Aug. 12, 1958 W. F. MATHENY ET AL 2,847,055

APPARATUS FOR FORMING AND SPIRALLY WINDING A FIN STRIP ON AN ADVANCING TUBE

Filed Jan. 6, 1955 4 Sheets-Sheet 1

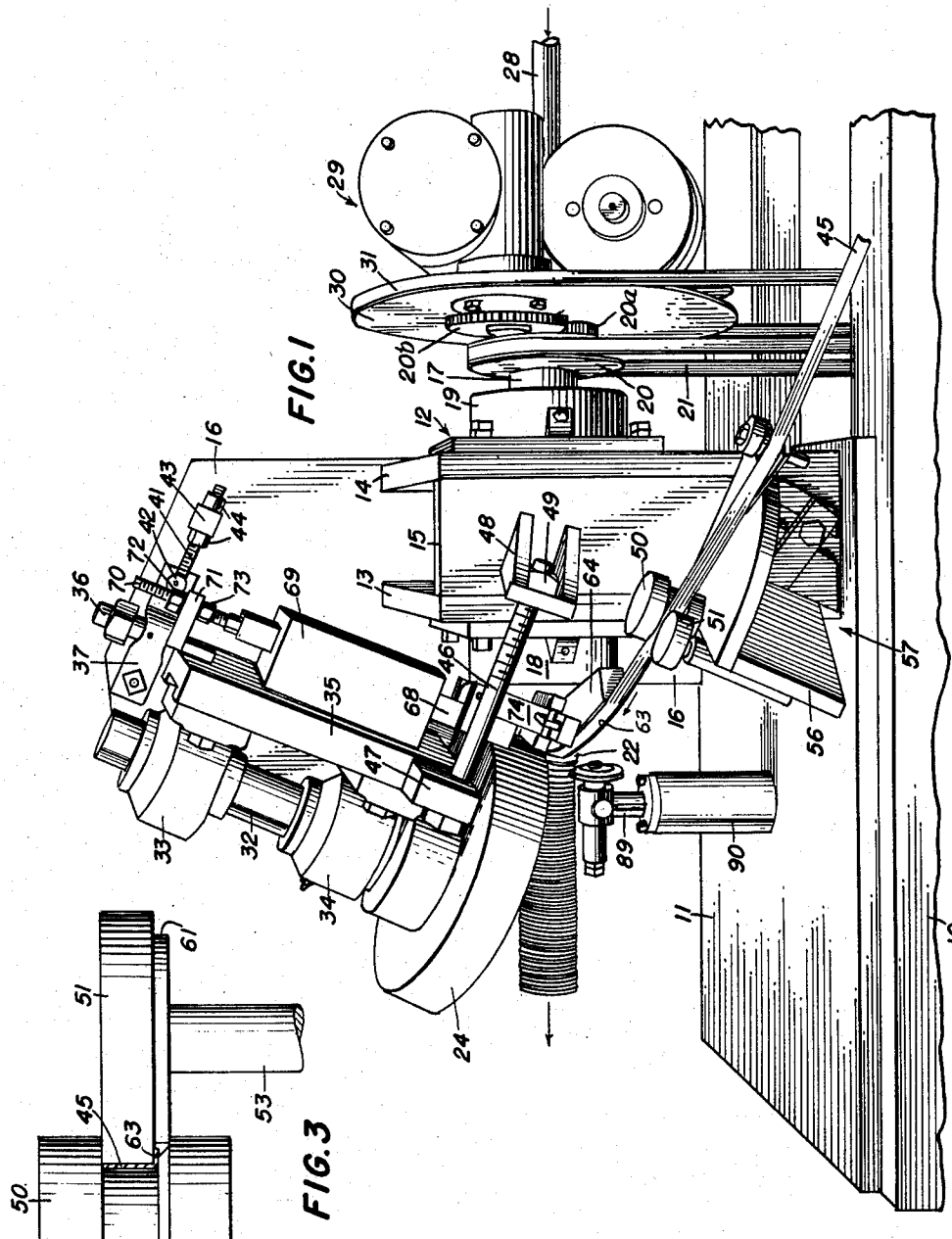


FIG. 1

FIG. 3

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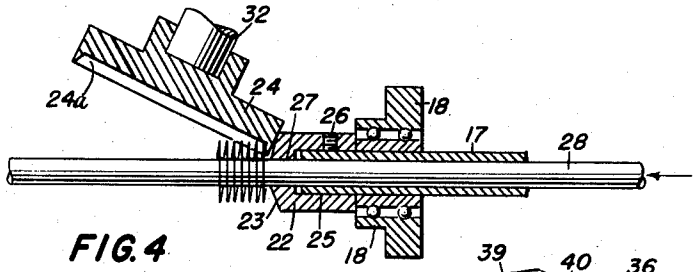


FIG. 4

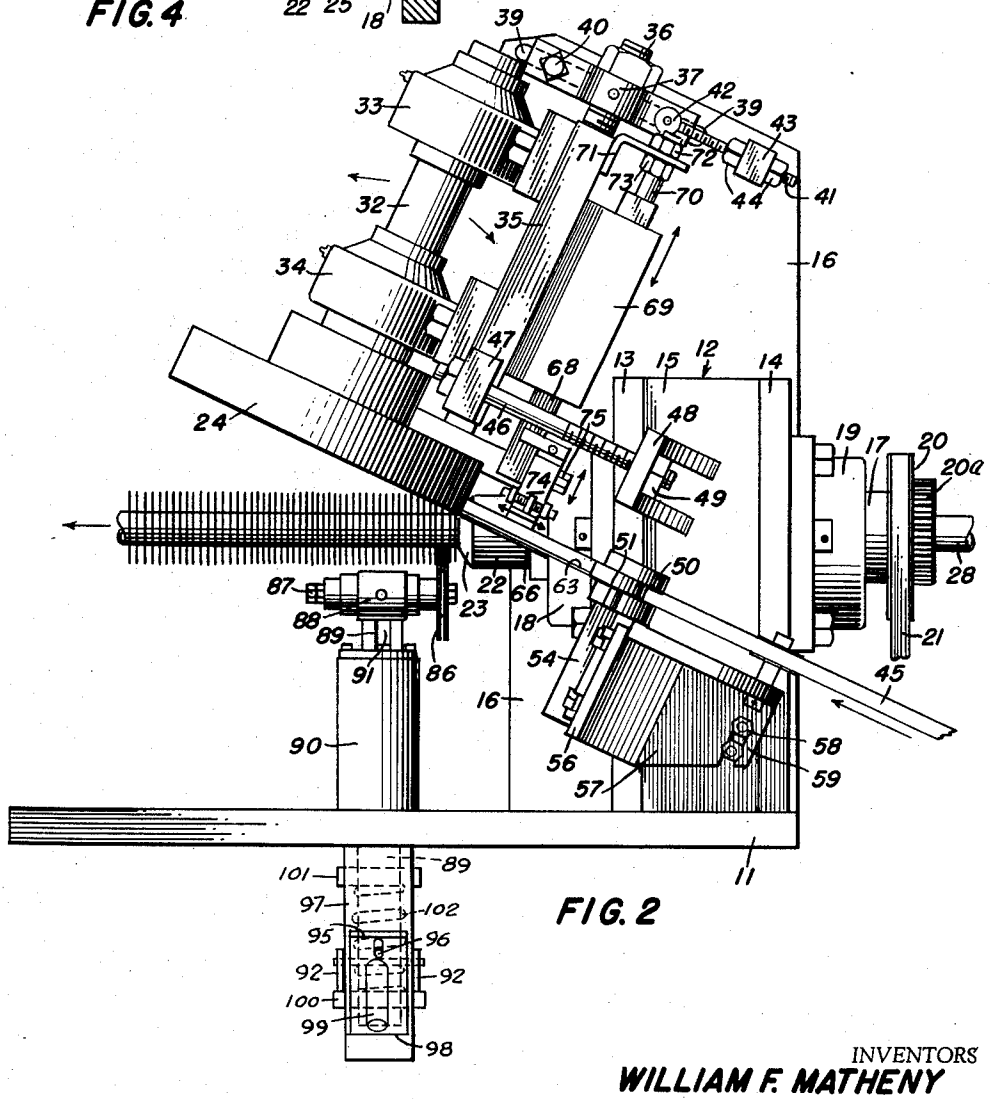


FIG. 2

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Aug. 12, 1958 W. F. MATHENY ET AL 2,847,055

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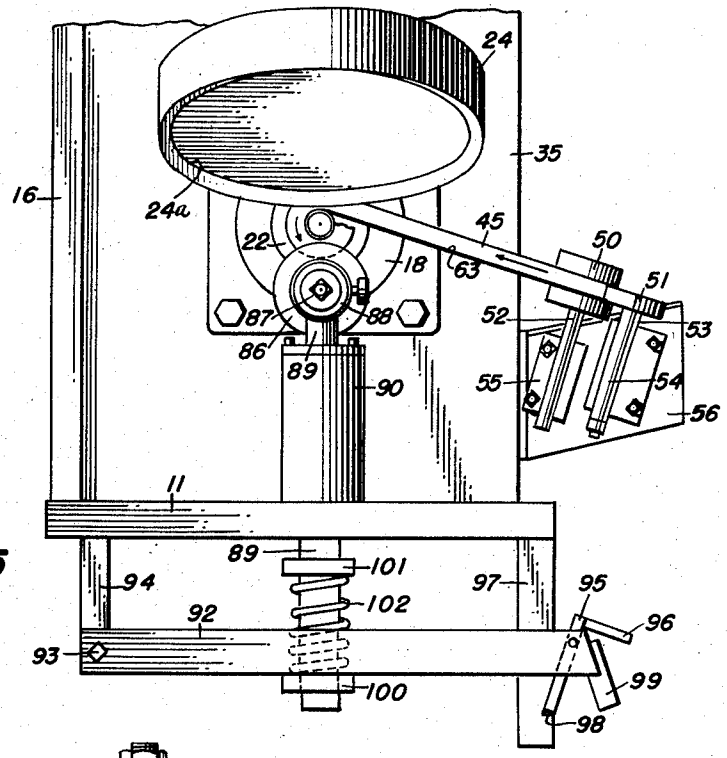


FIG. 5

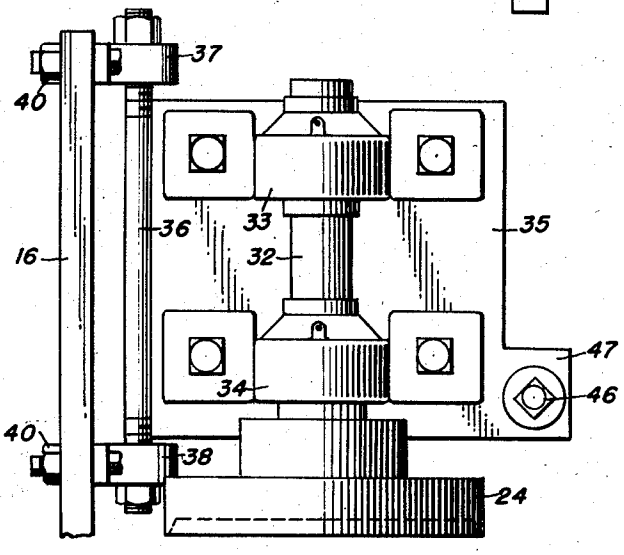


FIG. 6

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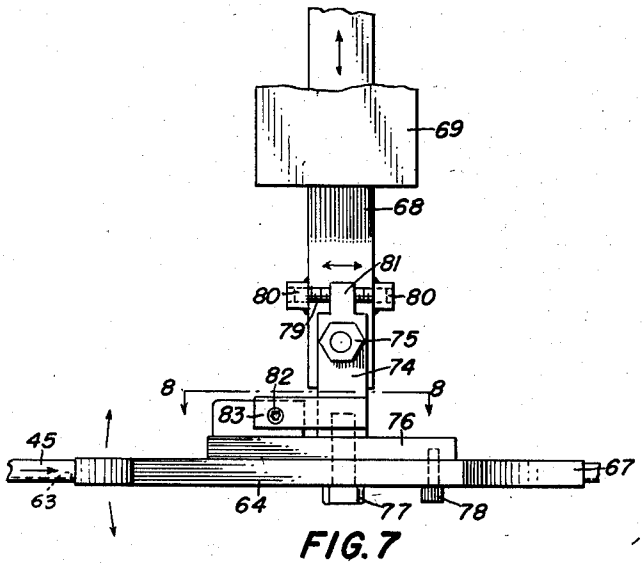


FIG. 7

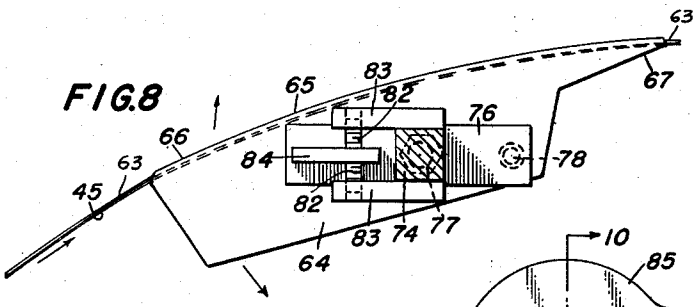


FIG. 8

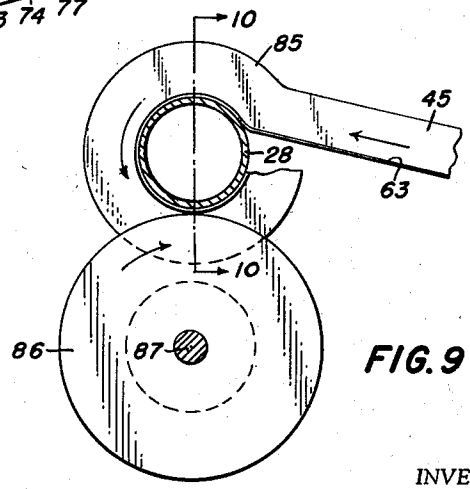


FIG. 9

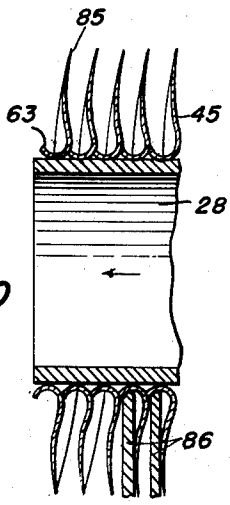


FIG. 10

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United States Patent Office 2,847,055
Patented Aug. 12, 1958

2,847,055

APPARATUS FOR FORMING AND SPIRALLY WINDING A FIN STRIP ON AN ADVANCING TUBE

William F. Matheny and William F. Matheny, Jr., Tulsa, Okla.

Application January 6, 1955, Serial No. 480,114

10 Claims. (Cl. 153—64.5)

This invention relates to apparatus for forming and shaping metal strips into edge wound spiral coils having integral flanges at their inner edges and simultaneously applying the helixes to longitudinally advancing, rotating tubes for use in the manufacture of heat exchange equipment and the like.

More particularly the invention consists in new and useful improvements in a method and apparatus for manufacturing finned tubing for heat exchangers, wherein a strip of flat metal is continuously fed first through an edge forming device adapted to initially provide a longitudinally extending angular flange along one edge of the strip and thence between two fin forming rolls designed to flatten and stretch the opposite or non-flanged edge of the strip while simultaneously presenting the strip to the periphery of a longitudinally advancing, rotating tube.

An object of the invention is to provide apparatus of this character having guide means associated with the fin forming rolls and adapted to present the successive convolutions of the coiling fins, to the supporting tube or core, in a non-radial plane which intersects the periphery of the tube so that the flanged edge of the strip contacts the periphery of the tube under a slight radial deforming pressure which in effect, causes the edge of the fin strip to flow onto the tube, as it is wound on the tube, whereby the convolutions of the coil are caused to firmly grip the tube and are maintained in place without the use of solder or other securing medium.

Another object of the invention is to provide a finned tube forming machine which is highly adjustable to facilitate and control the action of the forming rolls and the angle of presentation of the strip to the tubes.

A further object of the invention is to provide finned tube forming apparatus designed both for speed of operation and ease of adjustment and manipulation.

With the above and other objects in view which will appear as the description proceeds, the invention consists in the novel features herein set forth, illustrated in the accompanying drawings and more particularly pointed out in the appended claims.

Referring to the drawings in which numerals of like character designate similar parts throughout the several views,

Figure 1 is a perspective view from one side of the machine.

Figure 2 is a generally similar view in side elevation.

Figure 3 is an enlarged detail illustrating the preferred form of edge flanging device for the strip.

Figure 4 is a sectional detail of the fin forming and wrapping rolls.

Figure 5 is an end elevational view as seen from the left side of Figure 2 with the strip guide assembly omitted.

Figure 6 is an elevational view of the main forming roll mounting plate.

Figure 7 is a front elevation of the adjustable strip feeding assembly.

Figure 8 is a sectional view of the same, taken on line 8—8 of Figure 7.

Figure 9 is a transverse sectional view through a tube in the course of being wrapped and swedged, and

Figure 10 is an enlarged sectional view through a finned tube, taken on line 10—10 of Figure 9.

In the drawings, **10** represents a horizontal machine bed having a platform **11** at one end. The platform **11** has welded thereon an upstanding frame or support **12** which may be formed of a pair of transversely extending, side plates **13** and **14** having an end plate **15** welded between the vertical edges of the side plates at one end of the frame. The edges of the side plates **13** and **14** at the opposite end of the frame are welded to a main supporting plate **16** which as seen in Figures 1 and 2, extends vertically beyond the frame **12** and laterally to one side thereof. The bottom edges of all of the plates **13**, **14**, **15** and **16** are welded to the platform **11** to form a rigid supporting structure for the various parts of the apparatus, as will hereinafter appear.

Each of the side plates **13** and **14** is provided with openings to receive a hollow shaft **17** rotatably supported by aligned bearings **18** and **19**, secured to the side plates **13** and **14** respectively. A drive pulley **20** runs on a bearing which is pressed on shaft **17** and suitably secured to the pulley, a gear **20a** being fixed to one side of the pulley to drive the sun gear **20b** of a system of planetary gears hereinafter referred to. The pulley **20** is driven by a belt **21** running from a source of motive power (not shown). The opposite end of the hollow shaft **17** carries a forming roll **22** (Figs. 2 and 4) having a beveled nose **23** which as will later appear, is adapted to cooperate with a second angularly disposed forming roll or wheel **24**, in forming and applying a continuous strip of metal to a length of tubing in the fabrication of finned tubes. The forming roll **22** is longitudinally recessed as at **25** from one end, to receive the end of the hollow shaft **17** and a set screw **26** may be provided for firmly securing the roll **22** to the shaft **17**, so as to rotate therewith, as will be seen from Figure 4.

The inner end of the forming roll **22** abuts the annular face of bearing **18** which serves the dual purpose of a rotary bearing for the hollow shaft **17** and an end thrust bearing for the forming roll **22**.

An axial opening **27** is provided in the nose of the forming roll **22** to receive the tube **28** which forms the core of the finned tubing being fabricated, so that the annular bevelled nose **23** guides and supports the rotating and advancing tube **28** which is projected through the control bore of the hollow shaft **17**. Any suitable means may be employed for rotating and advancing the tube **28** such as shown at **29** in Figure 1. The details of the mechanism **29** are not important to the present invention but it will be understood that a main drive pulley **30**, driven by a belt **31**, running from a source of motive power (not shown), and operated through some such mechanism as a train of planetary gears, may be employed for this purpose. One form of mechanism for accomplishing this purpose is shown in the copending application of W. F. Matheny, Serial No. 343,944, filed March 23, 1953, and issued September 18, 1956 as Patent No. 2,763,364.

The complementary forming wheel **24** is carried at one end of a shaft **32** rotatably supported in bearings **33** and **34** on an adjustable supporting plate **35**. As seen in Figures 4 and 5, the forming wheel **24** is in the form of solid circular disc having its under face dished out as at **24a**, to accommodate the radial fins which have been formed and applied to the tube **28** by the action of the nose roll **22** and the periphery of the angularly disposed forming roll **24**, as will be described later on. The supporting plate **35** is hingedly mounted at one

vertical edge, by means of a shaft 36 welded to the edge of the plate 35 and projecting vertically beyond the upper and lower extremities thereof, where it is rotatably embraced by bearings 37 and 38, bolted to the fixed supporting plate 16 of the main supporting frame 12. As seen in Figure 2, where only the bearing 37 is shown, the fixed plate 16 is slotted as at 39 to receive the bearing bolts 40, whereby the bearing 37 is adjustable laterally in a plane parallel to the plate 16. This same arrangement is provided for the lower bearing 38 and the bearings 37 and 38 are preferably of the universal type to provide for minute adjustment of the angular position of the forming wheel 24 with respect to the forming nose 23, by manipulation of the bearings 37 and 38, to change the angle of the axis of the shaft 36 with respect to the axis of the hollow shaft 17 and the forming nose 23. To facilitate the adjustment of the shaft 36 and bearings 37 and 38, a set screw arrangement 41, fixed to one end of the housing of bearing 37, as at 42, passes through a lug 43 secured to the plate 16. Lock nuts 44 retain the set screw 41 in adjusted position.

The hinged plate 35 carrying the forming wheel 24 and its shaft 32, is adjusted by the means just described, to regulate the angle of contact of the periphery of the wheel 24 with the nose 23 of the forming roll 22, so that as the ribbon 45 passes between the two forming elements, the degree of deformation of the strip can be predetermined. In other words, as will later appear, it is desirable to subject the outer edge of the fin strip 45 to a deforming or flattening pressure as it passes between the forming elements, so as to stretch the outer edge and cause the strip to courve around the axis of the tube 28 in the form of a helix. Thus, the angle of contact between the periphery of the forming wheel 24 and the nose 23 is such that the periphery of said wheel 24 lies more closely to the outer edge of the frustoconical nose 23, than to the inner edge thereof. Obviously, by increasing the proximity of the adjacent peripheries of the forming elements toward the outer extremity of the nose 23, the resulting curve or curling of the fin is rendered more acute to determine the ultimate shape of the ribbon as it is presented to the tube 28 and wrapped thereon.

After this angle of contact has been set, the hinged plate 35 is maintained in locked position by a lock bolt 46 which extends through a fixed lug 47, attached to the edge of the plate 35, with its other end engaging a lug 48 fixed to the plate 15 of the supporting frame 12. The lock bolt 46 is threaded to receive a nut 49 by means of which the pressure of the forming wheel 24 against the forming nose 23, may be governed. Obviously, this hinge arrangement also permits the plate 35 and the elements supported thereby, to be retracted from the tubing being worked upon.

The metal strip 45 is fed from a reel (not shown) and before entering between the forming elements 22 and 24, is preformed with a longitudinal flange or substantially right angular leg along one edge so as to provide a base for supporting the fin on the tube 28. The preforming mechanism consists of a pair of complementary guide rolls 50 and 51, respectively mounted on shafts 52 and 53, rotatably supported in bearings 54 and 55. The bearings 54 and 55 are bolted to the front plate 56 of a bracket 57, bolted to the plate 15 of frame 12 as at 58 in Figure 2. A slot arrangement 59 cooperates with the bolts 58 to permit the adjustment of the bracket 57 to align the preforming mechanism 50—51 with the strip feeding guide to be described.

Although various forms of preforming mechanisms may be employed, the arrangement shown in Figure 3 has proven satisfactory. Here it will be seen that the main roll 50 is provided with a peripheral recess 60 of a transverse dimension to receive the periphery of the complementary roll 51. The latter is provided with an annular recess 61 at its lower edge, shaped to accommodate a radial inclined ridge 62 at one side of the recess 60 in the roll 50, with sufficient clearance therebetween to permit the lower edge of the strip 45 to be bent at an angle into the recess 61, thus forming a foot or base flange 63, along the lower edge of the strip 45 as the strip leaves the preforming rolls. It will be seen in Fig. 3 that the width of the recess 60 is the same as that of the unbent strip 45 and there is just sufficient clearance between the lateral margins of the recess and the lateral edges of the roll 51 to receive the latter with a running fit. Thus, the roll 51 is kept vertically centered in recess 60 of roll 50, to prevent the strip from being cut as the flange 63 is being turned. The inclined ridge 62 facilitates the bending operation by making it more gradual.

Turning now to the strip feeding assembly shown in detail in Figures 7 and 8, it will be seen that a guide plate 64 forms the means for presenting the strip 45 to the forming elements 22—24, after leaving the preforming rolls 50—51 which are located anterior to the feeding device. The guide plate 64 consists of an elongated plate having an arcuate edge 65 on one side bounded by a pair of parallel spaced guide flanges 66 between which the strip 45 passes over the arcuate surface. The feeding end of the plate 64 terminates in a reduced tapering nose 67 which forms a continuation of the arcuate edge 65 and is adapted to be positioned so as to properly direct the strip 45 between the forming elements 22 and 24.

It is important to the proper operation of this apparatus, that the guide plate 64 be capable of adjustment in three different planes. In other words, it must be adjustable in a substantially vertical plane toward and away from the axis of the tube 28 on which the strip is being wound, to control the elevation of the feeding nose 67 with respect to the tube 28. It must be rotatably adjustable about a substantially vertical axis to control the distance of the nose 67 from the tube 28 and it must be rotatably adjustable about a horizontal axis to regulate the angle of presentation of the strip 45 to the tube 28. This latter adjustment is to facilitate the proper feeding of the strip 45 onto the tube 28 in a non-radial plane which intersects the periphery of the tube so that the flanged edge 63 of the strip contacts the periphery of the tube under a slight radial deforming pressure which as previously stated, causes the edge of the fin strip to flow on to the tube.

This triple adjustment is accomplished by mounting the strip feeding assembly on a supporting bar 68, slidably mounted in a guide block 69 which is welded to the supporting plate 35 as will be seen in Figures 1 and 2. The supporting bar 68 is adjustable longitudinally, by means of a screw threaded member 70 secured to the upper end of the bar and projecting through a bracket 71 welded to and projecting laterally from the plate 35 and after the proper longitudinal adjustment is made, lock bolts 72 and 73 are screwed into engagement with the intervening bracket 71.

The lower end of the supporting bar 68 carries an intermediate connecting link 74 which is offset and pivotally mounted on one side of the bar 68, by a horizontal pivot 75 and extends downwardly into abutting relation with a mounting strip 76 which, together with the guide plate 64 is pivotally mounted on the lower end of the link 74 by a vertical pivot bolt 77 which extends through both the plate 64 and the strip 76 and into the lower end of the link 74, as seen in Figure 7. A lock screw 78 extending through the plate 64 and into the strip 76 prevents rotary movement of the latter relative with the plate 64.

Adjustment of the guide assembly about the horizontal axis 75 is accomplished by means of two opposed adjusting screws 79 extending through complementary threaded ears 80 welded to opposite sides of the supporting bar 68, with their inner ends in abutting relation to an intervening lug 81, formed integrally with and pro-

jecting upwardly from the link **74**. Thus, by manipulating the adjusting screws **79** to force the lug **81** either in one direction or the other, the link **74** and the assembly suspended therefrom, is caused to describe an arc about the axis **75** to either elevate or lower the nose **67** of the guide plate **64**.

A generally similar arrangement is employed for affecting the adjustment of the feeding assembly about the vertical axis **77**. As seen in Figure 8, a pair of adjusting screws **82** are supported in opposed relation by a pair of spaced ears **83** welded to opposite sides of the link **74**. The inner ends of the screws **82** abut an upstanding lug **84** which is welded to the upper face of the strip **76** and is interposed between the screws **82**. Thus, by manipulating the screws **82**, the lug **84**, the strip **76** and the guide plate **64** are rotated about the axis **77** to control the proximity of the nose **67** with respect to the tube **28**.

With the guide plate **64** and its nose **67** properly adjusted, the fin strip **45**, with its preformed base flange **63**, is fed between the forming roll **22** and forming wheel **24**, with the flanged edge **63** advancing into engagement with the tube **28** in a non-radial plane which intersects the periphery of the tube **28** as shown in Figure 9. The action of the forming roll and wheel flattens and stretches the outer edge **85** of the strip **45**, causing the strip to coil about the tube **28** as the opposite flanged edge **63** of the strip is being slightly radially deformed and caused to flow on to the tube **28** which is continuously rotating and advancing through the hollow shaft **17** carrying the nose roll **22**. The result of this operation is a tight binding of the flanged edge **63** of the strip on to the tube **28** which avoids the necessity of soldering or other securing medium.

However, in order to provide a more effective gripping action and to produce a more finished product, it is desirable to employ a swedging roll which engages the base flange **63** of the advancing convolutions of the coil and presses it firmly into engagement with the tube **28**. This swedging roll consists of a pair of parallel discs **86** spaced on a horizontal axle **87** a sufficient distance to accommodate the fin strip **45**. The axle **87** is rotatably mounted in a bearing **88** carried at the upper end of a vertical rod **89**, which is reciprocably mounted in a support **90** secured to and projecting upwardly from the platform **11**, as seen in Figures 2 and 5. A longitudinal slot **91** in the periphery of the rod **89** engages a key within the support **90** to prevent rotation of the rod **89** and displacement of the swedging rolls **86**.

The swedging roll **86** is maintained under a spring tension in its engagement with the fin tube and is retractable from the latter by means of a releasable mechanism shown in Figures 2 and 5. A pair of spaced cross arms **92** are pivotally mounted at one end as at **93**, on an intervening vertical leg **94**, said cross arms having pivoted between their opposite ends a latch member **95** having a handle **96**. A second vertical leg **97** also extending from the platform **11**, has a notch **98** for engagement by the latch **95**. A grip **99** is fixed to the end of the cross arms **92** of the assembly for elevating the arms into locked position. The swedging roll supporting rod **89** extends between the spaced cross arms **92** and has fixed thereto an abutment **100** which is also secured to the undersides of the cross arms **92**. Between the abutment **100** and a collar **101**, spaced upwardly on the rod **89**, is a coil spring **102** which, when the cross arms **92** are in their upper or locked position, causes a spring tension on the rod **89**, forcing the same upwardly and with it the swedging roll **96**. When it is desired to release the swedging roll from the tube **28**, the operator trips the handle **96** upwardly, releasing the latch **95** from the notch **98** which permits the cross arms **92** and with them the rod **89** and swedging roll **86**, to be lowered. The elements are returned to operative position by simply lifting the grip **99** until the latch **95** engages the notch **98**.

It will thus be seen that in operation, as the constantly

rotating and advancing tube **28** emerges from the bore of the forming roll **22**, the preflanged strip **45** is presented to the periphery of the tube and between the periphery of the forming wheel and the nose **23** of the forming roll. The upper edge of the strip is flattened and stretched to form a coil about the tube **28** and as previously explained, the flanged edge of the strip being presented in a non-radial plane which intersects the periphery of the tube, it is deformed by the tube and caused to firmly grip the tube during its advance. The flanged edge is then swedged on to the tube by the swedging rolls **86** to progressively complete the formation and wrapping of the convolutions of the coiled fin tube. As a result of this operation there is provided a very rigid fin tube structure wherein the base of the fins is firmly supported all along the tube without the need of additional securing means such as solder, etc.

By means of the triple adjusting mechanism for the feeding plate **64**, the most minute adjustment is made possible to facilitate the use of different materials and to regulate the pitch of the convolutions of the coiled fin.

It is to be noted that the present invention is primarily designed for the manufacture of flat or smooth helical finned tubing, as distinguished from the corrugated types and the relationship of the forming wheel to the forming nose is such as to enable the simultaneous forming and winding of a minute fin on extremely small tubing. Considerable difficulty has been encountered in the past, in the manufacture of finned tubing of small diameter such as is required in the fabrication of automotive radiators and the like. However, with the present invention, by employing a hollow guide shaft having protruding therefrom a substantially frusto-conical smooth forming nose with a coaxial opening to receive the advancing tubing, and arranging the complementary forming wheel on an inclined fixed axis which intersects the axis of the hollow shaft so that the periphery of the wheel is directly opposed to the periphery of the nose, a fin of extremely small radial extent may be formed.

From the foregoing it is believed that the invention may be readily understood by those skilled in the art, without further description, it being borne in mind that numerous changes may be made in the details of structure without departing from the spirit of the invention as set forth in the following claims.

What we claim:

1. In apparatus for forming spirally wound finned tubing, including a hollow guide shaft, means for rotating said shaft, and means for continuously rotating and advancing longitudinally through said shaft, a length of tubing; a strip feeding and fin forming assembly comprising a forming roll fixed coaxially on the exit end of said hollow shaft and rotatable therewith, said roll having protruding therefrom, a substantially frusto-conical smooth forming nose with a coaxial opening to receive said advancing tubing, said nose being rotatable in the same direction and at the same rate of speed as said advancing tubing, a complementary forming wheel freely mounted for independent rotation, on an inclined fixed axis which intersects the axis of said hollow shaft, the periphery of said wheel having a smooth forming surface concentric with the axis of the wheel and arranged in opposed relation to the periphery of said nose, a strip feeding device for delivering a continuous strip of metal between the opposed peripheries of said wheel and nose, and means for adjusting the angle of the axis of said wheel to regulate the plane of presentation of the periphery of said wheel to the periphery of said nose.

2. In apparatus for forming spirally wound finned tubing, including a hollow guide shaft, means for rotating said shaft, and means for continuously rotating and advancing longitudinally through said shaft, a length of tubing; a strip feeding and fin forming assembly comprising a forming roll fixed coaxially on the exit end of said hollow shaft and rotatable therewith, said roll hav-

ing protruding therefrom, a substantially frusto-conical smooth forming nose with a coaxial opening to receive said advancing tubing, said nose being rotatable in the same direction and at the same rate of speed as said advancing tubing, a complementary forming wheel freely mounted for independent rotation, on an inclined fixed axis which intersects the axis of said hollow shaft, the periphery of said wheel having a smooth forming surface concentric with the axis of the wheel and arranged in opposed relation to the periphery of said nose, a strip feeding device for delivering a continuous strip of metal between the opposed peripheries of said wheel and nose, means for adjusting the angle of the axis of said wheel to regulate the plane for presentation of the periphery of said wheel to the periphery of said nose, and means for positioning the strip feeding device to present said strip edgewise to said tubing, in a non-radial plane which intersects the periphery of said tubing.

3. Apparatus as claimed in claim 2, including means located anterior to said feeding device, for forming an angular flange along one longitudinal edge of said strip, said feeding device presenting said strip to the periphery of said tubing with the preformed flange in contact with the latter.

4. Apparatus as claimed in claim 3, including a swedging roll arranged for engagement with said preformed flange, after the coiled fin and tube leave the forming mechanism.

5. Apparatus as claimed in claim 3, including a swedging roll arranged for engagement with said preformed flange, after the coiled fin and tube leave the forming mechanism, spring means normally urging said swedging roll into contact with said flange, and means for retracting said swedging roll from said tubing.

6. In apparatus for forming spirally wound finned tubing, including a frame, a hollow guide shaft supported by said frame, means for rotating said shaft, and means for continuously rotating and advancing longitudinally through said shaft, a length of tubing; a strip feeding and fin forming assembly comprising a forming roll fixed coaxially on the exit end of said hollow shaft and rotatable therewith, said roll having protruding therefrom, a substantially frusto-conical smooth forming nose with a coaxial opening to receive said advancing tubing, said nose being rotatable in the same direction and at the same rate of speed as said advancing tubing, a complementary forming wheel freely mounted on said frame for independent rotation, on an inclined axis which intersects the axis of said hollow shaft, the periphery of said wheel having a smooth forming surface concentric with the axis of the wheel and arranged in opposed relation to the periphery of said nose, a strip feeding device for delivering a continuous strip of metal between the opposed peripheries of said wheel and nose, a mounting rod suspended from a portion of said frame above said hollow shaft, said device being supported adjacent the periphery of said tube, on the suspended end of said mounting rod, means for longitudinally adjusting said mounting rod to vary the elevation of said device with respect to said tubing, means on the suspended end of said rod for rotatably adjusting said device about one axis parallel with the axis of said rod and about a second axis perpendicular to the axis of said rod, for varying the angle of presentation of said feeding device with respect to said tubing, and means for adjusting the angle of the axis of said wheel to regulate the plane of presentation of the periphery of said wheel, to the periphery of said nose.

7. Apparatus as claimed in claim 6, including a main mounting plate on said frame, supporting said forming wheel and mounting rod and means hingedly supporting one edge of said mounting plate, whereby said plate and the elements supported thereby may be retracted from said tubing.

8. Apparatus as claimed in claim 7, including a lock bolt extending between said hinged plate and a fixed lug on said frame, for locking said plate and the elements supported thereby, in operative position.

9. In apparatus for forming spirally wound finned tubing, including a hollow guide shaft, means for rotating said shaft, and means for continuously rotating and advancing longitudinally through said shaft, a length of tubing; a strip feeding and fin forming assembly comprising a forming roll fixed coaxially on the exit end of said hollow shaft and rotatable therewith, said roll having protruding therefrom, a substantially frusto-conical smooth forming nose with a coaxial opening to receive said advancing tubing, a complementary forming wheel freely mounted for independent rotation on an inclined axis which intersects the axis of said hollow shaft, the periphery of said wheel having a smooth forming surface concentric with the axis of the wheel and arranged in opposed relation to the periphery of said nose, the bottom of said wheel being dished to provide a concentric recess, a strip feeding device for delivering a continuous strip of metal between the opposed peripheries of said wheel and nose, means for adjusting the angle of the axis of said wheel to regulate the plane of presentation of the periphery of said wheel, to the periphery of said nose, and a swedging roll rotatably mounted on an axis parallel with that of said hollow shaft, for swedging a tube contacting flange portion on said strip material against that portion of the tube on the side opposite the forming wheel.

10. Apparatus as claimed in claim 7, including means associated with said mounting plate for regulating the pressure of the periphery of said forming wheel on said forming nose.

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