June 2, 1953 R. S. CARR 2,640,451

TUBE WINDING MACHINE

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Fig. 3.

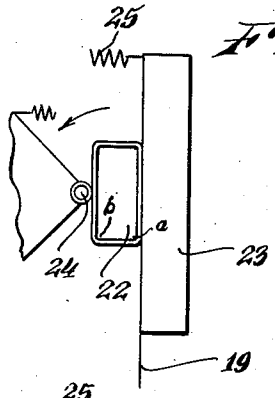


Fig. 4.

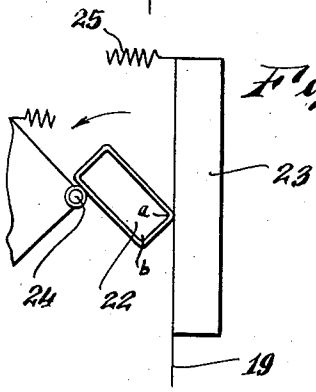


Fig. 5.

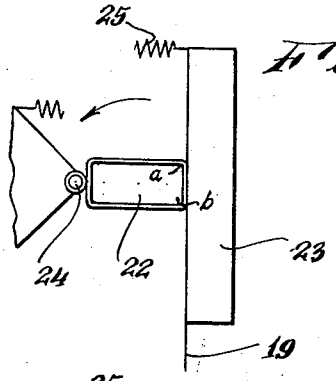


Fig. 6.

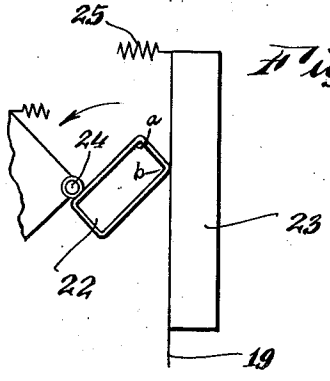


Fig. 1.

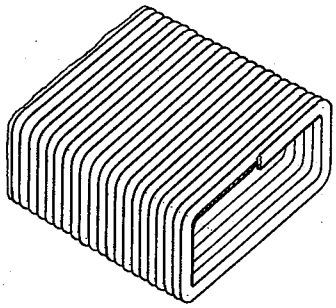


Fig. 16.



Fig. 17.

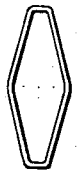
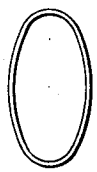


Fig. 18.



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Fig. 9.

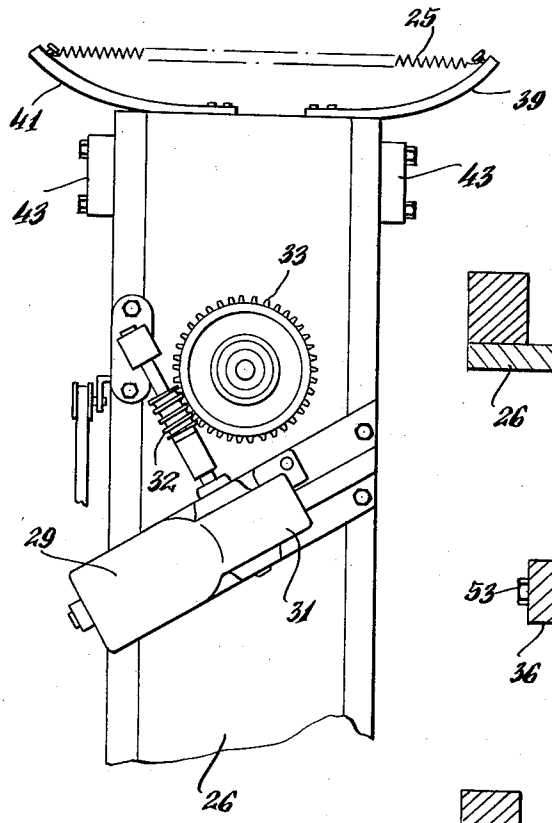


Fig. 10.

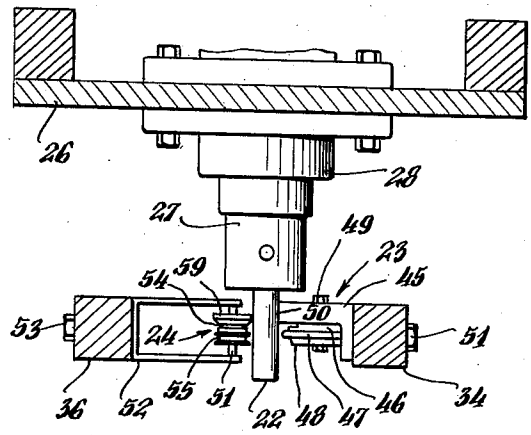
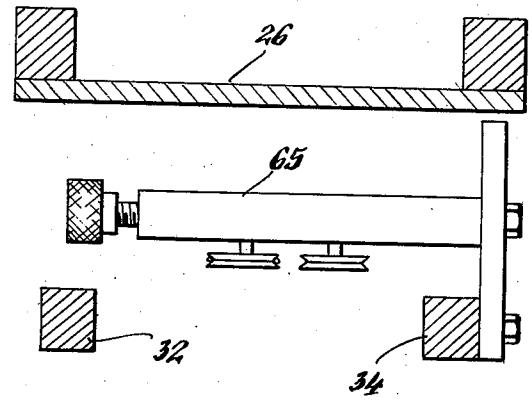


Fig. 11.



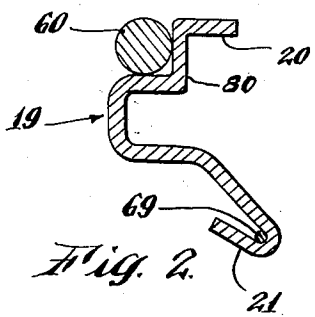


Fig. 2.

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TUBE WINDING MACHINE

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Fig. 7.

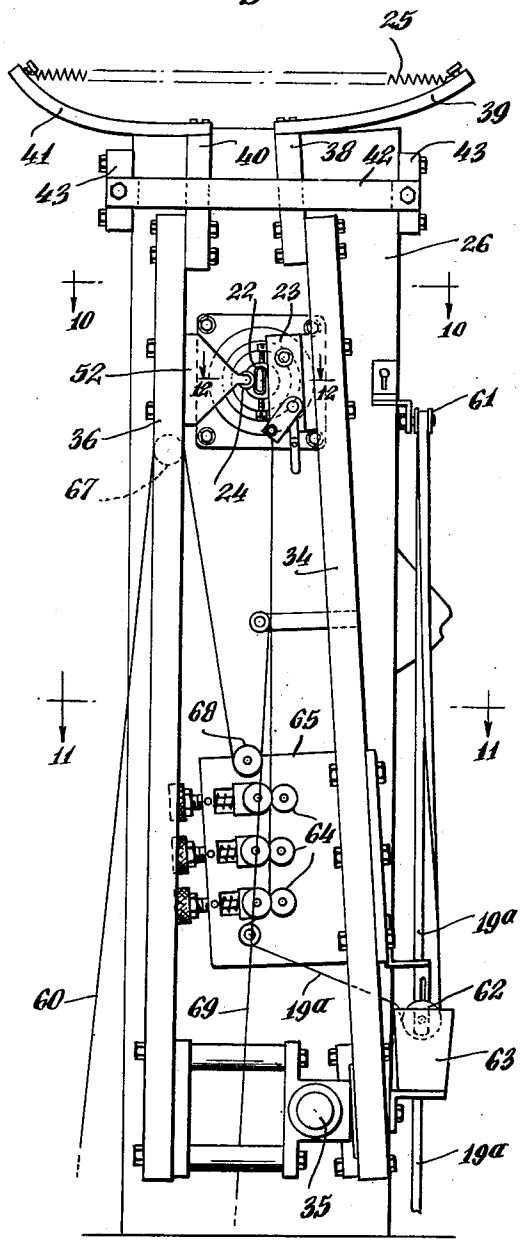
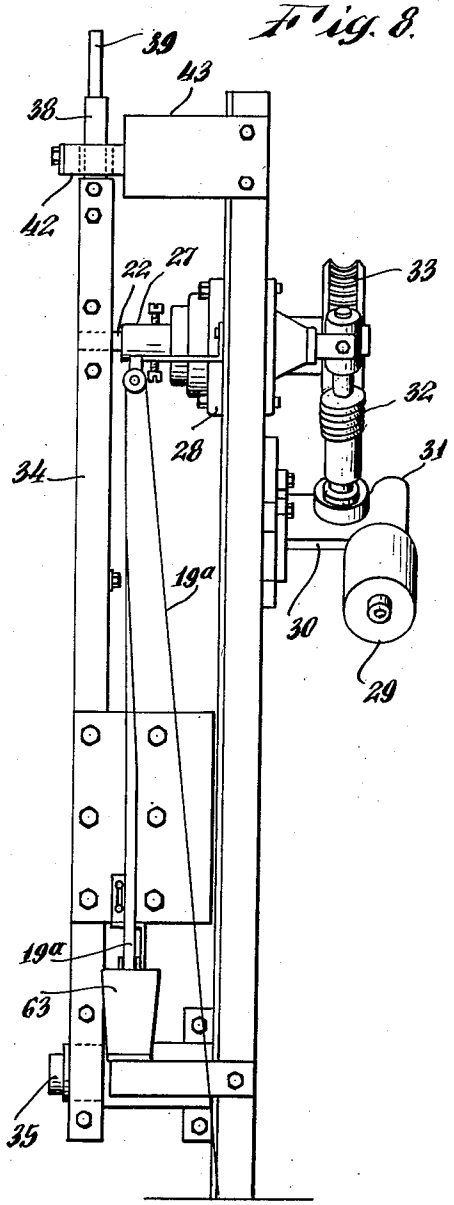


Fig. 8.



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June 2, 1953 R. S. CARR 2,640,451

TUBE WINDING MACHINE

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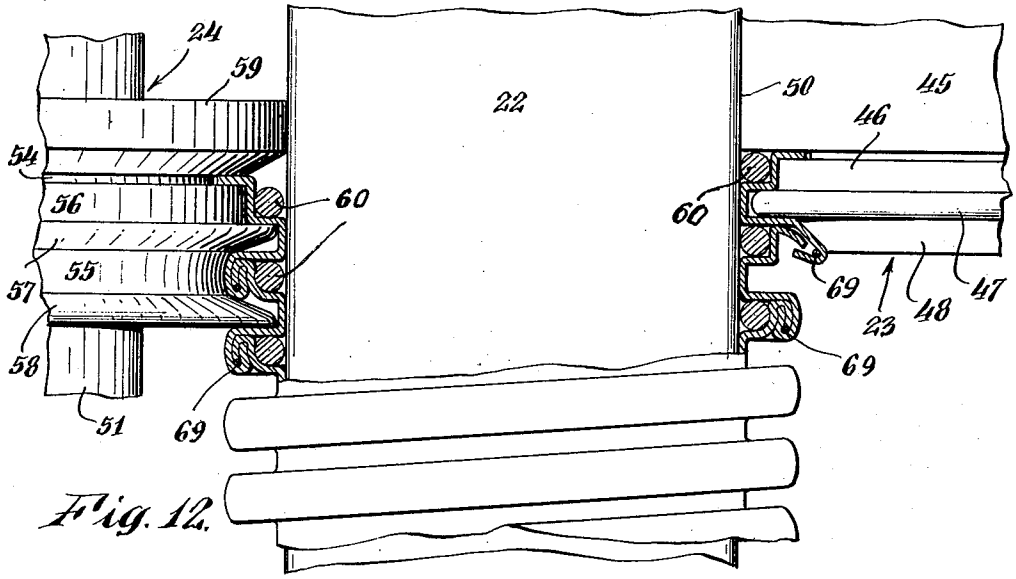


Fig. 12.

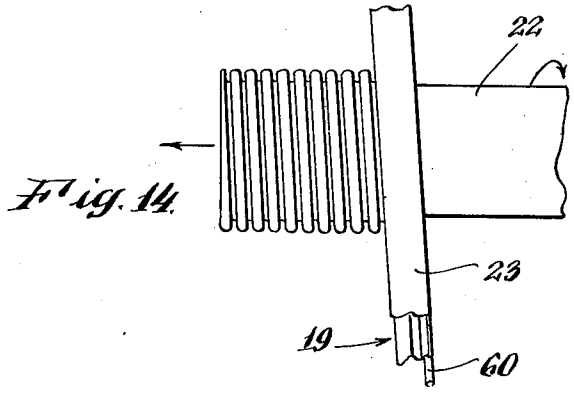


Fig. 14.

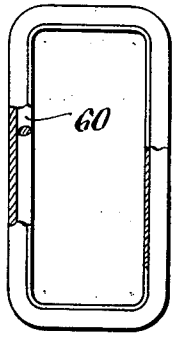


Fig. 13.

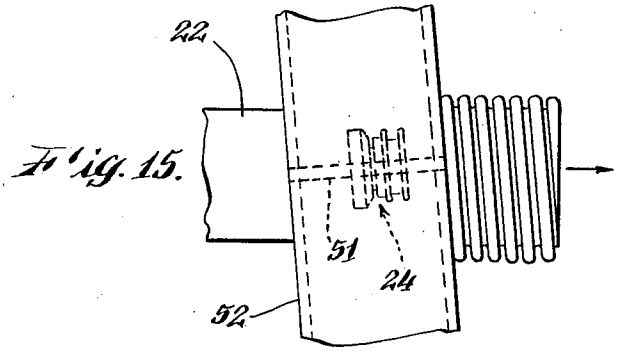


Fig. 15.

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Patented June 2, 1953

2,640,451

UNITED STATES PATENT OFFICE

2,640,451

TUBE WINDING MACHINE

Robert S. Carr, Maplewood, N. J., assignor, by mesne assignments, to Titeflex, Inc., Newark, N. J., a corporation of Massachusetts

Application May 3, 1948, Serial No. 24,781

7 Claims. (Cl. 113—35)

1

This invention relates to tube manufacture and more especially to the production of continuous tubing from initially flat strip material.

The principal object of the invention is to provide a machine which is adapted to coil strip material of suitable kind and character into tubular form of any of a variety of cross sectional shapes, including for example, triangular, rectilinear and other polygonal forms having one or more straight surfaces, as well as ovals and various other curved but not necessarily circular configurations.

It is another object of the invention to provide a machine of the foregoing kind having guiding means for laying strip material in a generally helical course upon the surface of a continuously rotating mandrel with one edge of each turn of material overlapping the other edge of the next adjacent turn, and for advancing the coiled strip along the mandrel to produce continuous tubing having a cross sectional shape corresponding to that of the mandrel.

Another and more specific object of the invention is to provide a machine having a mandrel of other than truly circular cross section, and a guide chute which is adapted to be reciprocated by the mandrel in such a way that the latter element may lay the strip material on a course which is always tangent to the surface of the mandrel, whether that surface be a flat or curved one and thus to cause the material to conform itself properly to the variously shaped surfaces of the mandrel.

It is a further object of the invention to provide a machine for the manufacture of flexible metal tubing of various cross sectional shapes, and particularly those having one or more flat sides which are joined by relatively sharply rounded corners, with a guide chute of some considerable length which is adapted to support metal strip of an appropriate preformed contour, and to lay that strip tangentially upon the curved and flat sides of the continuously rotating forming mandrel with one edge of each turn of material lying within a folded edge portion of the next adjacent turn; and with a seaming roll which is independent of the chute and which is adapted to fold the engaged edges of the coiled strip and thus to lock them firmly together.

Other objects and various features and advantages of the invention will be made apparent in the following detailed description of one embodiment thereof, in the light of the accompanying drawings in which:

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Fig. 1 is a perspective view of a fragment of tubing of the general type for the production of which the machine of the present invention is particularly intended,

Fig. 2 is a sectional view, on a very much enlarged scale of a preformed metal strip of the type used in making the tubing of Fig. 1 and showing the location of the solder and supporting wires which are employed in the tube assembling operation,

Figs. 3, 4, 5, and 6 are diagrammatic views showing the sequence of operation of the essential elements of the tube making machine embodying the present invention,

Fig. 7 is a front elevation of one form of a tube making machine embodying the invention,

Fig. 8 is a side elevation of the machine shown in Fig. 7,

Fig. 9 is an elevational view, from the rear, of the upper part of the machine of Figs. 7 and 8,

Figs. 10 and 11 are enlarged sectional views taken on the lines 10—10 and 11—11 respectively of Fig. 7,

Fig. 12 is a sectional view taken on an even larger scale on the line 12—12 of Fig. 7,

Fig. 13 is an end view, partly broken away, of tubing made in the machine of the preceding figures,

Figs. 14 and 15 are elevational views, on an enlarged scale of a fragment of the tube making machine taken from the right and left hand sides respectively of Fig. 7, and

Figs. 16, 17, and 18 are profiles of tubing of various sizes and shapes which may be produced by the machine of the present invention.

The product which is shown in Fig. 1 of the drawing is a flexible metal tube of rectangular cross section such as to suit it for use as a wave guide in the transmission of ultra high frequency currents in radar and other electronic applications. The process by which this product is made involves, as a first step, the rolling or otherwise working of a thin strip of brass or any other metal having desired characteristics into an appropriate preformed contour as shown in Fig. 2. This particular type of preform is well known in the art and need not be particularly described. The next step of the tube making process involves the coiling of the preformed strip 19 with the flange 20 of each turn of material engaged in the folded edge 21 of the next adjacent turn to produce a continuous tubular structure. It is generally desirable to roll the engaged flange and fold in such a way as to interlock the edges, and where a fluid-

tight structure is required to solder the edges or to seal them in some other fashion. The tubing as so far shown and described is of a kind which has been on the market for some years so that further and specific description of it appears unnecessary. It does suffice, however, to illustrate the type of product which can be made in the machine of the invention.

In the manufacture of tubing of noncircular cross section, as for example the rectangular tubing of Figs. 1 and 13, the laying of the preformed strip upon the mandrel in such a way as to cause it to conform to the contour of the latter element has presented very real and difficult problems. It has been the practice, for example, to provide for an intermittent driving of the mandrel to advance the strip a given distance, and for an intermittent operation of the guiding means to lay that strip about the momentarily stationary mandrel. It was likewise necessary, of course, to provide for an intermittent driving of the seaming means in step with the other elements, all of which required the use of complicated driving and timing mechanism. In fact, the complexity of these prior art devices was so great as effectively to limit their use to the production of rectangular tubing, and that in a few sizes, each of which was made on a single machine. The production of ovals, half-rounds, and other odd-shaped tubing in this way was considered to be thoroughly impractical. The machine of the present invention solves all of these problems in a simple and effective way. Thus, and referring to Figs. 3 to 6 inclusive, it consists essentially of a mandrel **22** which is adapted to be rotated about its own axis at a constant desired speed, and a guide chute **23** which is mounted for reciprocation crosswise of the axis of the mandrel and is adapted to be advanced and retracted by the mandrel to deliver strip material at a tangent to the rotating surface of the latter element. The guide chute serves of course to lay the strip material upon the mandrel so that it may be wrapped on a generally helical course, and also to support the preformed strip so that it may be bent around the mandrel without collapsing. In this latter connection the element provides lateral support for the upstanding parts of the preform to permit them to be stretched and drawn as they are bent around the mandrel surface. In the event that coiled strip material requires a bending of its edges to form a lock seam between adjacent turns, then the machine is further provided with a seaming roll **24**, this element, too, being mounted for reciprocation in a direction crosswise of the rotating mandrel, and being arranged to be advanced and retracted by that element so that it may press constantly against the engaged edges of the strip to roll them in the desired way.

The cycle of operation for these essential forming elements is illustrated in Figs. 3 to 6 inclusive. Thus, when mandrel **22** is in the position shown in Fig. 3, chute **23** supports strip **19** across the entire width of one of the flat sides of the mandrel. As that latter element rotates in a counterclockwise direction toward the position shown in Fig. 4, it pushes chute **23** towards the right and out of its path. It will be noted, however, that in the course of this relative movement, chute **23** holds strip **19** in a position which is tangent to the surface of the mandrel, and thus causes it to bend properly around that element. Further rotation of the mandrel completes the turn of the strip around the first corner to the position shown in Fig. 5 where the short flat side of the mandrel is presented to the guide chute **23**. During the latter part of this movement the guide chute obviously must be moved toward the left to hold it against the rotating part, and this is accomplished by tension spring **25** or any other suitable device. It will be observed that here again the strip is maintained tangent to the surface of the forming element and is supported across the entire face thereof. In the course of further rotation of the mandrel to the position illustrated in Fig. 6, chute **23** is again moved outwardly, thus turning another corner, and approaching the second of the wider flat surfaces to return to the position which it occupied in Fig. 3. Beyond that point further rotation will start a new cycle to complete the turn, and to duplicate it in additional ones. During the course of the foregoing operation roller **24** was moved to the left from the position shown in Fig. 3 to that in Fig. 4 by the pressing of the mandrel against it, then returned a short distance to the right under the urging of a spring or other suitable means, thence to the left, and finally to the right under the urging of the mandrel and the spring means as shown in Figs. 5 and 6. It will be evident from the foregoing that during the entire cycle of operation, the seaming roll followed the mandrel and pressed the coiled strip firmly against the latter element so as to roll the interlocked edges to form the desired seam.

In the machine of Figs. 3 to 6 inclusive the coiled strip is advanced along the mandrel by the reaction of the material against guide chute **23** during the coiling operation. Thus, as will later be evident, the chute is set at a slight angle to the axis of the mandrel in the manner and direction indicated in Fig. 14. It follows therefore that as the point at which the strip is laid on the mandrel is advanced along the chute by the non-circular mandrel, the strip material must follow the angle of the chute and advance along the mandrel. In forming the rectangular tubing illustrated in Figs. 1 to 5, this advancing of the point of contact occurs, of course, only during the turning of the corners, with the result that each course of strip is pushed ahead as it is bent around a corner by just the amount necessary to lay its flange **20** in a position to receive the fold **21** of the succeeding course of strip. Those familiar with the art will recognize, however, that a stripping element, such as a helical bushing, may be provided for engaging the strip as it is coiled in such fashion as to force it ahead in the desired way, in which case the chute can be wholly or partially relieved of the stripping function.

The practical embodiment of the invention which is shown in Figs. 7 to 15 includes an upright frame **26** carrying a mandrel holder **27** near its upper end which is journaled in bearing **28**. The forward end of the holder is adapted to receive mandrel **22**, and is provided with two or more set screws for holding the latter element firmly in place while permitting an easy and rapid substitution of one mandrel for another. The mandrel holder is adapted to be driven continuously and at an appropriate speed by a motor **29** which is attached to the back of the frame by bracket **30**, and is operatively connected to the rear end of the mandrel shaft by reduction gearing **31** and worm and wheel **32, 33**.

The guide chute **23** of this device is mounted upon an arm **34**, which in turn is mounted to rock

upon stub shaft 35 secured to the lower end of frame 26. The seaming roll 24 is in this case mounted upon a similar arm 36 which is likewise journaled for rocking motion on shaft 35. These arms are normally urged inwardly toward the center of the machine by spring 25 which is secured to extensions 38 and 39 on right hand arm 34 and extensions 40 and 41 on the left hand arm 36. It will be observed that the extensions 38 and 40 are confined within a guide 42 attached to the upper end of frame 26 by supports 43. The pivotal mounting of the guide chute and seaming roller upon the relatively long supporting arms permits these elements to be moved outwardly in response to rotation of the forming mandrel, and to be drawn inwardly to maintain their contact with the latter element under the urging of the spring 25.

The construction of a preferred form of guide chute, generally identified by numeral 23, is best shown in Figs. 10 and 12. Referring to those figures it may be seen to comprise a body 45 having a base portion which is adapted to be secured to arm 34 and a flange for supporting and cooperating with a series of guide plates 46, 47, and 48. The latter elements are arranged with their straight rear edges aligned against the base, and with their inner edges spaced from the mandrel and so shaped that they serve collectively to define a pass having substantially the contour of the preformed strip 19. These elements may be secured to the angle part of the body by any convenient means, such as bolts 49, which permit them to be removed and replaced with the greatest of facility. It will be observed that with a guide of the type so far described, the preform 19 lying in the pass defined by plates 46, 48 can serve to transmit motion from the rotating mandrel 22 to the guide chute and to its supporting arm 34. In the preferred construction, however, the flange of the body 45 extends beyond the inner ends of the guide plates by an amount which is slightly greater than the thickness of strip material 19, say by from .001 to .003 inch, and the end of the flange constitutes a bearing 50 for engaging the surfaces of the rotating mandrel. In this construction, motion is imparted by the mandrel to the guide chute through bearing 50 of the body, thus avoiding the building up of excessive friction between the comparatively large surfaces of preform 19 and the supporting surfaces of the guide plates. The completed guide assembly is secured to arm 34 as by bolts 51 in such a position that its surfaces lie at an angle to the axis of the mandrel, to the end that the guide may lay the strip on the mandrel so that it may be coiled on that element on a generally helical course as shown in Fig. 14.

The seam roll 24 as may best be seen in Figs. 10, 12, and 14, is mounted for rotation on a shaft 51 which is supported in the forward ends of the legs of bracket 52, and the latter is conveniently secured to pivoted arm 36 of the machine by bolts 53 or in any other suitable fashion. The surface of the seaming roll is, of course, shaped to conform and cooperate with the preformed strip 19. Thus it has a peripheral recess 54 for receiving the upturned flange 20 of the preform, and a wider peripheral groove 55 into which the engaged flange 20 and folded portion 21 of adjacent turns of material pass after they leave the guide chute; and between these grooves are supporting surfaces 56, 57, and 58 which engage various portions of the strip as best shown in Fig. 12. If desired the parts can be so arranged

that outward components of motion of the rotating mandrel may be transmitted through the strip to the seaming roll to force that element outwardly against the reaction of spring 25. It is generally preferable, however, to provide roll 24 with a peripheral flange element 59 which is of greater diameter than the supporting surfaces 57, 58 by an amount equal to the thickness of the strip material 19 plus a few thousandths of an inch. With this construction flange 59 acts as a bearing surface against which the rotating mandrel can react to force the seaming roll out of its path against the reaction of spring 25, thus avoiding the building up of excess friction between the strip, the roll and the mandrel. It will be observed in Fig. 15 that seaming roll 24 is mounted upon pivoted arm 34 at an angle to the center line of mandrel 22 so that its surfaces may readily engage the surfaces of the strip as it is coiled about the mandrel on a generally helical course.

Other constructional details of the machine will be brought out in the course of the following consideration of its operation. In that operation, flat strip material 19*a* is fed from a reel (not shown) over guide pulley 61 secured to the frame, and thence with a quarter turn over guide pulley 62, through a lubricating bath 63 and to a set of forming rolls 64. These rolls which are of conventional construction and are journaled in a suitable stand 65, serve to bend the strip to the contour shown in Fig. 5. In this particular embodiment of the invention the roll stand is preferably mounted on pivoted arm 34 so that it may move back and forth with the guide chute 23 and deliver the strip in general alignment with that element.

After the preformed strip leaves the last of rolls 64 it meets a soft metal wire, such as copper wire 60, which is fed from any suitable source over guide pulleys 67 and 68, so that it may lie in the space between the main body of the preform and flange 20. It follows that wire 60 will be wrapped around the mandrel with the strip material, and will lie in a position where it can support offset 30 of the strip during the bending of the preform around the mandrel; and that it serves a further function in supporting the offset during the rolling of the interlocked edges 20, 21, in the course of the subsequent seaming operation. It will be evident from the foregoing that the wire 60 will be employed only in the coiling of preforms which, by reason of their cross sectional shapes, require radial support during the bending and seaming operations, and that it may be omitted in any case in which radial support for the preform can be furnished by the mandrel or in some other fashion.

If desired, a thread of solder 69, supplied from a reel or other suitable source (not shown) may be drawn into fold 21 of the preform as the strip advances from the forming rolls toward the guide chute. The thread 69, employed in making the illustrated tubing, is a cored solder which provides both the flux and bonding material for the carrying out of a soldering operation. Thus the formed tubing may be made tight by the simple expedient of heating it to a temperature at which the solder will flow under the seam and seal the lock joint. It will be equally evident that the solder or other bonding material may be applied to the formed tube in any other suitable and convenient way, and that where a bonded seam is not required, wire 69 or its equivalent may be dispensed with.

The preformed strip, 19, and supporting wire 60 and solder wire 69, where these wires are used, are all drawn into the guide chute 23, and are laid by that element on the surface of mandrel 22. As that element is continuously driven by motor 29, at a constant speed, the preform is pulled into the machine by that element, being applied first on one of its flat sides, then around a corner, then on another flat side and around another corner, etc. In the course of this operation the strip is supported radially by mandrel 22 and wire 60 as previously described. It will be evident, however, that flange 20, fold 21, and other upstanding portions of the strip must also be supported throughout the course of the bending operation so that they may be drawn and stretched into shape, rather than to collapse. This lateral support is furnished by the guide chute which is purposely shaped to conform closely to the contour of the preform 19. Thus, and referring to Fig. 12, it will be noted that flange 20 of the preform lies in a groove between the forwardly extending flange of the body 45, and the adjacent surface of guide plate 46, of the chute; that plate 47 projects into the central depressed portion of the preform to support its sides; and that the folded edge portion 21 is supported by the angularly disposed surface of guide plate 48.

The strip material which has been laid on the mandrel at one side of the machine is engaged by the seaming roll 24 on the other side thereof, to turn the interlocked edges of the coiled material to form a desired seam. In this operation, as can best be seen in Fig. 12, groove 59 supports flange 20 of one turn of strip in its recess 54, while groove 55 engages interlocked flange 20 and fold 21 of the next adjacent turn, and bends them together to form a seam, the seaming force being transmitted from the roll to the mandrel through supporting wire 60.

The advancing of the coiled material along the mandrel, and the stripping of the finished tubing from that element, is accomplished in the illustrated device entirely by the guide chute 23. This operation can best be understood by a reference to Figs. 3 to 6, 12 and 14. Thus it will be observed that the chute 23 is firmly secured to its supporting arm 34 in a position such as to slope forwardly of the axis of the mandrel, as is clearly indicated in Fig. 14. It follows that as the strip material is wrapped around corner *a* of the mandrel, for example, the point of contact between the mandrel and strip is progressively moved upwards along the guiding surfaces of the chute, as clearly indicated in Figs. 3 and 4. In view of the angular disposition between the rotating and guiding parts (Fig. 14) this advancing of the point of contact must be accomplished by a pushing of the strip material along the mandrel. The laying of the strip on the flat sides of the mandrel is not accompanied by any relative motion of the point of contact along the chute, so that no advancing takes place during those parts of the coiling cycle. As a matter of fact, the turning of any one corner, simultaneously completes the laying of the strip on the adjacent flat side of the mandrel, and immediately shifts the point of contact from that corner to the next one. It follows that the advancing operation which ceases with the turning of corner *a* of the mandrel, is immediately picked up as the strip begins to bend around the next corner *b*. The overall result of this operation is a progressive moving of the strip forwardly along the mandrel as it is coiled about that element. In order that this may be accomplished in the desired way, the guide chute is set at an angle such that one corner of the coiled material is advanced just far enough along the mandrel to leave its flange 20 standing in a position where it may be engaged by the fold 21, as the next succeeding turn of material is laid in place. The seaming roll takes no part in this stripping operation. In fact, that element is preferably so mounted as to be capable of sliding back and forth upon its supporting shaft 51, so that the corners and flanges which define its operating surface may follow the generally helical course of the coiled material. This is particularly desirable in a machine for making tubing of rectangular or other form where one surface may be longer than another, and where the coiling does not necessarily follow a truly helical course but some variant thereof.

It will be observed that the stripping action which is described above is facilitated by the rather light pressing of the strip material against the roller. Thus, as has heretofore been pointed out, mandrel 22 engages chute 23 along bearing surface 50 to transmit outward motion to the chute, and that this bearing lies ahead of the front of the shaped surfaces of guide plates 46, 47, 48 so as to minimize friction between the guide surfaces, the strip and the mandrel. So too, outward motion of the mandrel surface is transmitted to seaming roll 24 through a bearing surface 59 rather than through the strip, for the express purpose of minimizing friction between the strip and the opposing mandrel and roller surfaces. In both cases therefore the tension of spring 25 and the other forces which are involved in advancing and retracting the guide and seaming roll, are diverted from the strip so that it may offer a minimum frictional resistance during the stripping operation.

It will be readily evident that the angular positioning of the chute and mandrel is an important feature of the invention, in that it simplifies the construction of a machine for making polygonal tubing by allowing a single part, the guide chute, to perform the several functions of guiding the strip material to the mandrel, of supporting it while it is laid on that element, and of stripping the coiled material from the mandrel. Those familiar with the art will understand, however, that the chute can be limited to the function of guiding and supporting the strip, and that independent means may be provided for advancing the coiled material along the mandrel. It is entirely feasible, for example, to mount a stripping collar immediately behind the guide chute and seaming roll, with its helical face partially encircling the mandrel and in a position to engage the strip at the corners of polygonal tubing, or along the curved surfaces of a round or oval one, in such manner as to thus push the coiled strip along the mandrel in the desired way. In such a case, the collar may assist in the stripping action or perform that entire operation, and the guide chute may be partially or entirely relieved of its stripping function.

The completed tubing leaves the forming mandrel with the supporting wire 60 and solder wire 69 in the positions shown in Figs. 12 and 13. The first of these wires has completed its entire function in the forming and seaming operation, and may be stripped out for reuse or scrapping. This may readily be accomplished by merely pulling upon the wire which, being unsupported, merely collapses and is drawn out. The solder wire, how-

ever, is in a position where it is needed, and stays there until the tube is heated to a temperature such as to cause it to flow.

The invention is not limited to the manufacture of the one particular type, size and shape of flexible tubing which has heretofore been described, nor is this particular machine so limited. Thus, if another size or shape of tubing is to be made of the same preform as illustrated in Fig. 2, then all that is required is the substitution of a mandrel of appropriate size and shape for the one shown in the drawings. Upon the assumption that a larger size of rectangular tubing is required, it is only necessary to loosen set screws of the holder 27, and to remove mandrel 22 for the substitution of a larger mandrel. This step alone suffices to complete the conversion, and the machine may then be run to form the larger tubing. If a different size of preform is required, then the conversion is made by substituting an appropriate stand of forming roll 65 for those shown, by removing guide plates 46, 47 and 48 and replacing them with plates which define the contour of the new preform, and by substituting an appropriate seaming roll.

In the event that the machine is to be employed in the manufacture of a different type of tubing, say the common interlock type such as is shown in Patent No. 1,338,187 rather than the particular form of convoluted tubing here shown, an appropriate stand of rolls will be provided for preforming the strip, and the guide chute and seaming roll 24 will be arranged to accommodate and support that type of preform. It will be evident that in the manufacture of such tubing, radial support for the preform will be furnished by the mandrel, making unnecessary the winding in of supporting wire 60. So too, various forms of convoluted tubing having a seam formed next to the mandrel, that is to say, an inside seam, as exemplified by Patent No. 1,340,818, rather than the outside seamed tubing heretofore considered, may be formed in this machine by the provision of suitable preform material and an appropriate shaped guide chute and seaming roll; and that in such cases, the need for the supporting wire 60 also disappears.

The foregoing has dealt entirely with the manufacture of flexible tube from a single strip of material having its edges overlapped and turned to form a suitable lock seam. The invention is not limited however, to the manufacture of tubing of this particular kind, but may be employed in the making of various conventional forms of tubing with which the art is thoroughly familiar, and which require the wrapping of one or several strips of metal around a mandrel with the edges overlapped and secured together by a folded seam or otherwise.

It will be further evident that the machine may be used for the formation of continuous tubing of various cross sectional shapes such, for example, as those shown in Figs. 16, 17 and 18. While these figures illustrate several odd shapes, they do not define the full capacity of the machine which obviously can be used for making tubing of any cross section which includes flat surfaces, or curved surfaces of convex shape, or both, and obviously it is readily adaptable to the manufacture of tubing of circular cross section. All that is necessary in any of these cases is to feed suitable preformed strip to an appropriately shaped guide chute, and to wrap it around a mandrel having the selected contour.

The versatility of the machine, and its ready adaptation to the manufacture of various forms of spirally wound tubing including both convoluted and nonconvoluted types and in both polygonal and curved shapes has been illustrated hereinbefore. In essence, all that is required is the provision of a rotating mandrel of a desired shape, and of a guide chute which is shaped to support the particular type of preform required, and is mounted to reciprocate in a crosswise direction to follow the contour of the mandrel. In this latter connection, of course, it will be recognized that the guide chute must always be of sufficient length to maintain the strip in contact with the mandrel as the point of contact with that element shifts lengthwise of the chute, and to assure delivery of the strip along a line which is always tangent to the surface of the mandrel presented to the strip and chute at any given instant.

With these as essentials, the machine may be modified in various ways, as for example by the provision of a seaming roll, independent means for advancing the coiled material along the mandrel, feed arrangements for winding in a supporting wire or a solder thread or both; and obviously the preforming rolls may be included as a part of the unit, and may be mounted to reciprocate with the feed chute, or the rolls may be eliminated and provision be made for the feeding of preformed strip from any source to the guide chute.

Having described the invention in its broadest aspects and illustrated it by way of specific examples, what is claimed as new and useful is:

1. A machine for making helically wound, non-circular tubing including, in combination, a non-circular mandrel on which is wound a transversely formed strip that has an upwardly extending flange along one side, driving means for imparting continuous rotation to the mandrel about its longitudinal axis, guide means for applying a strip to the mandrel in substantially the same direction at all times and at a slight angle to the axis of the mandrel so as to wind as a helix on the mandrel, and to engage the flange along one side of the strip with a folded-over edge along the other side in the next convolution of the strip on the mandrel, said guide means including a chute having a face confronting the mandrel and shaped to the contour of the strip with a surface that holds the strip adjacent to the mandrel and with one or more shoulders that provide surfaces that confine and guide the strip against displacement lengthwise of the mandrel at the region of application of the strip to the mandrel, the face of the chute having a length equal to at least the range of movement of the point of application of the strip to the mandrel, a support for the chute movable to swing the chute toward and from the axis of rotation of the mandrel as the radius of the non-circular mandrel confronting the chute changes during rotation of the mandrel, and means urging the chute support to swing toward the axis of the mandrel.

2. A machine for making helically wound, non-circular tubing including, in combination forming apparatus through which a strip passes and in which a strip is bent to a transverse contour having a central corrugation, a turned-up flange along one side and a folded-over edge along the other side, a non-circular mandrel to which the strip is supplied, driving means that impart continuous rotation to the mandrel about its longitudinal axis, guide means that supply the strip

to the mandrel progressively and from substantially the same direction during the entire time of each revolution of the mandrel, and along which the strip passes to the mandrel at an angle to the axis of the mandrel so as to wind as a helix and engage the flange of the strip with the folded-over edge along the other side of the strip in the next convolution of the strip on the mandrel, said guide means including a chute confronting the mandrel and shaped to the contour of the strip with a face that holds the strip adjacent to the mandrel and with one or more shoulders that confine and guide the strip against displacement lengthwise of the mandrel at the point of application of the strip to the mandrel, a support for the chute comprising an arm that swings about an axis substantially parallel to the axis of rotation of the mandrel but spaced at a substantial distance from the axis of the mandrel to swing the chute toward and from the axis of rotation of the mandrel, a bearing that prevents movement of the chute support longitudinally of and parallel to the longitudinal axis of the mandrel, an abutment carried by the support at a location along the mandrel ahead of the region at which the strip is applied to the mandrel, spring means holding the abutment in contact with the mandrel at a phase angle substantially equal to that at which the chute face is tangent to the mandrel so that changes in the radius of the mandrel under said abutment move the abutment and the associated support and chute with a cam action that shifts the chute away from the axis of the mandrel in accordance with the changes in diameter, the face of the abutment on the chute support being slightly closer than the chute face to the axis of the mandrel so that the chute face clears the mandrel for a distance that allows for the thickness of the strip, the portion of the chute having said face and shoulders that fit the contour of the strip being of a length at least as great as the entire range of movement of the point of application of the strip to the mandrel as the radius of the mandrel under the chute changes.

3. A machine for making helically wound, non-circular tubing including, in combination, a non-circular mandrel on which is wound a transversely formed strip that has an upwardly extending flange along one side, driving means for imparting continuous rotation to the mandrel about its longitudinal axis, guide means for applying a strip to the mandrel in substantially the same direction at all times and at a slight angle to the axis of the mandrel so as to wind on the mandrel as a helix, and to engage a flange along one side of the strip with a folded-over edge along the other side in the next convolution of the strip on the mandrel, said guide means including a chute having a face confronting the mandrel and shaped to the contour of the strip with a surface that holds the strip adjacent to the mandrel and with one or more shoulders that provide surfaces that confine and guide the strip against displacement lengthwise of the mandrel at the region of application of the strip to the mandrel as the flange and folded-over edge are brought together to form the seam of the tubing, the face of the chute having a length equal to at least the range of movement of the point of application of the strip to the mandrel, a seaming roller located along the seam and angularly spaced from the chute around the mandrel in position to bend over the engaged flange and folded edge to form an interlocked seam, supports for the chute and seaming roller, means urging both the chute and the seaming roller toward the mandrel as the radii of the non-circular mandrel adjacent to the chute and seaming roller change during rotation of the mandrel.

4. The machine for making helically wound non-circular tubing as described in claim 3, and in which there is a bearing for the seaming roller along which the seaming roller is movable axially parallel to the axis of the mandrel, and in which the chute is held against movement parallel to the axis of the tube so that the chute serves to strip the tubing from the mandrel progressively as the tubing is formed on the mandrel.

5. A machine for making helically wound, non-circular tubing, as decribed in claim 1, with a cam follower for moving the chute outwardly as the radius of the mandrel increases, the cam follower comprising an abutment connected with the chute and positioned at a location along the mandrel ahead of the region at which the strip is applied to the mandrel, means holding the abutment in contact with the mandrel at a phase angle substantially equal to that at which the chute face is tangent to the mandrel so that changes in the radius of the mandrel under the abutment move the abutment and chute in accordance with the changes in the radius of the mandrel, the face of the abutment being slightly closer than the chute face to the axis of the mandrel so that with the abutment in contact with the mandrel the chute face clears the mandrel by a distance that allows for the thickness of the strip.

6. A machine for making helically wound, non-circular tubing including, in combination forming apparatus through which a strip passes and in which the strip is bent to a transverse contour having a central corrugation, a turned-up flange along one side and a folded-over edge along the other side, a non-circular mandrel to which the strip is supplied, driving means that impart continuous rotation to the mandrel about its longitudinal axis, guide means along which the strip passes to the mandrel in substantially the same direction at all times and at a slight angle to the axis of the mandrel so as to wind as a helix and engage the flange of the strip with the folded-over edge along the other side of the strip in the next convolution of the strip on the mandrel, said guide means including a chute having a face confronting the mandrel and shaped to the contour of the strip with a face that holds the strip adjacent to the mandrel and with one or more shoulders that confine and guide the strip against displacement lengthwise of the mandrel at the region of application of the strip to the mandrel, means supporting the chute for movement toward and from the axis of the mandrel, said chute being so located with respect to said mandrel that components of motion of the tubing-forming surfaces of the mandrel in an outward direction are transmitted to the chute to force it outwardly, means urging the chute inwardly to maintain it in operative relation to the mandrel, the portion of the chute having said face and shoulders that fit the contour of the strip extending along the length of the chute for a distance that includes the full range of the movement of the point of application of the strip to the mandrel during the various changes of the radius of the mandrel confronting the chute.

7. The machine for making helically wound, non-circular tubing, as described in claim 6, with

an abutment connected to the chute and positioned at a location along the mandrel ahead of the region at which the strip is applied to the mandrel, said abutment being in contact with the mandrel at a phase angle substantially equal to that at which the chute face is closest to the mandrel so that changes in the radius of the mandrel under the abutment move the abutment and the chute with a cam action that shifts the chute away from the axis of the mandrel in accordance with the changes in the radius of the mandrel.

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