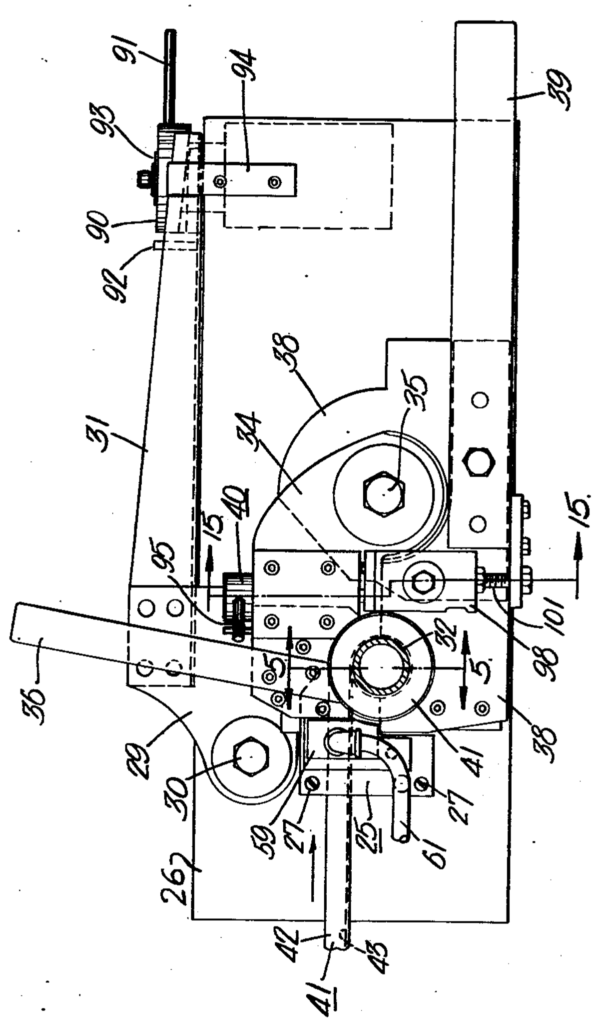
July 22, 1952 A. J. HARRISON 2,604,138

TOOL FOR WINDING RADIATING FIN ON PIPE

Filed Aug. 13, 1947 9 Sheets-Sheet 1

FIG. 1.



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TOOL FOR WINDING RADIATING FIN ON PIPE

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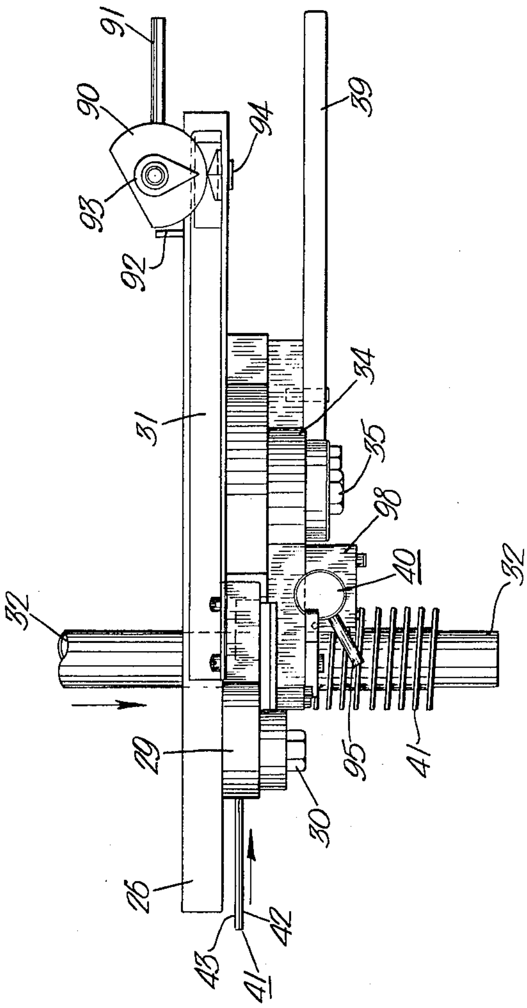
FIG. 2.



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TOOL FOR WINDING RADIATING FIN ON PIPE

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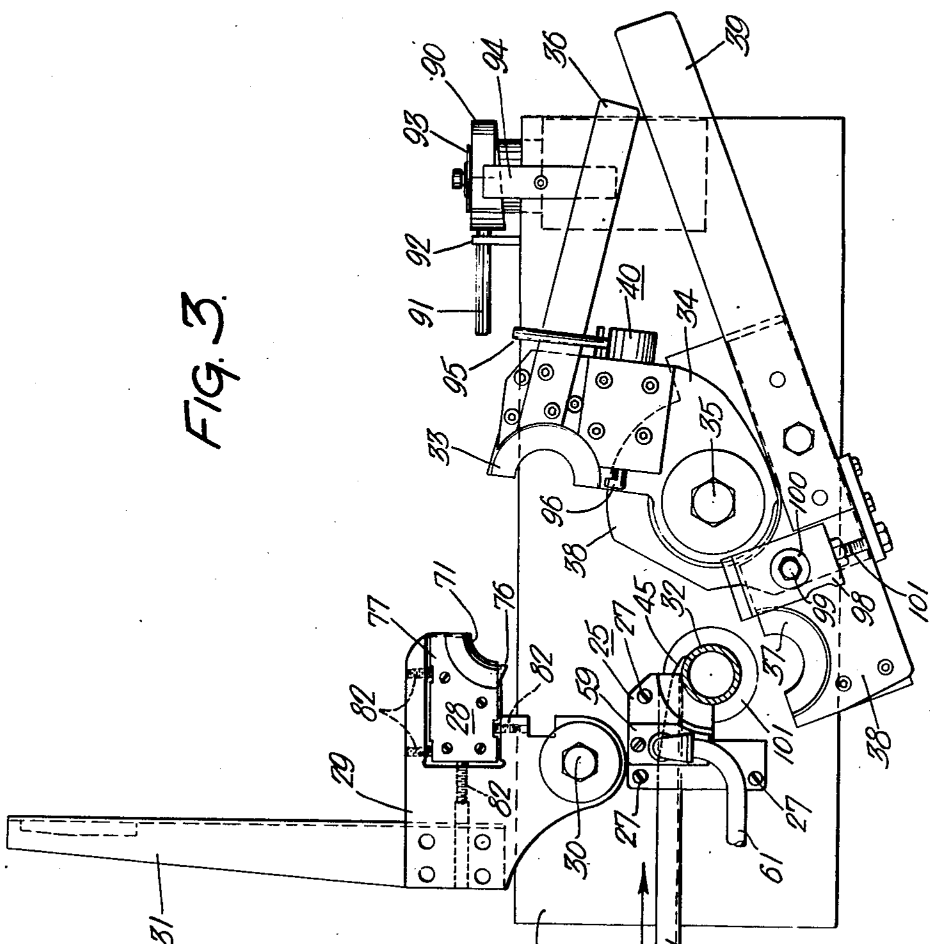
FIG. 3



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TOOL FOR WINDING RADIATING FIN ON PIPE

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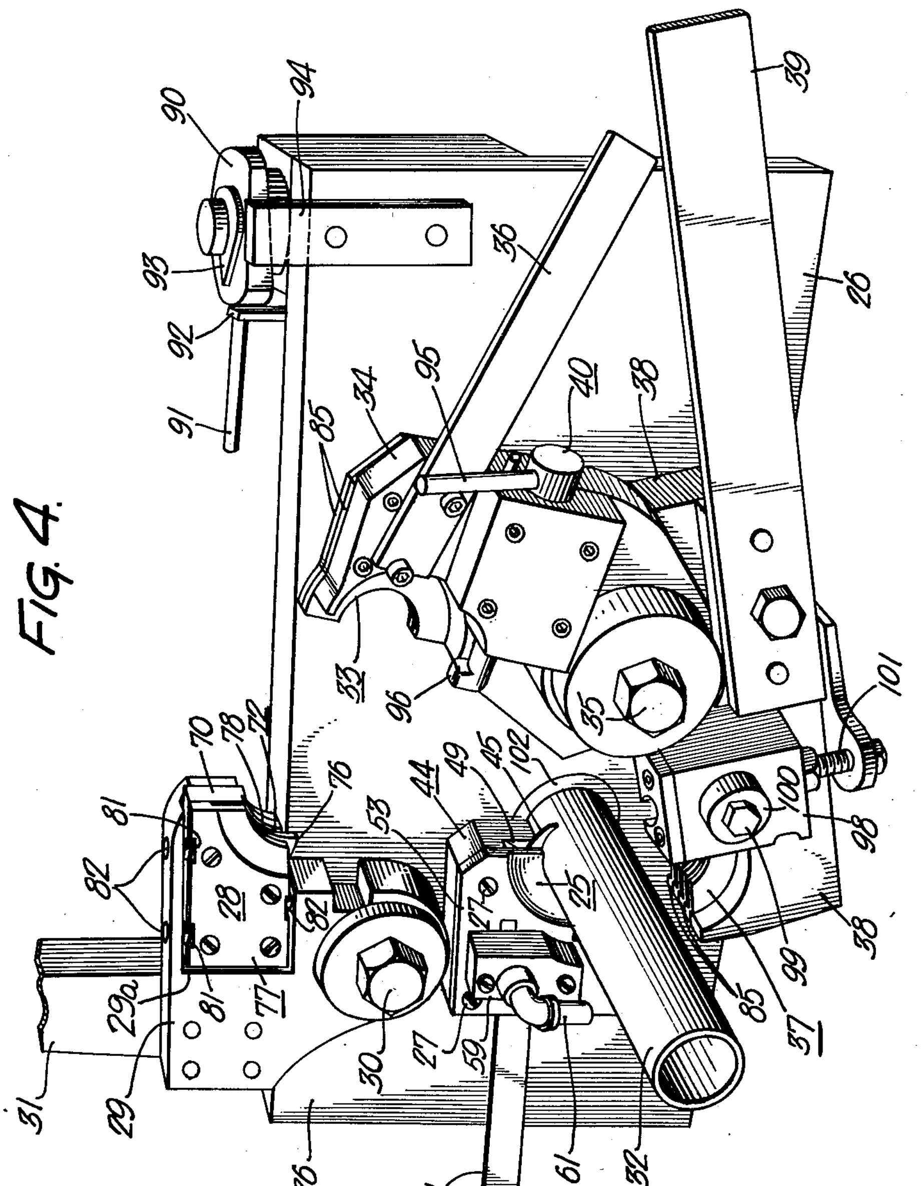
FIG. 4.



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TOOL FOR WINDING RADIATING FIN ON PIPE

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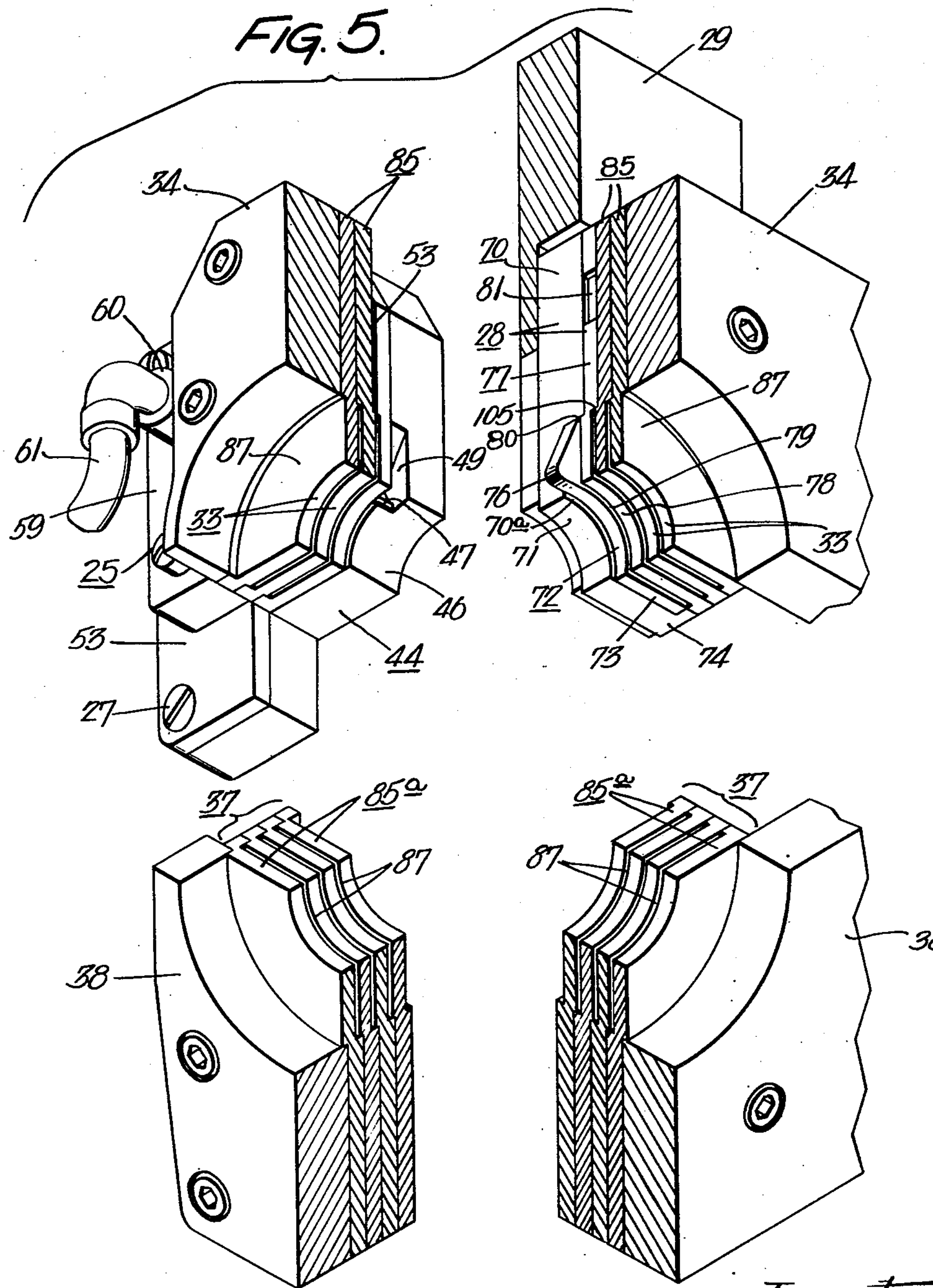
FIG. 5.



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TOOL FOR WINDING RADIATING FIN ON PIPE

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FIG. 6.

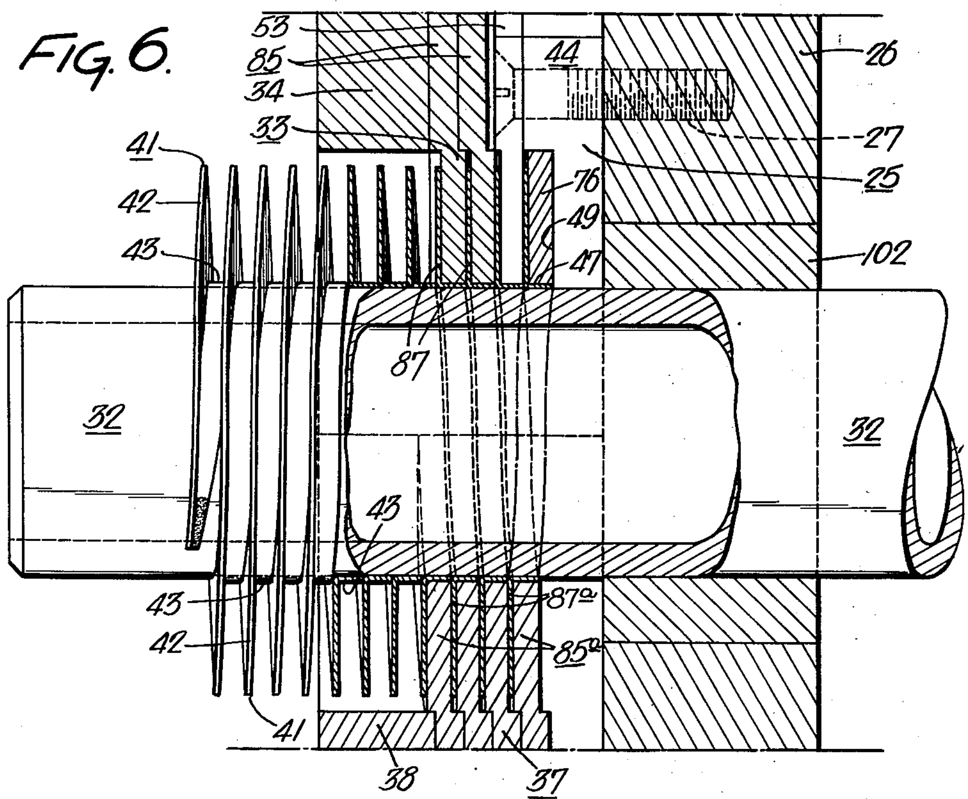


FIG. 7.

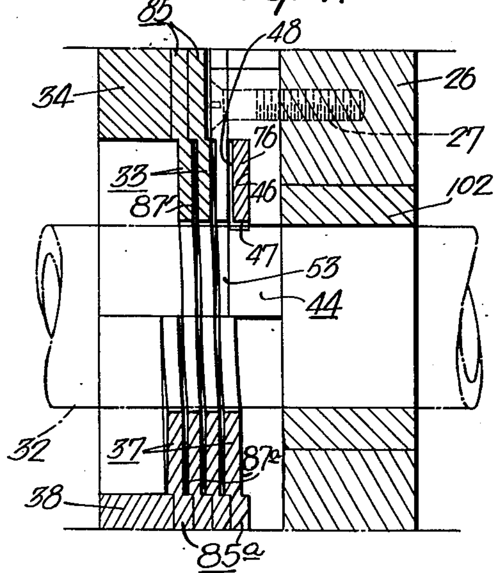
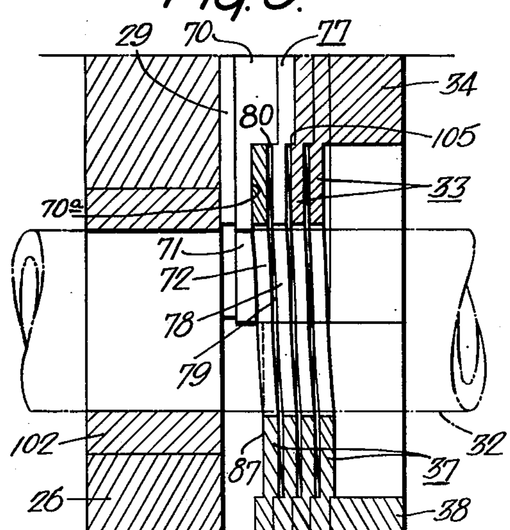


FIG. 8.



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July 22, 1952 A. J. HARRISON 2,604,138

TOOL FOR WINDING RADIATING FIN ON PIPE

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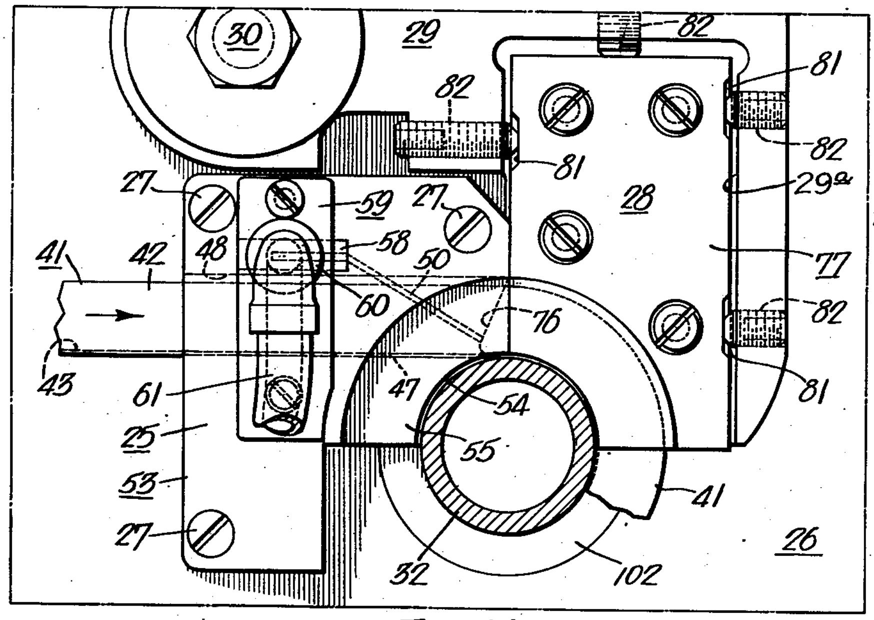

FIG. 9

FIG. 11.

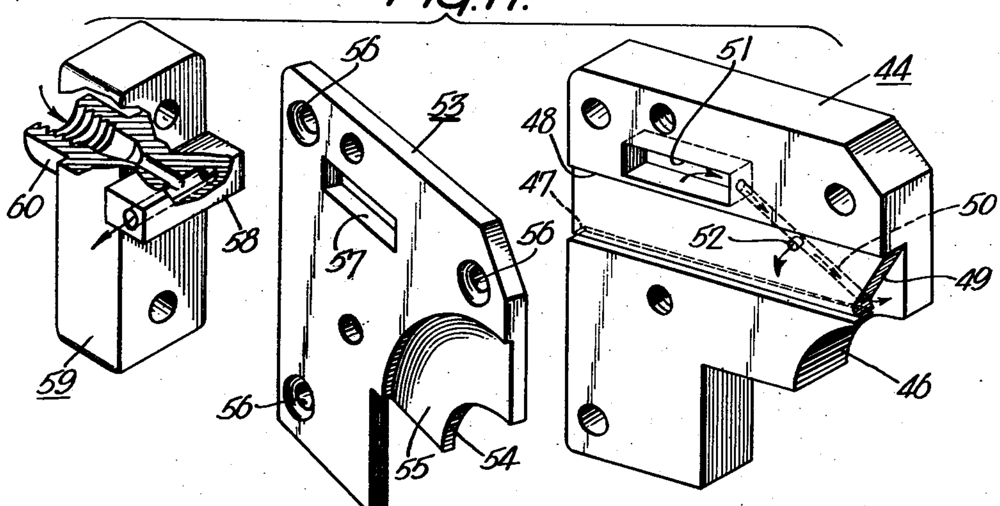

FIG. 10.

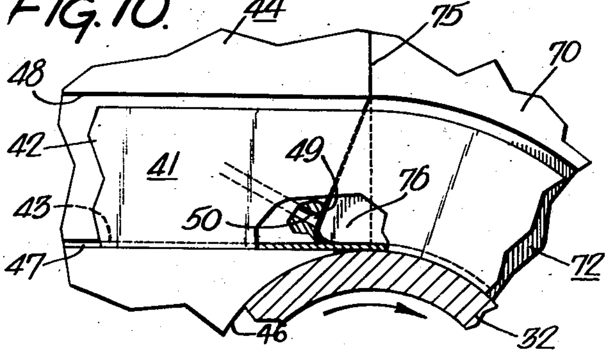

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FIG. 15.

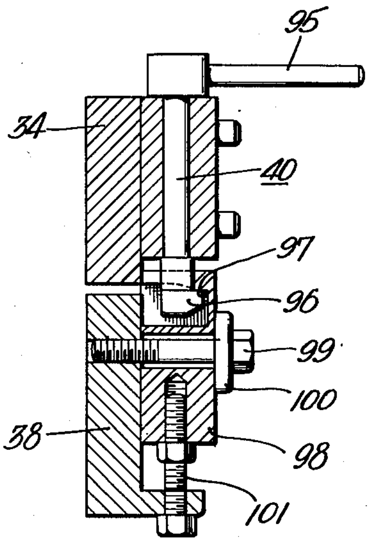

FIG. 13.

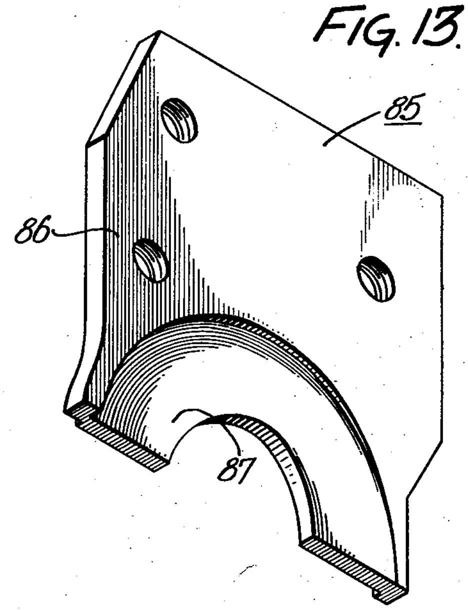

FIG. 14.

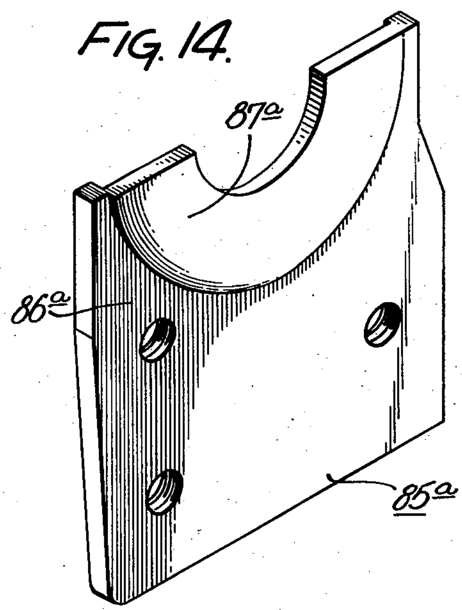

FIG. 12.

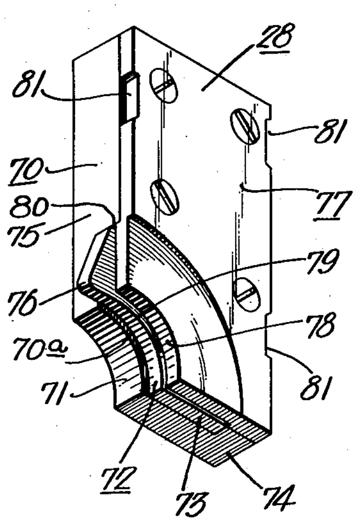

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FIG. 16.

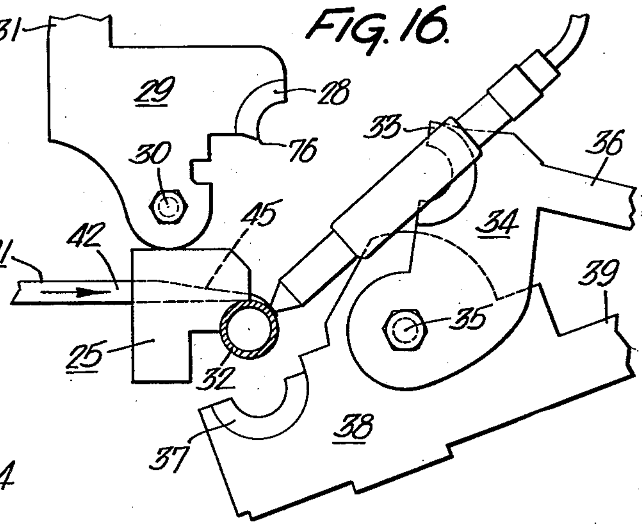


FIG. 17.

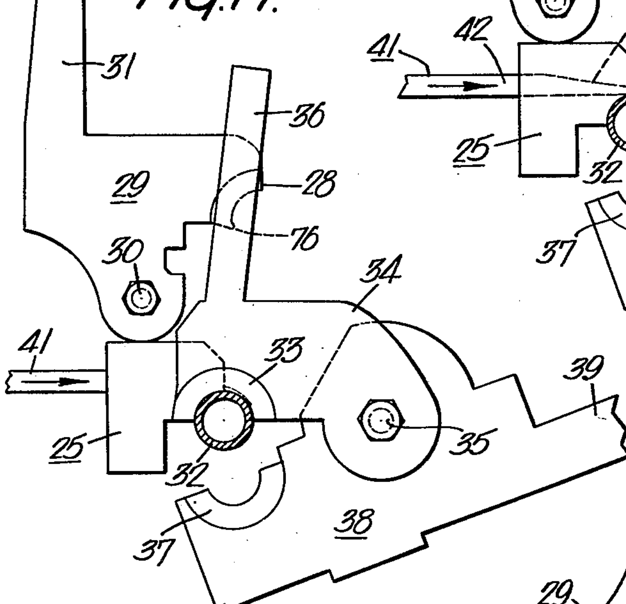


FIG. 18.

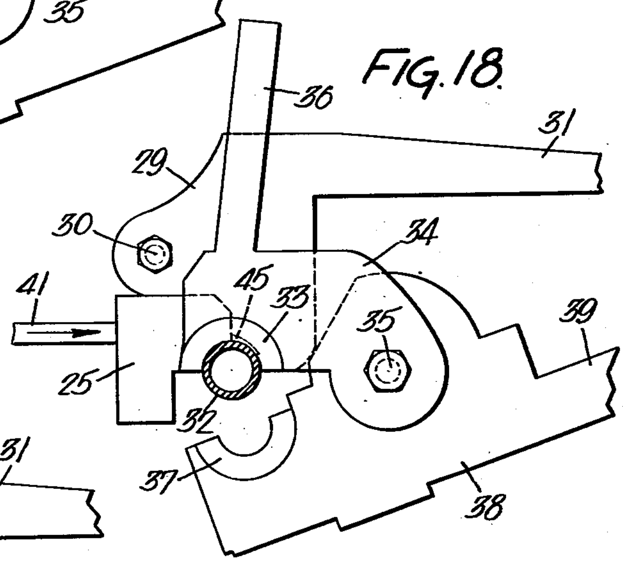
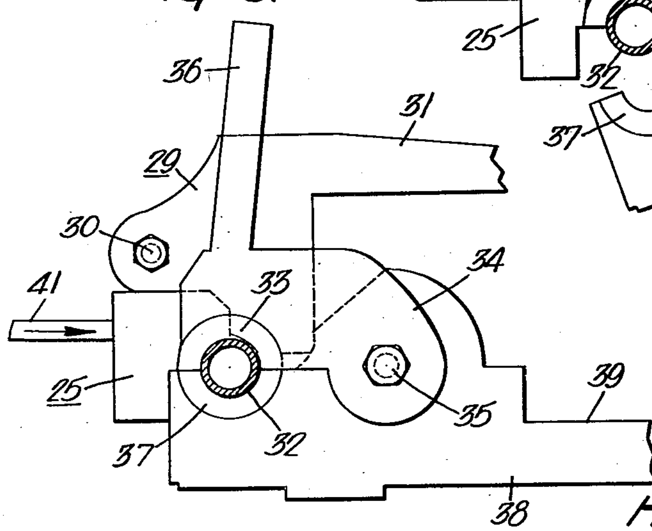


FIG. 19.



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Patented July 22, 1952 2,604,138

UNITED STATES PATENT OFFICE

2,604,138

TOOL FOR WINDING RADIATING FIN ON PIPES

Alma J. Harrison, Philadelphia, Pa., assignor to Proctor & Schwartz, Inc., Philadelphia, Pa., a corporation of Pennsylvania

Application August 13, 1947, Serial No. 768,323

9 Claims. (Cl. 153—64.5)

This invention relates to apparatus for winding a continuous strip of thin metal edgewise around the circumference of a cylindrical member such as a tube or bar, and more particularly is directed to the winding head of such as apparatus.

Finned tubes of this general construction are widely used in connection with driers and heat exchangers, and it is, therefore, important that good contact be made between the fin and the tube in order to produce efficient heat transfer from the tube to the fins and vice versa.

Finned tubing made in accordance with the invention is characterized by a "leg," a term applied to the fin proper, which extends radially at right angles to the axis of the tube. The inner edge of the fin is rolled at right angles to the leg to form a "foot" which tightly encircles the tube. Depending upon the use to which the tubing will be put, the foot may extend axially of the tube the entire distance between adjacent legs, or a gap between the foot spirals may be provided in order to reduce the thickness of metal through which the heat must be transferred.

Although many machines and methods of fabricating spiral finned tubing have been proposed, I am aware of no machine which, for example, enables the application to 1¼" pipe, of spiral fins ½" in width. Narrow fins have been applied by one means or another but invariably when greater efficiency through larger radiating surface has been attempted, the stresses set up in the fin as it is wound on the tube have been so great that no successful commercial production of this type of tubing has been possible. These stresses have in the past prevented the production of a smooth spiral fin characterized by the complete absence of corrugations in both the leg and the foot, as well as the total absence of splits and it is specifically the ability to produce such an improved product that renders the present machine a notable advance in the art. Furthermore, the apparatus permits the use of steel fin material in place of the more expensive but more ductile copper or brass. Nevertheless, the latter materials can be used if desired with equal facility due to the ease of adjusting the apparatus.

In winding the fin on the tube, the metal in the outer edge portion of the fin or leg is subjected to a drawing action whereas the metal of the inner edge portion of the leg and the foot is compressed. This ordinarily results in producing a ripple either radially on the leg or longitudinally on the foot, with consequent poor mechanical and thermal contact because any gaps between the periphery of the tube and the adjacent inner surface of the foot thereby materially reduce heat transfer efficiency. This undesirable result is prevented by providing means for pressing or ironing the foot smoothly against the surface of the tube.

Furthermore, after the fin is applied to the tube and the foot compressed against the periphery thereof, it has been found necessary to guide and to straighten the convolutions in order to avoid uneven spacing of the fin convolutions, as well as to insure the proper radial position of the leg on the tube.

For this purpose, means for guiding the fin after the foot has been compressed against the tube are provided in the form of a nut assembly having laminations which form a spiral groove in conformity with the desired pitch of the finished product. The invention also includes means for positioning the spiral guide brackets as well as of applying variable pressure to the ironing element.

A primary object of the invention, therefore, is to produce a spirally finned tube which is entirely free of all ripples and splits in the leg and foot portions.

A further object of the invention, therefore, is to provide a head assembly for a finned tube winding machine which eliminates all rippling in both the leg and the foot of the fin and at the same time permits the rapid fabrication of tube elements having greater heat transfer efficiency.

A further object of the invention is to provide a sectional tool through which the spiral fin is drawn as it is applied to the periphery of the tubing, the sections of which may be independently adjusted to achieve proper application and contour of the fin.

A further object of the invention is to provide in a tool of the character described, a novel means for pressing or ironing the foot of the fin smoothly upon the surface of the tube.

A further object of the invention is to provide means for regulating and varying the angularity and pressure of the ironing means.

A further object of the invention is to provide a laminated guide nut construction for winding flat fin material onto a cylindrical element.

A still further object of the invention is to provide a method of fabricating finned tubing.

Further objects will be apparent from the specification and drawings in which:

Fig. 1 is a front elevation of the winding head with the tool segments in place;

Fig. 2 is a plan of the structure of Fig. 1;

Fig. 3 is a view similar to Fig. 1 but with the tool segments opened;

Fig. 4 is a perspective view similar to Fig. 3;

Fig. 5 is an enlarged perspective detail of the assembled tool segments sectioned along the lines 5—5 of Fig. 1 and shown with each side in opposite perspective;

Fig. 6 is a schematic sectional representation on the same plane as that of Fig. 5 but showing the tool segments in operative position with relation to a section of finned tubing as it is turned through the segments;

Fig. 7 is a reduced sectional view similar to Fig. 6 but with the tube shown only in phantom;

Fig. 8 is a view similar to Fig. 7 but of the opposite facing tool half;

Fig. 9 is an enlarged detail of the upper tool segments and the ironer:

Fig. 10 is an enlarged detail of the ironer tip as it presses the foot around the tube;

Fig. 11 is an exploded view of the feed segment of the tool showing its laminated construction and lubricant passages;

Fig. 12 is a perspective view of the ironer or upper tool segment assembly;

Fig. 13 is an enlarged perspective view of one of the upper tool segment laminae;

Fig. 14 is an enlarged perspective view of one of the lower tool segment laminae;

Fig. 15 is a sectional view along the lines 15—15 of Fig. 1;

Fig. 16 is a schematic view illustrating the first step in the method of applying the spiral fin to the tube;

Fig. 17 is a schematic view of the second step showing the first tool segment in closed position;

Fig. 18 is a schematic view of the third step showing the first and second tool segments in closed position, and

Fig. 19 is a schematic view of the fourth step showing all the tool segments in closed position.

The invention resides essentially in a tool comprising a fixed guide for initially presenting the preformed fin to the periphery of a rotating tube; a pivoted ironing or pressing means adapted to press the foot of the fin smoothly against the periphery of the rotating tube; and a pair of pivoted jaws having internal spiral grooves adapted to receive the fin as it passes out of the ironer and to straighten it during further rotation of the finned member. The guide element, ironing member and jaws are arranged about the tube and are movable into intercooperative association with each other, and with a fixed guide to form an internally threaded spiral tool.

The fixed guide is provided with suitable coolant passages for applying coolant to the fin at the point of maximum stress; namely the first convolution of the fin on the tube. The ironing member is made adjustable not only with respect to the other segments but also with respect to its carrier and the pressure which it applies to the foot. The invention also includes the principal steps in applying the fin to the tube.

Referring now more particularly to the drawings, the fin winding head assembly has a guide segment indicated by 25 in Fig. 3 which is rigidly bolted to main support plate 26 by screws 27. A displaceable segment 28 is adjustably retained in bracket 29 pivoted to plate 26 by means of cap screw 30. Lever arm 31 is secured to bracket 29 and serves to pivot the segment 28 from operative to inoperative position and vice versa, as well as to provide a means for applying clamping force between segment 28 and tubing 32. It will be understood that the apparatus described herein is capable of applying a fin to any generally cylindrical object and reference to "tube" or "tubing" is intended to include both hollow and solid members such as rods, bars, and sleeves.

Nut segment 33 is mounted in bracket 34 which is likewise pivotally secured to plate 26 by means of cap screw 35. Handle 36 attached to bracket 34 provides means for swinging the bracket and segment 33 into place against tube 32.

The lower nut segment 37 secured in bracket 38 is likewise pivoted on cap screw 35 and is operated by means of lever 39. A locking clamp 40 on bracket 34 serves to securely retain segments 33 and 37 in operative closed position.

It will be understood that for purposes of clarity, only the fin applying structure is shown but that the entire machine includes mechanism for rotating and advancing tube 32 through plate 26. Also (not shown) are the strip feeding and forming rollers as well as the carriage for receiving a finished finned element. These allied structures while essential to the complete operation of the machine, form no part of the present invention and are well known in the art.

In general, a strip of fin material 41 having a vertical leg portion 42 and a horizontal foot portion 43 (Fig. 6), which is formed in passing through suitable dies or rollers (not shown), is fed through guide block 44 (Fig. 11). The leg of the fin is provided with a tapered or cut away portion of the leg at 45. When initially applied to the tube, the tip of the fin 41 is secured to the periphery of tube 32 by welding, (Fig. 16) whereupon brackets 29, 34 and 38 with their respective laminated segments are clamped about the tube 32 as shown in Fig. 1. The machine is then operated to rotate tube 32 in clockwise direction as shown in Figs. 1–4 and at the same time to advance the tube through plate 26 at a rate equal to the desired pitch of the spiral fin. This action serves to draw strip 41 through guide block 44 and wind it about the periphery of the tube, thereby producing the desired finished product. Details of the clamping operation and the construction of the various elements are described more fully hereinafter.

Referring now to Fig. 11, fixed segment 25 is composed of guide block 44 having a concave quadrantal face 46 of substantially the same radius as tube 32. A channel 47 (Fig. 7) adapted to receive the foot 43 of the fin material, extends lengthwise of block 44 and tangent to face 46 at substantially its upper terminus. A groove 48, milled in one face of block 44 to a depth slightly greater than the thickness of leg 42 provides, in conjunction with channel 47, an L-shaped feed passage for the strip to the point of contact with the periphery of tube 32. The inner face of block 44 is recessed at 49 immediately above the terminus of channel 47 to provide means for application of lubricant or coolant through hole 50 which connects with recess 51 in block 44. Passage 50 also communicates with the face of slot 48 by means of hole 52 drilled at right angles to passage 50.

Plate 53 of the same general configuration as block 44 is bolted to the side of block 44 by means of screws 27 and serves to form an enclosed guide for the fin material along with grooves 47 and 48. One corner of plate 53 is concavely ground to form a face 54, coextensive with face 46 in block 44 and is also provided with a tapering milled surface or flat 55 having somewhat greater radius than the outside of the completed finned tubing. The degree of spiral taper applied to flat 55 is such that it conforms to the desired pitch of the fin as it is being applied and likewise forms a part of one of the spiral grooves in the complete tool assembly. Plate 53 is also provided with suitable drilled holes 56 through which cap screws 27 extend and a slot 57 on the plate accommodates projection 58 for lubricant manifold 59. Manifold 59 is provided with a nipple 60 internally threaded to accommodate, lubricant or coolant supply connection 61 (Figs. 1–3) and the manifold is bolted to block 44 through plate 53. Nipple 60 is drilled as is projection 58 to provide lubricant connection between the nipple and passage 50.

Referring now to Fig. 12 which is an enlarged perspective of adjustable segment 28, it will be seen that this section is constructed of a body member 70 of rectangular shape, having a quadrantal concave face 71 at one corner and of a radius substantially the same as that of the tube 32. A larger quadrantal milled flat 70*a* on block 70 is cut at a bias with the face of the block in an amount corresponding with the pitch of the spiral fins. An arcuate pressing member on ironer 72 fits in the large flat 70*a* and is rigidly secured therein. The lower edge 73 of member 72 is flush with the corresponding edge 74 of block 70, whereas the upper extremity of member 72 extends beyond the lateral surface 75 to form a projecting nose 76. When member 28 is in operative position, nose 76 projects into the recess 49 in guide block 44 and serves to iron out any ripples which might otherwise have a tendency to form in the foot of the fin material before actual contact with the tubing. The method in which nose 76 cooperates with the foot even before contact with the periphery of the tubing is illustrated in Fig. 10.

Also, bolted to block 70 (Fig. 12) is guide plate 77 which is of the same general rectangular shape as block 70 except that the face 78 of plate 77 has a radius adapted to bear against the compressed foot of the fin after having been wound on the tube. Sufficient clearance at 79 between the side of face 78 and ironer 72 is provided to permit free passage therebetween of leg 42 of the fin as the latter feeds therethrough. The offset guide surface of member 77 partially underhangs the large milled flat 70*a* in block 70 as shown at 80 in order to provide proper spiral pitch. Plate 77 is also notched at 81, 81, 81 to accommodate adjusting screws 82 (Fig. 3) which support member 28 in recess 29*a* of bracket 29. The location of screws 82 in bracket 29 is such that assembly 28 is firmly retained in bracket 29 and is capable of adjustment in all directions in a radical plane by means of screws 82.

After being pressed upon the tube, the fin continues to be guided and formed by means of further travel through the tool segments. The torque necessary to draw the strip through guide block 25 and around the periphery of the tube has a tendency to cause the leg portion 42 to buckle, particularly at its base where it is compressed, and also to induce waves or ripples in the foot portion. The pressure exerted by member 72 operates to smooth and eliminate all ripples in the foot 43, and the axial spacing of members 72 and 77 at 79, as well as the additional guide members 85, 85*a* serve to preclude formation of any ripples in the leg portion 42.

Guides, 85 85*a* may be stamped or ground from steel plates as shown in Fig. 13 and have clamping surfaces 86, 86*a* and biased semicircular flats 87, 87*a* which likewise correspond to the pitch of the spiral. Fig. 5 shows the assembled relationship of guides or plates 85, 85*a* in nut segments 33 and 37. In the preferred embodiment four stacked plates 85*a* comprise the lower segment 37 and the interstices between the plates serve to form the desired pitch in the spiral as well as to provide proper spacing between the leg portions 42. A stack of two plates 85 mounted in bracket 34 comprises segment 33 and the edges of the laminations of segment 33 are in abutting relationship with the laminations of segment 37. The biased faces 87 and 87*a* (Fig. 13) are juxtaposed top to bottom so that the fin helix travels from in back of guide 85*a* in Fig. 14, from thence upwardly in front of face 87 in guide 85 of Fig. 13, and thence clockwise around the front of face 87*a* and guide 85*a*.

In operation, the fin material is fed through guide block 25 and a triangular portion is cut from the leading upper edge of the strip as shown in Fig. 16. This enables the initial bending action to take place without maximum deformation of the leg until approximately one convolution of the fin has been wrapped around the tube 32. The end of the strip is then spot welded to the tube as shown in Fig. 16, whereupon bracket 34 is rotated into closed position by means of lever 36 as shown in Fig. 17.

Bracket 29 is then rotated into position by means of lever 31 and may be securely locked by a rotatable cam 90 actuated by handle 91, which also enables variable pressure to be applied to nut segment 28 through lever 31. The total pressure applied with a tool segment depends of course, upon the angular position of handle 91 so that when the pipe section is in place, the pressure applied may be varied within limits by rotating the handle 91 to engage the surface of cam 90 progressively with lever 31. A suitable limit stop 92 prevents the handle from obstructing the path of the lever 31 in closing. A pointer 93 on the cam 90 conveniently serves to indicate the most desirable position for handle 91 and may be used as a reference point to increase or decrease the pressure exerted. Guide 94 serves to retain lever 31 in position, thereby preventing misalignment due to twisting on pivot 30. Fig. 18 illustrates the nut segments 28 and 33 in place.

Bracket 38 is then closed as shown in Fig. 19, so that the guide plates 85 cooperate radially with each other to form a complete internal spiral nut for guiding and shaping the fin.

Brackets 34 and 38 are clamped in position by means of bolt 40 rotated with handle 95. This serves to engage lug 96 with shoulders 97 (Fig. 15) on block 98 which is in turn bolted to bracket 38 by means of cap screw 99 and washer 100. Proper locking action of brackets 34 and 38 may be retained at all times by means of adjusting block 98 with adjusting set screw 101. After all the segments have been securely locked in position, the tubing is then rotated in a clockwise direction in Figs. 3 and 9, thus drawing the fin strip onto the periphery of the tube as it is at the same time advanced longitudinally through plate 26 in accordance with the predetermined pitch. The mechanism for turning tube 32 and advancing it form no part of the invention. A bearing sleeve 102 in plate 26 serves to guide the advancing tubing in the proper position with respect to the nut segments.

Figs. 5–8 clearly show the assembled relation of the various segments and the manner in which the spiral groove between the laminated segments serves to straighten the legs of the spiral fin after its initial application to tube **32**. Fig. 5 is a true perspective clearly showing the individual laminae formed by means of the plates **85**.

It will be noted that the fin forming face **87** of segment **33** in Fig. 8 underhangs the adjacent shoulder on segment **28** at **105**, and it is this construction which requires that bracket **34** be pivoted into operative position as shown in Fig. 17, before bracket **29** is swung into place. The flats of the laminations in the portions contacted by the legs of the tubing when the various brackets and segments are in place, present a smooth, continuous spiral with parallel and equally spaced sides.

Depending upon the speed with which the fin tube is being fabricated and the ductility of the material employed, the pressure of the ironer on the tubing may be adjusted during the operation to insure the absence of ripples in the compressed foot **43**. The mechanical advantage obtained in lever **31** is ample to provide sufficient compressive force for this purpose.

Furthermore, the adjustability of the nut segment **28** with respect to the bracket **29** enables the operator to control to a high degree the results obtained.

I have therefore provided a winding head for finned tubing machines which produces a greatly improved product in that much higher heat transfer is obtained by means of the relatively wide leg of the fin, plus the tight contact between the foot and the surface of the tube. The apparatus is designed for mass production of finned tubular elements and is extremely simple to operate.

I claim:

1. A sectional tool assembly for applying to a cylindrical member a spiral fin having a radial leg and an axially extending foot arranged circumferentially of the cylindrical member comprising a fixed guide block having a slot for feeding finned material substantially tangent to the surface of said cylindrical member, a guide plate attached to said block and having a helical quadrantal side flat adapted to form a predetermined spiral pitch in the fin, an adjustable nut segment in alignment with the guide block, a pivoted bracket for supporting the adjustable nut segment, a quadrantal cylindrical front face on the adjustable section adapted to press the foot of the spiral fin against the cylindrical member during the first fin convolution, a second guide plate in spaced axial relation with the adjustable section and secured thereto, said second guide plate having an axially facing flat biased in accordance with the pitch of the fin, and means for clamping said bracket and adjustable nut segment against the foot of the fin.

2. A sectional tool assembly in accordance with claim 1, having a pair of pivoted nut segments adapted to be clamped around the cylindrical member and having internal spiral grooves adapted to receive the fin convolutions as the tubing is advanced through the fixed guide block and the adjustable nut segment.

3. A sectional tool assembly in accordance with claim 1 in which the adjustable nut segment carries an ironer having a helical quadrantal face in progressive helical relation to the quadrantal face on the adjustable segment and a nose on the ironer extending into the fixed guide block.

4. In apparatus for applying spiral fin having a radial leg and an axial foot to a cylindrical member, a sectional tool assembly having an upper pivoted nut segment comprising a plurality of laminations, each lamination having a concave semicircular and radially biased flat, said flats being axially spaced with respect to each other, a pivoted lower nut segment comprising a plurality of laminations, each lamination having a concave semicircular and radially biased flat, said flats being axially spaced with respect to each other, the gaps between the flats forming a continuous internal spiral when the segments are closed, and means for clamping the upper segment and the lower segment around the circumference of the cylindrical member.

5. In apparatus for applying a spiral fin having a radial leg and an axial foot to a cylindrical member, a sectional nut segment comprising a body member having an outwardly disposed concave cylindrical quadrantal front face at one corner, a flat on the side of the body member, said flat being concentric with the front face and biased with respect to the plane of the body member, an ironing concave quadrantal pressure face concentric to the front face of the body member and being substantially the width of the axial foot on the fin, a nose on said ironing face and forming a continuation thereof, said nose extending forwardly of the edge of the body member, and a guide plate secured to the side of the body member, said guide plate having a helically disposed biased flat in spaced relation to the body member, the quadrantal ironing face being positioned in close proximity to the periphery of the cylindrical member whereby radial pressure is applied to the periphery of the cylindrical member by said face through the foot of the spiral fin.

6. Apparatus in accordance with claim 5, having a pivotally mounted bracket recessed to position the body member and guide plate, and means for adjusting the recessed body member with respect to the bracket in at least three directions in a radial plane.

7. Apparatus in accordance with claim 5, having a pivotally mounted bracket recessed to position the body member and guide plate, means for adjusting the recessed body member with respect to the bracket in at least three directions in a radial plane, and pressure applying means for forcing the body member and ironing face into contact with the cylindrical member and fin through the bracket.

8. A sectional tool for applying to a cylindrical member a spiral fin having a radial leg and an axially extending foot arranged circumferentially of the cylindrical member comprising, a fixed guide block having a slot for feeding finned material substantially tangent to the periphery of said cylindrical member, a guide plate attached to said block and having a helical quadrantal side flat adapted to form a predetermined spiral pitch in the fin, an adjustable nut segment in alignment with the guide block, a pivoted bracket for supporting the adjustable nut segment, a quadrantal cylindrical front face on the adjustable segment adapted to press the foot of the spiral fin against the cylindrical member during the first fin convolution, a second guide plate in spaced axial relation to the front face on the adjustable segment and secured thereto, said second guide plate having a biased axially fac-

ing flat in accordance with the pitch of the fin, means for clamping said bracket and adjustable nut segment against the cylindrical member and the foot of the fin, a second nut segment mounted on a pivoted bracket comprising a plurality of laminations, each lamination having a concave biased semi-circular flat axially spaced with respect to each other, a third nut segment mounted on a pivoted bracket comprising a plurality of laminations, each lamination having a concave biased semi-circular flat axially spaced with respect to each other, the gaps between the flats of the second and third segments forming a continuous internal spiral when the brackets are pivoted to close the segments, and clamping means between the second and third nut segments to securely position the segments around the cylindrical member.

9. In apparatus for applying a spiral fin having a radial leg and an axial foot to a cylindrical member, a main support plate having a bearing adapted to guide the cylindrical member as it is rotatably advanced through the plate; a guide member for feeding the fin material to the periphery of the cylindrical member, said guide member being secured to the plate in spaced relation to the bore of the bearing and having a fin carrying groove extending at right angles to the bore of the bearing; a closure for said groove, said closure having a helical quadrantal face; a nut segment pivotally supported on said main support plate and adapted to be clamped around the periphery of the cylindrical member to cooperate with the guide member, said nut segment comprising a body portion having a concave cylindrical quadrantal front face adapted to be pressed against the cylin-

drical member; a second cylindrical quadrantal front face on the nut segment in progressive helical relation thereto; a nose on said second face extending beyond the edge of the body portion and positioned to receive the foot of the fin and to iron the foot against the periphery of the cylindrical member; and a guide plate secured to the side of the body portion, said guide plate having an axially biased flat in spaced relation to the body portion to receive the leg of the strip as it is wound on the cylindrical member.

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