March 9, 1943. K. H. EVERT 2,313,329

METHOD OF PRODUCING FLEXIBLE METAL HOSE

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Fig. 1.

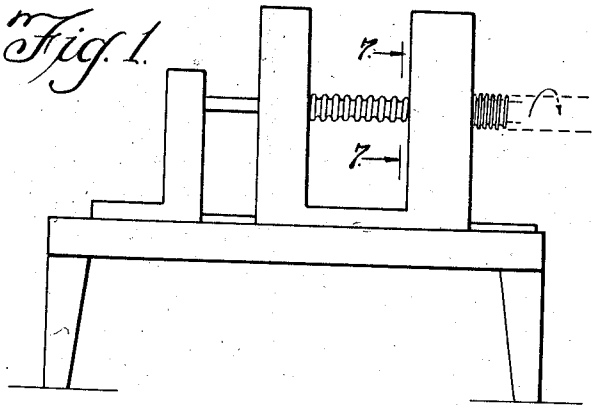


Fig. 5.

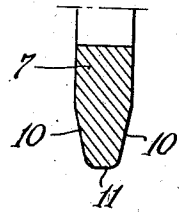


Fig. 6.

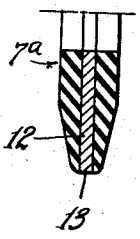


Fig. 2.

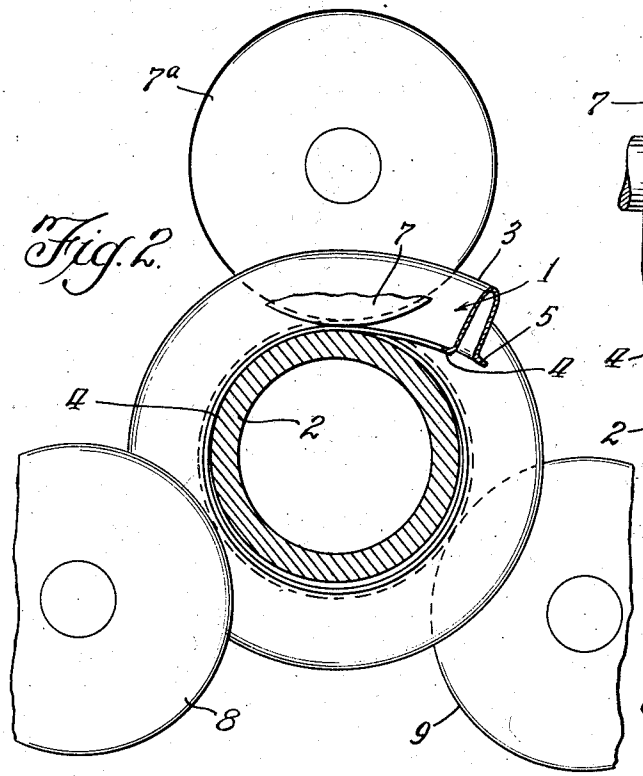


Fig. 3.

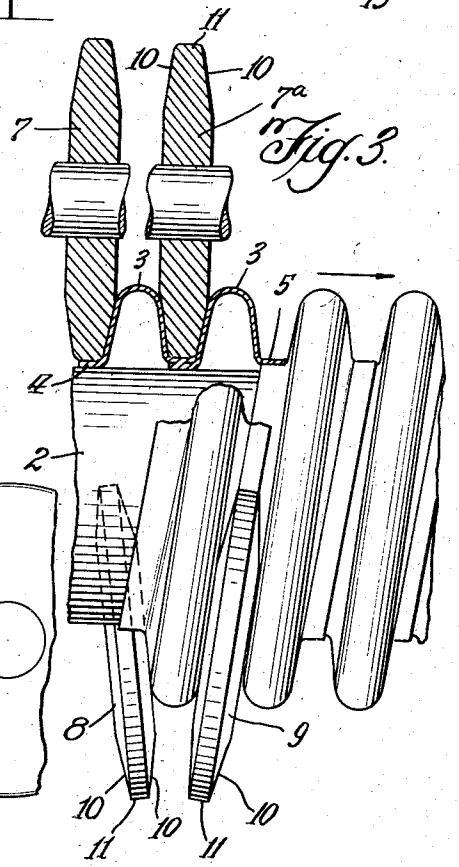
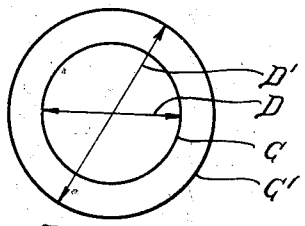


Fig. 4.



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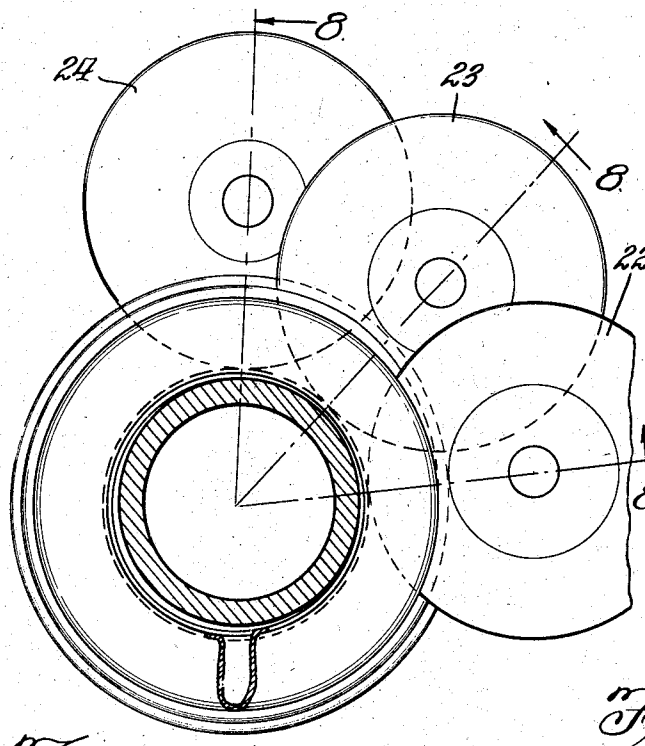


Fig. 7.

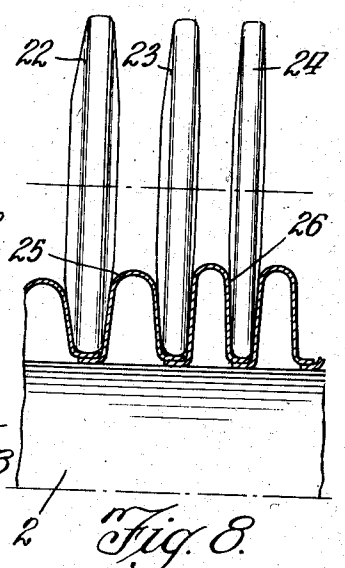


Fig. 8.

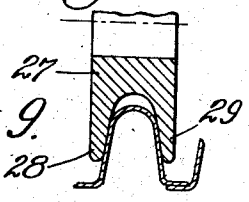


Fig. 9.

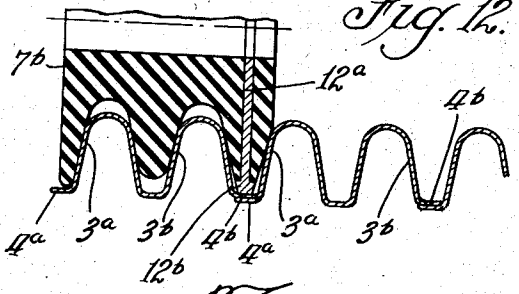


Fig. 12.

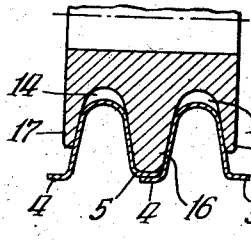


Fig. 10.

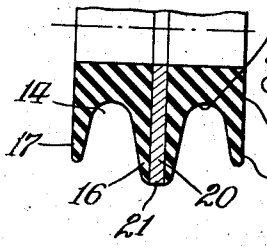
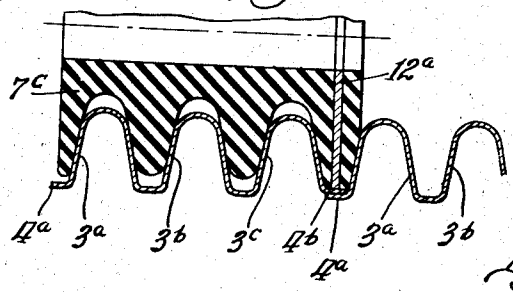


Fig. 11.

Fig. 13.



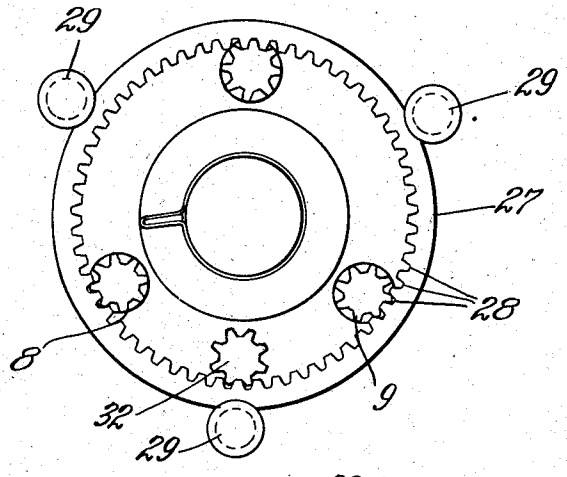
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Fig. 14.



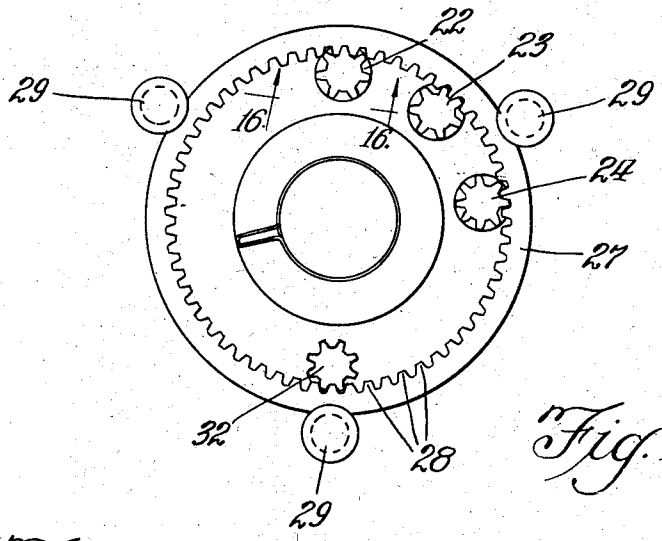
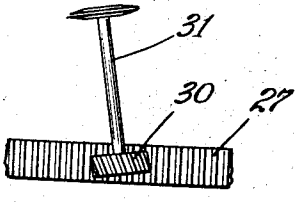


Fig. 15.

Fig. 16.



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UNITED STATES PATENT OFFICE

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METHOD OF PRODUCING FLEXIBLE METAL HOSE

Karl H. Evert, Elmhurst, Ill.

Application June 16, 1941, Serial No. 398,272

3 Claims. (Cl. 219—10)

The present invention relates to metallic flexible conduits, and more particularly to the method of producing the same.

Metal conduits or hose of this type are formed from preformed metallic strips helically wound in a suitable rotating device whereby the adjacent edge portions of the convolutions of the strip are joined, as by brazing or otherwise, to effect a seam. The finished conduit is longitudinally corrugated in shape.

The present invention comprehends a novel method of producing a novel metal hose or conduit, using also novel means to effect the same.

I run the strip of metal through a suitable forming or profiling device, not specifically shown, so that the strip is formed with a U-shaped profile with laterally extending edge flanges at the open end of the U, and also generally curving the profiled strip to approximately the curvature of the mandrel upon which the profiled and curved strip is to be wound.

Then, according to my invention, the strip passes between one or more novel rollers and the novel mandrel, the latter being a smooth surfaced cylindrical mandrel free of any projections or ribs or the like, along which smooth surface the coils or convolutions of the conduit will slide. The roller or rollers are so located as to position the adjacent convolutions in given spaced relation whereby the adjacent flanges will overlap for joining. These flanges are at the base of the helical trough formed between the convolutions, and located against or adjacent the smooth cylindrical surface of the mandrel, preferably at the locus of first contact of the profiled strip with the mandrel as the strip initially becomes associated with the mandrel.

Other rollers may be used and located at different points around the mandrel so as to guide the movement of the convolutions around the mandrel. These rollers may be spaced from the mandrel so that the convolutions will not touch the mandrel but will spacedly encircle it. In such case the axial movement or feed of the convolutions relative to the mandrel will be greatly facilitated, with practically no friction nor resistance.

Preferably, one of the discs, such as the lead disc, is designed to weld the overlapping adjacent flanges. By welding at a point where the profiled strip initially contacts the mandrel then the convolutions are fixed in relation and will turn about and slide along the mandrel as a single unitary corrugated tube.

An important novel feature is the welding at the base of the trough between the adjacent convolutions, that is, adjacent to the surface of the mandrel. This welding forms a continuous seam between the overlapping flanges and for the full width of the overlapping portions of such flanges.

The invention also comprehends as a part thereof the provision of novel means for gathering the convolutions, that is, spacing the coils or convolutions closer together for the finished profile of the coil or conduit fed from the mandrel. This novel means comprises a roller or rollers which stress the coils or convolutions to make them gather closer together. In doing so the outer diameter is increased, the inner diameter remaining the same, that is, approximately that of the outside diameter of the mandrel.

Other objects, advantages, capabilities, features, process steps, and the like are comprehended by the invention as will later appear and as are inherently possessed by the invention.

Referring to the drawings:

Fig. 1 is a conventional side view of a machine embodying the invention;

Fig. 2 is a transverse view, on an enlarged scale, with parts in section, of the invention;

Fig. 3 is a fragmentary side view, on a further enlarged scale, of the invention;

Fig. 4 is a diagram showing the advantage of welding an inner seam;

Figs. 5 and 6 are fragmentary sectional views of different kinds of rollers used in the invention;

Fig. 7 is a fragmentary and transverse sectional view taken in a plane represented by line 7—7 in Fig. 1 of the drawings;

Fig. 8 is a fragmentary part sectional and part side view developed from planes represented by lines 8—8 in Fig. 7 of the drawings;

Figs. 9, 10, 11, 12 and 13 are fragmentary sectional view of different types of rollers used in the invention;

Figs. 14 and 15 are part transverse views and part end views of the invention showing the novel means for driving the rollers about the tube; and

Fig. 16 is a fragmentary view for illustration of the drive means for a roller.

Referring more in detail to the drawings, for illustrating the invention, the preformed or profiled strip 1 is helically wound upon a mandrel 2 having a smooth cylindrical outer surface upon which the strip is wound and along which the tube slides axially to be fed off to a take-up means. The mandrel is axially stationary but preferably rotates at the same or faster angular speed as or than the tube, yet the invention com-

prehends the use of a mandrel which may not rotate. In the latter case as the tube turns over the mandrel there would be a little more friction between the tube and the mandrel but that would not be sufficient to affect the efficient production of the tube in accordance with my invention. Suitable lubrication can be used between the mandrel and the tube if desired or found necessary.

The tube is made from metal strips, such as stainless steel, or the like. The strip is forced through any suitable preforming or profiling device (not shown) to give the strip the desired cross-sectional form or profile, and longitudinal curve to wind around the mandrel.

In the present invention it is preferable to profile the strip in U-shape with the bend of the U forming the outer crest 3 of the strip, and with the legs of the U formed with lateral flanges 4 and 5 which when united constitute a part of the inner trough 6 between adjacent convolutions of the profiled strip when helically wound on the mandrel 2. As the strip is helically wound on the mandrel one of the flanges, such as flange 4, will lie in contact with the surface of the mandrel, as at the top, as shown, and the other flange, such as flange 5 of the succeeding convolution of the strip, will lie upon and in contact with the adjacent flange 4 of the preceding convolution of the strip. These overlapping flanges are later welded together as hereinafter described.

It is preferable to have these flanges overlap along a narrow width where the welded seam is produced so that there will be no fissure between the overlapping portions of the flanges on either or both sides of the welding trace, and also for economy wherein strips of less width may be used than was heretofore required, when bonding by solder or by brazing.

The strip is helically wound upon or about the outer cylindrical surface of the mandrel as the strip is fed out of the preforming or profiling device and moved in between the mandrel and a series of rollers 7, 7a, 8 and 9 (conventionally shown in Fig. 2) having suitable profiled peripheries conforming to the inter-profiles of the convolutions of the strip. These rollers are rotatable about respective axes generally parallel with the axis of the mandrel and the tube but normal to the circumferential portions of the convolutions contacted thereby, and are distributed around the mandrel, besides being progressively axially spaced in accordance with the pitch of the helically wound strip. These rollers are principally for holding the convolutions of the strip properly spaced, and for pressing against the overlapping flanges 4 and 5 to effect a correct welding of such flanges, as later explained.

These rollers may be of simple form as shown in Figs. 2, 3 and 5, preferably composed of insulating material (although that is not wholly necessary) more or less in disc form and with a tapered periphery 10, to easily enter between convolutions of the strip, and the pressing periphery 11. The thickness of these rollers gauges the spread or spacing of such convolutions. The periphery 11 of the roller 7 presses against the flange 4 to hold it in contact with the mandrel, and the periphery 11 of the roller 7a presses against the overlapping flange 5 to hold it in good contact with the underlapping flange 4 and the surface of the mandrel 1.

The axial spacing of these rollers is such that as the entering convolution from the preforming device passes to the mandrel the first roller or rollers will correctly position or direct such convolution axially relative to the previously formed convolution; the second and third rollers, as rollers 7a and 8, will hold such adjacent convolutions properly spaced, and the fourth roller, as roller 9, will guide the convolutions into their helical paths for axial feed of the tube along the mandrel in the direction of the arrow shown in Fig. 3.

One of these rollers may be a welding roller, such as roller 7a. In such case the body of the roller will be composed of electrically insulating material and will include a central metal or carbon disc 12 (see Fig. 6) constituting one of the welding electrodes, for conduction of the electrical energy for welding at the periphery 13 while applying pressure to the flanges 5 and 4, the mandrel 1 constituting the other of the welding electrodes.

The rollers may be of the form shown in Figs. 10 and 11, which are useful when working with strips having high altitude convolutions. In this case each roller may have a pair of grooves 14 and 15 with an intermediate annular pressing periphery 16 for functioning in the trough between adjacent convolutions for maintaining proper spacing or spread and for pressing the flanges thereof, and with lateral rims 17 and 18 so spaced as to span the adjacent convolutions, and to contact the opposite remote sides of the adjacent convolutions, as shown in Fig. 10. By such means the profile of the convolutions is maintained, beside keeping them properly spaced for the welding function to be performed.

Any of these rollers may act as the welding electrode. In such case the body of the roller serving as the welding electrode (see Fig. 11) will be made of electrically non-conducting material 19, and include a central metal or carbon disc 20 to carry the current, the welding being effected at the periphery 21 of such disc.

In the case of using the type of roller shown in Fig. 11, in such a position as shown at 7a in Fig. 2, the use of other rollers at positions 8 and 9 in Fig. 2 would not be necessary, because the roller at position 7a would perform all the functions of maintaining the relation of the adjacent convolutions, and welding them together by way of their adjacent over-lapping flanges. However, because the tube would be usually larger than the mandrel, the use of rollers 8 and 9 would be useful to hold the tube substantially coaxial or central with the mandrel. After the strips are welded they will wind or turn about the mandrel together as a unit. All that would be necessary when starting the winding of the strip would be to direct, in any suitable manner, the initial end of the profiled strip into a curved path around the mandrel for the first convolution to the point where it becomes welded to the next convolution. After that the strip will wind perfectly about the mandrel as the adjacent convolutions which are welded together proceed in helical path from the point of welding.

The welding is effected electrically between the contacting points of the rotary electrode and the mandrel. The desired number of electrical energy impulses for a given unit of length of the line of welding or welding trace may be used. This relation may be so chosen that the welding "spots" will so overlap that there will be a substantially continuous welded seam between the flanges 5 and 4 whereby the tube will be fluid tight, and the width of the welded seam will be sufficient to avoid

fissures between the flanges at the edges of the flanges.

If it were assumed that the welding took place along the helical line of the crest 3 of the convolutions with impulses of the value i for a given unit u of length along such line, the weld spots would be equal to i times u. Assuming the diameter D of the tube at the trough 6 to be $2a$ and the diameter D' at the crest 3 to be $3a$, the circumference C of the former would be $2a\pi$ and the circumference C' of the latter would be $3a\pi$, or in the proportion of 2 to 3. Hence, by welding along the helical trough line instead of along the helical crest line, the work can be speeded up 50%. That is, for obtaining i u spots along the helical trough line per unit of time the tube can be rotated 50% faster and fed off the mandrel 50% faster. To increase production 50% in this kind of work is immense and not a matter that would be apparent from the methods and means previously used.

As the profiled strip is wound on the mandrel 2 it travels in screw-fashion, that is, the tube rotates about the axis of the mandrel and also progresses axially in proportion to the pitch of the helical form of the convolutions and the speed of rotation. This may be called the "feed-off" from the rolls.

The strip may have two or more U-shaped portions between the side flanges. In Fig. 12 the strip is shown with two U-shaped portions $3a$ and $3b$ between the side flanges $4a$ and $4b$, and in Fig. 13 the strip is shown with three U-shaped portions $3a$, $3b$ and $3c$ between flanges $4a$ and $4b$. In such cases rollers $7b$ and $7c$ for guiding and placing the convolutions would be used as shown in Figs. 12 and 13. The disc part of such roller pressing the adjacent flanges $4b$ and $4a$ together would act as the welding roller to weld such flanges together.

The disc electrodes shown in Figs. 6 and 11, corresponding to the disc electrode $12a$ shown in Figs. 12 and 13, may have an enlarged rim $12b$, as shown in section in Fig. 12. Any or all of the electrodes may use such rim when and where desired. In such case the sides of the peripheral portions of the rollers will be more sharply tapered or bevelled so as to leave sufficient insulating air spaces at both sides of the enlarged rim $12b$. See Fig. 12.

Along the feed-off path of the tube it is desirable to compress the convolutions. See Figs. 7 and 8. This may be effected by the use of compressing rollers 22, 23 and 24. These rollers may be of the general form shown in Fig. 3, but thinner and more closely axially spaced. They also are preferably rotatable on axes, which are at a normal to the convolutions being compressed, and are suitably arranged angularly about the tube, whereby two adjacent rollers may have overlapping portions between which a convolution of the tube may be axially squeezed or compressed.

As for example, when convolution 25 passes between rollers 22 and 23 it is given a decreased axial dimension and increased outward radial dimension, as shown in Fig. 8. When the convolution 26 passes between rollers 23 and 24, it is further decreased in axial dimension and increased in outward radial dimension, as shown in Fig. 8. More rollers may be used to still further compress the convolutions and increase their outer diameters. The inner diameter of the convolutions remains the same because of the trough portions bearing on the surface of the mandrel 2.

If the metal used is thin and has a tendency to be weak then the rollers 22, 23 and 24 may be of the form as roller 27 shown in Fig. 9, which roller has compressing and supporting rims 28 and 29 at each side of the convolution to be axially compressed.

It is preferable that the rollers be driven. In Fig. 14 is shown means for driving the rollers as shown in Figs. 2 and 3, and in Fig. 15 is shown means for driving the rollers as shown in Figs. 7 and 8. In both cases the drive means is of generally annular form to surround the rollers to be driven and to be clear of the tube and the mandrel.

In both cases the driving means is shown as having an annular driving ring 27 having inner teeth 28 and rotatably supported between rollers or idlers 29. Meshing with the teeth 28 are spiral gears 30 (see particularly Fig. 16) fixed to shafts 31 leading and secured to rollers 7, 7a, 8 and 9 (see Fig. 14 and Figs. 2 and 3) and to rollers 22, 23 and 24 (see Figs. 7 and 8, and Fig. 13). The annular gear 27 may be rotated by a suitable driving gear 32. The shafts 31 are at an angle to the axis of the annular gear 27 and at a normal to the convolutions to be acted upon by the rollers 7, 7a, 8 and 9, and 22, 23 and 24 as the case may be.

As the tube now feeds off it may be taken-up by a suitable take-off device and wound on a suitable wind-up spool or reel.

While I have herein described and upon the drawings shown illustrative embodiments of my invention it is to be understood that the invention is not limited thereto but comprehends other constructions, arrangements of parts, details, features, process steps, and the like, without departing from the spirit of the invention.

Having thus disclosed the invention, I claim:

1. The method of making flexible tubing from a strip of bendable weldable material having an undulated transverse profile and a lateraly directed flange extending along each edge of the profiled strip, comprising the steps of guiding said profiled strip into a helical path around a smooth faced cylindrical mandrel with the flanges of the strip proximately encircling said smooth faced mandrel and with a flange in each convolution of the guided strip in overlapping relation with the other flange in the next preceding convolution whereby a helical trough is provided radially outwardly of said overlapping flanges, said guiding of the strip acting to maintain said convolutions in given spaced relation axially for a given overlap of said flanges, pressing said flanges together and against said smooth faced mandrel at a locus through which said flanges are helically moved by applying a force radially outwardly of the tubing upon a portion of the inner of said overlapping flanges while applying a second force upon the outer side of said outer flange portion contiguous to said inner flange portion, said second force comprising a force component directed oppositely to the radially outwardly applied force for coacting therewith in pressing said flange portions together and a force component directed tangentially of the tubing for causing the same to rotate and thus advance the overlapping flanges through the locus where said forces are applied, and welding said flanges at said locus while the flanges are pressed against said mandrel at said locus by passing an electric current through said flanges to said mandrel which acts as an electrode to effect a resistance weld of the flanges.

2. The method of making flexible tubing from a strip of bendable weldable material having an undulated transverse profile and a laterally di-

rected flange extending along each edge of the profiled strip, comprising the steps of guiding said profiled strip into a helical path around a smooth faced cylindrical mandrel with the flanges of the strip proximately encircling said smooth faced mandrel and with a flange in each convolution of the guided strip in overlapping relation with the other flange in the next preceding convolution whereby a helical trough is provided radially outwardly of said overlapping flanges, said guiding of the strip acting to maintain said convolutions in given spaced relation axially for a given overlap of said flanges, pressing said flanges together and against said smooth faced mandrel at a locus through which said flanges are helically moved by applying a force radially outwardly of the tubing upon a portion of the inner of said overlapping flanges while applying a second force upon the outer side of said outer flange portion contiguous to said inner flange portion, said second force comprising a force component directed oppositely to the radially outwardly applied force for coacting therewith in pressing said flange portions together and a force component directed tangentially of the tubing for causing the same to rotate and thus advance the overlapping flanges through the locus where said forces are applied but wherein said tangential force component is also directed diagonally of the tubing for advancing it axially along the mandrel during the rotation of the tubing, and welding said flanges at said locus while the flanges are pressed against said mandrel at said locus, by passing an electric current through said flanges to said mandrel which acts as an electrode to effect a resistance weld of the flanges.

3. The method of making flexible tubing from a strip of bendable weldable material having an undulated transverse profile and a laterally directed flange extending along each edge of the profiled strip, comprising the steps of guiding said profiled strip into a helical path around a smooth faced cylindrical mandrel with the flanges of the strip proximately encircling said smooth faced mandrel and with a flange in each convolution of the guided strip in overlapping relation with the other flange in the next preceding convolution whereby a helical trough is provided radially outwardly of said overlapping flanges, said guiding of the strip acting to maintain said convolutions in given spaced relation axially for a given overlap of said flanges, applying a plurality of forces radially outwardly of the tubing upon respective circumferentially spaced portions of the inner overlapping flange while applying a second plurality of forces upon circumferentially spaced portions of the outer overlapping flange, said second forces comprising radially inwardly directed force components respectively cooperating with said radially outwardly directed forces in pressing the aforesaid portions of the inner overlapping flange against contiguous portions of the outer flange, said second forces also including force components directed tangentially of the tube for causing the same to rotate and thus advance the overlapping flanges through the zones at which the forces are applied, welding said flanges at said locus while the flanges are pressed against said mandrel at said locus by passing an electric current through said flanges to said mandrel which acts as an electrode to effect a resistance weld of the flanges.

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