to facilitate said cold forging effect.

18. Apparatus as in claim 9, means being provided for deforming portions of the tube material anchoringly against the inner portions of the fin ribbon.

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