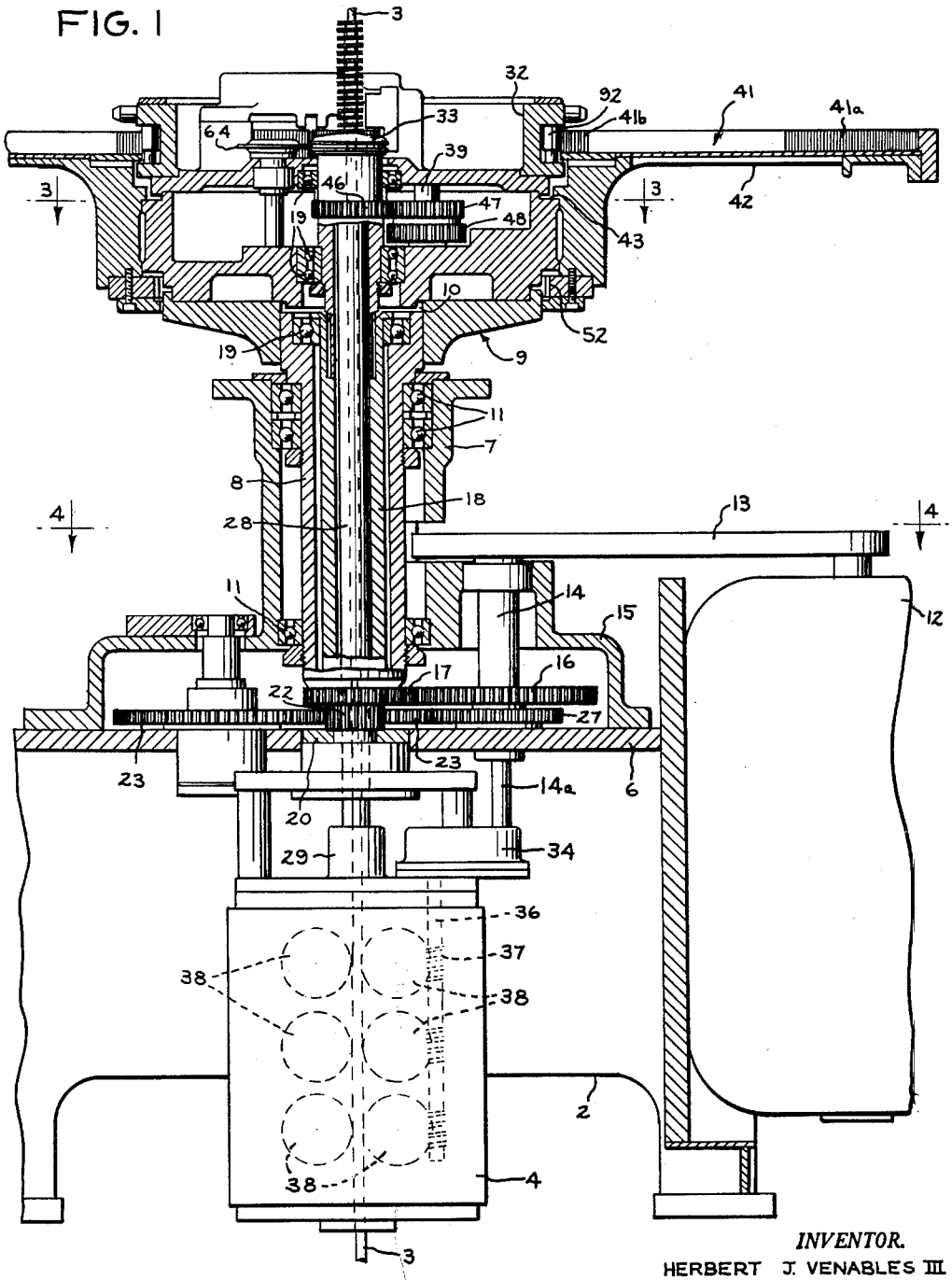
May 26, 1964 H. J. VENABLES III 3,134,166

MANUFACTURE OF HEAT EXCHANGE TUBING

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FIG. 1



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MANUFACTURE OF HEAT EXCHANGE TUBING

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FIG. 2

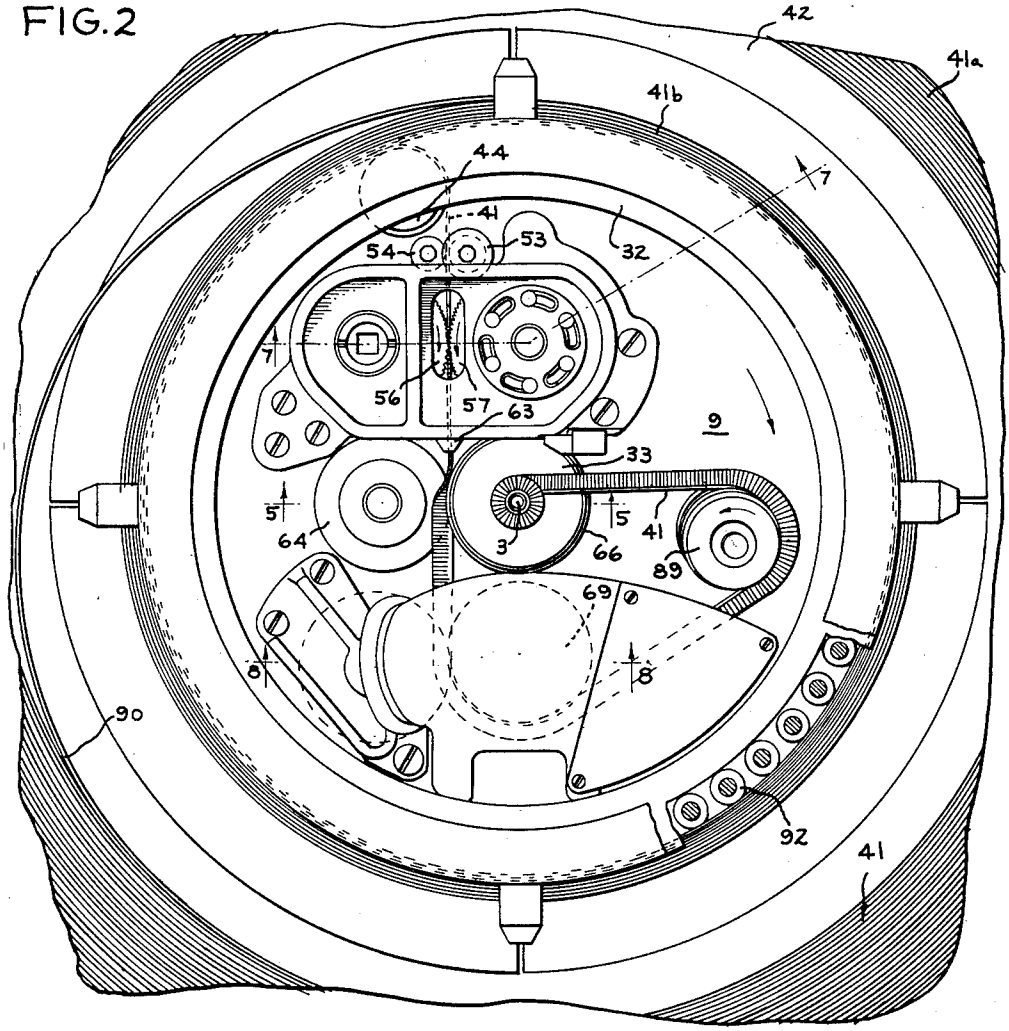


FIG. 5

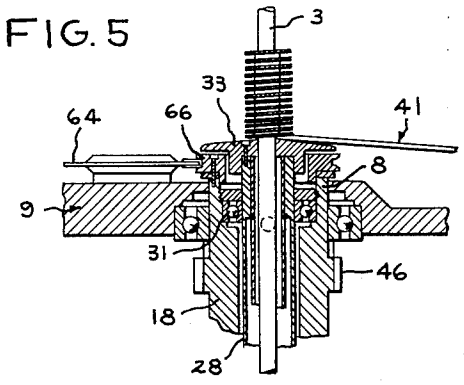
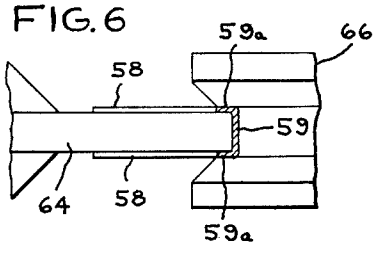


FIG. 6



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MANUFACTURE OF HEAT EXCHANGE TUBING

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FIG. 3

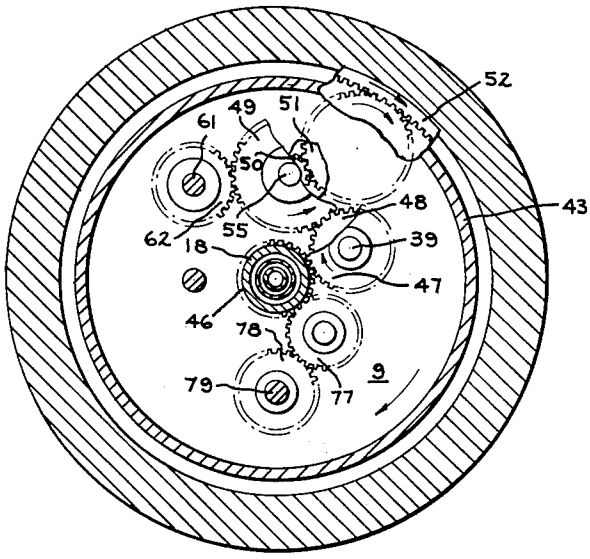
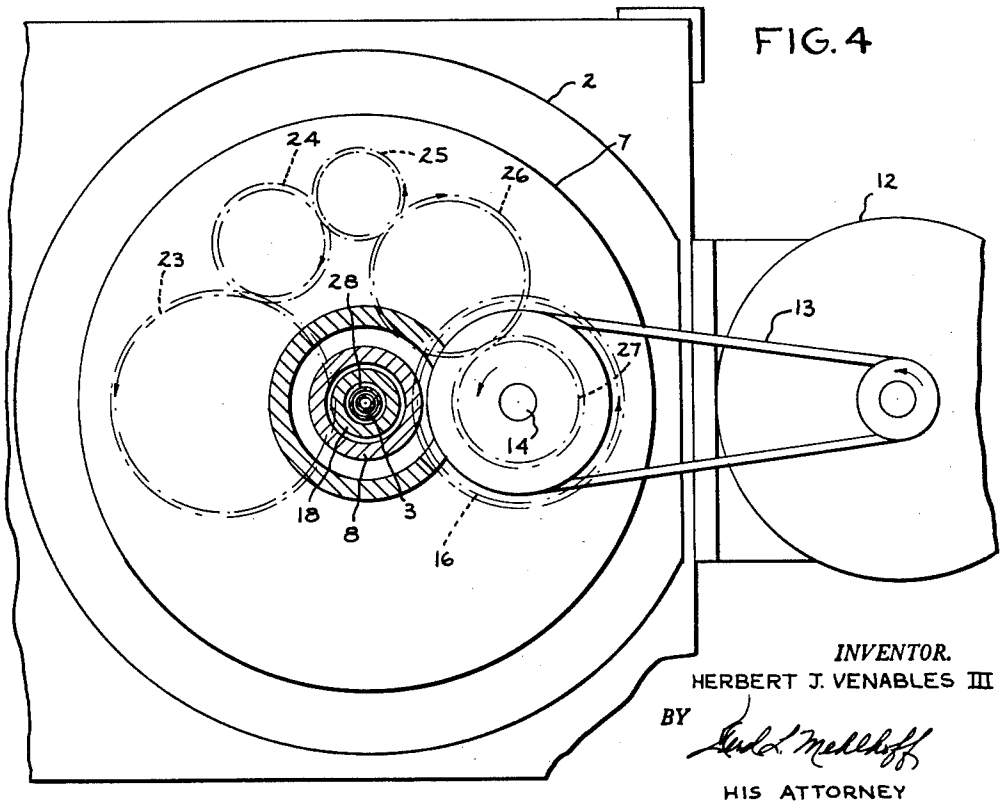


FIG. 4



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MANUFACTURE OF HEAT EXCHANGE TUBING

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FIG. 8

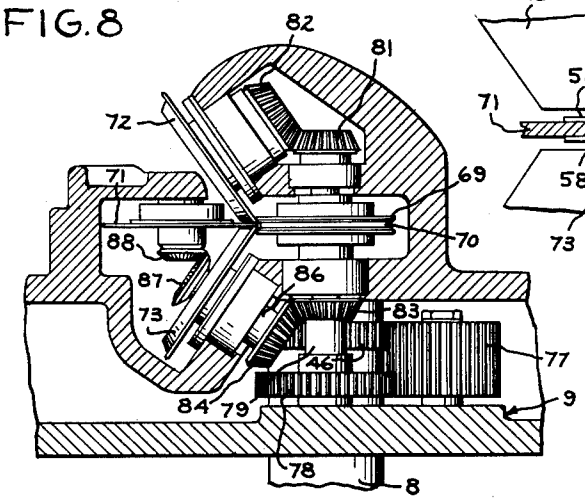


FIG. 9

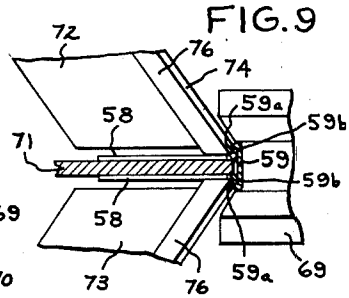


FIG. 11

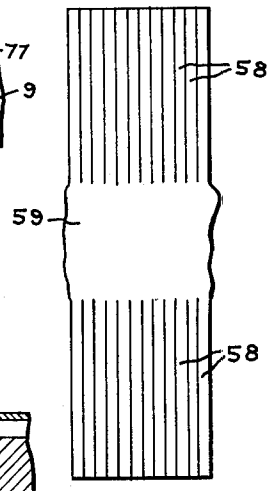


FIG. 7

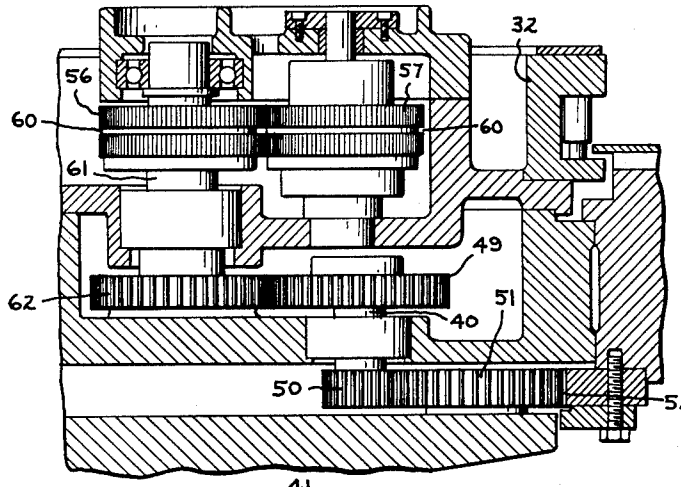


FIG. 12

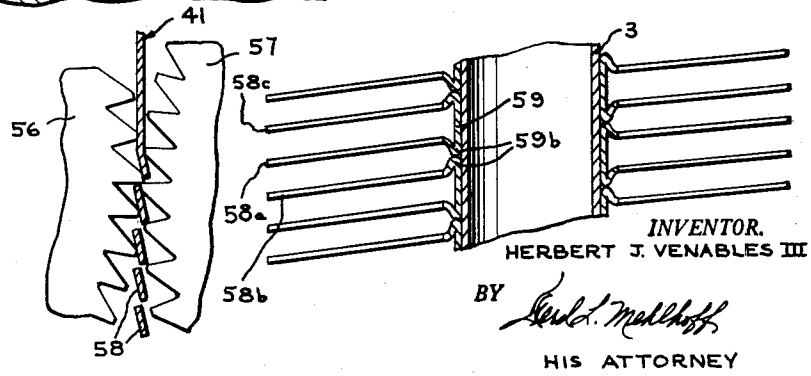


FIG. 10

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United States Patent Office 3,134,166 Patented May 26, 1964

3,134,166

MANUFACTURE OF HEAT EXCHANGE TUBING

Herbert J. Venables III, Cleveland, Ohio, assignor to General Electric Company, a corporation of New York

Filed Aug. 26, 1960, Ser. No. 52,252
2 Claims. (Cl. 29—157.3)

The present invention relates to the manufacture of finned tubing employed for heat exchange purposes and has as its principal object the provision of an improved method and machinery for producing finned tubing having a multitude of slender fin sections extending outward in radiating fashion from the tubing.

The present invention is an improvement over the invention of my previous application S.N. 763,514, filed September 26, 1958, now Patent No. 3,005,253, dated October 24, 1961, and assigned to the assignee of the present invention, which invention was made by me prior to the present invention. I, therefore, do not herein claim anything shown or described in the previous application, which is to be regarded as prior art with respect to this present application.

The machine of the present invention comprises a rotatable head mounted for rotation in a base member. The head carries a coil supporting table around the periphery thereof which is rotatable with respect to the head. A hollow spindle extends upwardly through an axial passage in the head and is mounted for rotation independently from but in timed relation with the rotation of the head and at a rotational velocity differing from that of the rotatable head. The hollow spindle carries a sun gear for driving gear means in the rotatable head which, in turn, advance the coil supporting table around the rotatable head a predetermined amount for each revolution of the head. Also driven in timed relation with the rotation of the head by the gear means on the head is a slitting means which acquires strip stock from the coil supporting table and slits the stock at intervals inwardly from both edges thereof toward the center to form a plurality of slender fin sections each connecting at their inner ends with a base section extending the length of the strip. After slitting, the strip stock is directed between a pair of forming rolls, including a grooved roll on the upper end of the spindle and a backing roll journalled in the head. The backing roll forces the base section of the strip into the grooved roll and forms the strip into a substantially U-shaped cross section with narrow portions of the base section on both sides thereof being formed at approximately a right angle with respect to the remaining portions of the base section. A hem forming means is mounted on the head and driven in timed relation with the rotation of the head. The hem forming means includes a grooved roll for receiving the base section of the U-shaped strip, a backing roll extending into the opening of the U-shaped strip, and a pair of diagonal rolls adapted to engage the narrow portions of the base section and bend them inwardly upon the remaining portion of the base section while the backing roll retains the fin sections on either side thereof extending outwardly at approximately a right angle with respect to the base section. Means are also provided in the base for advancing a tubular member through the hollow spindle at a programmed rate and into the head wherein the formed fin strip is wrapped thereon in helical fashion as the head is rotated about the tubing.

The invention includes as a further aspect thereof, the method of forming a heat exchange structure including the steps of providing a tubular member and a longitudinal strip of fin stock, slitting the strip stock at equal intervals along the edges thereof toward its center to form a plurality of slender fin sections each connecting

at one end with a base section extending the length of the strip, forming the strip into a substantially U-shaped cross section with narrow portions of the base section on opposite sides thereof being bent approximately at right angles with respect to the remaining portions of the base section, folding the narrow portions of the base section inwardly upon the remaining portions of the base section while retaining the fin sections, connecting with the narrow portions of the base section, outwardly at substantially a right angle with respect to the base section, and helically wrapping the formed strip of fin stock onto the tubular member with the base section in flatwise engagement upon the surface of the tubular member and with the fin sections extending outwardly therefrom.

For a better understanding of the invention, reference may be had to the accompanying drawings in which:

FIG. 1 is an elevational view of the machine of the present invention with portions of the machine broken away;

FIG. 2 is a plan view of the rotatable wrapping head looking down upon the head from the top;

FIG. 3 is a cross sectional view taken substantially along line 3—3 of FIG. 1 showing the gearing arrangement for driving the various components in the rotatable head;

FIG. 4 is a cross sectional view taken approximately along line 4—4 of FIG. 1 showing the gear arrangement for independently driving the rotatable head and the hollow spindle extending upwardly into the head;

FIG. 5 is a cross sectional view taken substantially along line 5—5 of FIG. 2 illustrating the grooved forming roll on the upper end of the spindle and mating backing roll on the head for bending the fin strip into a substantially U-shaped cross section;

FIG. 6 is an enlarged view of the forming rolls of FIG. 5 showing the fin strip being formed into a substantially U-shaped cross section;

FIG. 7 is a cross sectional view taken substantially along line 7—7 of FIG. 2 showing the fin slitting rolls and the gearing means on the head for driving the slitting rolls;

FIG. 8 is a cross sectional view taken approximately along line 8—8 of FIG. 2 illustrating the hem forming rolls and the gear drive in the rotatable head for operating these hemming rolls;

FIG. 9 is an enlarged detail view of the hemming rolls showing the bending operation wherein the narrow portions of the base section are reversely bent upon the base section to form the double thickness hem or edge portion on opposite sides of the base section;

FIG. 10 is a detailed view of one side of the slitting rolls illustrating their slitting operation;

FIG. 11 is a view of a section of the strip stock after it has passed through the slitting rolls illustrating the fin sections on both sides of the strip all connecting with a center or base section extending the length of the strip; and

FIG. 12 is a cross sectional view of the finned tube showing the manner in which the double thickness edge portions provide spacing between adjacent wraps of fin material.

Referring now to FIG. 1, there is shown a machine for forming and helically wrapping a finned strip onto a tubular member which is advanced through the machine. The machine is supported on a base or bench 2 which carries the machine for rotation about a substantially vertical axis. A suitable supply of tubular material 3 is fed substantially vertically in the upward direction through the machine. Mounted within the base 2 of the machine is a tube feeding and swaging assembly 4 which provides means for reducing the circumference of the tubing as

well as for driving the tubing upwardly through the remaining components of the machine. Arranged on the top plate 6 of the base 2 is a supporting member 7 which supports a rotatable drum 8 for rotation about a substantially vertical axis. The upper end of the rotatable drum carries a rotatable wrapping head generally designated 9 which in turn carries means for supporting a coil of sheet stock as well as fin slitting, forming and wrapping mechanism.

As may be seen in FIG. 1, the rotatable drum 8 is supported within the vertical support 7 by means of anti-friction bearings 11 which permit rotation of the drum. Means are provided for rotating the drum 8 and the head 9, carried by the drum. These means include the drive motor 12 which, through a belt or chain 13 supplies power to a main drive shaft 14. The shaft 14 extends downwardly into a gear box 15 formed in the bottom of the supporting member 7. Attached to the shaft 14 is a large driving gear 16 which meshes with gear 17 affixed to the bottom of the rotatable drum 8 for rotating the drum and the head 9.

Again referring to FIG. 1, there is shown a second tubular member 18, supported within the rotatable drum 8, and rotatable with respect to the rotatable drum 8. For purposes of clarity in the following specification and claims, this tubular member will be referred to as the rotatable spindle 18. As may be seen in FIG. 1, the rotatable spindle 18 is supported at its upper end within the drum 8 and in an axial passage 10 formed in the wrapping head 9 by anti-friction bearings 19, and at its lower end by a thrust bearing 20 mounted in the upper plate 6. Thus, the spindle 18 is completely free from the drum 8 and is adapted for rotation independently therefrom. Referring to both FIGS. 1 and 4, the spindle 18 has affixed to its lower end a gear 22 which meshes with a gear 23 of a gear train also including the gears 24, 25 and 26. The gear train and therefore the spindle 18 are driven by the drive shaft 14 through a gear 27 positioned on the shaft below the gear 16. Through this gear train, rotation is imparted to the spindle 18 in same direction as the rotational motion applied to the rotatable drum 8. Inasmuch as both the rotatable spindle 18 and the rotatable drum 8 are driven by gearing means deriving their power from the common shaft 14, both of these means are driven in timed relation with each other. However, for purposes to be explained later on in the specification, the rotatable drum 8 is geared to rotate at a rotational velocity slightly faster than that of the rotatable spindle 18.

A tubular guide 28 is disposed centrally within the spindle 18 and arranged to receive the tube 3 from the feed roll assembly 4 during operation of the machine. The tubular guide 28 is rigidly supported at its lower end by a supporting strut 29 extending from the housing of the feed roll assembly 4, and vertically supported at its upper end by an anti-frictional bearing 31 (best seen in FIG. 5), journalled in the rotatable spindle 18. The tubular guide 28 is rigidly supported and extends upwardly through the rotatable spindle into a turret 32 carried on the rotatable head 9. On the end of the tubular guide within the turret 32 there is provided a wrapping member 33 through which the tubing 3 is advanced while fin material is helically wrapped onto the tubing 3 as the head 9 is rotated about the tubing.

Referring again to FIG. 1, in order to drive the tube feeding and swaging assembly 4 for advancing the tubing 3 upwardly through the machine, the shaft 14*a* extends downwardly through the upper plate 6 into a gear box 34 positioned on the top of the housing carrying the tube swaging and feeding assembly 4. Gearing means (not shown) in the gear box drive a worm shaft 36 having a plurality of worms 37 thereon, each meshing with gearing means on the swaging and feeding rolls for driving the three sets of rolls provided in the illustrated machine. Tubing 3, after it has been sized in the swaging and tube feeding assembly 4 is advanced upwardly into the tubular guide 28 as shown in FIG. 1. This carries the tubing 3 upwardly through the guide 28 where it enters the turret 32 through an opening in the top of the wrapping member 33. The tube feed and swaging assembly is clearly described in my aforementioned patent application S.N. 763,514 and a more detailed description of this tube driving and swaging means is not deemed necessary in the present application except to state that the operation of the swaging and feeding rolls is in timed relation with the rotation of the wrapping head 9 for advancing a required amount of tubing of a precise dimension through the wrapping member 33 for each revolution of the wrapping head.

As may best be seen in FIGS. 1 and 2, a coil supporting means or coil supporting table 42 is provided on the rotatable head for carrying a large coil of strip stock around the periphery of the rotatable head 9. The table 42 is mounted around the periphery of the rotatable head 9 and is so mounted that it is free to rotate with respect to the head. More specifically, the supporting table 42 rests on the shoulder 43 around the periphery of the rotatable head 9 and is slideable thereon. A coil 41 of strip stock is positioned on the table and is clamped at its outer diameter so that for all practical purposes there is no slippage between the coil and the table. As may be seen in FIG. 2, strip stock 41 pays off from the inner diameter of the coil and passes around an idler roll 44 where it is guided into the turret 32. As will be explained later on in the specification, strip stock is removed from the coil 41 and pulled into the turret 32 by a slitting means which comprises a pair of lancing rolls 56 and 57. The lancing rolls alway acquire the same amount of strip material for each revolution of the head.

In order to feed strip material from the inner diameter of the coil 41, it is necessary to rotate the table 42 around the wrapping head 9 at the same time that the wrapping head 9 is rotating around the tubing. As was mentioned previously, the head 9, which is mounted on the drum 8, it rotated in the clockwise direction (as seen in FIG. 3) slightly faster than the spindle 18, and the head 9, therefore, advances around the spindle 18 a predetermined amount for each revolution of the head.

Referring to FIG. 3, it can be seen that the spindle 18 is provided with a gear means 46, which for ease of explanation should be considered a sun gear and will be hereinafter referred to as such, although the spindle 18 is also rotated in the clockwise direction. Because the head 9 is also rotated in the clockwise direction, but slightly faster than the spindle 18, the planetary gear 47, which engages with the sun gear 46 on the spindle, is actually progressed around the sun gear 46. Thus gear 47 is rotated in the clockwise direction with respect to its mounting axis or shaft 39 during rotation of the wrapping head 9. Shaft 39 also carries the gear 48 which engages with the idler gear 49 on the shaft 55 also journalled in the wrapping head 9 and drives gear 49 in the counter-clockwise direction with respect to the shaft 55. As may be seen in FIGS. 3 and 7, shaft 55 also carries the small gear 50 which engages the large drive gear 51 and rotates this gear in the clockwise direction. Drive gear 51 engages with a ring gear 52 mounted on the inner diameter of the supporting table 42 and progresses the table 42 around the head 9 in the clockwise direction as seen in FIG. 3, during rotation of the head in this same direction. Thus, for each revolution of the head 9, the table 42 is advanced a predetermined distance around the head 9 and strip material 41 is paid off from the head.

Returning now to FIG. 2, the strip stock 41 is pulled from the inner diameter of the coil into the turret 32 by the slitting rolls 56 and 57 and passes through an aperture in the turret having mounted therein an idler roll 44.

The strip stock 41, as will be hereinafter explained, is formed within the turret into a finned member which is wrapped onto the tubing 3 being advanced upwardly

through the turret. The strip stock **41** passes through a pair of guide rolls **53** and **54** which direct the stock into the slitting means which slits the strip material at intervals from its outer edges toward the center thereof to provide a plurality of slender fin sections each connecting with a base section extending the length of the strip material. In the preferred embodiment of the invention, the slitting means comprises the aforementioned pair of slitting rolls **56** and **57** which, as may be seen in FIG. 7, are tandem slitting rolls including upper and lower slitting units separated by a short open space **60**. The slitting rolls slit the fin stock **41** at equal intervals from the outer edges thereof toward the center of the material, which passes through the open space **60** between the respective cutting edges of the tandem rolls **56** and **57**. Thus the material passing through the slitting rolls **56** and **57** is slit into the form shown in FIG. 11 with a plurality of longitudinal fin sections **58** being formed on either side of the central or base section **59** which passes through the center portion of the slitting rolls and, thus, is not serrated.

In order to rotate the slitting rolls, there is provided in the rotatable head **9** a gearing means or gear chain which derives its rotational power from the sun gear **46** as the rotatable head **9** advances around the rotatable spindle **18**. Referring now to FIGS. 3 and 7, it can be seen that the shaft **61** which is attached to the slitting roll **56** extends downwardly into the rotatable head and has affixed to the bottom thereof a gear **62**. Gear **62** meshes with gear **49** which is, in turn, driven by the gear **48** (seen in FIG. 3) attached to the same shaft as the planetary gear **47**. Thus, as the planetary gear **47** is advanced around the sun gear **46** on the spindle, it imparts rotational motion to the slitting rolls **56** and **57** through the gear train journalled in the wrapping head **9**. As the strip stock passes through the slitting rolls the cutting teeth of the slitting roll **56** displaces the fin stock thereby serrating the fin stock and, by this action, also drives the slitting roll **57** through the fin stock. In other words, as may best be understood by reference to the FIG. 10, the meshing of the slitting teeth of the two slitting rolls **56** and **57** respectively causes the roll **57** to be driven through the material by the slitting roll **56**.

It should be mentioned in passing that each fin section **58** is canted at an angle with respect to the original plane of the strip stock **41** as the strip passes through the slitting rolls. It has been found that these canted fin sections are not as desirable in the finished heat exchange tubing as sections which are arranged to present less resistance to air flow. Moreover, these canted fin sections make the wrapping of the fin material somewhat difficult in that they tend to hang up on each other and various components of the machine. Therefore, means, which will be described in greater detail later on in the specification, are provided for straightening the individual fin sections with respect to the plane of the remaining fin sections.

Referring to FIG. 2 it can be seen that, as the strip material leaves the slitting means, it is directed by a guide **63** into a forming means comprising a pair of forming rolls **64** and **66**. As may be seen in FIGS. 5 and 6, the forming roll **66** is provided with a groove around the peripheral edge thereof into which the backing roll **64** extends. The backing roll **64** is journalled into the rotatable head **9** while the grooved roll **66** is attached to the upper end of the rotatable spindle **18**. While the roll **66** is rotated by the spindle **18**, the roll **64** is carried by the rotatable wrapping head **9** around the roll **66** during rotation of the head **9** around the rotatable spindle **18**. Thus, although both the spindle **18** and thereby the roll **66** are rotated in the clockwise direction, the fin material is passed between the forming rolls **64** and **66** because the backing roll **64** moves in a planetary type of motion in the clockwise direction (as seen in FIG. 2) around the grooved roll **66**. As the fin material passes between the rolls **64** and **66**, the individual fin sections **58**, and narrow portions **59***a* of the base section on both sides of the base section **59** are bent at approximately a 90° angle with respect to the remaining portions of the base section **59**. This may best be seen by referring to the enlarged view of the forming rolls shown in FIG. 6. Thus, the forming rolls cooperate to provide a U-shaped or channel-shaped opening into which the base section **59** is confined as it advances through the rolls. As the slit fin stock progresses between the two rolls the fin sections **58** are bent toward each other as the base section **59** is folded into the channel or U-shaped opening between the rolls and the narrow sections **59***a* on both sides of the base section are bent at approximately 90° angle with respect to the remaining portion of the base section. Thus, as the fin material emerges from between the two forming rolls **64** and **66**, it takes on a substantially U-shaped cross section. It should be noted that the backing roll **64** is not powered by any positive driving means and rotates because of the frictional force resulting when it forces the strip stock into the groove of the roll **66**.

After the strip stock is formed into a substantially U-shaped cross section by the forming rolls **64** and **66**, it is directed into a hem forming means shown best in FIGS. 8 and 9, for crimping or folding the narrow portions **59***a* of the base section downwardly upon the remaining portion of the base section to form double thickness edge portions **59***b* on each side of the finned strip. The hem forming means in the present invention, comprises a plurality of forming rolls including a roll **69** having a groove **70** around the peripheral edge thereof. The groove **70** in the roll **69** is of a width just large enough to receive the width of the base section of the U-shaped cross section of the strip stock. The base section of the U-shaped strip material enters the groove **70** of the roll **69** and is confined therein by a backing roll **71** and a pair of diagonally disposed hemming rolls **72** and **73**. The hemming rolls **72** and **73** and the rolls **69** and **71** all have their axes in a single vertical plane (as seen in FIG. 8) with the roll **69** meeting the hemming rolls **72** and **73** to bend the edge portions **59***a* on opposite sides of the base section downwardly upon the remaining portion of the base section **59** as the rolls meet in substantially common line tangency, as shown in the larger diagram of FIG. 9. Each of the rolls **72** and **73**, which approach the roll **69** diagonally, are provided with forming surfaces **74** and **76**, disposed at an angle with respect to each other, which engage the narrow portions **59***a* on opposite sides of the base section and confine or crimp these portions between the base section **59** and opposite sides of the backing roll **71**. This provides a continual trend or force against the narrow portions **59***a* of the base section as the U-shaped strip is advanced through the hemming rolls and causes these portions **59***a* to bend over upon the remaining portion of the base section **59** while, at the same time, the fin sections **58** are retained outwardly from the base section at substantially a perpendicular angle therefrom.

As was previously mentioned, the slender fin sections **58** are canted at an angle with respect to the original plane of the strip stock as they are serrated in the slitting rolls **56** and **57**. As may be seen in FIG. 9, the fin sections **58** are confined against the opposite surfaces of the backing roll **71** and the surfaces **76** of each of the rolls **73** and **72**. This provides a means for straightening the individual fin sections with respect to the plane of the remaining fin sections. As the fin sections are each successively passed between the surfaces **76** of the diagonal hemming rolls and the backing roll **71**, the cant in each fin section **58** is "ironed out" by the pressure exerted on these sections at their connecting point with the base section **59**. This effectively straightens each fin section **58** and places all of the fin sections extending outwardly from the base section **59** in two planes substantially parallel with each other and at right angles with respect to the base section.

In order to drive the various hem forming rolls there is provided a gear **77**, as may be seen in FIGS. 3 and 8, journalled in the rotatable head **9**, which also engages with the sun gear **46** on the spindle **18**. This gear **77** is also a planetary gear and, similarly to the gear **47**, also slowly advances around the gear **46** as the head **9** rotates around the spindle **18**. As the head **9** rotates around the spindle **18** and the gear **77** rotates around the sun gear **46**, rotational motion is imparted to the planetary gear **77** which motion is transmitted to a gear **78** also journalled in the head **9**. Gear **78** drives the shaft **79** attached to the grooved roll **69**. On the upper end of the shaft **79** is a bevel gear **81** meshing with a bevel gear **82** attached to a shaft which drives the diagonal roll **72** in the opposite rotational direction than the direction that the roll **69** is rotated. Similarly on the lower portion of the shaft **79** is a second bevel gear **83** which engages a bevel gear **84** for rotating the shaft **86** to drive the diagonal roll **73**. On the upper end of the shaft **86** is a small bevel gear **87** which drives the bevel gear **88** to impart rotary motion to the roll **71**. Through this gearing arrangement all of the rolls **69**, **71**, **72** and **73** are all positively driven so that their peripheral edges are all moving in the same direction at their point of common tangency with the fin strip as it is passed therethrough.

Referring again to FIGS. 2 and 5, the finned strip of stock follows a short distance around the grooved roll **69** and is directed onto a turn-around roll **89**. The roll **89** is mounted at a slight angle with respect to the head **9** and causes the finned strip to be directed slightly upward with respect to the head **9** so that it is wrapped onto the tubing **3** being advanced through the head. Thus, the fin strip approaches the tubing **3** at the angle required for helically wrapping the strip onto the tubing as the tubing is advanced through the wrapping member **33**. This wrapping member **33** is attached to the tubular guide **28** extending upwardly through the spindle **18**. Below the wrapping member **33** the grooved roll **66** is rotating at a fairly substantial rotational velocity. However, the wrapping member **33** is stationary, as is the tubular guide **28**, and provides a wrapping surface upon which the material is wrapped onto the tubular member **3** being advanced upwardly through the tubular guide **28**.

The strip of fin material is wrapped onto the tubing **3** with the base section **59** in flatwise engagement with the surface of the tubing and with the fin sections **59** projecting outwardly from the tubing. As the strip is wrapped the fin sections **58** spread apart toward their outer ends leaving a pie-shaped opening between adjacent fin sections thereby breaking up the continuity of the helical fin structure around the tubing. In the preferred embodiment of the invention, as seen in FIG. 12, the double thickness edge portions **59***b* on opposite sides of the base section of the adjacent wraps of the strip are placed in abutting relationship. The double thickness edge portions **59***b* serve to space the outwardly extending fin sections of one wrap from the outwardly extending fin sections of adjacent wraps.

It should be mentioned that for each revolution of the wrapping head **9**, there is wrapped onto the surface of the tubing **3** a length of fin material slightly greater than the circumference of the tubing **3** as determined by the helical wrapping angle. Thus, for each revolution of the head **9**, approximately this length of fin stock must be paid off the inner circumference of the coil **41** and passed through the slitting rolls and fin forming rolls. It will be understood therefore that this length of fin material, wrapped for each revolution, governs the rotational sped at which the slitting rolls **56** and **57** and the hemming rolls **69**, **71**, **72** and **73** are rotated. Furthermore, this length of fin material to be wrapped onto the tubing governs the velocity at which the forming roll **64** is to be rotated around the grooved roll **66** to form the strip stock into a substantially U-shaped cross section. That is, the length of fin stock formed into a substantially, U-shaped cross section is determined by the velocity at which the backing roll **64** rotates around the grooved roll **66** (considering a grooved roll **66** having a preselected diameter or size). Since the grooved roll **66** is carried by the spindle **18** and the backing roll is carried by the wrapping head **9**, it is actually the difference in rotational velocity between the head **9** (or drum **8**) and the spindle **18** which determines the length of fin stock formed by these rolls. It can be seen, therefore, that once the length of fin stock to be wrapped onto the tubing for each revolution is determined, then the difference in rotational velocity between the head **9** (or drum **8**) and spindle **18** is necessarily fixed and a proper gear ratio must be obtained to provide this difference in rotational velocity between these two members. This proper gear ratio is provided in the gear box **16** which promotes the requisite difference in rotational velocity between the drum **8** and the spindle **18** through the gear trains which drive these members from the common drive shaft **14**.

When the difference in rotational velocities between the spindle **18** and drum **8** (or head) is small then the length of fin stock formed by the fin forming and slitting components is small. And conversely, when the difference in rotational velocities between the spindle **18** and drum **8** (or head) is greater, then the slitting and forming components on the head or operated at a greater speed to form relatively more fin material for each revolution of the head. Thus, it is only necessary to change the gear ratios (in the gear box **15**) affecting the rotational velocity of the drum **8** and the spindle **18**, thereby, changing the difference in rotational velocity between these members, to accomplish a change in the amount of fin material formed for each revolution of the head. This is very advantageous when changing over from one size tubing **3** to another which, of course, necessitates a change in the length of fin material to be wrapped for each revolution of the wrapping head **9**.

Referring now to FIGS. 1 and 2, it would appear that there are two coils **41***a* and **41***b* of strip stock on the support table **42**. Actually this is one continuous coil of strip stock which has gradually separated so that the inner portion **41***b* thereof is built up around the turret **32**. The separation of the coil of strip stock **41** is caused by the fact that the coil supporting table **42** is always advanced the same amount, or an equal rotational angle, around the head **9** for each revolution of the head while the linear length of strip stock "payed off" by a new coil when first placed on the table is less than that demanded by the fin slitting, forming and wrapping components. It, of course, is understood that the inner diameter of a coil of strip stock of material is necessarily much smaller than the outer diameter of the coil and that, for all of the radii of the coil from the inner diameter of the coil to the outer diameter, the length of strip stock advanced for each revolution of the head must necessarily vary over a wide range. Therefore, the linear length of strip stock paid off from the coil will necessarily be less for each revolution of the head when the coil of strip stock is first placed on the table and the radius from the axis of rotation to the inner diameter of the coil is relatively smaller than when most of the coil has been used and the pay off point from the inner diameter of the coil is consequently at a greater radius from the center of the machine.

The machine of the present invention is designed so that the length of strip stock required by the components in the turret **32** is greater than that payed off by a new coil having a relatively small inner diameter. This means that, for each revolution of the head, the wrapping components require a small increment more fin stock than is supplied by the advancement of the coil around the head. This causes the pay off point **90** on the new coil to gradually progress counterclockwise (as seen in FIG. 2) around the coil so that the strip stock wraps itself around the turret to provide the two separate coils **41***a* and **41***b*. However, as the coil **41***a* is consumed, its inner radius

eventually reaches a point where it will "pay off" an equal length of strip stock as that required for wrapping during each revolution of the wrapping head **9**. When this point is reached, the build up of coil **41***b* around the turret ceases and the inner coil **41***b* begins to gradually diminish. It should be mentioned that, as the inner radius of the coil **41***a* gets even larger, the linear length of stock advanced by the table, for each revolution of the head, becomes gerater than that required by the components in the turret. This causes the pay-off point **90** to reverse and to progress in the opposite or clockwise direction around the coil **41***a*. As the pay off point **90** moves in the clockwise direction, there is a gradual reduction in the build up of coil **41***b* as well as a reduction in the outer coil **41***a*. Thus, as is illustrated in FIG. 1, the coil **41***b* of strip stock builds up around the outer periphery of the head **9** for the first portion of wrapping of each new coil of stripstock. This build up must be kept to a reasonable amount so that the friction developed by the material as it is pulled into the turret for forming operation does not create too great a force and thus cause the material to break or tear. A plurality of rollers **92** have been mounted at spaced intervals around the outer periphery of the turret upon which the inner coil **41***b* of strip material rides to reduce the friction as much as possible. The rollers prevent the inner coil **41**b from binding around the turret **32** and aid the uniform pay off from the inner diameter of the inner coil **41***b*. As stated previously, when the inner radius or pay-off point **90** on the coil **41***a* from which the strip material is taken, reaches that point wherein the advancement of the coil at that particular radius equals the linear length of strip stock acquired for each revolution of the head by the slitting rolls **56** and **57**, then the amount of build-up around the periphery of the turret begins to diminish. The machine of the present invention is designed so that, when the build up around the outer periphery of the turret **32**, or the coil **41***b*, is completely eliminated, there is no longer any strip stock left in the outer coil **41***a*, so that there is no chance of overrunning the point of entry or idler roll **44** in the turret. However, overrunning the point of entry or idler roll **44** is not too critical a factor inasmuch as the material is merely fed from the opposite direction into the entry and one of the small rollers **92** acts as an idler roll to reduce friction at the point of entry.

As mentioned in my previous application, an adhesive bonding material is directed onto the tubing **3** in the area just prior to its winding point with the fin material. This is provided by an adhesive bond which is directed onto the tubing in the tubular guide at some point just ahead of the wrapping member **33**. In the illustrated embodiment of the invention, this adhesive applicating means is not illustrated although it is shown and claimed in the previous application.

The machine of the present invention uses a new and improved method for manufacturing a finned heat exchange tube of this type. The new method includes as its first step the slitting of a strip of sheet stock inwardly from opposite edges thereof toward the center at spaced intervals to provide a plurality of slender fin members each connecting with an unslit center or base section extending the length of the strip. This step is performed by the slitting rolls **56** and **57** (best seen in FIG. 7) on the wrapping head **9** which slit the strip stock into the form shown in FIG. 11 with the slender fin sections **58** extending outwardly from the unserrated central base section **59** that extends the length of the strip of stock. The base section is then folded into a substantially U-shaped cross section with narrow portions **59***a* of the base section and the connecting fin members **58** being folded at approximately 90° with respect to the remaining portions of the base section **59**. This U-shaped cross section is formed by the forming rolls **64** and **66** (shown in FIGS. 5 and 6) as the fin stock is advanced through these rolls with the backing roll **64** engaging the unslit base section **59** of the slit fin stock and forcing it into the groove **70** in the roll **66**. After the fin stock is formed into a U-shaped cross section it is passed through a hemming means in which the narrow portions **59***a* of the base section are folded over onto the remaining portion of the base section to form double thickness edges **59***b* on opposite sides of the base section while the slender fin members are retained in their outwardly extending position. This step is performed in the hemming means on the machine comprising the rolls **69**, **71**, **72** and **73** (shown best in FIGS. 8 and 9). As previously explained, the upwardly extending portions **59***a* of the base section are folded over onto the remaining portion of the base section **59** to form double thickness edge portions **59***b* while the fin sections **58** are retained in their outwardly extending position from the base section by the cooperation of the backing roll **71** and the two hemming rolls **72** and **73**.

In the preferred embodiment of the invention, the narrow upwardly extending portions **59***a* of the base section **59** which form part of a U-shaped cross section are of a width substantially 1/6 of the total width of the base section shown in FIG. 11. Thus, when these portions **59***a* are folded over to form the double thickness edge portions of the fin strip, they form a double thickness edge portion of a width approximately ¼ that of the remaining base section. The finned strip is then wound onto the surface of a tubular member with the base section in flatwise engagement with the surface of the tubular member and with the slender fin sections extending radially outward therefrom.

As best seen in FIG. 12, the double thickness edge portions **59***b* are ¼ the width of the remaining base section **59** and provide a spacing means for spacing the adjacent wraps of helically wound fin material on the tubing. The double thickness edge portions **59***b* of two adjacent wraps space the adjacent rows of fin sections **58***a* and **58***b* a distance apart substantially equal to the distance that the rows of fin sections **58***a* and **58***c* are apart on a single wrap of finned material. Thus all of the rows of fin sections are spaced apart equal distances in the finished tubular structure.

In the past, it has been a very difficult operation to form a finned surface structure with a serrated type fin member because the fin stock would not permit too great a wrapping tension before it would sever or break. By the present method, the base section of the fin member is formed into a substantially stronger structure prior to the wrapping operation thus permitting a much greater tension to be applied to the fin stock during the wrapping process. Furthermore, two rows of outwardly extending fin sections are helically wrapped simultaneously, therefore, increasing the overall wrapping efficiency. That is, by the present method it is possible to wrap two rows of finned sections simultaneously thereby doubling the wrapping speed.

While in accordance with the patent statutes there has been described what is at the present considered to be the preferred embodiment of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention and it is, therefore, the aim of the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. The method of making an extended surface heat exchange unit comprising the steps of providing a length of tubing and a longitudinal strip of sheet stock, slitting said strip of sheet stock inwardly from its opposite sides toward the center thereof at spaced intervals to provide a plurality of relatively slender fin members each connecting with an unslit center section extending lengthwise of said strip, folding opposite side portions of said strip including said slender fin members and narrow portions of

predetermined width of said center section materially less than one-half the width of said center section toward each other to form a substantially U-shaped cross section with said side portions including said narrow portions and said fin members constituting the respective arms of said U-shaped cross section and the remaining unfolded portion of said center section forming the base of said U-shaped cross section, folding said narrow portions over the remaining portion of said center section to form double thickness edges on opposite sides of the remaining portion of said center section while simultaneously bending said slender fin members in the opposite direction to retain said slender fin members directed perependicularly outwardly from said remaining portion of said center section and so as to be in spaced apart relation with each other due to the predetermined width of said folded narrow portions of said center section, coating said tubing with an adhesive and helically wrapping said strip of sheet stock formed by the preceding steps onto said tubing with said double thickness edge portions of each wrap lying closely adjacent the double thickness edge portions of the wraps on opposite sides thereof and with said slender fin members extending generally radially outward therefrom, whereby the fin members of adjacent wraps are spaced from each other by said adjacent double thickness edge portions.

2. The method of making an extended surface heat exchange unit comprising the steps of providing a length of tubing and a longitudinal strip of sheet stock, slitting said strip of sheet stock inwardly from its opposite edges toward the center thereof at spaced intervals to provide a plurality of slender fin members each connecting with an unslit base section extending the length of said strip, folding opposite sides of said strip including narrow edge portions of said base section of approximately 1/6 of the width of said base section on opposite sides of said base

section and the slender fin members extending therefrom at right angles with respect to the remaining portion of said base section to form a substantially U-shaped cross section in which the arms thereof are formed by said slender fin members and said narrow edge portions, reverse folding said narrow portions of approximately 1/6 of the width of said base section over onto the remaining portion of said base section to form double thickness edges on opposite sides of the remaining portion of said base section of a width approximately 1/4 the width of the remaining portion of said base section while simultaneously bending said slender fin members relative to said narrow portions to maintain said slender fin members directed perpendicularly outwardly from said remaining portion of said base section, coating said tubing with an adhesive, and wrapping said formed strip of sheet stock onto said coated tubing with the remaining portion of said base section in flatwise engagement with said tubing and said double thickness edge portions of each adjacent wrap in abutting relationship with each other and with said slender fin members extending radially outward therefrom.

References Cited in the file of this patent

UNITED STATES PATENTS

1,689,568	Wade	Oct. 30, 1928
2,053,239	Forrer et al.	Sept. 1, 1936
2,251,074	Sibley	July 29, 1941
2,307,355	Bredeson	Jan. 5, 1943
2,416,865	Bronander	Mar. 4, 1947
2,426,920	Bronander	Sept. 2, 1947
2,449,840	Brown	Sept. 21, 1948
2,553,142	McCreary	May 15, 1951
2,635,571	Edwards	Apr. 21, 1953
2,865,424	McElroy	Dec. 23, 1958