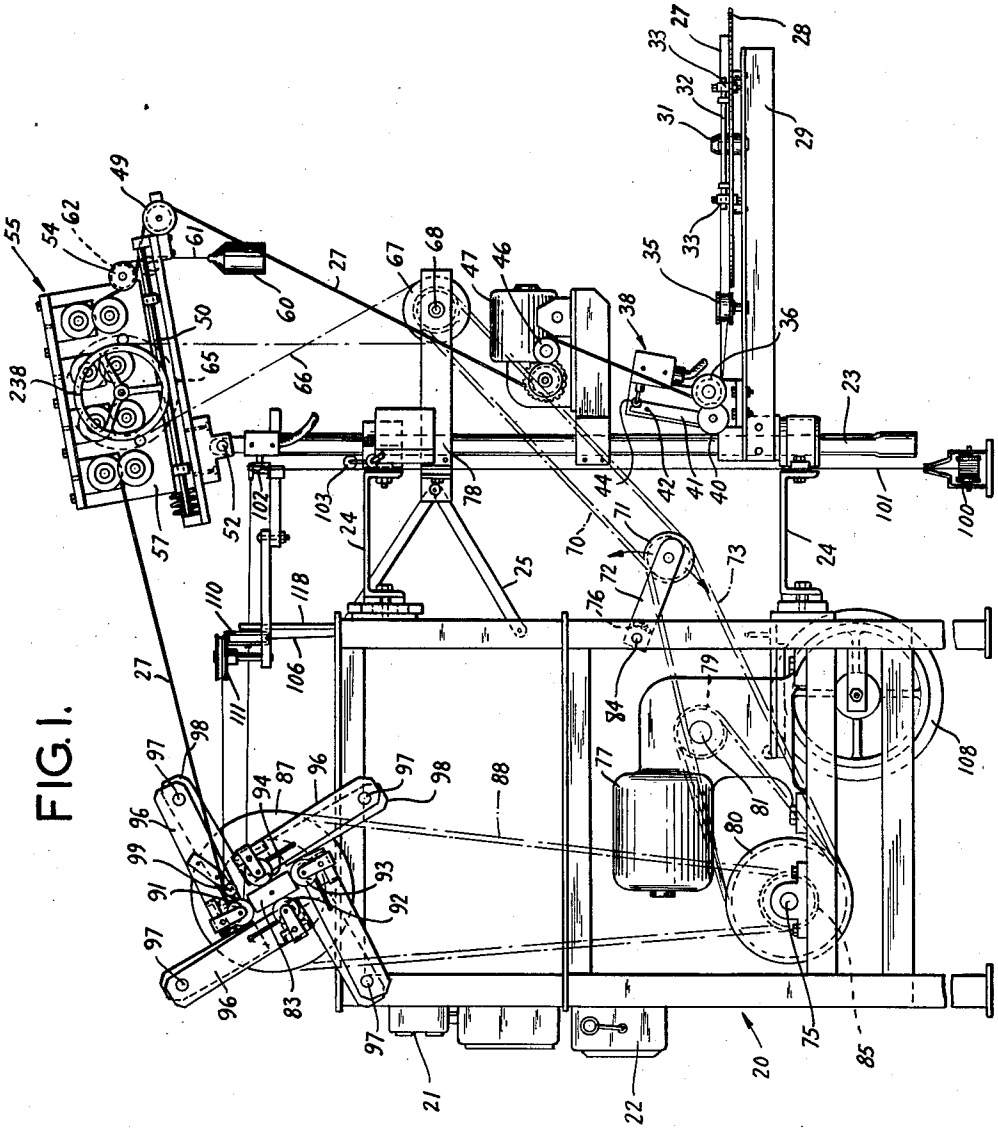
Nov. 18, 1952 P. M. PADGETT 2,618,233

MACHINE FOR MAKING NONCIRCULAR TUBING
ON CONTINUOUSLY ROTATING ARBORS

Filed Nov. 5, 1948 7 Sheets-Sheet 1

FIG. I.



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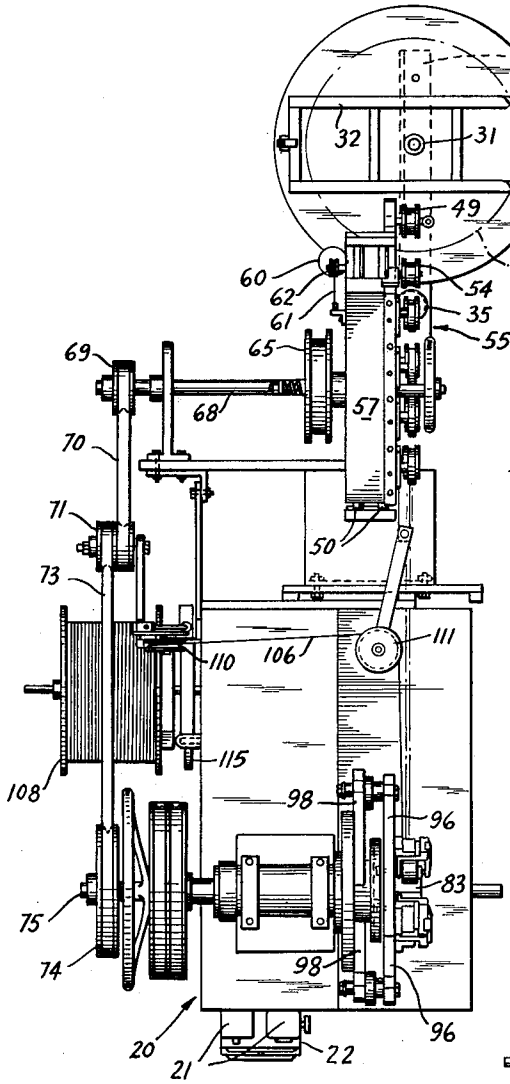

FIG.3.

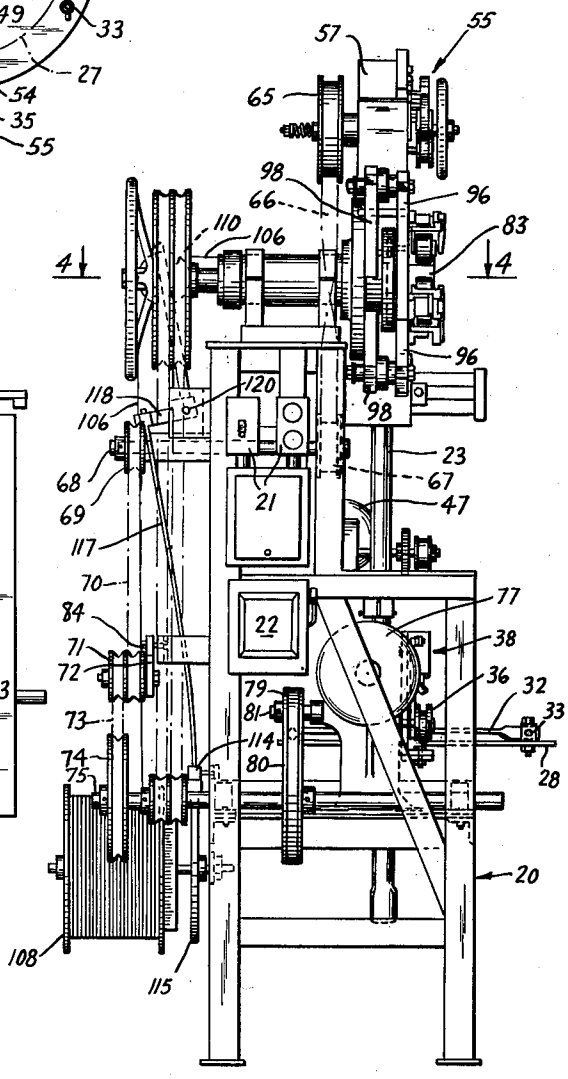

FIG.2.

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MACHINE FOR MAKING NONCIRCULAR TUBING
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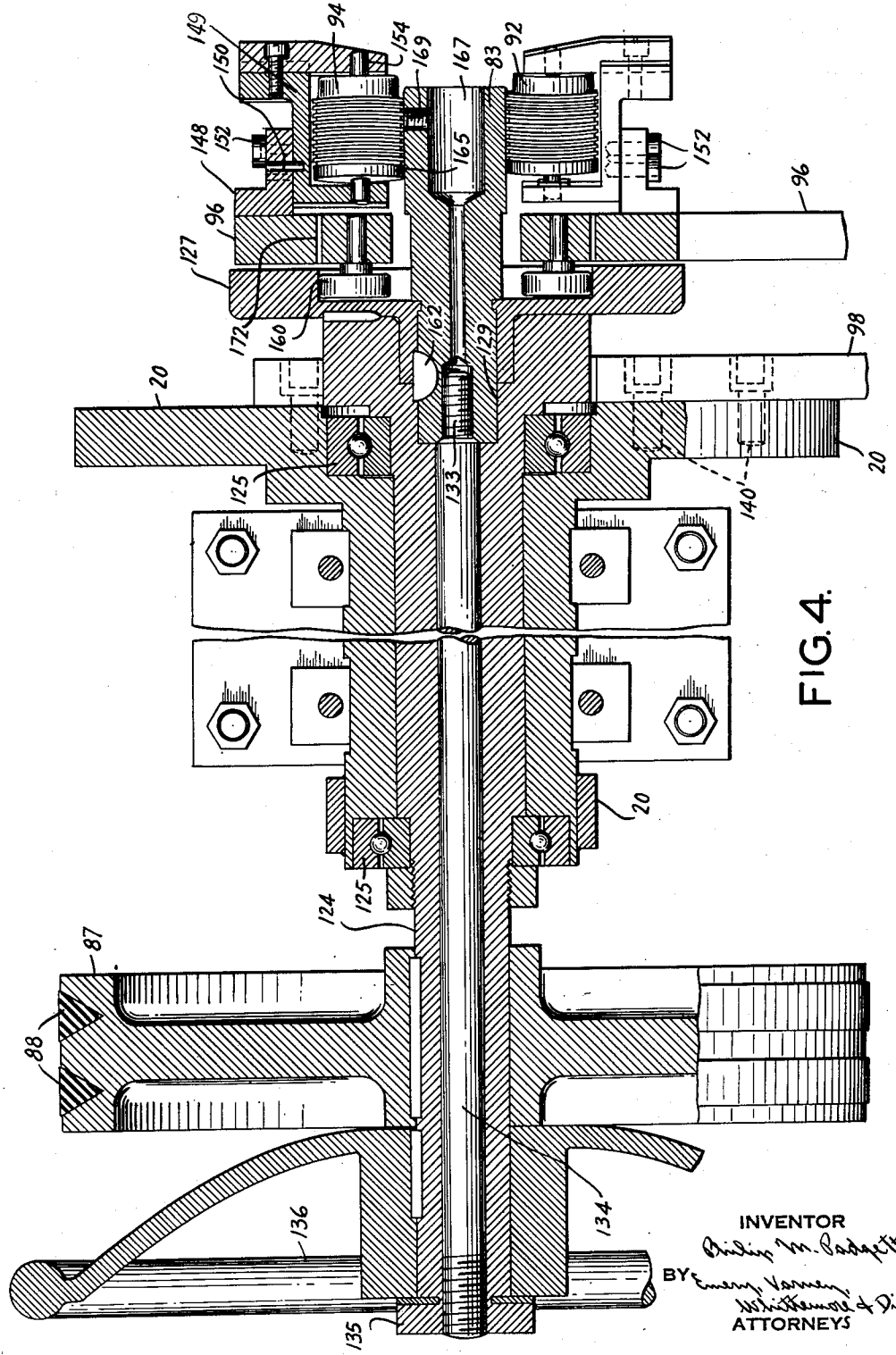

FIG. 4.

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MACHINE FOR MAKING NONCIRCULAR TUBING
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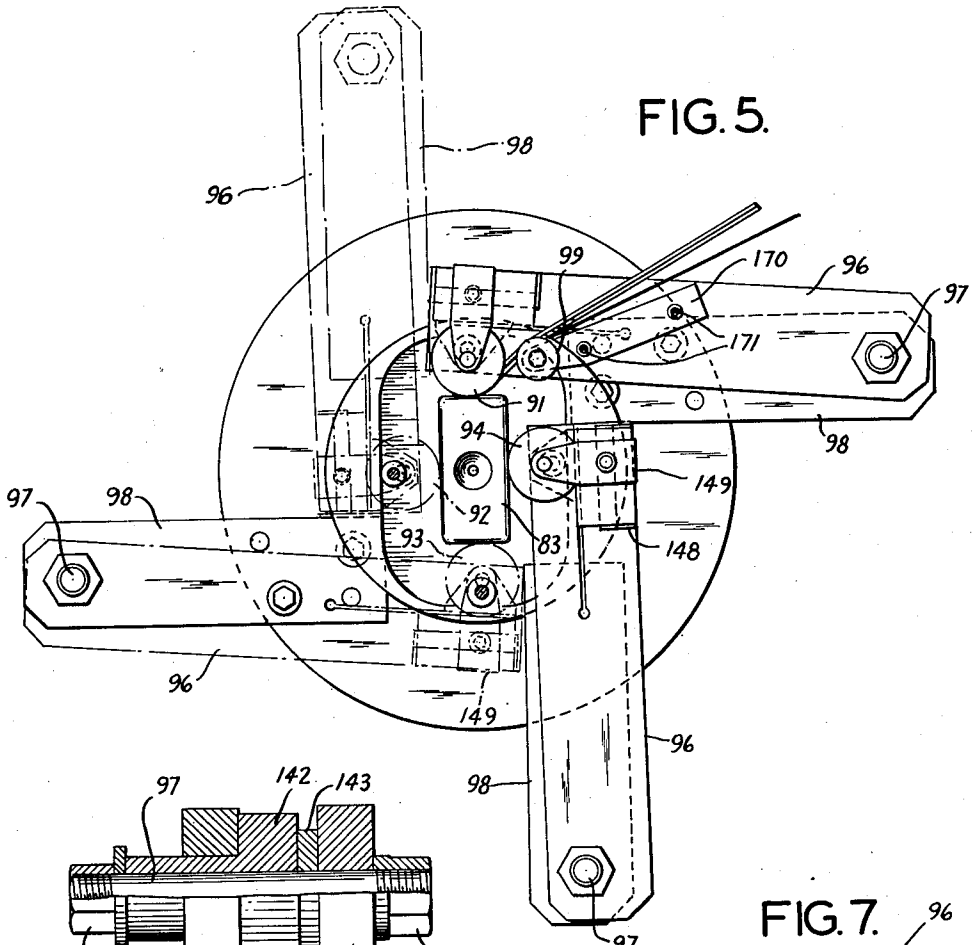
FIG. 5.



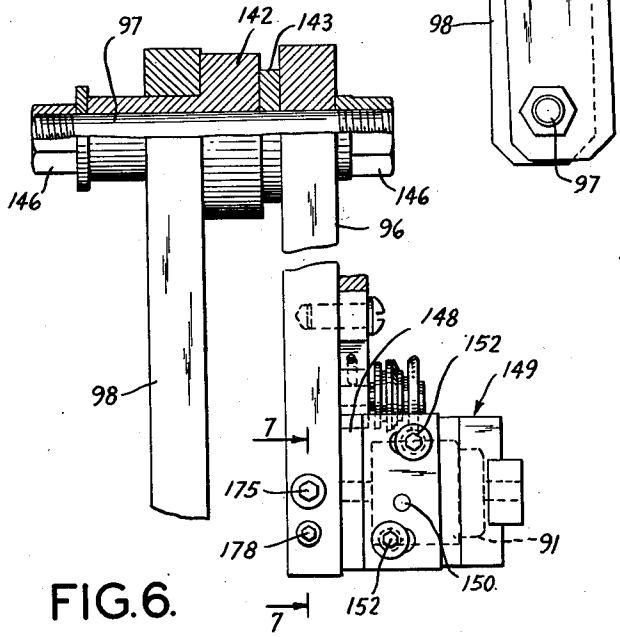
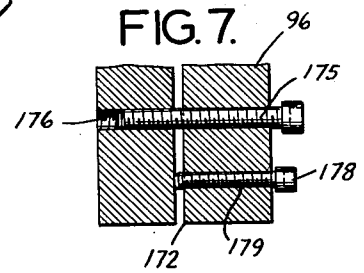


FIG. 6.

FIG. 7.



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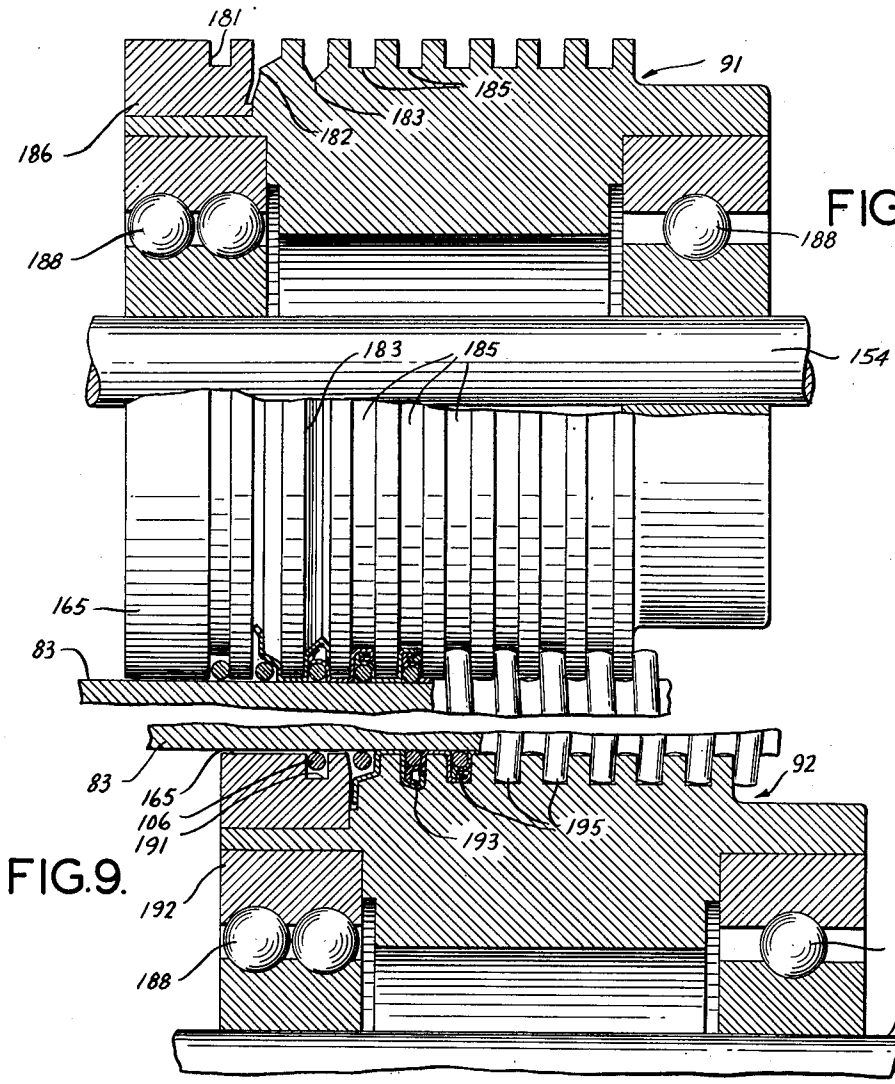

FIG.8.

FIG.9.

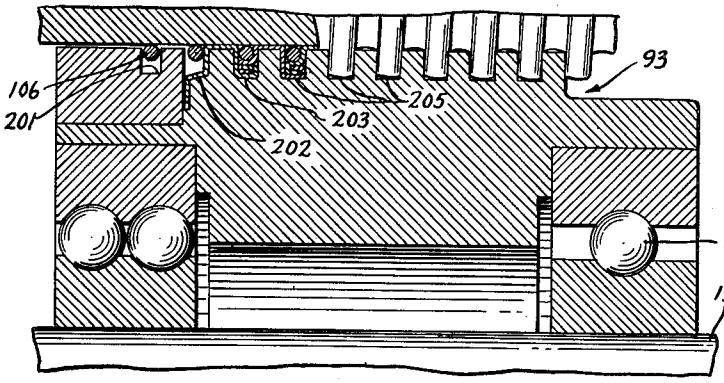

FIG.10.

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MACHINE FOR MAKING NONCIRCULAR TUBING
ON CONTINUOUSLY ROTATING ARBORS

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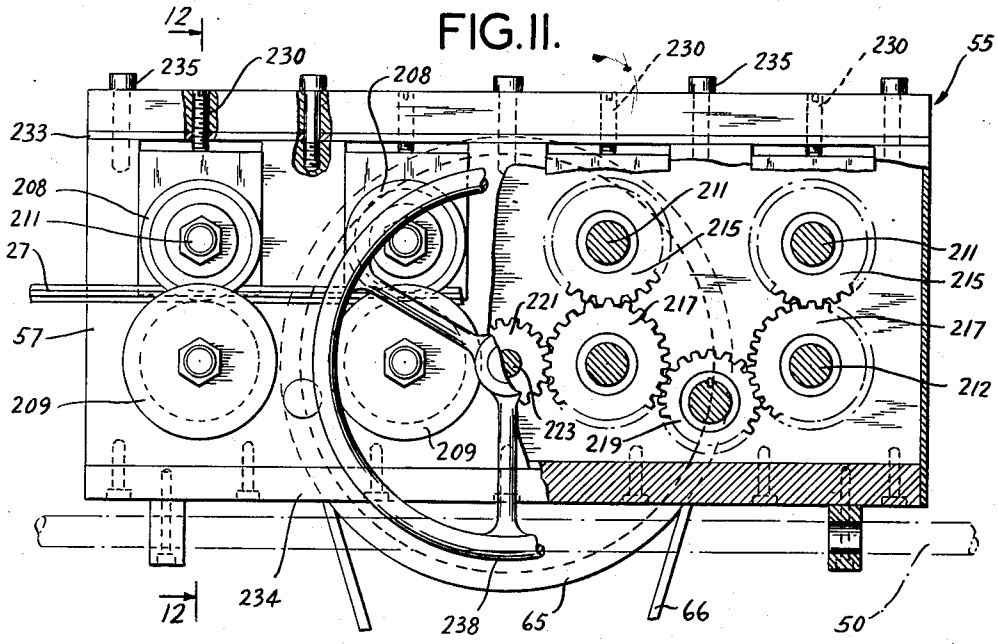
FIG. 11.



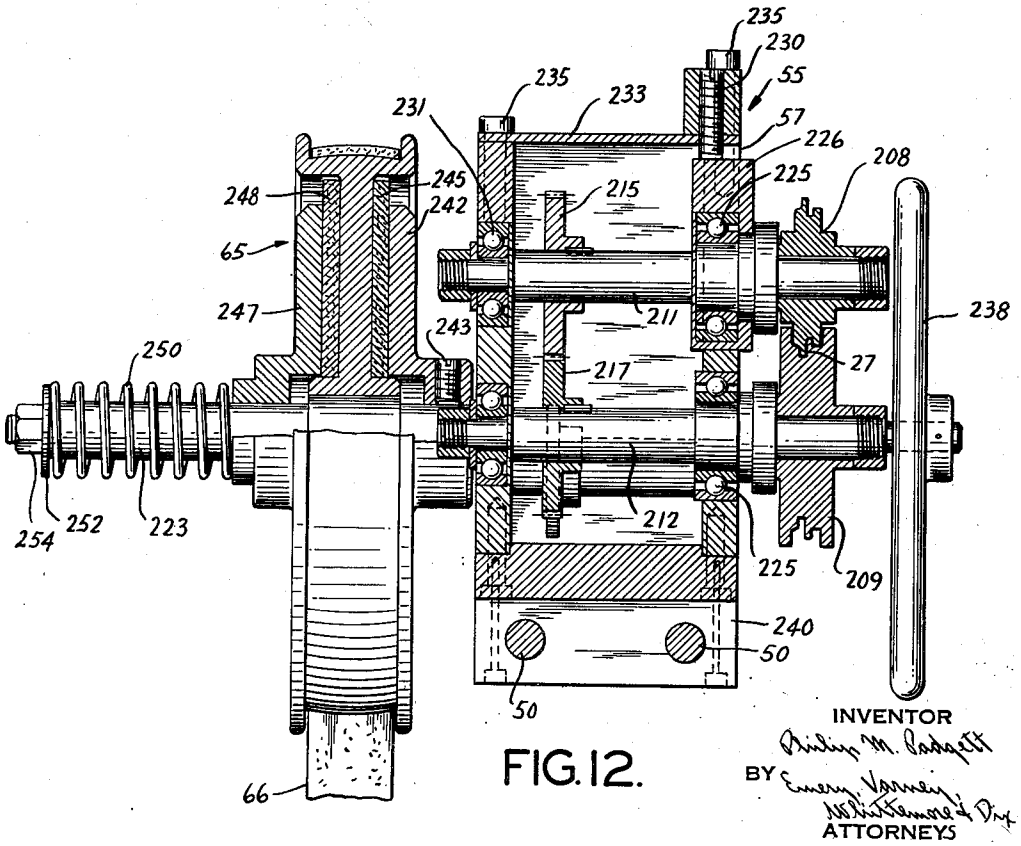


FIG. 12.

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MACHINE FOR MAKING NONCIRCULAR TUBING
ON CONTINUOUSLY ROTATING ARBORS

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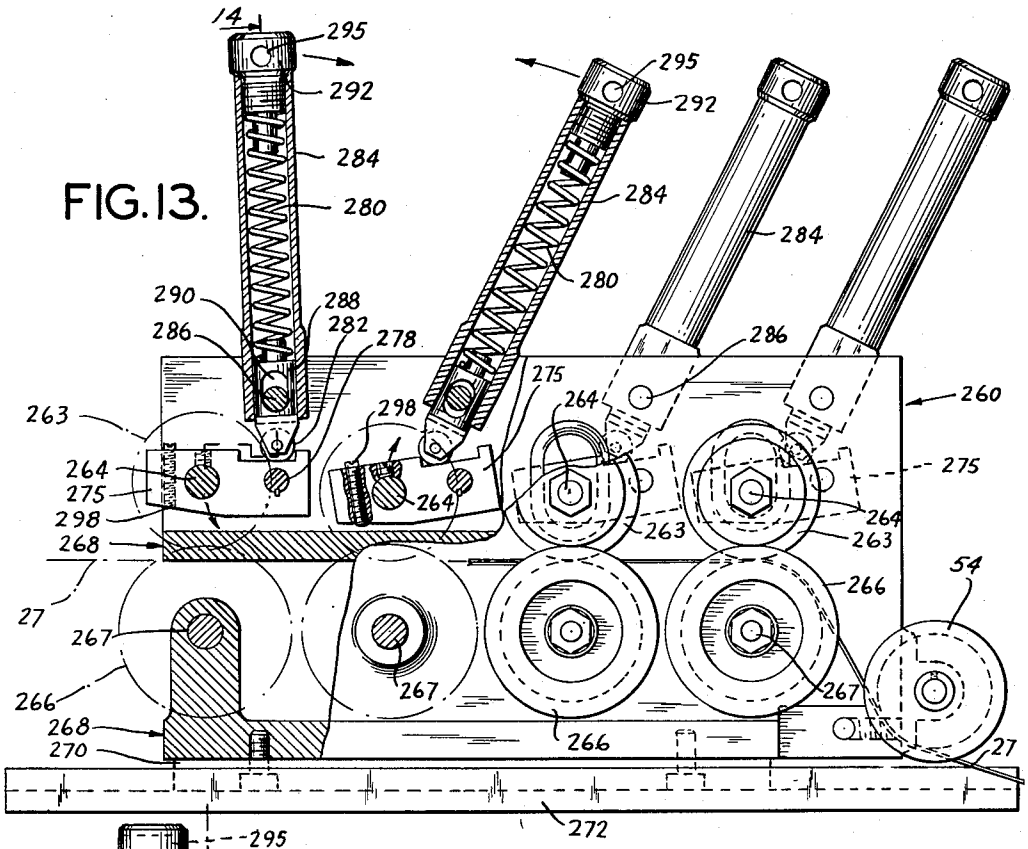
FIG.13.



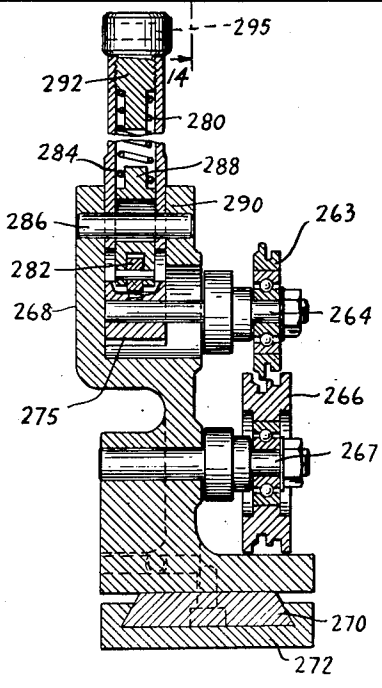


FIG.14.

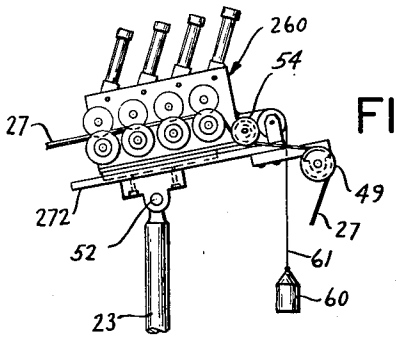


FIG.15.

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Patented Nov. 18, 1952 2,618,233

UNITED STATES PATENT OFFICE

2,618,233

MACHINE FOR MAKING NONCIRCULAR TUBING ON CONTINUOUSLY ROTATING ARBORS

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Application November 5, 1948, Serial No. 58,472

17 Claims. (Cl. 113—35)

1

This invention relates to machines for making flexible metal tubing.

It is an object of the invention to provide an improved machine for making metal tubing by helically winding a preformed metal strip around a rotating mandrel, and particularly a mandrel of non-rectangular cross section having two of its opposite sides substantially longer than the other two opposite sides.

A more specific object of the invention is to make helically wound, flexible metal tubing of rectangular cross section at higher speed than has been possible on the machines of the prior art, and to make such tubing with more uniform seams and with less scrap losses.

One feature of the invention which makes possible the higher speed operation and resulting greater production relates to positive displacement means for moving guiding and seaming rolls both toward and away from the axis of rotation of the mandrel. Such positive displacement means maintain the rollers in contact with the non-circular surface of the tubing as it is formed on the mandrel.

Another object of the invention is to provide a tube making machine in which guiding and seaming rollers located at angularly spaced regions around the mandrel produce a progressive movement of the flanged and folded edges of the preformed strip in such a way that tearing and cracking of the edges is eliminated and a locked seam is formed while the rollers strip the tubing progressively from the mandrel.

Another feature of the invention relates to the manner in which a wire is applied to the mandrel ahead of the strip and in such a way as to eliminate any kinks and irregularities in the wire before the strip is laid on the mandrel over the wire. Another feature of the wire feed relates to the application of substantially uniform tension to the wire regardless of the diameter of the supply reel from which the wire is payed out.

Other objects, features and advantages of the invention will appear or be pointed out as the description proceeds.

In the drawing, forming a part hereof, in which like reference characters indicate corresponding parts in all the views,

Figure 1 is a side elevation of a tube making machine embodying this invention,

Figure 2 is an end elevation of the machine shown in Figure 1,

Figure 3 is a top plan view of the machine shown in Figures 1 and 2,

Figure 4 is a greatly enlarged sectional view taken on the line 4—4 of Figure 3,

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Figure 5 is an enlarged detailed view of the mandrel and the guiding and seaming rollers for applying the strip material to the mandrel,

Figure 6 is an enlarged detail view, partly in section, of one of the supporting arms for the guiding and seaming rolls,

Figure 7 is a sectional view taken on the line 7—7 of Figure 6,

Figures 8, 9 and 10 are greatly enlarged sectional views showing the different rollers by which the preformed material is guided and seamed as it wraps around the mandrel.

Figure 11 is an enlarged view, partly broken away and partly in section, of the strip forming roll assembly shown in Figure 1,

Figure 12 is an enlarged sectional view taken on the line 12—12 of Figure 11,

Figure 13 is a side elevation, partly in section, showing a modified forming roll assembly that can be used in place of the structure shown in Figure 11.

Figure 14 is a sectional view taken on the line 14—14 of Figure 13,

Figure 15 is a side elevation, on a reduced scale, showing the way in which the forming roll assembly of Figures 13 and 14 is assembled with the frame of the machine shown in Figure 1, when this modified forming roll assembly is used in place of the forming roll assembly of Figure 1.

The tube making machine includes a fixed frame 20 that rests upon a floor or other support. This frame has suitable control switches 21 and 22 at the front in position for convenient actuation by the operator of the machine. There is a post 23 connected with the back of the main frame by brackets 24 and 25. These brackets and the post 23 are part of the fixed frame 20 of the machine.

A reel of metal strip 27 rests on a plate 28 supported from the main frame of the machine by a bracket 29. The plate 28 is held in position by a stud 31 which extends through an opening in the center of the plate; and the reel of strip 27 is held down on the plate 28 by a frame 32 connected with the plate 28 by hinges 33.

When a roll of strip 27 becomes exhausted, the plate 28 is lifted from the bracket 29 and another plate having a full reel of strip is substituted. This quick change keeps the rate of production of the machine at a high value.

The strip 27 passes out from the reel across a guide roller 35 and then turns upward around a roller 36 of an automatic stop device 38. This automatic stop device has a feeler 40, preferably a roller, at the lower end of a lever 41. A pivot 42 supports the lever 41, and a switch operator

44 bears against the upper portion of the lever 41 above the pivot 42.

As long as the roller 36 and feeler 40 are held apart by the presence of a strip of metal between them, the automatic strip device 38 is ineffective. Whenever there is no strip between the roller 36 and feeler 40, either because of breakage of the strip or the exhaustion of the supply reel on the plate 38, the feeler 40 moves closer to the roller 36 and this motion permits the switch operator 44 to move far enough to operate the automatic stop device and shut off the electric power that operates the machine.

The strip 27 passes upward through feed rollers 46 operated by a motor 47 that supplies the power for paying out the strip 27 from the supply reel on the plate 28. The strip 27 passes upward further to an idler roller 49 supported by a bracket at one end of a track 50. This track 50 is attached to the fixed frame of the machine by a connection 52 that is adjustable to change the inclination of the track 50. The strip 27, after passing around the roller 49, passes around a guide roller 54 and then through a number of successive roll passes in a forming roll assembly 55.

The forming roll assembly 55 includes a frame 57 that slides on the track 50. In the ordinary operation of the machine, the track 50 is set on an inclination that makes the assembly 55 tend to slide down the incline in a direction away from the guide roller 49. The forming roll assembly 55 is counterbalanced on the track 50 by a weight 60 connected to the frame 57 by a ribbon or cord 61 that passes around a pulley 62 carried by a lug extending upward from the track 50.

The forming rolls in the forming roll assembly 55 are geared together for operation in unison and include successive pairs of rolls that comprise roll stands through which the strip passes successively. This construction will be described more fully in connection with Figures 10 and 11. It is sufficient for the present to understand that the forming rolls are driven by a pulley 65 to which power is supplied by a belt 66 from a smaller pulley 67. This pulley 67 is on a shaft 68 with another pulley 69 that receives power through a belt 70 from a double-groove adjustable pulley 71.

The belt 70 runs in one groove of the adjustable pulley 71 and another belt 73 runs in the other groove of the pulley 71 and connects this pulley 71 with a driving pulley 74 on a jack shaft 75 near the bottom of the machine. The jack shaft 75 is rotated by an electric motor 77 through reduction gearing, and by pulleys 79 and 80 secured to a reduction gear output shaft 81 and the jack shaft 75 respectively.

The adjustable pulley 71 rotates on an axle carried by a bracket 72 which is movable in either direction about a pivot 84 that connects the bracket 72 with the fixed frame 20 of the machine. A clamping screw 76 extends through the fixed frame 20 and through an arcuate slot in the bracket 72. This clamping screw can be tightened to hold the bracket 72 in any adjusted position. The movement of the bracket 72 about its pivot 84 provides an adjustment for the tension of the belt 73; and the tension of the belt 70 can be adjusted by raising and lowering a clamp 78 that supports the pulley 67 from the post 23.

The position of the pulley 65 with respect to the pulley 67 is correlated with the slope of the track 50 so that movement of the frame 57 along the track 50 under the influence of the weight 60 reduces the distance between the centers of the pulleys 65 and 67. This results in a decrease in the tension of the belt 66 so that the belt slips and stops the rotation of the forming rolls in the forming roll assembly 55. Such movement of the frame 57 can only occur when the strip 27 breaks beyond the forming roll assembly 55. The movement of the forming roll assembly 55, therefore, under the influence of the weight 66, provides an automatic stop for cutting off the supply of power to the forming rolls whenever the strip 27 breaks beyond the forming rolls.

The strip 27 is pulley from the forming rolls by a mandrel 83. Power for rotating the mandrel is supplied from a pulley 85 on the jack shaft 75, to a pulley 87 through V-belts 88. The motion transmitting connections through which the pulley 87 rotates the mandrel 83 will be described more fully in connection with Figure 4. For the present it is sufficient to understand that the mandrel 83 is rotated continuously and at uniform speed by the power drive.

There are a plurality of rollers adjacent the mandrel 83 and angularly spaced around the mandrel. In the construction shown there are four rollers 91, 92, 93 and 94. Each of these rollers is carried by a support 96 connected by a pivot 97 with fixed extensions 98 of the frame of the machine. The supports 96 are movable about the pivots 97 to shift the rollers 91 to 94 toward and from the axis of rotation of the mandrel 83. This movement is necessary in order to enable the machine to operate with non-circular and polygonal mandrels which have variations in their width at different regions around the periphery of the mandrel. There is a guide, preferably a roller 99, across which the strip passes just ahead of the roller 91. This guide roller 99 is carried by the same support 96 that carries the roller 91 and is in a definite fixed relation to the roller 91 that causes the strip to always maintain an arc of contact with the roller 91.

In order always to maintain the strip wrapped around the first roller 91 far enough so that the strip contacts with this roller 91 before wrapping around the mandrel 83, it is necessary to locate the guide roller 99 high enough so that its contact with the strip is at an elevation at least as high as the upper limit of the range of the tangents to the roller 99 at the various points of nearest approach of the roller 99 to the mandrel 83. For example, if no tangent to the roller 91, at its point of nearest approach to the mandrel, ever passes above the elevation at which the guide roller 99 holds the strip, then the strip will never come in contact with the mandrel before contacting with the roller 91, and this means that the strip is always guided by the roller 91 as the strip reaches the mandrel. This guiding is important because the initial engagement of the edges of the strip with the opopsite edge of the preceding convolution on the mandrel must be accurate to insure tubing having a uniform seam.

For making tubing having a soldered seam, means are provided for feeding a thread of solder toward the mandrel into position to be incorporated into the seam of the tubing at the time that the strip 27 is wrapped around the mandrel to form the tubing. These means include a solder supply roll 100 from which a thread of solder 101 passes upward around guide rolls 102

to the mandrel 83. A switch feeler 103 bears against a run of the solder and actuates an automatic stop switch in the event that the solder thread breaks. The solder thread travels past a fluxing device in a manner well understood in the art, and no illustration of the fluxing device is necessary for a complete understanding of this invention.

In addition to the metal strip 27 and the solder thread 101, a wire 106 is supplied to the mandrel from a reel 108 near the bottom of the machine; the wire passing first over a vertical guide roller 110 and then around a horizontal guide roller 111. The purpose of the wire is to provide a support under the corrugations of the metal strip to prevent these corrugations from being mashed down during the forming of the tubing on the mandrel.

In order to have the wire 106 wind on the mandrel without kinks, the wire is maintained under tension as it comes to the mandrel. This is done by providing a brake 114 (Figure 2) which bears against a disc 115 to supply friction that resists the unwinding of the wire from the reel 108. This brake 114 is applied by a spring, and the pressure of the brake can be relieved by pulling upward on a pull rod 117 that connects with a bell crank 118.

The bell crank 118 is supported from the main frame by a pivot 120, and the guide pulley 110 is carried by the upwardly extending arm of the bell crank 118. As the pull on the wire 106 increases, the guide roller 110 is pulled to the right in Figure 2, and this rocks the bell crank 118 in a direction to relieve some of the pressure of the brake so that the wire unwinds more easily from the reel and is under reduced tension. This construction provides an automatic control for maintaining substantially constant tension on the wire as it is supplied to the mandrel.

Figure 4 shows the apparatus for rotating the mandrel 83 and for moving the rollers 92 and 94 to follow the changes in the width in the mandrel. The pulley 87 is keyed to a hollow shaft 124 that turns in bearings 125 mounted in the main frame 20 of the machine. One end of the mandrel 83 is rigidly connected with a cam 127 and the assembly comprising the mandrel 83 and the cam 127 fits into a socket 129 in an enlarged end portion of the sleeve 124.

There is a threaded socket 133 in the rearward end of the mandrel 83. A draw bolt 134 extends through the hollow shaft 124 and threads into the socket 133. The rearward end of the draw bolt is threaded to receive a nut 135 which reacts against the hub of a hand wheel 136 to pull the draw bolt 134 rearwardly and to hold the mandrel 83 and cam 127 securely in the socket 129 at the end of the hollow driving shaft 124.

The hand wheel 136 is keyed to the driving shaft 124 and provides a convenient means for turning the mandrel by hand when starting the forming of a new piece of tubing on the mandrel, or when adjusting the machine. The mandrel 83 and cam 127 are also connected with the driving shaft 124 by keys as will be more fully explained in describing the operation of the cam.

The fixed extensions 98 are connected with another part of the fixed frame 20 by screws 140, and the supports 96 are spaced some distance ahead of the fixed extensions 98 by spacers 142 and 143. Nuts 146 threaded over the opposite ends of the pivot 97 hold the assembly together.

At the lower end of the support 96, there is an angle 148 by which a composite bearing bracket 149 is connected with the support 96. This bearing bracket 149 is held in place on the angle 148 by a dowel pin 150, but the angular position of the bearing bracket 149 is determined by screws 152 extending through slots in the angle 148 and threaded into the composite bearing bracket 149. The roller 94 has an axle 154 connecting it with the bracket 149. All of the other rollers around the mandrel 83 are similarly connected with the other supports 96.

A cam follower, preferably a roller 160, is connected with each of the supports 96 and is located in position to contact with the face of the cam 127. This cam 127 is held in a fixed and definite angular relation to the mandrel 83 by a key 162; and the face of the cam 127 is shaped to maintain the roller 94, and the other rollers that are located around the mandrel, in working relation to the mandrel at all times. Thus the cam 127 displaces the cam follower 160 to move the roller 94 closer to the axis of rotation of the mandrel 83 whenever a portion of the mandrel having a reduced width is moving into position under the roller 94.

The other cam followers 169 cause the other rollers around the mandrel to stay in working relation with the mandrel 83 during its rotation. It is necessary for the cam 127 to move the rollers toward the mandrel only, because the mandrel itself, being non-circular, acts as a cam and pushes the rollers outward away from its axis of rotation whenever portions of the mandrel having greater width are moving into position under the rollers 92 or 94, or the other rollers that are located adjacent the mandrel but not visible in Figure 4.

The roller 94 has a peripheral surface 165 at the rearward end of the roller for contact with the surface of the mandrel 83. Since this surface 165 is beyond the grooves of the roller that guide the metal strip, and beyond the portion of the mandrel on which the metal strip wraps, it can contact directly with the mandrel and serve as a follower for pushing the roller outward away from the axis of rotation of the mandrel under the cam action of the mandrel.

In the preferred construction, the radius of the face 165 is greater than the radius of any other part of the roller 94 by a value at least as great as the thickness of the metal strip with which the roller is intended to be used. This makes it possible for the face 165 to touch the surface of the mandrel 83 while the metal strip is being wrapped on the mandrel.

Because of the fact that the roller 94 is free to rotate and therefore has comparatively little friction against the metal strip, it is also practical to rely upon pressure transmitted from the mandrel through the strip to the roller 94 for camming the roller 94, and the other rollers that surround the mandrel, outward away from the axis of rotation of the mandrel, instead of having the peripheral surface 165 of a diameter sufficient to maintain contact with the mandrel. Depending upon the diameter of the peripheral surface 165 and its relation to the diameters of the other parts of the roller 94 and the thickness of the metal strip, the roller 94 will clamp the metal strip tightly against the surface of the mandrel 83 or press and guide the metal strip into a position close to the mandrel as the strip is drawn into actual contact with the surface of the mandrel by the tension of the strip approaching the mandrel. The roller 94, and the other rollers around the mandrel 83, are said to be in

"working relation" with the mandrel 83 when they are either clamping the metal strip against the mandrel or located close enough to the mandrel to guide and form the tubing as the strip is wrapped around the mandrel by the tension of the approaching strip.

The brackets 149 are angularly adjusted about the dowels 150 so as to make the grooves of the roller 94 extend in the same direction as the helical seam that is to be formed when wrapping the strip on the mandrel. The roller 92 and the other rollers around the mandrel are similarly turned, and the corresponding grooves of the successive rollers around the mandrel contact with the strip on the mandrel at regions which are spaced axially to correspond with the pitch of the helix in which the strip is wound. The rollers 92 and 94, and the other rollers around the mandrel, are held against axial movement on their axles, however, so that as the mandrel continues to rotate, the material on the mandrel is progressively stripped from the mandrel as it forms into a tube.

There is a socket 167 in one end of the mandrel for receiving an extension that can be used to support the tubing as it is pushed beyond the end of the mandrel by the stripping action of the rollers 92, 94 and the other rollers around the mandrel. A set screw for holding this mandrel extension in place can be threaded into the opening 169. This opening 169 is located in a portion of the mandrel beyond the region where the strip is formed into tubing so that the opening through the surface of the mandrel will not affect the wrapping or seaming of the tube.

The guide roller 99 turns on an axle supported by a bracket 170 which is attached to the support 96 by screws 171. It is a feature of the invention that the guide roller 99 is located above a line passing through the point of tangency of the roller 91 on the mandrel 83, or the point on the roller circumference that is closest to the mandrel with constructions that do not have actual contact between the roller 91 and the mandrel 83. The importance of this feature is that it insures the guiding of the strip by the roller 91 at all times.

It will be apparent that the point of tangency of the roller 91 on the mandrel 83 or the point of the roller closest to the mandrel will vary and will be at different phase angle positions of the roller 91, that is, at points which are in different angular relation to the axis of the roller, when the roller 91 swings with its support 96 toward and from the axes of rotation of the mandrel as wider and narrower portions of the mandrel move into position under the roller 91. The guide roller 99 is located in position to wrap the strip 27 around the roller 91 along an arc of contact that includes all of the points of tangency, or points of nearest approach, of the roller 91 with the non-circular mandrel 83.

In order to obtain accurate positioning of the cam follower 160 with respect to the roller 94, there is a slot 172 cut in the support 96 between the portions of the support to which the cam follower and roller are connected. The respective distances of the cam 160 and roller 94 from the center of rotation of the mandrel 83 can be controlled by increasing or decreasing the width of the slot 172. This is done by means of screws, best illustrated in Figure 7.

There is another screw 178 that threads through an opening 179 and that presses against the wall on the side of the slot 172 opposite the end of the threaded opening 179. When this screw 178 is turned in a direction to screw it further into the threaded opening 179, the end of the screw pushes against the wall of the slot 172 and spreads the slot to make it wider.

It will be evident that the screws 175 and 178 must be operated in such a way that one of them does not make the adjustment of the slot by the other one impossible. The fact that the screws 175 and 178 operate in opposition to one another enables an attendant to lock these screws in position by merely screwing both of them tightly into position opposing the other screw.

Figure 8 shows the roller 91 which guides the strip 27 into its initial contact with the mandrel 83. There are a plurality of circumferentially extending grooves in the face of the roller 91. These include a groove 181 for guiding the wire 106 as it wraps around the mandrel 83. Another groove 182 in the roller 91 guides the flanged edge of the strip 27 as the strip wraps around the mandrel. It is a feature of the invention that the groove 182 has sloping faces which permit the upstanding flange of the preformed strip 27 to bend over part way out of its original vertical position. This bending over of the flange prevents the flange from stretching and tearing in a way that has been experienced on other tube making machines using non-circular mandrels.

A particular problem is presented by the non-circular mandrel, even though it rotates continuously, because the changes in the radial width of the portion of the mandrel with which the strip has its initial contact cause substantial variations in the rate at which the strip is drawn to the mandrel. This causes an uneven pull on the strip, and with this invention the flange of the strip is relieved of some of the strain resulting from the pulling and bending of the strip by being allowed to bend over part way so that the outer edge of the flange is nearer to the center of curvature of the bend, with the result that the flange does not have to stretch as much.

In order to obtain economically the particular shape desired for the groove 182, the roller 91 is of composite construction with a ring 186 pressed over a reduced diameter portion of the body of the roller 91, and the inner face of this ring 186 comprises one side of the groove 181. The roller 91 has ball bearings 188 for reducing its friction as it rotates about its axle 154. All of the other rollers around the mandrel 83 have similar ball bearings, though other types of bearings can be used if desired.

A third groove 183 of the roller 91 guides the folded over edge of the preformed strip 27 into engagement with the flange of the next adjacent convolution of the strip on the mandrel 83. There are other grooves 185 in position to receive subsequent convolutions of the seamed tubing on the mandrel. The roller 91, and the other rollers that are located around the mandrel 83, act in effect as a roller nut through which the tubing screws as the mandrel rotates. The tubing is thus stripped from the mandrel progressively as it is formed.

Figure 9 shows the roller 92 with a groove 191 for the wire 106, and a second groove 192 that bends the flange of the metal strip back into a substantially vertically extending position. The bending of the flange after the strip is wrapped on the mandrel, and while the strip approaches and passes into the groove 191, permits the flange to be returned to its upright position without tearing because the pressure is applied gradually

and substantially uniformly in a manner that permits cold flow of the metal of the strip.

A third groove 193 is not as deep as the corresponding groove 183 of the roller 91 and this groove 193 forces the folded edge of the strip toward the mandrel and starts the interlocking of the seam. Other grooves 195 correspond with the grooves 185 of the roller 91 and the side walls of these grooves serve to strip the tubing from the mandrel, in a manner already explained.

Figure 10 shows the roller 93 with a groove 201 for the wire 106 and a groove 202 for guiding the flanged edge of the metal strip and advancing the strip axially along the mandrel 83 in accordance with the progressive stripping action of the rollers previously explained. The next groove 203 is shallower than the corresponding groove 193 and the previous roller 92. The groove 203 is preferably shallow enough to bend the folded edge of the strip and its engaging flange all the way down to form an interlocked seam for the tubing, and the bottom of this groove 203 preferably rolls the interlocking seam against the wire 106 on the mandrel. The wire prevents the corrugation under the seam from being mashed down by the seaming operation.

The solder thread 101 is enclosed within the seam and is fused subsequently after the tubing is stripped from the mandrel. Other grooves 205 in the roller 93 assist in the stripping of the tubing from the mandrel. The fourth roller around the mandrel is preferably of the same construction as the roller 93 shown in Figure 10.

Figure 11 shows the roller assembly 55 with part of the structure broken away to show the apparatus for driving the rolls. Although each of the rolls in the roll assembly 55 is of different shape, the upper rolls are all indicated by the same reference character 208, and all of the lower rolls are indicated by the reference character 209. The upper and lower rolls 208 and 209 are secured to axles 211 and 212 respectively. There is a gear 215 keyed to each of the upper shafts 211; and there is a gear 217 keyed to each of the lower shafts 212. These gears 215 and 217 for each pair of complementary forming rolls mesh with one another. Idler gears 219 disposed between the gears 217, connect the different roll stands for operation in unison.

A driving gear 221 located between the second and third pair of forming rolls meshes with the gears 217 on opposite sides of it. This driving gear 221 is connected with a drive shaft 223 (Figure 12) which is rotated by the pulley 65. The axles 211 and 212 are supported in ball bearings 225. The upper ball bearings 225 are carried in blocks 226 which are adjustable in the frame 57 which hold down screws 230 for regulating the gap between each of the upper forming rolls 208 and its complementary lower forming roll 209. The rearward ends of the axles 211 and 212 are carried in ball bearings 231 held in the frame 57.

The sides of the frame of the roll assembly 55 are secured together at their upper and lower ends by a top plate 233 and a bottom plate 234, respectively; and these plates are connected with the sides of the frame by screws 235. For initially threading the strip 27 through the successive roll stands of the roll assembly 55, there is a large hand wheel 238 attached to the end of the drive shaft 223 in position to turn the drive shaft without the use of power. Brackets 240 attached to the bottom plate 234 serve as runners on which the roll assembly 55 is movable along the track 50.

Figure 12 shows also the connection of the pulley 65 with the shaft 223. The portion of the pulley that is rotated by the belt 66 is free to turn on the shaft 223, but the shaft 223 is secured to a flange 242 by a set screw 243, and a friction clutch disc 245 is located between one side wall of the pulley 65 and the confronting side wall of the flange 242. The pulley is urged against this friction clutch disc 245 by another flange 247 which is located on the other side of the pulley 65 and which transmits pressure to the pulley 65 through another friction clutch disc 248.

The pressure with which the pulley 65 is clamped between the flanges 242 and 247 is determined by a spring 250 compressed between the hub of the clutch flange 247 and a washer 252 that is retained on the end of the shaft 223 by a nut 254. A limited adjustment of the pressure of the spring 250 can be obtained by screwing the nut 254 along the threads that connect it with the shaft 223. In the illustrated construction, the threaded end of the shaft 223 is short because there is ordinarily no occasion to adjust the pressure of the spring 250.

The friction clutch comprising the flanges 242 and 247, and the parts clamped between them, is correlated with the forming rollers 207 and 208, and with the size and hardness or stiffness of the strip 27 so that the driving clutch will slip before it supplies enough torque to drive the forming rolls. Additional power must be supplied by turning the mandrel, and pulling the strip toward the mandrel as it wraps on the mandrel.

In the preferred construction, the pulley 65 and its associated friction clutch are made so that they will supply approximately two-thirds of the torque required for advancing the strip 27 through the forming roll assembly 55. The power driving connection to the forming rolls greatly reduces the tension in the run of the strip between the forming roll assembly and the mandrel, but some tension in the strip is desirable.

Figure 13 shows a forming roll assembly 260 that can be used in place of that shown in Figures 11 and 12, if desired. The forming roll assembly contains only idler rolls, and the strip 27 is advanced through these forming rolls entirely by the tension imparted to the strip by the wrapping action of the mandrel. This forming roll assembly is suitable for small or light gauge strip, but for strip that requires substantial power to form it, the roll assembly of Figures 11 and 12 is preferred.

The forming roll assembly 260 includes upper forming rolls 263 on axles 264; and lower forming rolls 266 on axles 267. The axles 267 are fixed with respect to a main frame 268. This frame has a dovetail slide 270 which runs along a groove in a track 272.

Each of the axles 264 is supported from a block 275 which swings about a pivot 278. The block 275 can be urged by a coil spring 280, to rock either clockwise or counterclockwise about its pivot 278. The force of this spring 280 is exerted through a roller 282 that is movable to either the right or left of the pivot 278.

This shifting of the spring 280 and roller 282 is effected by swinging a tubular housing 284, in which the spring 280 is enclosed, about a

pivot 286 that connects the spring housing 284 with the frame 268 of the forming roll assembly. Each of the rollers 282 is carried by an axle at the forked lower end of a block 288 that slides in the bottom portion of the tubular spring housing 284. This block 288 has a slot 290 extending through it, and the pin 286, which connects the tubular spring housing 284 with the frame 268, extends through the slot 290 and prevents the block 288 from rotating. The upper end of the spring 280 contacts with a plug 292 threaded in the upper end of the spring housing 284. The plug 292 has an opening 295 through which a tool can be inserted for unscrewing the plug 292 if it sticks in the spring housing.

In Figure 13 the left-hand spring housing is in position to apply the pressure of the roller 282 against a portion of the block 275 slightly to the right of the axis of the pivot 278 about which the block 275 swings. This separates the rollers 263 and 266.

The next spring housing 284 is shown in a different position in which it causes the pressure of the spring 280 to be applied to the block 275 on the left-hand side of the axes of the pivot 278 so that the upper forming roll is urged toward the lower forming roll. There is an adjustable stop screw 298 in each of the blocks 275. These stop screws extend beyond the lower end of the blocks 275 and strike against the portions of the frame 268 below the blocks to limit the minimum clearance between the upper and lower rolls 263 and 266.

Figure 15 shows the way in which the manually releasable forming roll assembly 260 is mounted on the track 272 with the adjustable connection 52 set to give the track 272 an inclination that will permit the entire forming roll assembly 260 to move upward under the pull of the weight 60 whenever there is a break in the strip 27 between the forming roll assembly and the mandrel. This movement of the forming roll assembly 260, along the track 272, can be made to operate a switch to shut off the supply of electric power to the machine in the event of such a break in the strip.

The preferred embodiment of the invention and some modifications have been described, but changes and other modifications can be made, and some features can be used alone or in different combinations without departing from the invention as defined in the claims.

What is claimed is:

1. A machine for making helically wound, convoluted tubing including, in combination, a non-circular mandrel, apparatus for rotating the mandrel, a plurality of rollers angularly spaced around the mandrel substantially in contact with the mandrel and in positions to guide a preformed metal strip and make it into convoluted tubing as it wraps around the mandrel, one or more of said rollers being shaped to seam adjacent convolutions of the strip, supporting means for at least the one of said rollers with which the strip first comes into contact as the strip is wrapped around the mandrel, said supporting means including bearings on which the supporting means are movable in directions that shift the first roller toward and from the axis of the mandrel along a predetermined path as the non-circular mandrel rotates under said first roller, and a combined guide and arc control element for the formed strip ahead of the first roller and in position to hold the formed strip wrapped around the first roller along an arc that extends beyond the range of locations at which the mandrel and first roller most nearly approach one another during the movement of the first roller toward and from the mandrel along said predetermined path.

2. A machine for making non-circular, convoluted tubing by helically winding a preformed strip, said machine comprising a non-circular mandrel about which the strip is wound, apparatus for rotating the mandrel, rollers around the mandrel that make the strip into a convoluted tubing as the strip is wound on the mandrel, said rollers including a first roller substantially in contact with the mandrel and that presses the preformed strip into contact with the mandrel, other rollers angularly spaced from the first roller around the mandrel in positions to guide and seam adjacent convolutions of the strip, supports by which the rollers are carried and with which the rollers are movable to follow the variations in the width of the non-circular mandrel, said supports including bearings that confine the movement of the rollers to predetermined paths and a combined guide and arc control element for the formed strip ahead of the first roller and in position to wrap the strip around the first roller along an arc of contact that includes all of the points on the circumference of the first roller that becomes tangent with the surface of the mandrel as the first roller moves along its predetermined path to follow the variations in the radial width of the portion of the mandrel immediately adjacent to said first roller.

3. A machine for making flexible metal tubing including a non-circular mandrel, apparatus for rotating the mandrel, forming rolls that shape a metal strip with a fold along one edge and an upturned flange along the other edge, a roller adjacent the mandrel in position to cause the preformed strip to wrap around the mandrel in a helix, a support for said roller movable toward and from the axis of rotation of the mandrel along a predetermined path, means for causing the roller to move with said support as the width radial of the mandrel under the roller changes during rotation of the mandrel, a guide that fits the preformed strip on the opposite side of the strip from the roller and that is located between said roller and the forming rolls in a position to deflect the run of strip between said roller and the forming rolls in a direction to wrap the strip around an arc of said roller, said arc being at least long enough to include all of the points on the circumference of the roller that becomes tangent with the surface of the mandrel as the roller moves along said predetermined path while following the variations in the radial width of the mandrel and other rollers located around the mandrel and angularly spaced in positions to guide successive convolutions of the strip and to interlock the folded and flanged edges of successive convolutions to form a helical seam.

4. A machine for making flexible, convoluted metal tubing including a non-circular mandrel, a roller adjacent the mandrel in position to cause a preformed metal strip to wrap in a helix around the mandrel, a support for said roller, a bearing on which said support moves about an axis that is parallel to and fixed with respect to the axis of rotation of the mandrel, means for causing the roller and its support to follow the mandrel as angular regions of the mandrel of greater and lesser radial width move under the roller, other rollers angularly spaced around the mandrel for

guiding and seaming adjacent convolutions together, and a combined guide and arc control element for the formed strip located adjacent the first roller in position to bear against the strip on the opposite side of the strip from the first roller before the strip reaches the first roller, and at a position that holds the strip against the circumference of the first roller along an arc that is at least long enough to include at all times the point on the circumference of the first roller that is nearest to the mandrel as the first roller swings about the axis of its support to follow changes in the radial width of the mandrel.

5. A machine for making helically seamed, non-circular tubing, said machine including a mandrel having the desired cross section of the tubing, mechanism for rotating the mandrel, a plurality of rollers located at angularly spaced regions around the mandrel in position to guide a strip and seam it as said strip wraps around the mandrel in a helix, a separate arm by which each roller is carried, a pivot about which each arm swings, a cam follower connected with each arm and located near the same end of the arm as the roller, a cam having a displacement surface upon which the followers run and by which each follower and its associated roller and arm assembly is displaced toward the axis of the mandrel as portions of the mandrel having reduced radial thickness come under the respective rollers, the surfaces of the non-circular mandrel itself comprising a second cam that cooperates with each roller, cam follower and arm assembly to move it away from the axis of the mandrel as portions of the mandrel having greater radial thickness come under the respective rollers, means on the arms adjustable to change the spacing of the axes of the cam follower and roller with respect to one another on the respective arms, and cam driving means that rotate the mandrel and cam in constant phase angle relation with one another.

6. Apparatus for making non-circular tubing including, in combination, a fixed frame, a non-circular mandrel, bearings in the frame in which the mandrel is rotatable about an axis, a plurality of rollers located at angularly spaced regions around the mandrel for guiding and bending a metal strip as it wraps around the mandrel, supports with which the rollers are movable toward and from the axis of the mandrel to follow the variations in the shape of the mandrel, cam followers connected with said supports and each of which comprises a unitary assembly with its associated support and roller, there being a separate cam follower for each support and said cam followers being angularly spaced around the axis of the mandrel and having their axes generally in alignment with the axes of the respective rollers, a cam that surrounds the mandrel and that has an inside displacement surface on which the cam followers run, said cam having changes in contour corresponding to the changes in radial width of the mandrel to move the rollers toward the mandrel during periods when the radial width of the mandrel under the respective rollers is decreasing, the surfaces of the non-circular mandrel itself comprising a second cam that cooperates with each roller, cam follower and arm assembly to move it away from the axis of the mandrel as portions of the mandrel having greater radial thickness come under the respective rollers, mechanism that drives the mandrel and cam with a continuous rotation at the same speed and at constant phase angle to one another, and releasable fastening means connecting the cam to the apparatus.

7. A machine for making convoluted, helically wound tubing including forming rolls that bend a metal strip to provide an upturned flange along one side, a folded edge along the other side and a longitudinally extending corrugation between the sides of the strip, a mandrel on which the strip is wound, a plurality of rollers angularly spaced around the mandrel including a first roller with which the strip has contact before reaching the other rollers, peripheral grooves in said rollers shaped to wind the strip around the mandrel in a helix, to guide the folded edge of one convolution into engagement with the flange of the adjacent convolution and to bend the engaged flange and folded edge to form an interlocked helical seam, other peripheral grooves in the rollers beyond the strip guiding and bending grooves for stripping the tubing progressively from the mandrel as the tube is formed upon the mandrel, guide means that control the movement of both the formed strip and a wire to the first of said rollers, the guide means being located in contact with the strip and wire at least as high as the upper limit of the range of tangents to the first roller at its various points of nearest approach to the mandrel, other peripheral grooves in the rollers ahead of the strip guiding and bending grooves and in positions to cause the wire to wrap as a helix around the mandrel and to advance the wire into position to support the seam in spaced relation to the mandrel beyond the initial convolution of the wire.

8. A machine for making helically wound, corrugated metal tubing, including a mandrel, apparatus for rotating the mandrel, a plurality of rollers located adjacent the mandrel and angularly spaced around the mandrel, peripheral grooves in the rollers guiding a preformed strip that has a turned up flange along one side and a folded edge along the other side and a longitudinally extending corrugation between the opposite sides of the strip, other grooves in the rollers for guiding a wire to wrap the wire in a convolution ahead of the metal strip, said other grooves of the successive rollers having side walls that advance the wire along the mandrel into position to be covered by a convolution of the metal strip upon the next revolution of the mandrel, a supply reel from which wire is payed out to the mandrel, a brake on the supply reel, and a device responsive to the pull on the wire for controlling the force with which the brake is applied to the supply reel.

9. Apparatus for making flexible tubing including a rotatable mandrel, a plurality of rollers angularly spaced around the mandrel and in position to cause a preformed strip to wrap in a helix around the mandrel and form tubing having an interlocked seam and a helical corrugation, apparatus for supplying a wire to the mandrel in position to wrap in a helix around the mandrel and to support the helical corrugation of the tubing during the interlocking of the seam and to brace the helical corrugation against forces used to strip the tubing from the mandrel, a brake retarding the feeding of the wire to provide a tension in the wire as it wraps around the mandrel, a yieldably supported element deflecting a run of the wire as it approaches the mandrel, and motion transmitting connections between said element and the brake for changing the braking

force in proportion to the extent to which the wire is deflected by said element.

10. In a machine for making helically wound, non-circular tubing, a roller that guides a strip into its initial contact with a non-circular mandrel as the mandrel rotates to wrap the strip around it, a guide located adjacent to said roller in position to wrap the strip around an arc of the roller, a common support for the roller and guide, a bearing on which said support is movable to shift the roller along a predetermined path toward and from the axis of rotation of the non-circular mandrel, the arc of contact being at least long enough to include each and every point on the circumference of the roller that is closest to the mandrel at various times as the roller moves along said predetermined path to follow the differences in radial thickness of the mandrel.

11. In a machine for making helically wound, flexible metal tubing from a preformed strip having a longitudinally extending corrugation between its edges, a mandrel about which the strip is wrapped as a helix with successive convolutions in overlapping relation, a roller adjacent the mandrel in position to guide the strip into its contact with the mandrel, a strip guide immediately ahead of said roller and in contact with the strip at an elevation at least as high as the upper limit of the range of the tangents to the roller at its various points of nearest approach to the mandrel, grooves in the roller and guide for guiding the strip, and other grooves in both the roller and guide for guiding a wire to the mandrel one convolution ahead of the strip.

12. Apparatus for making flexible metal tubing, said apparatus comprising forming rolls that bend a metal strip to provide a flange along one side and a folded edge along the other, and a longitudinally extending corrugation between the flange and folded edge, a mandrel about which the formed strip wraps as the mandrel rotates, a plurality of rollers adjacent the mandrel and angularly spaced around the mandrel, a peripheral groove in at least the first of the rollers for guiding the strip to wrap it as a helix around the mandrel with the flange of one convolution engaged in the folded edge of the next adjacent convolution, a peripheral groove in another roller in position to bend the flange and folded edge into an interlocked seam, said rollers having other grooves extending in such directions and in such correlation with the corresponding grooves of the respective rollers that they strip the tubing from the mandrel progressively as the tubing is formed, guide means immediately ahead of the first roller in contact with the strip at least as high as the upper limit of the range of the tangent to the first roller at its various points of nearest approach to the mandrel, other peripheral grooves in the rollers, ahead of the grooves that engage the strip, in position to guide the wire to wrap as a helix around the mandrel, said other peripheral grooves of the respective rollers being in correlated positions for advancing the convolutions of the wire axially along the mandrel at the same rate that the convolutions of the metal strip are advanced by the stripping action of the rollers.

13. In a machine for making corrugated, helically wound, flexible tubing, a non-circular mandrel about which a strip of metal is wound, means for rotating the mandrel, a forming roll assembly through which the strip of metal is pulled by the wrapping of the strip on the mandrel, a frame that supports the forming rolls of said assembly, a track along which the frame is movable, said track extending in a direction that has a substantial component in the direction in which the strip travels from the forming roll assembly toward the mandrel, and yieldable means that continuously opposes any force urging the frame to move along the track in the direction of the pull of the strip as the strip feeds from the forming roll assembly toward the mandrel, the force of said yieldable means in the direction of the mandrel pull being of a magnitude between the maximum and minimum pull on the strip as the radial thickness of the mandrel changes at the point of initial wrap of the strip on the mandrel.

14. A machine for making tubing by wrapping a formed strip around a mandrel, said machine comprising a fixed frame, apparatus for rotating the mandrel with respect to the fixed frame, a forming roll assembly movable toward and from the mandrel and through which a strip of metal passes on its way to the mandrel, a track along which the forming roll assembly is movable, a pulley carried by the forming roll assembly for supplying power to the rolls of said assembly, a belt for driving the pulley, and another pulley that drives the belt and that is located on the fixed frame in such a position that movement of the forming roll assembly along the track away from the mandrel loosens the belt between the pulleys, and means urging the forming roll assembly to move along the track in the direction away from the mandrel so as to loosen the belt and stop the supply of power to the rolls of said assembly whenever there is no pull on the strip between the mandrel and the forming roll assembly.

15. Apparatus for making helically seamed, non-circular corrugated tubing from a metal strip, said apparatus comprising a non-circular mandrel about which the strip is wound in a helix by the rotation of the mandrel, forming rolls between which the strip passes to the mandrel and by which the strip is shaped to a desired transverse contour, driving mechanism that rotates the non-circular mandrel at substantially constant angular speed with resulting variation in rate of speed at which the strip is pulled through the forming rolls, which speed is dependent upon the changes in the radius of the mandrel at the region where the strip starts to wrap the mandrel, other power driving mechanism for the forming rolls including friction clutch means that slip when the strip in the forming rolls is not subjected to supplemental power by the pull of the strip by the mandrel, the driving mechanism for the forming rolls including mechanism that rotates the driving element of said friction clutch means at a rate to give the strip a lineal speed through the forming rolls equal to the maximum rate of pull of the mandrel, a carriage by which the forming rolls are supported, a track along which the carriage is movable toward and from the mandrel, and means urging the carriage to move along the track in a direction away from the mandrel with a predetermined force that yields whenever a greater force is exerted in the opposite direction by the pull of the strip from the mandrel.

16. The apparatus described in claim 15, and in which the clutch means of the power driving mechanism for the forming roll includes a friction disc clutch with elements that slip on one another at a torque less than that required to

drive the forming rolls with the strip between them.

17. Apparatus described in claim 15, and in which the forming rolls comprise a plurality of rolls supported by the carriage in position to provide successive roll passes through which the strip travels, driving gears connected with the respective rolls, intermediate gears between the roll driving gears connecting the roll drive gears of the different roll stands for operation in unison, and a power shaft on the carriage and connected with one of the gears, and in which the clutch means include a clutch that drives the power shaft, said clutch including driving elements that slip on one another at a torque that is less than that required to drive the forming rolls with the strip between them and with no pull from the mandrel.

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