United States Patent [19]

Bittner

[11] **3,750,444**

[45] **Aug. 7, 1973**

[54] **METHOD OF CONTINUOUS PRODUCTION OF TUBING WITH HELICAL OR ANNULAR RIBS**

[75] Inventor: **Herbert Bittner**, Krahenwinkel, Germany

[73] Assignee: **Kabel-und Metallwerke Gutehoffnungshutte Aktiengesellschaft**, Hanover, Germany

[22] Filed: **Oct. 13, 1971**

[21] Appl. No.: **188,752**

[30] **Foreign Application Priority Data**

Oct. 29, 1970 Germany ..... P 20 53 085.2

[52] **U.S. Cl.** ..... **72/78**, 72/367, 29/157.3 AH, 72/98

[51] **Int. Cl.** **B21d 15/04**

[58] **Field of Search** 72/78, 98; 29/157.3, 29/454; 138/121, 122, 173; 165/184

[56] **References Cited**

UNITED STATES PATENTS

3,353,389	11/1967	Kelstrom	72/78
2,365,515	12/1944	Baudry	165/184
1,982,369	11/1934	Brinkman	72/100
1,963,057	6/1934	Wilcox	138/173
2,563,578	8/1951	Candee	138/121
2,023,417	12/1935	Guarnaschelli	72/115

Primary Examiner—Lowell A. Larson
Attorney—Ralf Siegemund et al.

[57] **ABSTRACT**

Method of continuous production of ribbed tubes using a smooth-walled tube, corrugating same, and axially squeezing hollow corrugation crests of the tube, preferably by means of revolving die rollers, so that the interior surface portions of the sides of the crests as facing each other axially are folded and squeezed into surface to surface contact, to obtain integral ribs.

6 Claims, 8 Drawing Figures

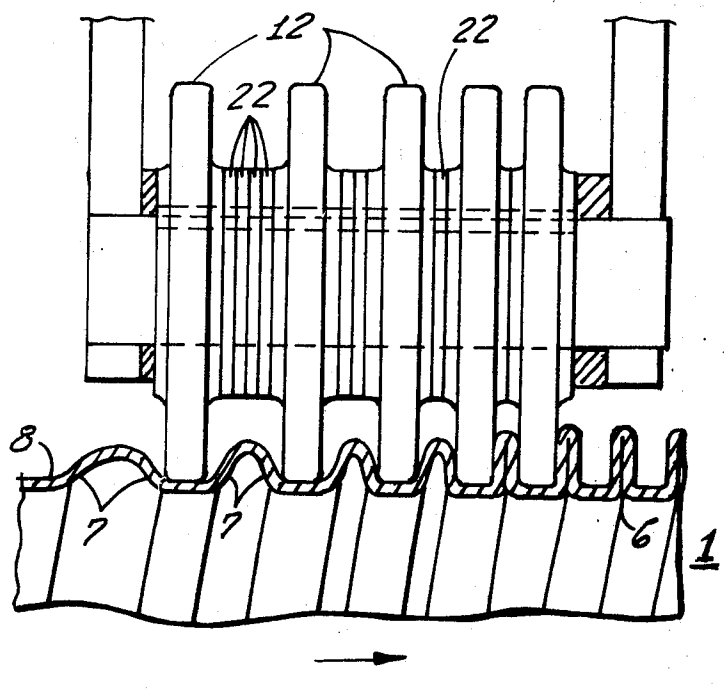


Fig. 1

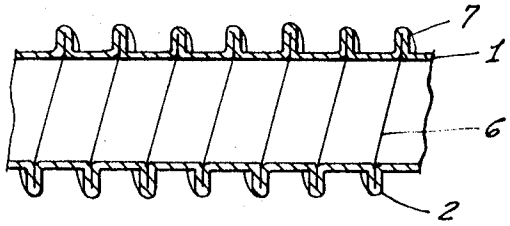


Fig. 2

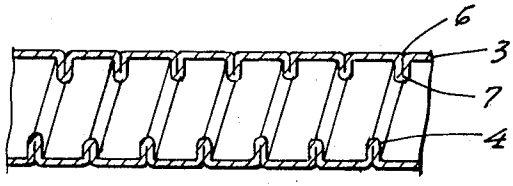


Fig. 3

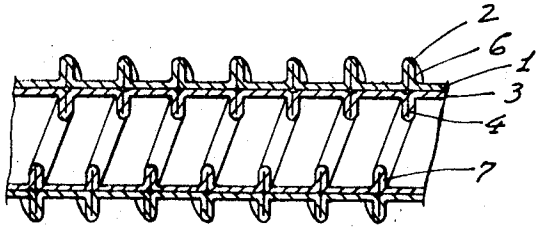


Fig. 4

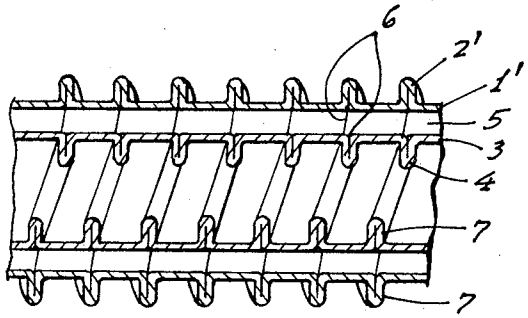
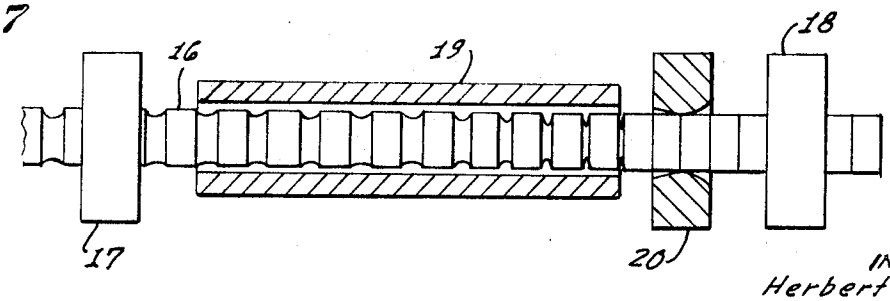


Fig. 7



INVENTOR:
Herbert Bittner
Smyth, Pavitt & Siegemund
By Ralf H. Siegemund
ATTORNEYS

Fig. 5

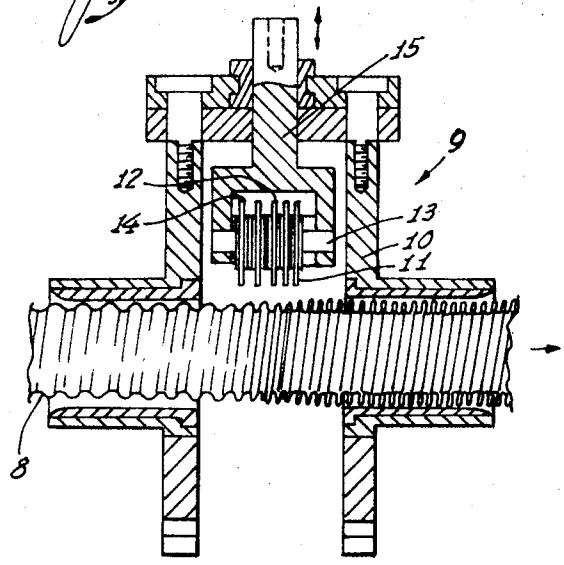
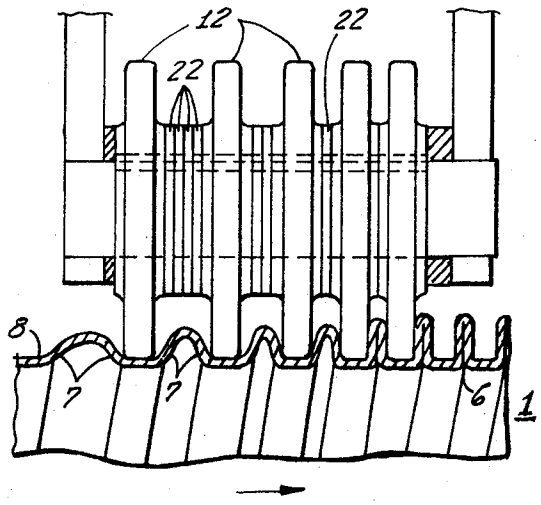


Fig. 5a



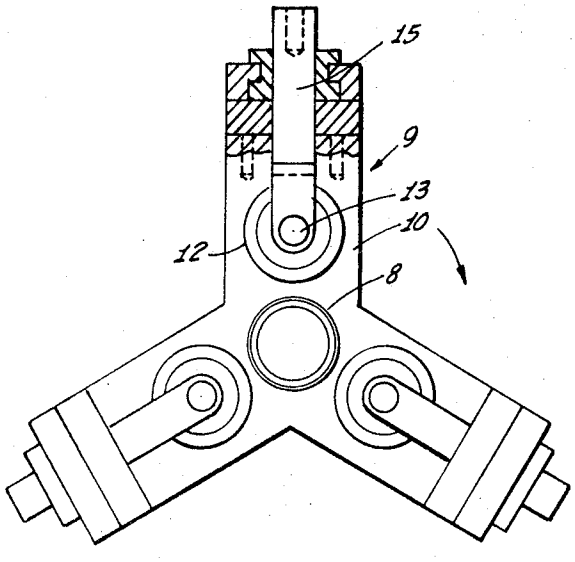


Fig. 6

INVENTOR:
Herbert Bittner
Smyth, Pastor & Pavitt
By Ralf H. Siegemund
ATTORNEYS

METHOD OF CONTINUOUS PRODUCTION OF TUBING WITH HELICAL OR ANNULAR RIBS

The present invention relates to a method for the continuous production of tubing that is provided with integral ribs. Tubes or pipes with ribs usually have the ribs extending transversely to the wall proper of the tube. Such tubes are, for example, used with advantage in heat exchangers using media with different heat transfer coefficients.

Basically, two types of ribbed or finned tubes are known; in the one variety, tubes and ribs are of integral construction and in the other variety, ribs are subsequently provided upon an originally smooth wall of the tube, for example, soldered thereto. Such tubes are also sometimes called gilled tubes. In both types of tubes, the ribs may run longitudinally, i.e., axially along the tube wall, or the ribs run circumferentially around the axis of the tube. The type of rib structure used in any particular case depends primarily upon thermal load and mechanical stress applied to the tube. Soldered tubes with ribs or those with gills, are, for example, used in heat exchangers, because such devices are not loaded mechanically. Tubes with integral ribs, however, have very high mechanical strength and may even be bent subsequently into different shapes, for example, for employment in flowthrough heaters. An example for this employment is desclosed in German printed patent application No. 1,817,474.

Each one of these known varieties for ribbed tubes or pipes, however, has significant disadvantages. For example, tubes having ribs that have been soldered to smooth wall tubing, have, in fact, very low mechanical resistance and, particularly, the solder limits the temperature range of operation and usage. In other words, tubing with soldered ribs cannot be used in heat exchangers operating at very high temperatures. On the other hand, pipes with integral ribs are quite strong, but not very flexible, and very expensive to make.

It is an object of the present invention to provide a method for the continuous production of ribbed pipes or tubes which is very economical and avoids drawbacks and deficiencies outlined above. In accordance with the present invention, it is suggested to provide a smooth tube by conventional process and to corrugate such tube, the corrugation having contour with circular or helical, hollow beads or crests. Subsequently, the hollow, outwardly or inwardly extending crests of the tubes corrugation are plastically deformed in axial direction so as to fold and squeeze axially the corrugation bead into a flat rib. Surface portions of the sides of a crest, as facing each other axially, are folded and squeezed axially into surface to surface contact to obtain integral ribs.

It is pointed out specifically that the invention is applicable to provide internal as well as external fins or ribs, as either the outwardly or the inwardly bulging corrugation crests can be deformed into a rib or ribs. In one case, outwardly extending crests are formed into ribs, while the inwardly extending crests are flattened again. For tubing with internal ribs, the situation will be reversed.

It should be mentioned that corrugating of smooth wall tubes is, of course, known, and it is also known to provide some axial upsetting of the corrugating pattern. This upsetting, for example, is provided so as to increase flexibility of corrugated metal tubing; see, for example, the German Pat. No. 493,930. The invention, however, is different from this method in that the hollow, corrugated beading of the tube wall is squeezed flat in axial direction.

It is particularly advantageous to size subsequently that portion of the tube that faces away from the rib. Thus, a tube with internal ribs provided in accordance with the invention should now be sized so that the outer surface, i.e., the outer wall, is as smooth as possible. Tubes with outwardly extending ribs should be sized to obtain almost smooth inner surface.

The method in accordance with the present invention is preferably carried out by particular equipment. In case radially outwardly extending ribs are to be provided, a continuous production line will be provided that includes a corrugating die, and particular equipment will be provided behind the corrugator that deforms and shapes the outward bulging beads or crests of the corrugation. In accordance with a particular feature of the present invention, this forming equipment should include at least two die rollers which revolve about the corrugated tube; the die rollers are on a common axis but in axially displaced relation to each other. These rolls as they revolve about the tube, deform the corrugation continuously, and squeeze the sides or flanks of the corrugation bead together. These two rolls, or the last pair of plural pairs of such die rollers, have an axial distance from each other which is about equal to twice the wall thickness of the corrugated tube. Preferably, pairs of die rollers are axially spaced along the tubing for stepwise squeezing the outwardly extending crests for obtaining ribs.

In another advantageous example for carrying out the method in accordance with the invention, it is suggested to have at least three pairs of die rollers of that type spaced apart by about 120°, i.e., regularly around the axis of the tube, whereby the axial distance between the two rolls forming one pair decreases in a trailing direction as far as the continuous process is concerned, and again, the rolls of the last pair provide the final squeezing action and actually have an axial distance equal to twice the wall thickness of the corrugated tube.

Plural die roller pairs have particular advantage in that rib-forming is carried out, not in a single step, but in at least three stages, without actually slowing down the rib-making process. The deforming process, which is basically a cold-working process, will not apply too much local stress to the material when carried out in steps. Axially and circumferentially spaced-apart die rollers can be used to obtain still more stages for squeezing and rib-forming in small steps as far as deformation is concerned.

The rolls of each pair may preferably be provided in an axially displaceable relation to each other. Of course, during operation the position remains fixed. However, the same equipment may be used to process different corrugations so as to obtain commensurate ribs.

While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention, it is believed that the invention, the objects and features of the invention and further objects, features and advantages thereof will be better understood from the following description taken in connection with the accompanying drawings in which:

FIGS. 1, 2, 3 and 4 show different types of ribbed tubes in cross section;

FIGS. 5 and 5a show somewhat schematically equipment for carrying out the rib-forming process in accordance with the present invention on the outside of a tube;

FIG. 6 shows the side view or front view of rib-forming equipment;

FIG. 7 shows equipment for forming internal ribs in a corrugator tube, without directly engaging the crests.

Proceeding now to the detailed description of the drawings, in FIG. 1 thereof is illustrated a tube 1 with external ribs 2. The ribs 2 particularly extend in radial, outward direction. Acutally, there is a single rib that runs in a helical pattern around the axis of the tube. However, it may be more convenient to consider ribs in the plurality as each 360° loop can be regarded as a separate rib. Originally the tube was corrugated with (axially) alternating inwardly and outwardly bulging portions, establishing a helical bead or crest line; the outwardly extending crest runs in helical contour. That crest was progressively axially squeezed together to form the ribs (see FIG. 5a). It can readily be seen that the inner surface portions 7 of any outwardly extending crest and as facing each other axially are tightly squeezed into surface to surface contact for the formation of the ribs.

As a consequence, the inwardly extending crests of the corrugation were flattened and a subsequent sizing or finishing operation may have established rather smooth-walled tubes as far as the inner surface contour is concerned. The interior of the tube is smooth, except for the small, helical groove 6 at the inner end of now abutting surface portions 7 that were the inner surface of the outwardly extending crest of the corrugated tube prior to rib-forming.

The example of FIG. 2 differs from FIG. 1 in that not the outwardly extending crests, but the inwardly extending crests of the corrugation helix has been axially squeezed or upset so as to produce radially inwardly extending ribs 4. Also here, the ribs may actually be a single ridge that runs helically around the axis of the tube and extends in radial inward direction.

The doubly ribbed tubing shown in FIG. 3 can actually be construed as a combination of FIGS. 1 and 2; a tube or pipe 1 with outwardly directed ribs has been slipped onto a tube 2 with inwardly directed ribs. It can readily be seen that the tubes were originally, and are still, of slightly different diameter, but the corrugation was similar for both of them, particularly the pitch of the helix is the same. That aspect is not changed by squeezing the crests axially. As a consequence, the two tubes can be telescoped in such a manner that, in fact, inner and outer ribs are radially aligned. One can produce a very compact and solid construction, if, for example, by operation of a shrinking and quenching step, the outer tube is firmly seated on the inner tube.

FIG. 4 illustrates a coaxial tube arrangement wherein the ribbed outer tube 1' receives coaxially a ribbed inner tube 3, there may be spacers provided in between having little or nothing to do with the ribs. Again, there is obtained radial alignment of the rib structure for both tubes, and that can readily be obtained through properly aligning inner and outer tubes in axial direction.

By way of example, the pipe or tubing in accordance with FIG. 4 may have been made through a continuous process that can be described as follows. First, metal strip is paid into a production line and longitudinally shaped and deformed to obtain a split tube. That tube is seam-welded in a protective atmosphere, corrugated, and subsequently the inwardly extending crests are squeezed axially to obtain ribs 4. Whether or not continuous process proceeds or whether the tubing so made is reeled on a drum for later use, is primarily a matter of economics; basically it is possible to continue on a production line and to wind a spacer onto the smooth outer surface of tube 3. Next, strip is again paid into the production line and another split tube is formed around the spacer, longitudinally seam-welded, corrugated, and finally the outwardly bulging helical corrugation crest is axially squeezed to obtain the outwardly extending ribs.

Tubing of the types shown in FIGS. 1 through 4 may be used as heat exchangers because the ribs as provided extend the effective surface of the tube actually available for heat exchange. It can readily be seen that pursuant to the rib-forming process the crests are to be squeezed so that the surface portions, which are to engage, do in fact, engage in flat surface-to-surface contact with little thermal resistance established in-between. On the other hand, it was found that the tubing made in that manner still retains the flexibility, or at least a substantial degree of flexibility corrugated tubing is known to have. As compared with the known ribbed tubes or pipes, tubing made in accordance with the invention is considerably more economical, and the manufacturing process is quite inexpensive.

The tubing shown by way of example is assumed to have been provided with helical corrugation. However, it can readily be seen that the principle of the invention is equally applicable to tubing that is provided with annular or ring-shaped corrugation. In one case then, a single helical rib is obtained, in the other case, the tube will have individual annular ribs. As will be shown below, a helical corrugation lends itself more readily to a rib-forming process. Moreover, a helical rib has the added advantage that fluid passing through the tube, receives an annular momentum which is highly advantageous for heat exchange due to thorough, continuous mixing process of liquid or fluid that is to receive or is to loose thermal energy.

The tube construction shown in FIG. 4 can be regarded as the preferred example for practicing the invention as far as employment in a heat exchanger is concerned. Liquid or fluid that is to be heated, or cooled, as the case may be, will pass through the cylindrical ring-space 5 between inner and outer tube, and a coolant or heating fluid can be provided internally as well as externally. In other words, the tubing shown in FIG. 4 may be included in another, outer pipe, and coolant or heating fluid will flow along the outside of tube 1' as well as inside of tube 3. Depending on the structure involved and the length of the tubing, a spacer between tubes 1' and 3 may or may not be needed. The seam-like groove 6 provided at the bottom of each rib may, for example, be sealed with tin or the like in order to avoid contact corrosion of the rib seam 7.

After having described features and characteristics of the resulting product, we now turn to the description of equipment illustrated in FIGS. 5 and 6 and used for making tubing with outwardly extending ribs. A corrugated tube 8 may enter the rib-forming equipment 9

after having left a conventional corrugating machine. A split clamp caterpillar or the like, as is known per se, may pull the tubing through the corrugator. Now, a rib-producing tool **9** is entered. There is provided, first, a head **10** which revolves about the axis of corrugated tubing **8.** A deforming tool **11** is provided in the head. Head **10** may preferably be driven in unison with or even from the corrugator so that there is synchronism between the providing of the corrugating pattern and the upsetting and squeezing operation performed on the corrugation crests by operation of head **10** to be described.

The tool includes plural roller dies **12** and FIGS. **5** and *5a* show five of such rolls journalled on an axis **13.** Respective two of these rolls, as disposed in axially juxtaposed relation constitute a pair that provides for partial axial squeezing of the outwardly extending hollow crest bead of the helical corrugation.

The set of die rollers, particularly as journalled on spindle **13,** is mounted in a fork **15** which can be adjusted in the radial direction as far as tube **8** is concerned. In the illustrated example of FIG. **5** fork **15** has position so that all of the rollers **12** are retracted. This radial positioning relative to the tube permits adjusting of the tool to differently wide tubes. FIG. *5a* shows rollers **12** in operating position. They are individually positionable on spindle **13** and the distance between adjacent two of them is determined by washers **22.** Thus, all of these rollers may be similar but the degree of squeezing action provided by respective two of these rollers may be determined by the number and axial dimension of the washers **22** provided between them.

The rolls **12** are radially outwardly of smaller dimension axially of tube **8** so that they can extend into the corrugation valleys. The gap between two adjacent rollers is reduced in direction of tube propagation (arrow) e.g., by reducing the number of washers **22** between rollers that form a die pair. Thus, each pair, beginning with the left most, provides for narrower and narrower axial squeezing. The last two rollers, having position most to the right, have an axial distance merely equal to twice the wall thickness, and they grip the already partially squeezed crest portion to now obtain a firm, axial squeeze resulting in completion of such a rib in which the inner surfaces **7** of the crest are now firmly squeezed together. The ribbed tube **1** may then run through a mandrel for internal sizing.

It can readily be seen that a helical corrugation facilitates the rib-forming process; the rib-forming tool may revolve continuously as the tubing advances axially, also continuously. However, in case of circular corrugation, the tool will advance axially with the tube while making one revolution, whereupon the fork retracts, the tool returns, the head advances, etc. This is mentioned here only to indicate that helical corrugation is not mandatory to practice the invention.

The FIG. **6** can be interpreted as a cross-sectional view of FIG. **5.** However, the arrangement, as shown in FIG. **5** per se, is complete, so that from a different point of view FIG. **6** can be regarded as a modification. The arrangement shown in FIG. **5** can be interpreted as operating with a tool comprised of a single set of rolls, which establish four axially spaced die pairs to provide stepwise squeezing. FIG. **6** shows that two more of such tools can be provided. They all are arranged angularly, regularly, i.e., at a distance of 120° around the axis of tool **1.** Assuming that the basic construction of each tool is the same, there will result a 12 stage deforming process, which, indeed, insures a rather gentle and small squeeze step by each roll pair.

Proceeding now to the description of FIG. **7,** there is illustrated an apparatus for providing internal ribs using a corrugated tube **16,** drawn by a split clamp caterpillar through a corrugator head. One of the clamps **17** of that caterpillar is shown. The corrugation head (not shown) is presumed to have provided for a circular corrugation, but between each annular corrugation bead remains an incorrugated portion.

Another split clamp caterpillar is provided, one clamp being shown at **18.** It is now assumed that the tube advancing device having clamp **17,** runs at a higher speed than the one having clamp **18.** Accordingly, the corrugated tube is upset and the inwardly extending corrugation crests are, in effect, squeezed together. A guiding pipe **19** prevents tube **16** from buckling so that the tube does not bend off laterally as a whole. The tube is additionally drawn through a sizing die **20** finishing the outer surface. If the speeds of the caterpillars are selected so that the tube must be shortened axially for the total axial lengths of the corrugation beads, these beads will, in fact, be completely squeezed flat axially to obtain the rib structure as shown in FIG. **2.**

The invention is not limited to the embodiments described above but all changes and modifications thereof not constituting departures from the spirit and scope of the invention are intended to be included.

I claim:

1. Method of continuous production of ribbed tubes, comprising the steps of:

providing a smooth-walled tube;

corrugating said tube;

axially squeezing hollow corrugation crests of the corrugated tubes in steps so that the interior surface portions of the sides of the crests as facing each other axially are folded and squeezed into surface-to-surface contact, to obtain integral ribs; and

providing for straight wall configuration between the ribs, so that the wall surface of the tube between the ribs as well as the wall surface opposite the ribs is substantially smooth.

2. Method as in claim **1,** using die rollers for axially squeezing the crests, the rollers revolving about the axis of the tube, while maintaining the tube wall straight between the crests.

3. Method as in claim **2,** using plural pairs of die rollers for progressively and stepwise squeezing the crests.

4. Method as in claim **3,** one pair or rollers included in the plural pairs, having rollers with operating surface portions axially apart by about twice the wall thickness of the tube squeezed.

5. Method as in claim **3,** wherein the pairs of rollers revolve about the tubes axis apart from each other by an angle of 120° from one pair to the next one.

6. Method as in claim **1,** wherein the squeezing is obtained by advancing the corrugated tubing axially at different speeds, acting on different locations, so that in-between the corrugation is upset.

* * * * *