United States Patent

Venables, III

[15] **3,688,375**

[45] **Sept. 5, 1972**

[54] **MACHINE FOR MANUFACTURING HEAT EXCHANGER TUBE**

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[52] **U.S. Cl.** ....**29/202 D,** 29/157.3 AH

[51] **Int. Cl.** **B23p 15/26**

[58] **Field of Search**....113/1; 29/202 D, 202 R, 157.3 AH, 29/33

[56] **References Cited**

UNITED STATES PATENTS

3,005,253	10/1961	Venables	...........29/157.3 AH
3,134,166	5/1964	Venables	...........29/157.3 AH
3,160,129	12/1964	Venables	.................29/202 D

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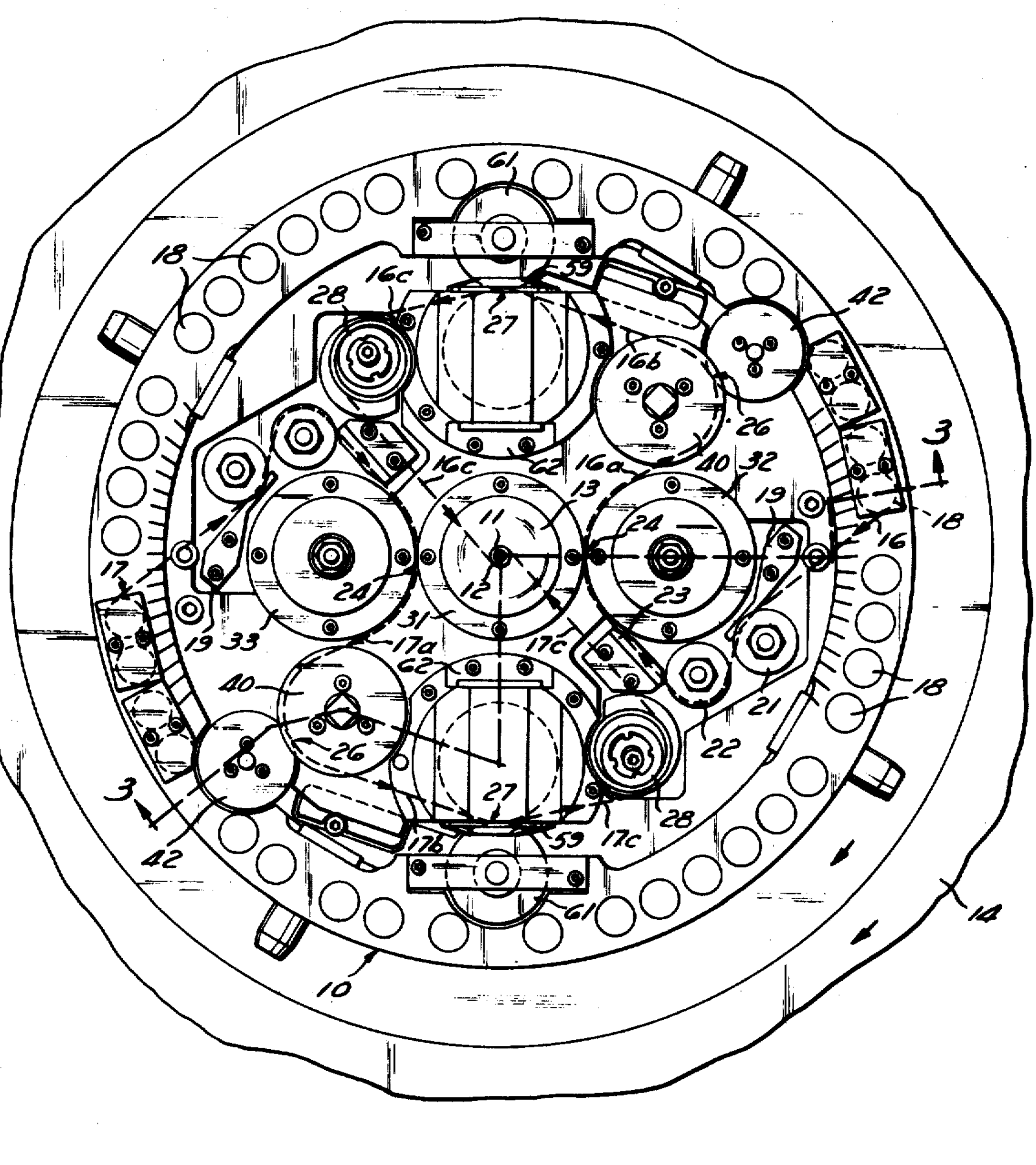
[57] **ABSTRACT**

Apparatus is disclosed for forming heat exchanger tubes having two helically wound foil strips each of which is provided with two lanced legs extending substantially perpendicular to the base tube. The foil stock is supplied from the interior of a coil consisting of two interleaved strips wound in a spiral form. The strips are separately fed and formed and are subsequently wound on an axially movable non-rotating tube. The winding head subassemblies are symmetrically positioned to provide dynamic balancing.

8 Claims, 14 Drawing Figures



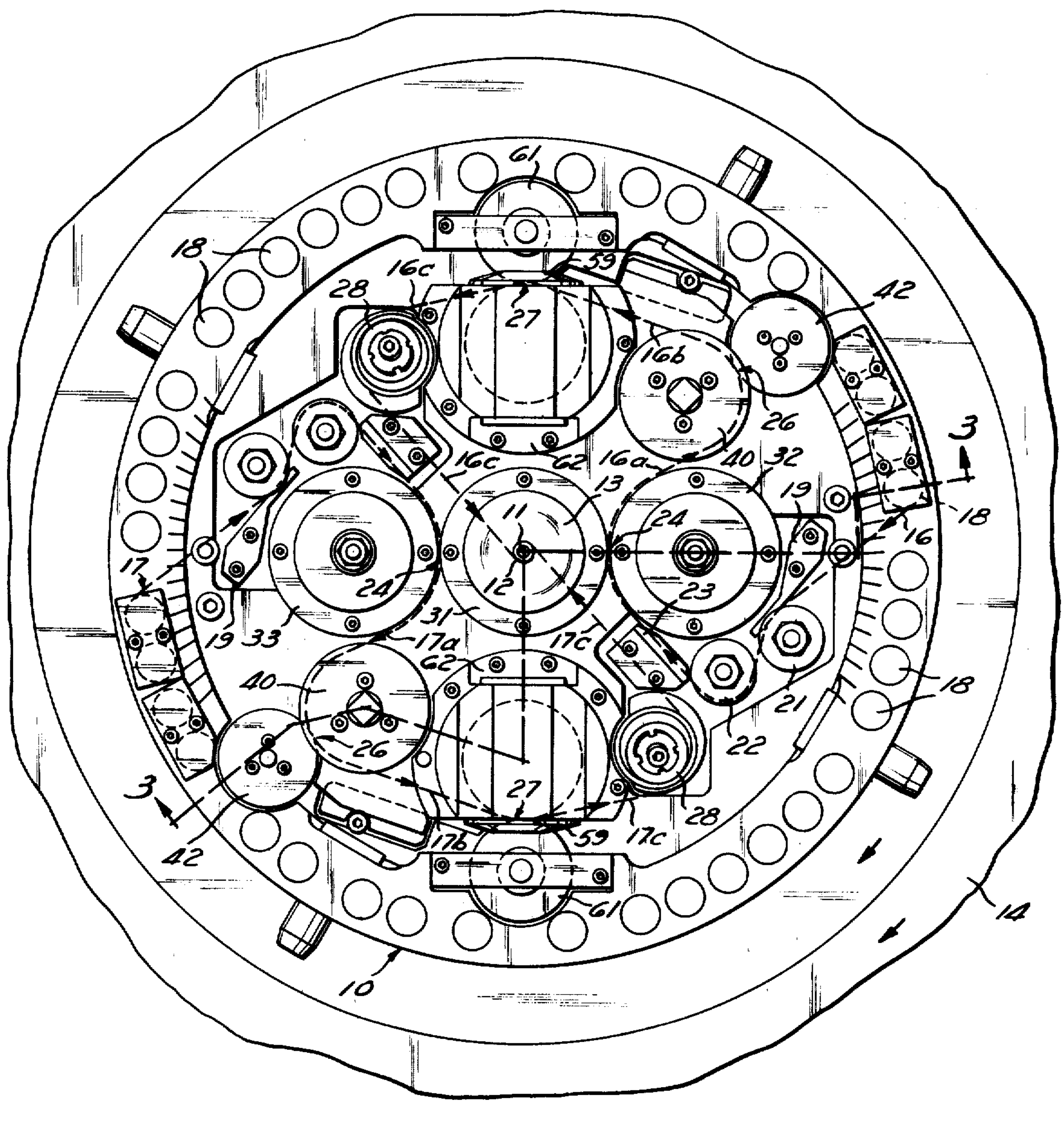


Fig. 1

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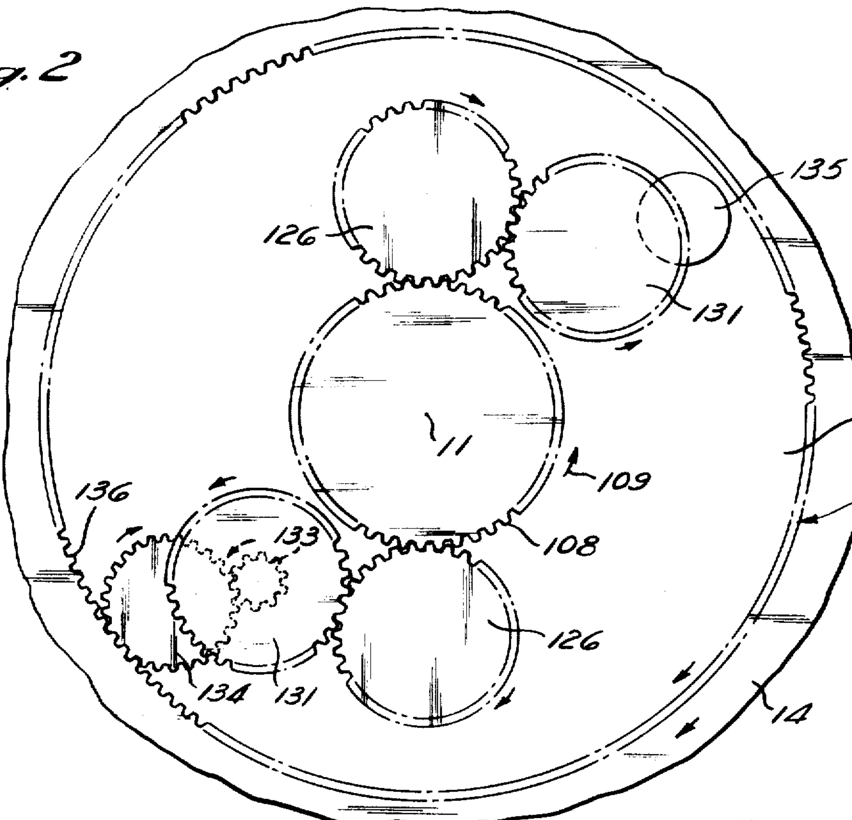
Fig. 2



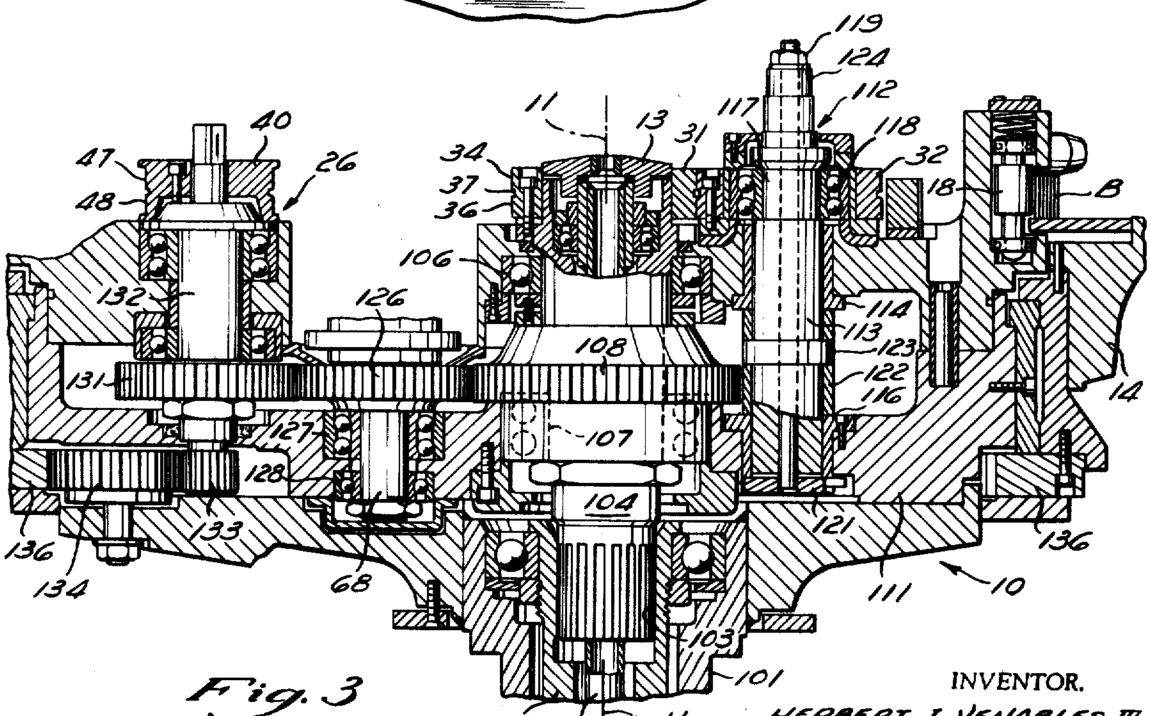


Fig. 3

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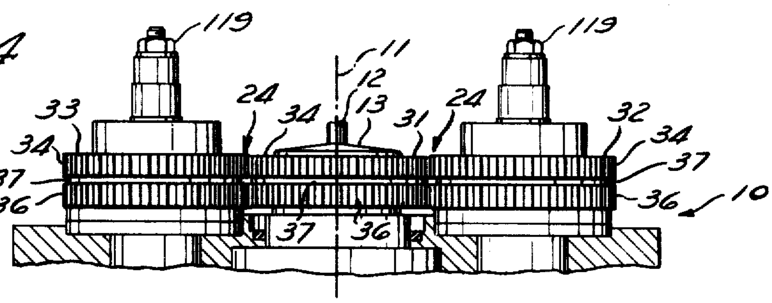
Fig. 4



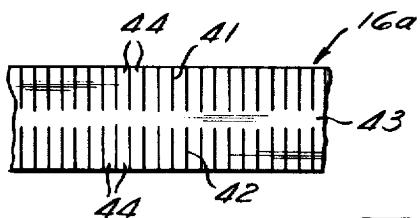


Fig. 4a

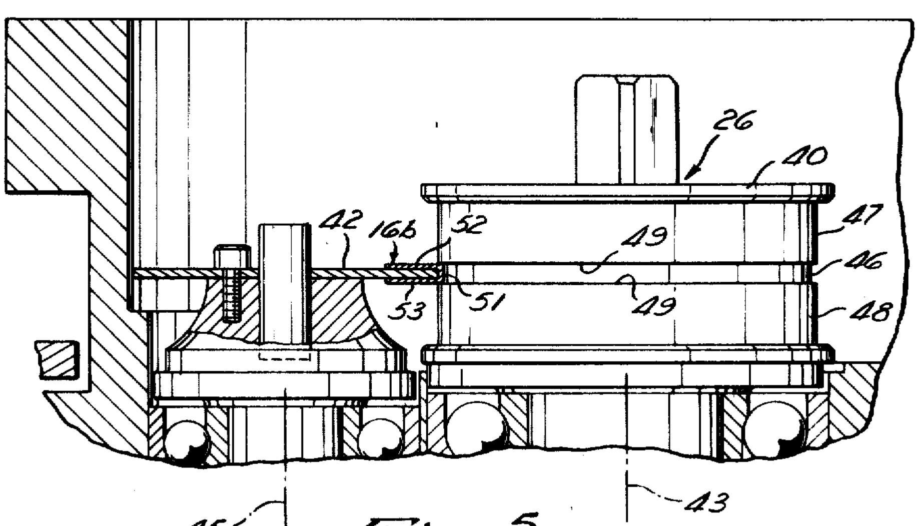


Fig. 5

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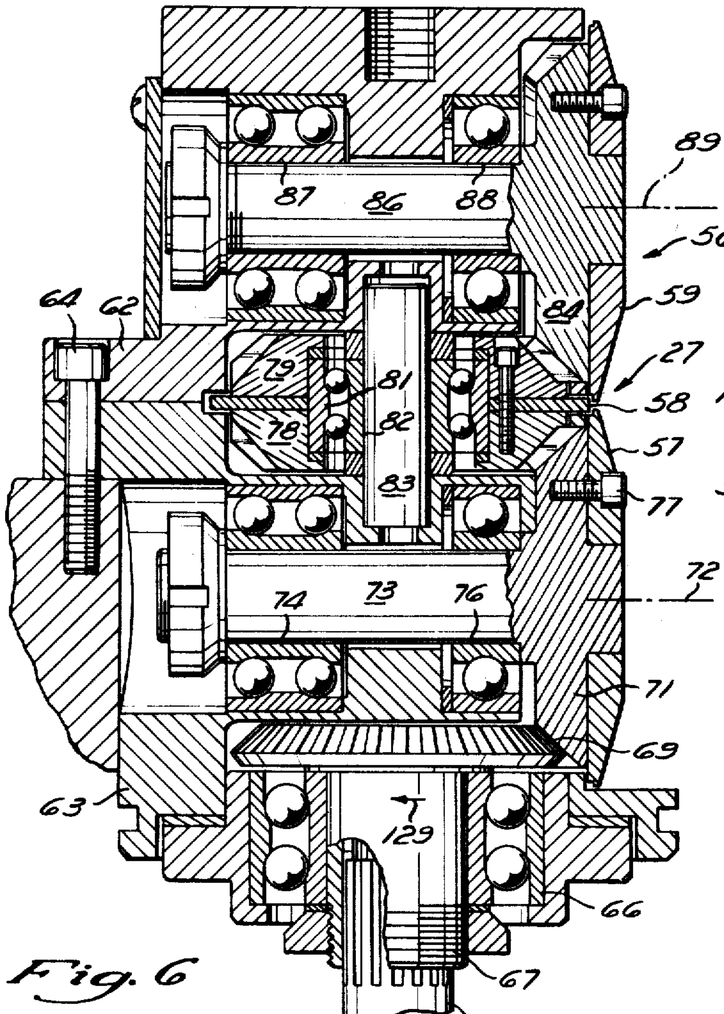

Fig. 6

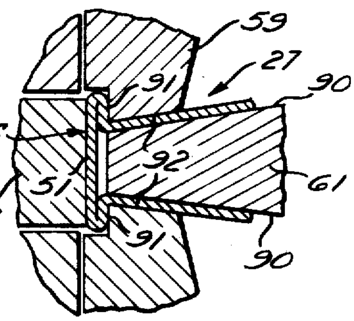

Fig. 6a

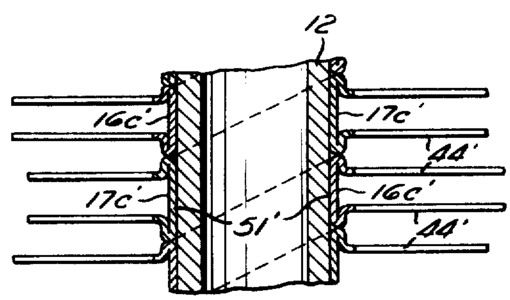

Fig. 7a

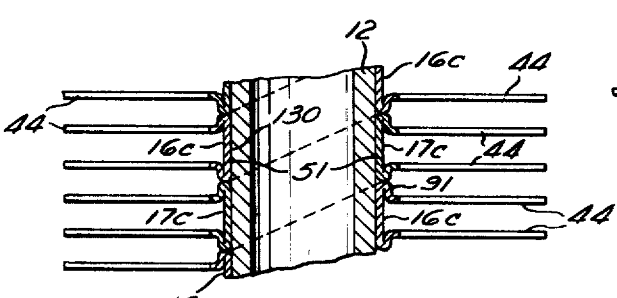

Fig. 7

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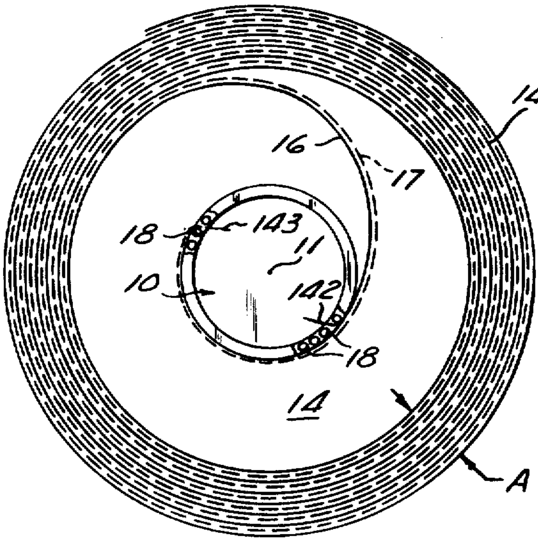

Fig. 8

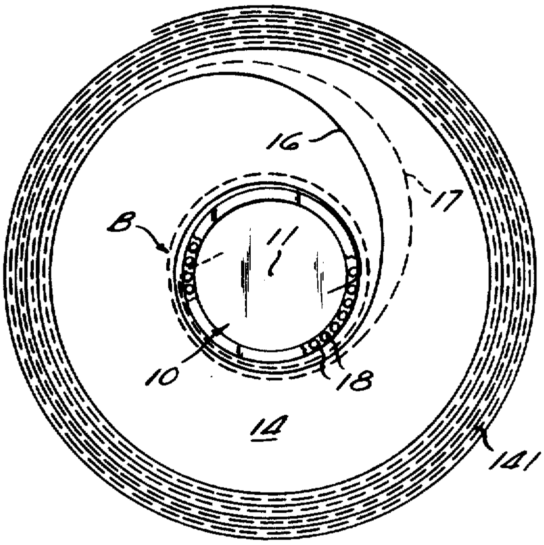

Fig. 9

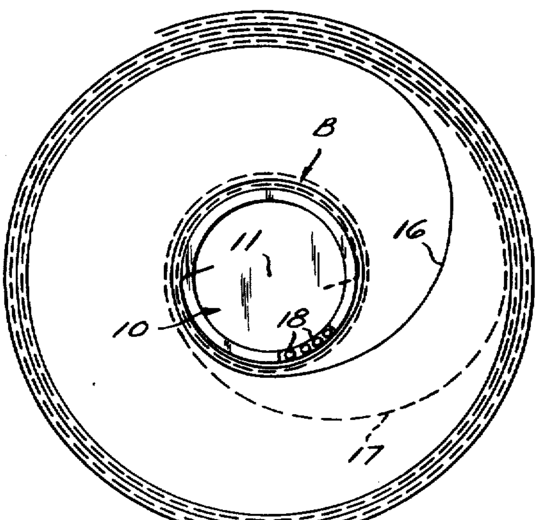

Fig. 10

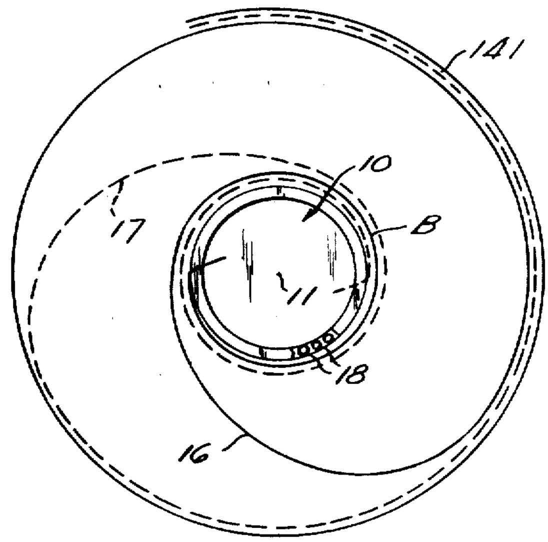

Fig. 11

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MACHINE FOR MANUFACTURING HEAT EXCHANGER TUBE

BACKGROUND OF THE INVENTION

This invention relates generally to the manufacture of heat exchanger tubes and more particularly to a novel and improved method and apparatus for forming such tubes and to a novel and improved heat exchanger tube produced by such method and apparatus.

PRIOR ART

The present invention is an improvement of the inventions disclosed in my prior U.S. Pats.; No. 3,005,253 of Oct. 24, 1961; No. 3,134,166 of May 26, 1964; and No. 3,160,129 of Dec. 8, 1964. Each of these prior patents relates to the manufacture of heat exchanger tubes in which the tube is helically wound with a strip of metal foil stock so as to provide a large external heat exchange surface for the efficient heat transfer through the tube wall. Although such tubing finds its greatest use in heaters and air conditioners, it may be used in many other types of equipment where efficient heat exchange is required.

SUMMARY OF THE INVENTION

The apparatus for forming heat exchanger tubing in accordance with the present invention involves means for the simultaneous winding of a tube with more than one continuous strip of metal foil from a rotating winding head. In the illustrated embodiment, two strips engage the tube at tangentially and diametrically opposite points of the tube and are simultaneously wound on the tube with a double helix, so that each turn of the winding head produces twice the length of wound tubing when compared to the prior machines of my patents referred to above.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view of the winding head of a preferred embodiment of this invention;

FIG. 2 is a plan view of the gear train drive for the various forming and feeding subsystems of the winding head;

FIG. 3 is a fragmentary broken section taken along 3—3 of FIG. 1;

FIG. 4 is a fragmentary section illustrating the foil lancing station;

FIG. 4*a* illustrates a strip after lancing;

FIG. 5 is an enlarged fragmentary section of one of the stations at which the foil is initially formed to a U-shape;

FIG. 6 is an enlarged fragmentary section illustrating the structure of one of the hemming stations;

FIG. 6*a* is an enlarged fragmentary section illustrating the forming operation which occurs at the throat of the hemming station;

FIG. 7 is an enlarged fragmentary section of one form of a novel and improved tube in accordance with this invention;

FIG. 7*a* is an enlarged fragmentary section of another form of a novel and improved tube in accordance with this invention; and

FIGS. 8–11 are schematic views progressively illustrating the manner in which the coils of foil stock are unwound as the machine operates.

DETAILED DESCRIPTION OF THE DRAWINGS

My prior U.S. Pat. No. 3,134,166 discloses a winding machine for the manufacture of heat exchanger tubing in which the tubing is fed up through the machine along the center of a winding head. Such machine is provided with feed rollers which operate to straighten the tubing and to insure that the tubing is circular in section. In such prior machine a single strip of foil stock is fed into the winding head and is lanced along opposite lateral extremities. The lanced foil strip is then formed to a U-shape and is subsequently hemmed to provide a base having a lateral width greater than the spacing between the lanced legs. The formed strip is then wrapped around the tubing in a single helix.

The method and apparatus in accordance with the present invention also utilizes strips which are first lanced, are subsequently formed to a U-shape, and are thereafter hemmed to the shape substantially as illustrated in such patent. However, the illustrated apparatus in accordance with the present invention is supplied with a coil consisting of two interleaved spiral strips of stock and the two strips are simultaneously formed and simultaneously wound onto the tube with a double helix rather than the single helix of such patent.

A number of distinct advantages are obtained with the present invention when compared to my prior machines as will be discussed in detail below. However, reference should be made to all of my prior patents, listed above, for a clear understanding of the background of the present invention and of the various advantages and features realized with the inventions disclosed therein. Therefore, such prior patents are hereby incorporated by reference.

In order to simplify the understanding of this invention only the winding head is illustrated and discussed in detail. Such winding head is preferably supported on a main frame as illustrated in my prior U.S. Pat. No. 3,134,166 and is driven by a lower drive gearing system as disclosed therein. The drive for feeding the tubing up through the winding head of such patent need only be modified to increase the rate of tube feeding compared to the rate of rotation of the winding head. For example, when the base width of the strip is the same as the base width of the strip formed on such prior machine, the rate of feeding of the tube is doubled by appropriate changes in the tube feed gear drive to accommodate the two strips which are simultaneously wound on the tube.

Referring to FIG. 1, the winding head, designated generally as **10**, is journaled for rotation about a vertical central axis **11**. The tube **12** to be wound is fed vertically upward through a stationary guide **13** along the central axis **11**. The entire winding head along with a stock support table **14** rotate in a counterclockwise direction as viewed in FIG. 1. However, the winding head **10** rotates at a speed slightly slower than the rotational velocity of the table **14**. The tube **12** moves only in a vertical direction and does not rotate.

Two separate but continuous strips of foil stock **16** and **17** indicated schematically by dotted lines, feed into diametrically opposite sides of the winding head **10**. The manner in which the supply coil is wound to provide two separate strips and the manner in which the strips move from the supply coil into the head is discussed in detail below.

Each of the strips **16** and **17** moves along a separate path to the tube **12**. However, the two paths are similar and are symmetrically arranged with respect to the central axis **11**. Since the two paths are similar, only one will be discussed in detail with the understanding that the detailed description applies equally to both paths. The strip **16** enters the winding head **10** by passing around a guide roller **18** at the periphery of the winding head. The strip then extends past a guide **19**, a pair of guide rolls **21** and **22**, and along a guide **23** to a lancing station **24** which is located substantially adjacent to the central axis **11**. The structure of the elements forming the lancing station and the operation of lancing is discussed in detail below.

From the lancing station **24** the lanced strips **16*a*** then passes to a first forming station **26** where the lanced strip **16*a*** is bent to a generally U-shaped configuration. From the first forming station **26** the U-shaped strip **16*b*** passes to a hemming station **27** wherein the strip is further formed to provide a hem at the edges of the base of the strip. From the hemming station **27** the hemmed strip **16*c*** passes around an inclined guide roll **28** which positions the hemmed strip for winding around the tube **12**.

Because of the composite movement resulting from the rotation of the winding head in a plane perpendicular to the axis **11** and the axial movement of the tube along the axis **11**, the hemmed strip is wound around the tube in a helical manner wherein the lead of the helix is equal to the amount of movement of the tube which occurred during one complete revolution of the winding head **10**. The strip **17** is similarly processed and moves along a similar but opposite path through a lancing station **24**, a first forming station **26** in which it is formed to a U-shape, and a hemming station **27**. From the hemming station **27** associated with the strip **17** the hemmed strip **17*c*** passes around an inclined guide roller **28** and passes to the tube **12** engaging the tube **12** tangentially directly opposite the engagement of the strip **16*c*** with the tube.

The various elements forming the winding head **10** are symmetrically positioned with respect to the central axis **11**. Therefore, the two lancing stations **24** are located on diametrically opposite sides of the axis **11** an equal distance therefrom. The two forming stations **26** are similarly located on diametrically opposite sides of the axis **11** equal distances therefrom. Similarly, the two hemming stations are equally spaced and diametrically opposite each other. In each instance the structure at each forming station is identical to the structure at the corresponding forming station for the other strip. Therefore, the basic structure of the winding head provides complete dynamic balancing with respect to the central axis **11**. It should be understood that dynamic balance is extremely important in such machine since the winding head and the structure associated therewith is relatively large and heavy and rotates at a speed in the order of 1,600 rpm or more.

Referring to FIG. **4**, the two lancing stations **24** are provided by a drive lancing roll **31** which is journaled for rotation about the central axis **11**. Similar idler rolls **32** and **33** are journaled on the winding head **10** on opposite sides of the drive roll **31** and each cooperates with the drive roll **31** to provide one of the lancing stations **24**. With this arrangement, two lancing stations **24** are provided with only three lancing rolls since the single drive lancing roll **31** functions as part of each of the lancing stations.

Each of the lancing rolls **31**, **32**, and **33** is formed with upper lancing teeth **34** and lower lancing teeth **36** separated by a space **37**. The lancing teeth intermesh so that the idler rolls **32** and **33** are driven by the drive roll **31** at the same rotational velocity as the drive roll **31** but in an opposite direction. The lancing teeth lance opposite sides of the strip **16*a*** as illustrated in FIG. **4*a*** so that the strip has cuts **41** and **42** extending in from the adjacent opposite edges, respectively, and terminating at spaced locations to provide a central uncut portion **43**. Between each cut **41** and **42** is a separate fin **44** which is joined to the uncut section **43** at its inner end.

From the lancing station **24** the strips **16*a*** and **17*a*** move to the respective first forming stations **26** one of which is illustrated in FIG. **5**. Located at each first forming station **26** is a driven roller **40** and an idler roller **42** which are respectively journaled for rotation about spaced and parallel axes **43** and **45**. The driven roller **40** is formed with a shallow annular groove **46** and cylindrical surfaces **47** and **48** on either side thereof. The total height of the space **46** and surfaces **47** and **48** is at least as great as the lateral width of the lanced strips so that the fins **44** are not damaged as the lanced strips engage the periphery of the roll **40**.

The idler roll **42** has a lateral width or height equal to the desired width of the U-shaped strip **16*b*** and **17*b***. This roll projects into the groove **46** and cooperates with the side walls **49** to deform the strip to a U-shape in which the strip has a base **51** and substantially parallel legs **52** and **53** extending from the opposite edges of the base **51**. The two strips **16*a*** and **17*a*** engage their respective driven rollers **40** at a tangential location spaced from the associated idler rollers **42** and are carried along the drive rollers until they engage the idler rollers **42**. At this location where the idler roller **42** projects into the groove **46**, the respective strips are deformed to a U-shaped condition.

From the first forming station each of the strips passes to a second forming or hemming station having a mechanism as illustrated in FIGS. **6** and **6*a***. Located at each hemming station **27** is a hemming assembly **56** which provides three interconnected forming rolls **57**, **58**, and **59** which cooperate with an idler roll **61** illustrated in FIG. **6*a***. The hemming assembly **56** is a separate assembly which may be installed in the winding head or removed therefrom as a unit. This greatly facilitates the servicing of the machine since a separate hemming assembly **56** can be serviced and adjusted while the machine operates with another hemming assembly in position.

The hemming assembly includes an upper housing member **62** and a lower housing member **63** which are bolted together and are in turn bolted to the winding head by bolts **64**. Journaled on the lower frame **63** in an antifriction bearing assembly **66** is an input drive shaft **67** provided with an internal spline adapted to fit over and be drivingly connected to a drive shaft **68**. The upper end of the shaft **67** is provided with a miter gear **69** which meshes with a miter gear **71** which is journaled for rotation about a horizontal axis **72**. The miter gear **71** is provided with a support shaft **73** journaled in bearings **74** and **76** in the lower housing **63**. The roller

57 is removably mounted on the forward face of the miter gear 71 by bolts 77.

The upper end of the miter gear 71 also meshes with a miter gear ring 78 which together with the base roll 58 and a second miter gear ring 79 form a ring assembly which is mounted on the outer race 81 of an antifriction bearing assembly 82. The bearing assembly 82 is in turn supported by a pin 83 mounted between the two housings 62 and 63 on a vertical axis intersecting the axis 72. The miter gear ring 79 meshes with a miter gear 84 which is similar to the gear 71 and which supports the upper roll 59. Here again the miter gear 84 is provided with a shaft section 86 journaled in bearings 87 and 88 for rotation about a horizontal axis 89 which intersects the axis of the pin 83 and is parallel to the axis 72 and vertically spaced therefrom.

The three rolls 57, 58, and 59 all have substantially the same diameter and rotate at the same velocity to minimize any tendency for skidding to occur when the strip is engaged. With this gear drive the adjacent surfaces of the three rolls move in the same direction. The various elements are proportioned so that the U-shaped strip 16*b* and 17*b* engages the base roll 58 ahead of the two rolls 57 and 59. As the strip is carried into the throat as illustrated in FIG. 6*a*, the two legs of the strip are deformed to provide a hem portion 91 extending inwardly from the edge of the base 51. The inner faces 92 of the two rolls 57 and 59 are formed with a shallow conical shape and cooperate with the conical side faces 90 of the idler roll 61 to insure that the fins 44 are substantially coplanar with their adjacent fins and to insure that the two legs diverge slightly.

The roll 61 is journaled for free rotation in response to engagement with the associated strip on a mounting spindle (not illustrated for purposes of simplification) which permits both vertical and radial adjustment of its position. With such adjustment the exact desired relative positioning of the side faces 90 with respect to the associated inner faces 92 can be obtained. Radial adjustment, because of the conical shape of the faces 90 and 92, provides adjustment of the total spacing therebetween and vertical adjustment permits equalizing of the spacing.

The hemmed strip 16*c* or 17*c* then passes around the associated inclined roll 28 which is positioned so that the respective strips are inclined upwardly toward the tube 12 at an angle substantially equal to the helix angle of winding. As the strips are wound on the tube the outer wall of the hem 91 is pulled tighter than the inner wall because of the difference in diameter, so the fins 44 are pulled inward and become substantially parallel.

FIG. 7 illustrates one form of a final heat exchanger tube which consists of the tube 12 and the two strips 16*c* and 17*c* which are wound on the tube with a double helix. The helix angle is such that the lead of the helix of each strip is equal to twice the width of the base 51 of each strip and the base 51 of the strip 16*c* is directly opposite the base 51 of the strip 17*c*. With such a helix angle the bases of the two strips engage opposite sides of the tube. In some instances where a spacing is desired between the two bases, the helix angle may be further increased by increasing the rate of feed of the tube during winding. This produces a space between the adjacent bases 51. In other instances where a wide space is desired, the winding head can be supplied with a single strip without changing the rate of tube feeding and a space will occur between the base of the strip along one turn and the adjacent turn which is equal to the width of the base which would otherwise be provided by the second strip.

FIG. 7*a* illustrates a modified form of tube wherein two strips of hemmed foil 16*c'* and 17*c'* are again wound on the tube 12' with a double helix. However, the base 51' of the strip 17*c'* is wider than the base 51' of the strip 16*c'* and the fins 44' of the strip 17*c'* are correspondingly shorter. In this form the stock for the two strips has the same initial width even though they are formed in different proportions. The two strips, however, do not have to have the same width when the strip shapes are not identical.

Reference should now be made to FIGS. 2 and 3 which illustrate the basic drive for the various elements of the winding head 10. The entire winding head 10 is supported on a tube 101 which is rotated about the central axis 11 by a drive system as illustrated in my prior U.S. Pat. No. 3,160,129. The drive in the illustrated embodiment causes clockwise rotation of the winding head as viewed in FIG. 2 in response to rotation of the drive tube 101.

Extending up through the drive tube 101 is an inner drive tube or torque tube 102. Here again this tube is driven by the lower drive unit in a clockwise direction as viewed in FIG. 2, but at a slower velocity than the winding head 10. A nonrotating guide tube 100 supports the guide 13. The drive tube 102 is formed with an internal spline 103 which engages a spline on a shaft 104 journaled in bearings 106 and 107, so that the shaft 104 is driven by the tube 102. The drive lancing roll 31 is carried by a shaft 104 and rotates therewith. Also mounted on the shaft 104 is a center drive gear 108.

Because the rate of rotation of the center drive tube 102 is slower than the rate of rotation of the winding head 10, the gear 108 and the lancing roll 31 rotate in an anticlockwise direction as indicated by the arrow 109 with respect to the winding head even though the absolute rotation of the gear 108 and lancing roll 31 is in a clockwise direction. For purposes of discussion the following description of the winding head drive refers to the rotation of the various elements of the winding head with respect to the main winding head frame as if the winding head frame were stationary and the various components of the winding head were rotated in a stationary winding head frame. It must be understood, however, that in fact the winding head itself is rotating and that the absolute rotational movement of the components is not necessarily in the directions set forth.

Because the gear 108 and the lancing roll 31 rotate about the central axis 11, the support bearings for these elements are not subjected to any substantial centrifugal force. Mounted in the frame assembly 111 of the winding head 10 is a pivot assembly 112 for each of the idler lancing rolls 32 and 33. This pivot assembly includes a pivot pin 113 supported by spaced bushings 114 and 116. During the operation of the machine the pivot pin 113 is clamped in its adjusted position, but it can be rotated with respect to the frame 111 for adjustment of the radial spacing of the associated idler lancing roll 32 or 33. The pin 113 is provided with an eccentric cylindrical surface 117 which supports the inner race of a bearing assembly **118**. Mounted on the external race of the bearing assembly **118** is the idler roll **32**. As the drive lancing roll **31** is rotated by the drive, the idler roll **32** is caused to rotate about the axis of the eccentric portion **117**. Radial adjustment of the idler roll **32** is provided by loosening a clamp nut **119** to release the clamping force of a clamp washer **121** to permit the, pivot pin **113** to be rotated. When the proper position is achieved, the nut **119** is tightened causing the clamp washer **121** to be pulled up against the lower side of the bushing **116** and causing it to be axially gripped by a spacer **122** which extends between a flange **123** and the upper side of the bushing **116**. The adjustment of the pivot pin **113** is easily accomplished by the use of a wrench on wrenching flats formed at **124** on the pin.

It should be recognized that this adjustment and mounting wherein the pivot pin **113** is not journaled for rotation with respect to the frame **111** permits the use of smaller bearings because the mass which must be supported by the bearings **118** is the roll **32** and the mounting parts adjacent thereto. Consequently, the only centrifugal forces which must be supported by the bearings **118** as the winding head rotates are the forces resulting from the relatively small mass of the lancing roll **32** and adjacent rotating parts. Of course, these bearings must also sustain the lancing loads.

Meshing with the central gear **108** are a pair of opposite gears **126** associated with each of the hemming assemblies. These gears are located at diametrically opposite locations with respect to the central axis **11** and both rotate in a clockwise direction with respect to the frame assembly **111**. FIG. **3** is a broken section so only one of these gears appears in the section.

The gear **126** is mounted on the shaft **68** which is in turn journaled in bearings **127** and **128**. The upper end of the shaft is provided with a spline which fits into the drive shaft **67** of the associated hemming assembly **56**. The clockwise rotation of the gear **126** is therefore transmitted to the first miter gear **69** illustrated in FIG. **6** as movement indicated in the direction of the arrow **129**. This causes movement of the lower portion of the miter gear **71** in a direction out of the plane of FIG. **6** and movement of the upper portion in the opposite direction or into the plane of FIG. **6** which is the desired direction of rotation for the roll **57**. Because of the interconnection of the three rolls discussed above, the movement of the adjacent portions at the hemming station is all in the same direction.

Each of the gears **126** meshes with an associated gear **131** which powers the roll **41** on a first forming station. Because of the clockwise rotation of the gears **126**, each of the gears **131** rotates in an anticlockwise direction with respect to the winding head frame assembly **111**. The gears **131** are connected through a shaft **132** to the drive roll **40** of the associated first forming station. This produces rotation of the drive rolls **40** in the correct direction with respect to the head. The drive shaft **132** is also provided with a smaller diameter gear **133** which also rotates in an anticlockwise direction and meshes with an idler gear **134** causing it to rotate in a clockwise direction at a velocity substantially slower than the velocity of the shaft **132** due to the difference in diameter of the two gears. The gear **134** meshes with a ring gear **136** which is mounted on the stock support table **14** to cause rotation of the stock support table **14** in a clockwise direction with respect to the winding head frame assembly **111**.

Preferably, the two first forming stations **26** are both provided with a gear **133** even though only one gear **134** is provided. With this arrangement the structure of the elements of the first forming stations are identical and interchangeable. Further, such an arrangement improves dynamic balance of the machine. The only nonsymmetry in the winding head is the single gear **134** which is not duplicated on the opposite side of the winding head. However, a weight **135** of identical mass is located opposite the gear **134** in the same physical location with respect to the central axis so complete dynamic balancing of the machine is achieved. Such dynamic balancing is, of course, important since the winding head rotates with a relatively high velocity and imbalance would cause extreme loads on the various bearing support systems.

Because the various gear elements are arranged so that proper rotational direction is obtained without need of idler gears or the like to reverse directions, a very simple gear train is provided even though the winding head is arranged to simultaneously process two strips of foil. The center gear **108** because of its central location, can be used to drive both of the gears **126**. Similarly, the gears **126** for each of the hemming stations are used to drive the gears **131** associated with the two first forming stations. The size of the gears are selective with respect to the size of the various rollers so that the strips are tensioned as they pass from one operation to the next and are actually stretched slightly at the time they are wrapped around the tube **12**. Consequently, the internal stress in each strip insures that each of the strips tightly adheres to the tube and a good heat exchange contact is provided. When the foil strips are formed of the same material as the tube these strips are directly wound onto the tube. However, when the tubing and the foil are formed of two different materials, such as aluminum and a ferrous metal, it is preferable to coat the tubing with a dielectric adhesive layer at **130** to prevent galvanic action between the two dissimilar metals. Such dielectric material is pumped into the tube **100** and coats the tube **12** as it passes therethrough. Such a layer is not required, however, for its adhesive function, although it tends to provide a bond between the tube and the foil strips.

Reference should not be made to FIGS. **8** through **11** which progressively illustrate the manner in which the stock of interleaved strips of material is fed into the winding head. In FIG. **8** a coil of stock **141** is illustrated on the stock support table **14** in a position around the winding head **10** and coaxial with the central axis **11**. This coil of stock consists of the two strips **16** and **17** wound in an interleaved double spiral. The strip **16** is illustrated in solid line and the strip **17** in dotted line for purposes of illustration. The strip **16** is threaded into the winding head **10** around the roller **18** and enters the head at **142**. The strip **17** however extends around the winding head over its associated roller **18** and enters the winding head at **143**, a location diametrically spaced from the location **142**.

Initially, the coil stock is spaced from the winding head **10** and has a thickness indicated at A. As the machine commences to wrap the tubing, the coil of stock **141** carried by the table **14** rotates in a clockwise direction at the same time the winding head rotates in a clockwise direction at a slower velocity. The two strips **16** and **17** unwind from the inner diameter of the coil **141** at a faster rate than the stock feeds into the winding head. This causes some of the stock to build up around the winding head and form an inner coil at B where it is guided by the rollers **18** carried by the winding head. The buildup of an inner coil continues until approximately one-half of the stock has been removed from the inside of the coil **141**. At this point in the cycle of operation illustrated in FIG. **10**, the thickness of the inner coil B is at a maximum thickness.

Continued operation of the machine approaching the condition of FIG. **11** wherein the outer coil **141** is almost exhausted results in the decreasing thickness of the inner coil as illustrated in FIG. **11**. Since the two strips are of substantially the same length, both strips are exhausted at about the same time. Of course, the inner of the two interleaved strips is shorter than the outer strip because it is wound on a spiral of smaller radius. However, the difference in length does not produce any problem since the manner in which the strips unwind from the outer coil and rewind on the inner coil accommodates the difference in length as illustrated by the progressive separation of the two strips extending from the outer coil to the inner coil. So long as the difference in length of the zone of interfacial contact between the two strips does not exceed the peripheral length of the outermost layer of such interfacial contact, the free portion of the outer strip **17** will not reach the free portion of the inner strip **16** and the two strips will feed properly. The manner in which the coils unwind and form an inner coil is described in more detail in my U.S. Pat. No. 3,134,166. The principal difference however, is that the two coils are not of the same length and it is necessary to accommodate this difference in length by arranging the mechanism so that the two strips can separate as they move from the outer supply or stock coil to the inner coil around the head.

With a machine in accordance with the present invention the lineal output of wound tube is doubled when compared to a prior single strip machine. The double wound tubing because of its greater helix angle tends to increase the turbulence of air flowing over the fins and thereby improves the heat exchange capacity of the tube. Further, the layer of the dielectric coating between the strips and tubes is more uniform since the lateral forces of the strips are balanced and the tube **12** is not pulled over against the guide **13**. Further, the double helix winding of the tube increases the helix angle of the stress zones which the strips produce in the base tube. Consequently, the tube is not as susceptible to rupture when it is bent for installation in the associated equipment.

The illustrated embodiment of the machine obtains such increased output with a simplified gear drive system. The machine is also arranged so that it may be easily serviced. For example, the idler lancing rolls can be easily removed and replaced and the hemming assembly can be easily removed and replaced. Since the load on the bearing of the lancing rolls is the greatest load involved in the forming operation, the central location of the lancing stations close to the central axis

11 reduces the load on the bearings by reducing the centrifugal force. Further, the two lancing operations are accomplished with only three lancing rolls. The use of hemming rolls located at right angles to each other further simplifies the structure of the machine and the drive of the various rolls.

Although preferred embodiments of this invention are illustrated, it is to be understood that various modifications and rearrangements of parts may be resorted to without departing from the scope of the invention disclosed and claimed herein.

What is claimed is:

1. A machine for winding strip material around a tube or the like comprising:

- a winding head rotatable about an axially disposed passage therein,
- means for advancing said tube at a governed rate through said axial passage,
- a coil support around said winding head supporting and rotating a coil consisting of a plurality of long strips wound in interleaved spirals,
- said winding head including feed means operable to separately and simultaneously feed said strips from the interior of said coil, forming means operable between said feed and winding means for forming each of said strips into a cross section having a base section and at least one leg section, and means to simultaneously wind the formed strips on the tube in a multiple helical form.

2. A machine as set forth in claim **1** wherein the rate said tube is advanced through said axial passage is at a rate timed with respect to the winding head rotation to wind said formed strips as a multiple helix in which the base sections of adjacent turns touch.

3. A machine as set forth in claim **2** wherein the forming means forms each of said strips into substantially U-shaped cross section having a base section and two spaced leg sections.

4. A machine as set forth in claim **3** including lancing means for separately and simultaneously lancing the edge portions of said strips fed from said coil,

- and said forming means includes means for separately and simultaneously forming said lanced strips into said U-shape with said lanced portions forming said legs, and hemming means operable to separately and simultaneously form a hem on each of said leg sections adjacent said base section.

5. A machine as set forth in claim **1** wherein the means for feeding, forming and winding of each of said strips are generally located on opposite sides with respect to said axis of said winding head.

6. A machine for winding strip material around a tube or the like comprising:

- a winding head rotatable about an axially and vertically disposed passage therein,
- means for advancing said tube at a governed rate vertically through said axial passage,
- a coil support around said winding head supporting and rotating a coil consisting of two strips wound in interleaved spirals,
- feed means including a pair of lancing stations symmetrically positioned with respect to said central axis for separately lancing a strip,
- a pair of first forming stations symmetrically positioned with respect to said central axis for initially forming a lanced strip,

and a pair of second forming stations symmetrically positioned with respect to said central axis for further formings of each strip,

said lancing stations being provided by a drive roll journalled for rotation around said central axis and two cooperating idler rolls journalled for rotation about axes on opposite sides of said central axis,

each idler roll cooperating with said drive roll to provide a lancing station on opposite sides of said drive roll.

7. A machine as set forth in claim 6 wherein the rate said tube is advanced through said axial passage is at a rate timed with respect to the winding head rotation to wind said formed strips as multiple helix in which the base sections of adjacent turns touch.

8. A machine as set forth in claim 7 wherein the formed strips tangentially engage diametrically opposite sides of said tube during winding of said strips onto said tube.

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