

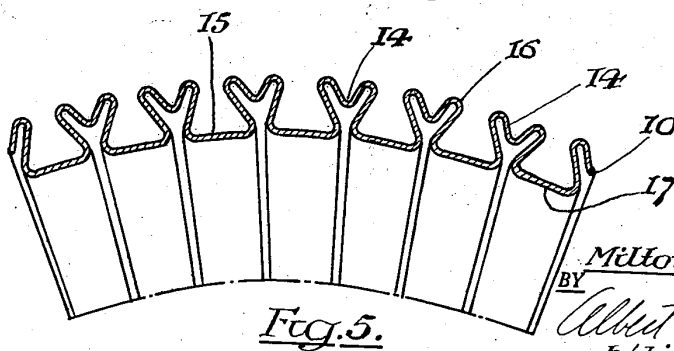
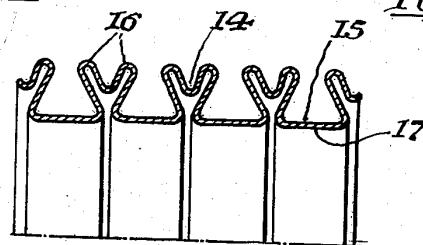
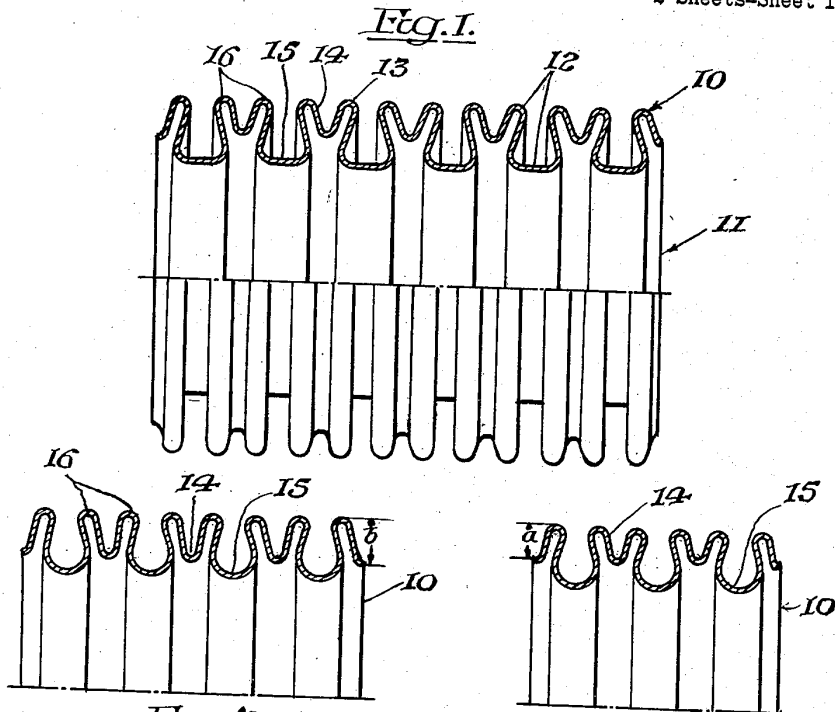
March 10, 1959

M. H. NOVEMBER
METAL CONVOLUTION TUBING

2,876,801

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2 Sheets-Sheet 1



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Fig. 6.

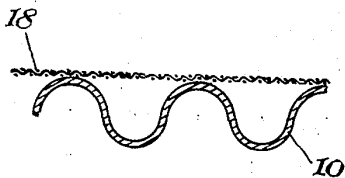


Fig. 9.

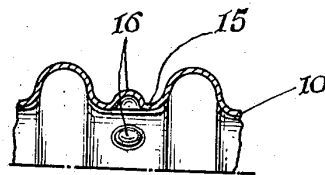


Fig. 7.

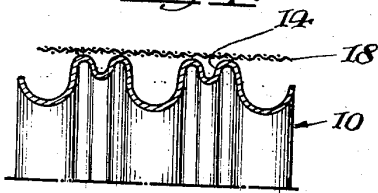


Fig. 10.

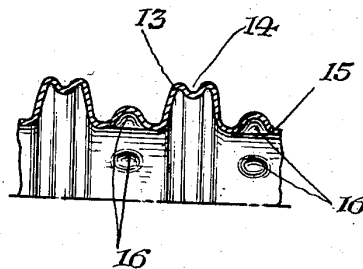
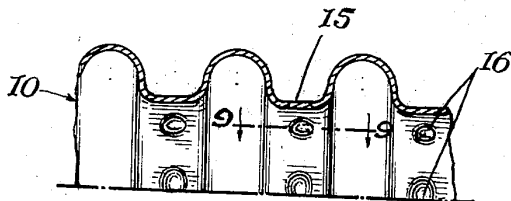


Fig. 8.



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METAL CONVOLUTION TUBING

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2 Claims. (Cl. 138—50)

This invention relates to metal tubing and specifically to metal tubing having a convoluted wall for the purpose of imparting flexibility and other characteristics thereto.

It is well known to form metal tubing having a series of convolutions therein, said convolutions being in the form of a plurality of parallel troughs and crests or a plurality of helically disposed troughs and crests. Presently known tubing is formed with identically shaped trough and crest sections and flexibility has been somewhat improved by compressing the tubing longitudinally after its formation.

The above described tubing is prone to failure and unsatisfactory behavior from several standpoints. Under high internal pressures the tubing tends to elongate and when so stretched fails to return to its original length. When so stretched the outside diameter of the tubing is decreased. Where tubing is covered by woven braid the elongation of the tubing also stretches the braid, causing it to crush the outside surfaces of the tubing. As a result, the wall of the tubing may become flattened or ruptured. High internal pressures also tend to compress the convolutions of the tubing, thereby causing damage to the thin walled structure.

Accordingly, it is an object of the present invention to provide convoluted tubing structures which will withstand a greater amount of pressure without excessive elongation.

Another object of the present invention is to provide a convoluted tubing structure of greater flexibility.

A further object of the present invention is to reduce peripheral damage to convoluted tubing from overlying braid structures or the like.

A still further object of the present invention is to provide convoluted tubing having a fairly smooth internal bore, so as to improve the passage of fluids therethrough.

An object of the present invention is to provide convoluted tubing which will withstand greater amounts of pressure without wall damage.

A feature of the present invention is its additional flex section, which results in less wall thinning during fabrication of the tubing.

Another feature of the present invention is its ability to withstand sharp bends without losing its smooth bore characteristics.

A further feature of the present invention is its trough form, whereby greater pressures are withstood.

The invention consists of the construction, combination and arrangements of parts as herein illustrated, described and claimed.

In the accompanying drawings forming a part hereof, there are illustrated six forms of embodiment of the invention, and in which:

Figure 1 is a view in side elevation, partially cut away, of a complete embodiment of one form of the present invention.

Figure 2 is a longitudinal fragmentary sectional view of a second form of the present invention.

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Figure 3 is a longitudinal fragmentary view of a modification of the form shown in Figure 2.

Figure 4 is a longitudinal fragmentary view of a third embodiment of the present invention.

Figure 5 is a view similar to that of Figure 4, showing the tubing in a flexed position.

Figure 6 is a longitudinal fragmentary view of conventional convoluted tubing, showing the manner in which an overlying braid structure bears upon the outside diameter of the tubing structure.

Figure 7 is a longitudinal fragmentary view of a fourth embodiment of the present invention.

Figure 8 is a longitudinal fragmentary view of a fifth embodiment of the present invention.

Figure 9 is a fragmentary view taken on line 9—9 of Figure 8.

Figure 10 is a longitudinal fragmentary view of a sixth embodiment of the present invention.

Referring to the drawings and specifically to Figure 1, 10 indicates a length of tubing formed from seamless tubing, helically wound and welded tubing or lapped and welded tubing, all of which are well known in the art. The parallel-walled tubing 10 is fed through suitable machines which form the wall of the tubing into a series of convolutions generally indicated at 12.

Presently known convoluted tubing, best shown in Figure 6, consists of a series of symmetrical crests and troughs. This tubing may be compressed to add flexibility, but maintains its symmetry. It has been found, however, that by varying the shape of the troughs and crests of the tubing in the manner hereinafter set forth, the behavior characteristics of the convoluted tubing may be substantially improved.

In the form of the invention shown in Figure 1, each of the crests 13 of the convolutions 16 have been inverted so as to provide an additional flex section 14 therein. In that the flex sections 14 are inwardly disposed toward the central axis of the tubing they have been referred to as inverted. As a result of the additional flex section 14, several surprising advantages have been derived. When high fluid pressures are present within the tubing 10, the said tubing has a tendency to stretch longitudinally and its outside diameter to contract diametrically. When the troughs and crests of the tubing were of uniform shape the amount of such elongation was great and the degree of recovery therefrom quite limited. The additional flex section 14, however, substantially increases the ability of the tubing to recover its original dimensions after such longitudinal extensions. Moreover, the initial longitudinal extension is found to be less with the convolution form shown in Figure 1.

Where tubing is covered with woven braid as in the practice, and great internal pressure is applied, the braid tends to crush the tubing as it is stretched during the elongation of the structure. As shown in Figure 6, the conventional tubing provides only a one point contact with the braid 18 at each crest. As a result, the likelihood of damage to the tubing at the crest is fairly great. Where the inverted flex section 14 is used and is covered by braid as shown in Figure 7, the points of contact between the crest and the braid 18 are doubled, and the distance between said points of contact is substantially reduced. As a result of the flex section 14 therefore, the ability of the convoluted tubing to withstand the pressure of the braid 18 is greatly increased. Moreover, since the form of the tubing shown in Figure 1 tends to have less longitudinal extension under pressure than conventional convolution tubing, the pressure of the braid 18 is further reduced.

A further result achieved by the use of the flex sections 14 in the convoluted tubing is an increase in flexibility. It has been found that for a convoluted tube of conventional construction and given amplitude of convolution,

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the flexibility will be substantially less than that of tubing made in accordance with the showing of Figure 1, which tubing has the same amplitude of convolutions.

The importance of the increased flexibility which may be secured by the use of the tubing having the flex sections 14 will be apparent when it is observed that to secure a given degree of flexibility with the inverted convolution one may use a smaller amplitude or wall height in the structure. Since the wall height is less, there will be less wall thinning during manufacture, and consequently a stronger structure.

In the embodiment of the invention shown in Figure 2, a fairly small flex section trough 14, as compared with the amplitude of the main trough 15 of the tubing 10 may be employed. This structure, while less flexible than that of Figure 3, in which the amplitude of the flex section 14 is greater, as indicated by the arrows *a* and *b*, is nevertheless cheaper to manufacture because it requires less material. It will therefore be seen that the inverted flex section is capable of producing a wide variety of performance characteristics without departing from the spirit of the invention.

Referring again to Figure 1, it will be seen that the troughs 15 are somewhat flattened, whereas those illustrated in Figures 2 and 3 are arcuate. It has been found that the flattened form of trough 15 will withstand greater pressure before collapsing.

As a further trough modification there is shown the form of Figure 4, in which an extremely flat surface 17 has been provided for the purpose of both increasing the resistance of the structure to pressure and improving the smoothness of the internal bore of the tubing. As a result of the combined flattened trough structure 17 and the use of the inverted flex section 14, the tubing form illustrated in Figure 4 may be bent as shown in Figure 5 without substantially decreasing the smoothness of the bore.

Referring to Figure 8, there is shown a further modification of the trough form 15, whereby the convoluted tubing's ability to withstand pressure is improved. In this form of the invention the troughs 15 are provided with a series of dimples or ribs 16, which are pressed into the metal of the tubing forming the trough portion 16. These ribs 16 may be either bent outwardly as shown in Figure 9, or pushed inwardly to achieve the same purpose, namely to prevent the trough 15 of the tubing from being collapsed under pressure. It will be apparent that the spacing of the ribs 16 and the size and shape thereof may be varied to achieve a wide variety of behavior properties. While the forms of the tubing shown in Figures 8 and 9 have not been longitudinally compressed, as for example those shown in Figures 4 and 5, it is within the purview of the present invention to compress these structures in order to impart greater flexibility thereto.

The convoluted tubing form shown in Figure 10 combines the rib structure 16 of the trough 15 with the inverted flex section 14 of the crests 13 to achieve a struc-

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ture having very high properties of flexibility and resistance to pressure. While the amplitude of the flex section 14 is fairly small in the showing of Figure 10, it will be understood that a greater flex section amplitude may be employed without departing from the spirit of the present invention.

When convoluted tubing of the types hereinabove discussed is bent sharply there is a tendency to crush the convolutions lying along the inner radius of the bend. As a result of the trough and crest structures hereinabove described, it has been found that damage to the tubing resulting from such bending has been substantially decreased.

From the foregoing it will be seen that there have been provided convoluted tubing structures by means of which greater internal pressures can be controlled. In addition, tubing structures have been provided having greater dimensional stability and wear properties. The above described structures are also capable of a wide variety of performance characteristics unknown in the present state of the art.

Having thus fully described the invention, what is claimed as new and desired to be secured by Letters Patent of the United States, is:

1. A convoluted flexible tube structure comprising a continuous fluid-tight member, said member being annularly corrugated into a series of troughs and crests of equal amplitude and an annular flex section formed in each of said crests, said flex section consisting of an inwardly disposed annular convolution having an amplitude smaller than that of the troughs and crests.

2. A convoluted flexible tube structure comprising a continuous self-supporting fluid-tight member, said member being annularly corrugated into a series of troughs and crests, flattened portions at the roots of said troughs, and inwardly disposed flex sections in each crest, a series of spaced ribs in said troughs and in which the cross-sectional form of each trough is dissimilar to the cross-sectional form of each of the crests.

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