

L. H. BRINKMAN.  
 HELICALLY CORRUGATED TUBE.  
 APPLICATION FILED JAN. 11, 1913.

1,120,268.

Patented Dec. 8, 1914.

2 SHEETS—SHEET 1.

Fig. 12,

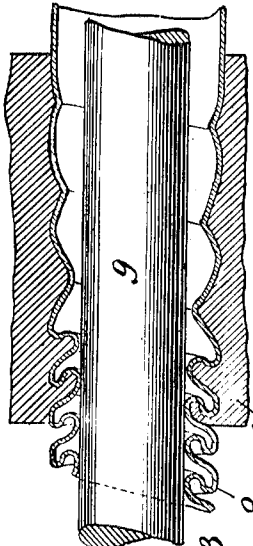


Fig. 11

Fig. 13

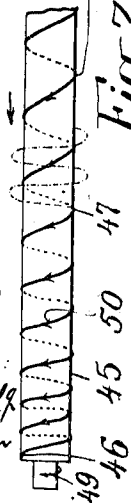


Fig. 7,

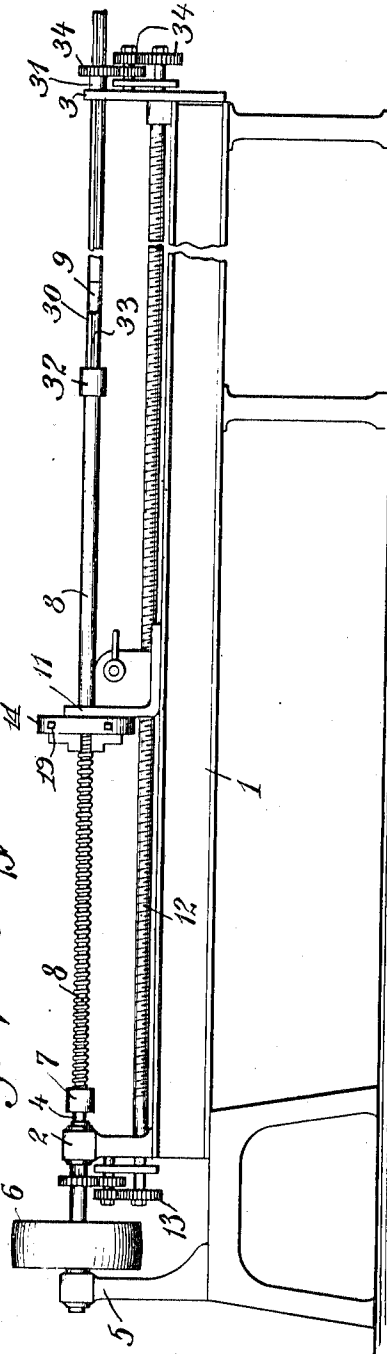


Fig. 4



Fig. 3,

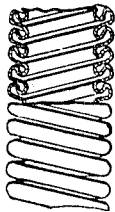


Fig. 2,

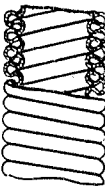
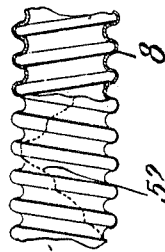


Fig. 1,



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 Samuel H. Ward  
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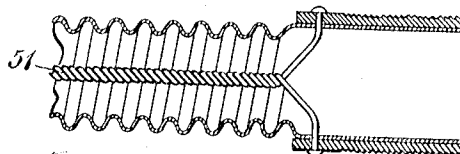
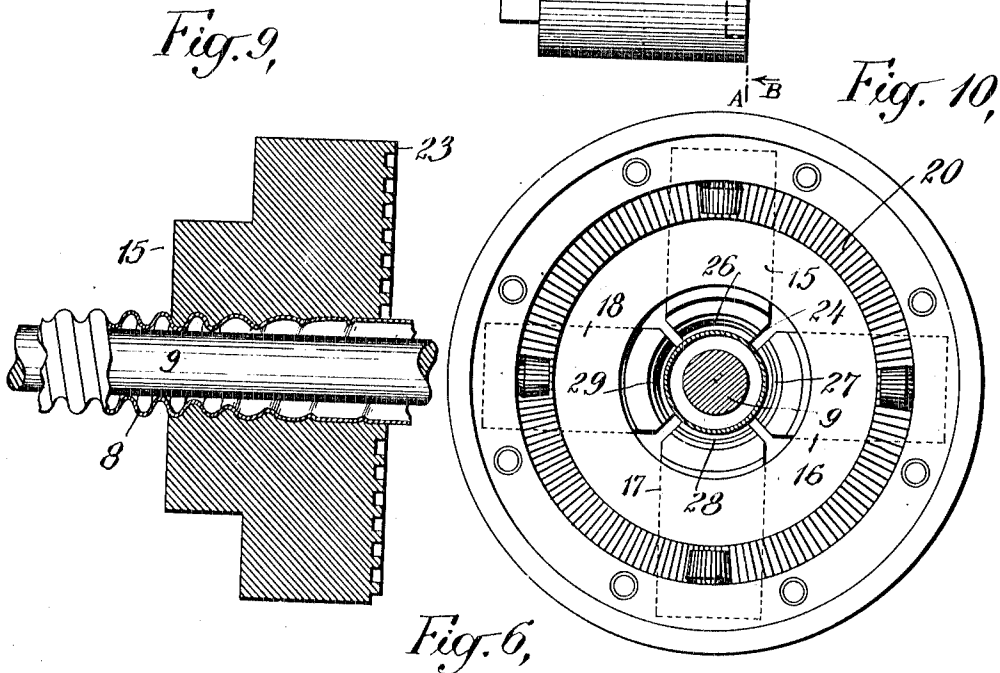
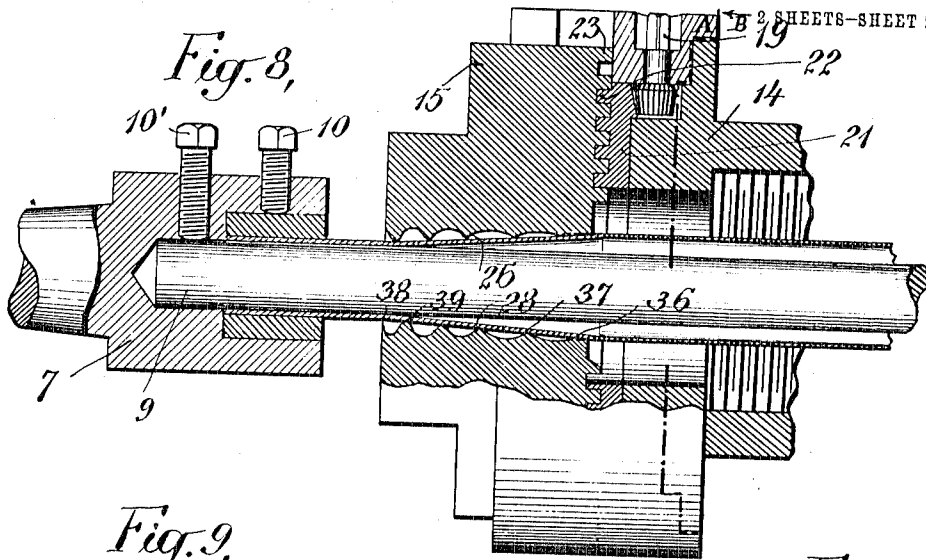
INVENTOR,  
 Louis H. Brinkman,  
 BY  
 Kenyon & Kenyon,  
 his ATTORNEYS.

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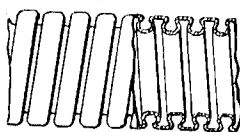
Patented Dec. 8, 1914.

2 SHEETS-SHEET 2.



WITNESSES:

Samuel M. Ward Jr.  
John O. Lempler



INVENTOR,  
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# UNITED STATES PATENT OFFICE.

LOUIS H. BRINKMAN, OF GLEN RIDGE, NEW JERSEY, ASSIGNOR TO BALTIMORE TUBE COMPANY, OF BALTIMORE, MARYLAND, A CORPORATION OF MARYLAND.

## HELICALLY-CORRUGATED TUBE.

1,120,268.

Specification of Letters Patent.

Patented Dec. 8, 1914.

Application filed January 11, 1913. Serial No. 741,388.

*To all whom it may concern:*

Be it known that I, LOUIS H. BRINKMAN, a citizen of the United States, and a resident of Glen Ridge, county of Essex, State of New Jersey, have invented certain new and useful Improvements in Helically-Corrugated Tubes, of which the following is a specification.

My invention relates to helically corrugated tubes, and the invention consists in the provision of helically corrugated tubes as hereinafter described and more particularly pointed out in the appended claims.

Various methods and apparatus have been proposed for corrugating tubes helically in an attempt to form helically corrugated tubes with deep folds to provide the flexibility or relatively great radiating surface necessary to the adaptation of such tubes to the extensive fields of uses such, for example, as for flexible connections, couplings, radiators, etc., but the methods and apparatus proposed for making such tubing either stretch or crush and stretch the metal into folds without twisting the metal, and this twisting I have found to be essential in deeply corrugating tubing. The methods and apparatus which have been proposed are such that the deeply corrugated tubes desired can not be commercially manufactured, and so far as I am aware, heretofore it has been impossible to commercially manufacture corrugated tubes with folds or corrugations of such depth as to render the tubes really flexible, and provide a relatively great radiating surface. But I have produced a new article in corrugated tubes differing in texture, and in their preferred forms differing in form and texture from corrugated tubes heretofore made.

The metal, or grain of the metal, so called, lies helically due to the fact that the tube is twisted while being corrugated, but the twisting or displacement of the metal is not equal to the pitch of the folds, that is, a line representing the actual twisting or displacement of the metal is of greater pitch than the pitch of the folds. By this twisting of the tube in folding or corrugating it, folds of extreme depth may be formed so that a tube of great flexibility and relatively large radiating surface may be obtained, and the metal of the tube is not appreciably crushed, spun or stretched out

during the folding process. The metal of my new product is not wrinkled as a result of being corrugated, its thickness is substantially unchanged during the folding process and is substantially uniform and equal to that of the uncorrugated tube.

In order to enable those skilled in the art to more fully appreciate the texture and advantages of my new product, I will describe the process by which tubes are corrugated.

I form the folds or corrugations by pressing upon a plain tube along a helical line, and while thus pressing upon it, twisting the tube to displace the pressed metal helically. The pressure is exerted upon the wall of the tube at a progressively shifting short portion thereof, and the actual twisting of the metal is localized to substantially the short portion of the tube being pressed upon or to the short portion being folded, so that the portion of the tube which has been folded to the desired final form is protected from distortion by the twisting force. The twisting of itself tends to fold the tube by distorting it helically and contracting it longitudinally, and thus greatly reduces the pressure required on the metal to deepen the folds, and if continued after the folds are thus formed, it reduces the pitch of the folds by continuously forcing the folds around helically analogous to the manner in which a helical spring of a certain pitch and diameter may be reduced in diameter and pitch by slipping it over a rod to prevent buckling, and holding one end down on the rod while twisting the rod and holding the opposite end of the spring from rotation, while permitting it to move along the rod.

In deeply corrugating tubing, I have found that it is of great importance, if not essential, to apply the pressure along the helical line inwardly against the wall of the tube.

When the pressure is exerted from the outside inwardly on the tube to form the folds by displacing the metal inwardly, the diameter of the pressed-in metal is less than that of the original tube hence there is more than sufficient metal for the circumferential measurement of the folds and the metal does not have to be stretched or spun out in forming the folds as would be the case if the pressure was exerted from the inside outwardly. The metal is crowded in as it

is pressed inwardly, producing what without the twisting of the metal would be an excess of metal along the helical line of pressure, such as takes place when it is attempted to force the metal of a hollow cylinder or tube inwardly at any point along its length to reduce the diameter at that point; in which event, by being crowded in along the line of reduced diameter, the metal is caused to wrinkle or pucker. This crowding of the metal would soon limit the depth of the folds if it were not for the twisting force above mentioned; but by producing a twisting force in the tube to actually twist the metal, and while the tube is under such force, pressing inwardly on it along a helical line, the excess metal is displaced helically as it is being forced inwardly so as to keep the wall substantially uniform in thickness during the folding process, permitting the formation of folds of great depth.

The resistance of the metal of a tube to inward pressure is so great that sufficient friction between the corrugating tool and the metal is produced to twist the tube, and because of this resistance the metal can be gripped and drawn together along the length of the tube to form the axial sectional configuration of the folds and otherwise formed into the desired shape without appreciable stretching or spinning of the metal.

In the more preferred method of forming my new product, I initiate a helical groove in the tube, of such pitch as to mark out along the tube sufficient metal to form an ultimate fold of the desired depth and pitch without substantial change in wall thickness, and progressively increase the depth of the groove and decrease its pitch by simultaneously pressing inwardly on the metal along the groove, drawing together its convolutions and twisting. By marking out along the tube substantially enough metal to form the ultimate fold of the desired depth and pitch, sufficient metal is provided to form the fold without having to spin or stretch from a less amount of metal a sufficient length to form the axial sectional configuration of the fold. This feature and the twisting permit the tube to be folded or corrugated without substantially changing its wall thickness. By pressing on the folds while they are being formed, they may be made to assume different desired cross-sectional configurations, depending upon the angle at which the pressure is exerted upon them.

In the preferred manner of forming corrugated tubing embodying my invention, I rotate the forward end of the tube at a certain speed and rotate the rear end of the tube at a less speed, and groove it at a speed having a definite relation thereto, the

ratio between the speeds being constant so as to produce a positive and constant twisting force in the tube to produce absolutely uniform corrugations or folds in the finished tube. In order to limit the pitch of the ultimate folds and their depth, and to hold the tube from buckling during the folding or corrugating process, I provide an inner support upon which the tube is folded. With this inner support the inward pressure may be progressively applied by the tool until the depth of the groove in the tube is positively limited by coming in contact with the support, whereupon, if there should be any irregularities or unevenness in the metal of the groove, the tool will act to smooth or iron out any unevenness in the metal.

In one form of my invention the folds are bent longitudinally of the tube to one side to further increase the flexibility and radiating surface of the tube, and they are preferably so bent while being formed.

The invention will be more fully understood and further advantages of the new product will more fully appear from the following description taken in connection with the accompanying drawings, in which, for the benefit of those skilled in the art who may desire to make such tubing, and to enable them to more fully appreciate the difference in texture between my new product and corrugated tubes of the prior art, I have included in the drawings and description the preferred form of apparatus for making the tubing, and have described forms of tubing embodying my invention in connection therewith.

Referring to the drawings, Figures 1 to 5 show different forms of tubing embodying my invention; Fig. 6 shows a form of the same with an inner tension member; Fig. 7 is a front elevation of the preferred form of apparatus for corrugating tubes, with a tube being corrugated; Fig. 8 is an enlarged view of a part of the mechanism showing the corrugating tool or die partly in section and in position to commence corrugating the tube; Fig. 9 is a view showing the die and a part of the corrugated tube in section; Fig. 10 is a cross-sectional view of the die shown in Fig. 8, taken on line A—A and looking in the direction of the arrows B; Fig. 11 is a fragmentary sectional view showing a modified form of corrugating die in process of operation; Fig. 12 illustrates the manner in which the metal of the tube is twisted or carried around helically as it is being compressed; and Fig. 13 is a diagrammatic illustration.

Referring to the drawings, Figure 1 shows a form of the product such as is made by the tool shown in Figs. 8 and 9, and the helical dotted line 52 represents the degree to which the tube has been twisted

or the helical direction in which the grain of the metal lies due to the twisting force which was exerted upon the tube in corrugating it.

5 In Fig. 2 I have shown a form of the product in which the folds have been brought closer together than in the product of Fig. 1, by further twisting the tube after it has been folded in the form shown in Fig. 1 or by forcing the folds together and twisting them.

Fig. 3 shows a form of the product in which the folds have a wall each bent longitudinally to one side to increase the flexibility and radiating surface of the tube.

15 Fig. 4 shows a form of the product in which the entire fold droops over longitudinally to one side and is the form which may be made by the tool shown in Fig. 11.

20 The axial sectional configuration of the folds may be given any desired shape by suitably shaping the tool used in corrugating or folding the tube, and it will be observed in Figs. 4 and 5 that the outer surface of the folds is flat instead of being curved as in Figs. 1 to 3, which gives a pleasing appearance and results in a highly useful form of tubing for many purposes.

The product shown in Fig. 6 is provided with an inner tension member 51 adapted to be secured to any pipe or connection to which the tube is to be secured to prevent longitudinal expansion, or to hold the tube in alinement.

35 Fig. 7 is a front elevation of a suitable machine frame 1 having a head stock 2 and a tail stock 3. 4 is a shaft journaled in the head stock 2 and counter pillow block 5 and driven through any suitable means such as pulley 6. The inner end of the shaft is provided with a chuck 7 (Fig. 8) to which is secured the tube 8 to be corrugated or folded, and also an inner support or mandrel 9 which extends through the tube, the tube and mandrel being secured to the chuck by any suitable means such as set bolts 10, 10', so that they will revolve together with the chuck. A carriage 11 of suitable construction is slidably mounted on the frame 1 and is moved longitudinally along the same by means of a screw spindle 12 journaled in the head and tail stocks and driven from shaft 4 through suitable gearing 13, the gearing being arranged like the usual lathe gearing so that the speed of the screw spindle 12 may be varied, depending upon the work to be performed. On the carriage 11 is mounted a suitable chuck 14 of the usual construction, but in which for the usual radially adjustable gripping jaws, are substituted radially adjustable die sections 15, 16, 17, 18. These sections are moved radially by adjusting pins 19 each carrying at its inner end the usual bevel gear meshing with the gear teeth 20 cut on one side of ring 21

on the other side of which are formed the spiral threads 22 which mesh with threads 23 for the purpose of moving the die sections in and out radially to adjust the diameter of the die. The inner ends of these die sections are tapered as shown at 24 in Fig. 10, to permit the desired radial adjustment, and the inner ends of the sections are provided with projections 26, 27, 28, 29, which, when the die sections are assembled, form a thread or helical projection increasing in height and decreasing in pitch toward the finishing end of the die. In the preferred form of the invention as shown herein, the projections of each section of the die constitute longitudinal sections of a continuous thread or helical projection progressively increasing in height and decreasing in pitch, so that when the die is assembled, the projections of the different die sections form such a helical projection.

In the form of apparatus herein shown, a hollow tail shaft 30 is provided extending through a sleeve 31 journaled in tail stock 3, the tail shaft being secured at its inner end by a suitable chuck 32 to the rear end of the tube 8. The purpose of this tail shaft is to produce a positive predetermined twist in the tube being corrugated, and for this purpose the tail shaft is rotated at a speed less than the speed of shaft 4, the difference in speeds being such as to produce the desired twist in the tube while it is being folded. This tail shaft may be rotated by any suitable means to produce this result, and in the present form of apparatus the shaft is provided with a groove 33 in which fits a suitable feather (not shown) projecting inwardly from the sleeve 31 to cause the shaft to rotate with the sleeve and permitting it to move longitudinally through the sleeve. The sleeve is driven in any suitable manner such, for example, as from screw spindle 12 through gearing 34. The tail shaft is preferably hollow so that the rear end of the mandrel 9 may extend into it.

Referring to Figs. 8 and 9, it will be observed that the helical die teeth or projections are so constructed that the advance projection simply initiates in the tube a helical mark or groove along which the tube is to be folded, and by thus starting a groove in the tube it gives it a line of least resistance along which to fold under the twisting force. It will also be noted that the advance convolution of the helical projection marks out along the length of the tube sufficient metal to form the axial sectional configuration of the desired fold in the ultimate product; that is, the distance between points 36 and 37 is equal to the length of the curved outline between points 38 and 39.

By marking out along the tube sufficient metal to form the sectional outline of a fold

of the desired depth and pitch, it is possible to form the desired folds without appreciably stretching or spinning out the metal, as hereinbefore explained. It will be further observed from inspection of these drawings, that the greatest diameter of the helical thread of the die is the same throughout the length of the thread and is equal to the diameter of the tube to be corrugated. This insures the diameter of the corrugated tube being the same as the original diameter of the tube, since it positively prevents any outward expansion of the tube during the folding process, and the outer surface of the folds may be made to assume an outline depending upon the outline of the grooves between the projections of the die. When a die of this character is used and relative rotation is produced between the tube and the die while the tube is gripped by the die, the friction produced is so great that the tube is twisted, and as the metal of the tube under this twisting force and the relative longitudinal movement between the die and the tube, is drawn through the helical path or grooves in the die, the helical lines along which the tube is gripped by the advance convolutions of the die are gathered or drawn together in forming the folds. The friction produced by a corrugating tool or die of this character is so great that sufficient friction is obtained for corrugating tubes of certain sizes without the use of any means for retarding the rear end of the tube or for positively driving it at less speed than the front end to produce a positive twisting force. Tubes as large as 3 inches in diameter and with walls a thirty-second of an inch thick, have been successfully corrugated by such dies without any additional twisting force applied at the rear of the tube, but the application of a twisting force at the rear end of the tube makes it possible to utilize a tool having less friction, and whether or not this be taken advantage of, it produces corrugations of greater uniformity and enables tubes of greater wall thickness to be more readily corrugated.

When it is desired to form tubes of a given size but with greater flexibility or larger radiating surface than is possible with the die shown in Figs. 8 and 9, means may be provided for pressing on the folds longitudinally of the tube while they are being formed so as to bend them as shown in Figs. 3, 4 and 11. This is done in the form of apparatus herein shown (Fig. 11) by gradually turning the edges of the helical projections at the finishing end of the die longitudinally of the tube so as to progressively bend the folds laterally as they are being deepened. I have found it preferable to commence this turning over or bending of the helical projections at about

one and a half convolutions from the finishing end of the die and gradually increasing the longitudinal projection until it is of such depth as to give the desired shape to the ultimate fold. While I have shown these projections with longitudinally bent edges as an integral part of the die sections, obviously they need not be made integrally with the remaining part of the sections.

Besides obtaining corrugated tubes of greater flexibility and radiating surface by bending the folds laterally as shown in Figs. 3, 4 and 11, the bending of the folds in this manner enables the corrugated tube to be more readily drawn from the mandrel, since the folds, instead of bearing down perpendicularly upon the mandrel, are inclined or so constructed that they will more readily yield when the mandrel is being drawn out.

In the drawings herein shown, the mandrel is of such diameter with respect to the setting of the die, that the last tooth of the die folds the tube down upon the mandrel; but if desired, the finishing tooth or convolution need not come down so close to the mandrel, and the twisting of the tube after it leaves the finishing end of the die may be relied upon to finish the folding of the tube down upon the mandrel.

The way in which tubes are corrugated by the use of the apparatus herein described, is as follows: The tube 8 to be folded is preferably, though not necessarily, drawn down to a taper near its forward end so as to fit the taper of the die, and the tube is then slipped over the mandrel and the mandrel and tube are secured in the chuck 9 in any suitable manner so as to rotate together with the chuck. The hollow tail shaft 30 (when one is used) is then pulled forward through the sleeve 31 and after the rear end of the mandrel has been slipped into it, the rear end of the tube 8 is secured in the chuck 32, and the carriage being up at the head of the frame to bring the die in the position shown in Fig. 8, the sections of the die are gradually moved inwardly by turning one of the pins 19 until the helical projection formed by the different projections on the die sections, grips the tube along the tapered portion. If power is now thrown on to rotate shaft 4, the mandrel and front end of the tube will be rotated, and simultaneously therewith the threaded spindle 12 will be rotated to move the carriage along the tube and to rotate the tail shaft and rear end of the tube at a definite predetermined speed less than that at which the forward end of the tube is being rotated so as to positively twist the tube a predetermined definite amount depending upon the relative rotation between the forward and rear end of the tube. As the die is moved along the tube, the advance point 36 of the helical projection progressively marks or

initiates a helical groove in the tube, and the metal marked out by the first convolution of the helical projection, as, for example, the metal between points 36 and 37, is gradually drawn together as the pitch of the helical projection decreases, and since the height of the projection progressively increases as the pitch decreases, the metal along the helical line is gradually and progressively pressed inwardly as the line along which the tube is gripped is drawn together; and as the metal is being gradually forced in by the helical projection, the excess metal, due to the reduction in the diameter along this line, is gradually displaced by the twisting force exerted on the tube, as indicated, by way of illustration, by the direction of the arrows in Fig. 12. This twisting force, as previously stated, not only displaces the metal so as to permit the deepening of the grooves to the desired extent without wrinkling or rupturing the metal, but the twisting in itself tends to fold the tube helically along the line of least resistance produced by the helical groove initiated in the tube. As the die carriage is moved along the tube, the die progressively marks the tube in this manner and the twisting force is continuously applied as described. The effect of the twisting force in the gradual drawing together of the metal of the tube into helical folds may be illustrated, in a way, by reference to Fig. 13, in which 45 is a rod or mandrel to the end 46 of which is secured a helical spring or piece of spring wire which is wound around the rod with a progressively increasing pitch from the end 46. If it is attempted to draw the convolutions of the spring toward end 46 so as to decrease the pitch of the longer convolutions as shown at the end 46 of the mandrel without rotating the mandrel or the free end of the spring, as the convolutions say at points 47 and 48, are gripped and drawn together, the convolutions of the spring between these points will rise from the mandrel as shown in dotted lines; but by gripping the convolutions at the free end of the spring so as to hold them from rotation, and then rotating the rod in the direction shown by the arrow 49, the spring will be folded down firmly upon the rod in the desired decreased pitch without increasing its diameter and without any tendency to buckle out of the desired form of the spring. During this rotation of the rod the spring will actually slide along and move around the mandrel in a helical line as indicated by the arrows 50. In a somewhat similar manner, when a tube is being folded according to my method of folding tubes, the twisting force applied actually displaces or carries the metal around helically so that the resulting corrugated tube formed under the twisting force is actually slightly longer than the tube would have been if it could have had

similar corrugations formed in it without the twisting force.

The amount that the tube may be twisted in forming the folds may be varied in several ways such as by varying the relative rate of rotation of the advance and rear ends of the tube, or by varying the pitch of the die relative to that of screw shaft 12, or the speeds of the shafts 4 and 12.

In practice I have found that it is very important to provide a support for the tube being corrugated, such, for example, as the mandrel. Such a support is an important feature in regulating the action of the twisting force on the folds, and by the regulation of this force, folds of the desired configuration and size may be formed. For example, when the finished folds are brought down firmly upon the support and only sufficient relative rotation between the shafts 4 and 30 is produced to displace the metal as it is being pressed upon by the die, or to bring the folds down upon the support after they leave the die, where the support is of less diameter than the die, the friction between the folds and the support is sufficient to prevent relative rotation between the support and the folds which have been forced firmly into engagement therewith, so that the support will serve to localize the twisting force in the tube by transmitting the force from the chuck to the portion of the tube being folded down upon the support. By reason of this the folds that have been brought firmly into engagement with the support are protected from further effects of the twisting force, so that the tube may be deeply corrugated under the twisting force and the pressure of the die, without crowding together the folds after they have been forced down firmly into engagement with the support. If, however, it is desired to force the folds more or less together to change the sectional configuration of the same, and to decrease their pitch after they have been forced firmly into engagement with the support, this may be done by decreasing the longitudinal travel of the die with relation to the pitch of the helix. I have found that without a suitable support, the tube under the twisting force necessary to deeply corrugate it, will twist up and buckle, since only a very short length of tube can transmit the twisting force necessary to overcome the friction of the die without being distorted; and again the corrugations formed would, under such force, likewise be twisted and distorted out of the desired shape and size.

While I have shown several forms of my new product, obviously the folds of the product may be given various axial sectional configurations, depending upon the use for which the product is desired; and while I have described the product in connection

with the preferred method and apparatus for making the same in order that those skilled in the art may understand the preferred manner of making such tubing and more fully appreciate the difference in character of the new product over previously corrugated tubes, I do not wish to be understood as limiting myself other than as set forth in the appended claims.

For convenience of description, I have used the terms "folds" and "each fold" in referring to the corrugated or folded tube, since each complete convolution of the helically folded tube may be considered as a fold.

I make no claim herein to my new method of corrugating tubing as herein described, or to the apparatus for carrying out the same, since the method and apparatus form, respectively, the subject-matter of my co-pending applications Serial No. 741,387, and Serial No. 741,390, each filed on even date herewith.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. A flexible helically corrugated metal tube the metal of which is twisted helically, the line representing the twist of the metal being of greater pitch than the pitch of the corrugations or folds.

2. A flexible helically corrugated metal tube each fold of which is twisted helically, the line representing the twist of the metal being of greater pitch than the pitch of the corrugations or folds.

3. A flexible helically corrugated metal tube each fold of which is twisted helically, the line representing the twist of the metal being more than twice the pitch of the folds.

4. A flexible helically corrugated metal tube the metal of which is twisted helically and the outer ends of the folds of which are straight in axial sectional configuration and overhang the intervening helical groove.

5. A flexible helically corrugated metal tube the metal of which is twisted helically

so that a line representing the twist of the metal is of greater pitch than the pitch of the folds, and in which the outer ends of the folds are straight in axial sectional configuration and overhang the intervening helical groove.

6. A flexible helically corrugated metal tube the outer ends of the folds of which are straight in axial sectional configuration and overhang the intervening helical groove the sectional outline of which is curved.

7. A flexible helically corrugated metal tube the metal of which is twisted helically so that a line representing the twist of the metal is of greater pitch than the pitch of the folds, the outer ends of the folds being straight in axial sectional configuration and overhanging the intervening helical groove the sectional outline of which is curved.

8. An integral flexible helically corrugated metal tube the folds of which are uniform, each fold being unsymmetrical in sectional outline longitudinally of the tube and each having a wall bent over in the same direction longitudinally of the tube.

9. A flexible helically corrugated metal tube the metal of which is twisted helically and the folds of which are unsymmetrical, each having a wall bent over longitudinally in the same direction.

10. A flexible helically corrugated metal tube the folds of which are unsymmetrical, each extending laterally in the same direction and overhanging the intervening groove.

11. A flexible helically corrugated metal tube the folds of which droop over bodily to one side of the helical axis of the folds and longitudinally of the tube.

In testimony whereof, I have signed my name to this specification, in the presence of two subscribing witnesses.

LOUIS H. BRINKMAN.

Witnesses:

EDWIN SEGER,

SAMUEL M. WARD, Jr.