R. & W. P. ABELL.

FLEXIBLE TUBING.

APPLICATION FILED SEPT. 18, 1912.

1,068,553. Patented July 29, 1913.

Fig. 1

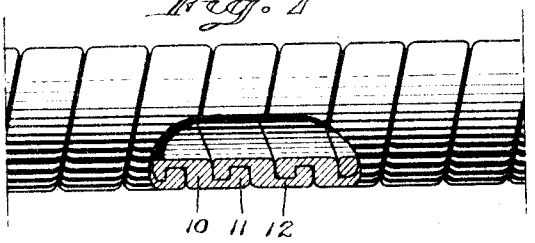



Fig. 3

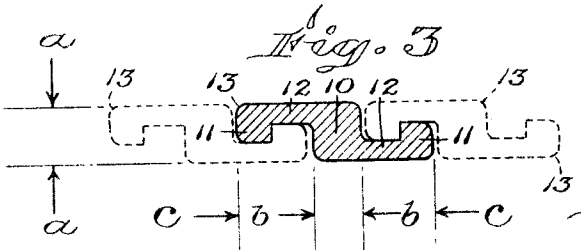



Fig. 5

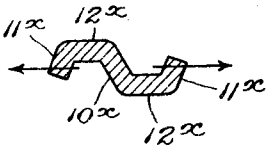



Fig. 4

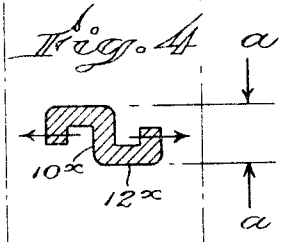



Fig. 2

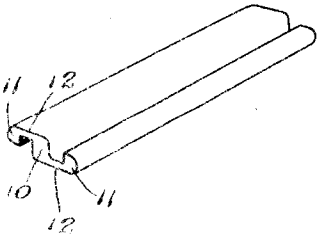



Fig. 7

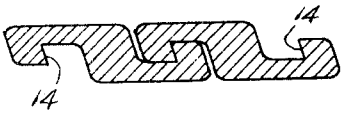
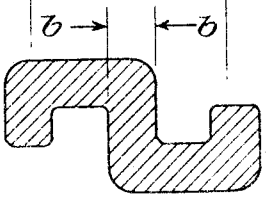



Fig. 6




Witnesses:
Thos. A. Jones
John E. Povey

Inventors
Rollin Abell.
Walter P. Abell

# UNITED STATES PATENT OFFICE.

ROLLIN ABELL, OF MILTON, AND WALTER P. ABELL, OF QUINCY, MASSACHUSETTS.

## FLEXIBLE TUBING.

1,068,553. Specification of Letters Patent. Patented July 29, 1913.

Application filed September 18, 1912. Serial No. 720,965.

*To all whom it may concern:*

Be it known that we, ROLLIN ABELL and WALTER P. ABELL, citizens of the United States, and residents, respectively, of Milton and Quincy, in the county of Norfolk and State of Massachusetts, have invented certain new and useful Improvements in Flexible Tubing, of which the following is a specification.

This invention relates to flexible tubing made of a metal strip wound in the form of a helix, the strip being provided with ribs and grooves whereby the several convolutions are interlocked one with another to prevent separation but at the same time to permit limited flexure of the tubing.

The invention consists in the relative width and thickness of the several parts of the strip, whereby greater strength is obtained without increasing the thickness of the strip, or, conversely, whereby the thickness of the strip may be reduced without decreasing the strength of the tubing.

Of the accompanying drawings which illustrate the invention: Figure 1 represents a side elevation of a short piece of tubing, a portion of which is broken away to expose the relation in which the convolutions of the strip are interlocked with each other. Fig. 2 represents a perspective view of a short piece of a strip before the same is wound into the form of a tube. Fig. 3 represents a cross section, on a larger scale, of the strip, the dotted lines representing other convolutions of the strip interlocked therewith in the relation which the convolutions of the tubing occupy. Fig. 4 represents a cross section of a strip of which the thickness of metal is uniform at all points, this form of strip having none of the features of the present invention but being illustrated solely for the sake of comparison. Fig. 5 represents a cross section of a distorted strip such as that shown by Fig. 4, the abnormal shape representing the result which the present invention is intended to avoid. Fig. 6 represents a cross section of a strip similar to that shown by Fig. 4, but larger. Fig. 7 represents a cross section of two interlocked portions of a strip which has undercut flanges.

The same reference characters indicate the same parts wherever they occur.

The strip which forms the subject-matter of the present invention and which is illustrated by Figs. 1, 2 and 3, is composed of ductile metal and comprises a central longitudinal body portion 10, marginal flanges 11, and webs 12 each of which connects one of the flanges with the body portion. The relative proportions of the several parts of the strip are shown best by Fig. 3. For the sake of description the depth of the strip will be regarded as the distance from top to bottom, or, in other words, the distance between the surfaces indicated by lines *a*, *a*. The depth of the body portion 10 is therefore equal to the depth of the strip. The width of the body portion is indicated by lines *b*, *b*, and the width of the entire strip is indicated by lines *c*, *c*. It will be observed that the depth of the flanges 11 is less than that of the body portion, and that the width of the flanges is likewise less than that of the body portion. It will also be observed that the depth of the webs 12 is less than every other measurement of the strip. The greatest strain to which tubing of this kind is ordinarily subjected is tensile strain. This strain may be the result of a mere pulling strain in the direction of the tube's length, or it may be the result of bending the tube until all lost motion between the convolutions is taken up. When the tube is bent so far as to take up all lost motion and is subjected to further bending stress, the tensile strain occurs at the outer side of the curve, and the tendency under such conditions is to bend the flanges 11 away from each other and to distort the body portion. The result of such stress upon a strip such as that shown by Fig. 4 is represented by Fig. 5, the direction of stress being represented by arrows upon the flanges. For the sake of comparison, the body portion of the strip shown by Figs. 4 and 5 is indicated at $10^x$, the flanges are indicated at $11^x$, and the connecting webs at $12^x$. The thickness of the metal throughout these different portions is uniform. When excessive strain is applied as indicated by the arrows on the strip, the body portion and the flanges become bent as shown by Fig. 5, because they are subjected to leverage due to their angles, and these portions tend to assume positions in line with the direction of the strain. As between the body portion and the flanges, the former is the first to yield because of the greater disadvantage

due to its greater depth. When the material along the outer side of the bent tube is distorted as shown by Fig. 5, the tube will not thereafter assume a straight condition, because the material along the inner side of the tube has not been appreciably distorted like that at the outer side.

In order to strengthen the strip at the point where the greatest strength is required, the body portion, according to the present invention, is given a greater width than any other portion of the strip, this greater width being designed to neutralize the disadvantages due to leverage and to the greatest depth. The width of the flanges 11 is also made greater than the depth of the webs, for the same reason; but the width of the flanges does not need to be as great as the width of the body portion, because the depth of the flanges is not so great as the depth of the body portion and consequently the leverage to which the flanges are subjected is not so great as the leverage to which the body portion is subjected. The proportions of the improved strip are designed with the purpose of rendering the strip substantially uniform with regard to its ability to withstand the unequal strains at the different points, to the end that there may be no unnecessary material at any point, because the presence of unnecessary material increases the difficulty of winding the strip and renders the tubing undesirably bulky.

The improved strip is in one sense a combination of the strips shown by Figs. 4 and 6 in that its thinnest parts are equal to the thickness of the metal in Fig. 4, while its body portion has the same width as the metal in the strip shown by Fig. 6. The depth of the strip shown by Fig. 3 is no greater than the depth of that shown by Fig. 4, and there is no more weight or bulk in the tubing, and yet the strip shown by Fig. 3 has greater width and greater strength than the form shown by Fig. 4. The ability of the strip shown by Fig. 3 to withstand lateral strain is even greater than that of the strip shown by Fig. 6, notwithstanding the greater bulk of metal in the latter figure. The thicker webs of Fig. 6 are of no advantage because there is no bending strain applied to them. This excessive thickness is undesirable, first, because it renders winding too difficult, second, it unduly limits the minimum diameter of the tubing, and third, it renders the tubing too bulky. The superior strength of the form shown by Fig. 3 is due to the fact that the depth of the body portion is less than the depth of the body portion in Fig. 6, while the width of that portion is the same. The leverage to which the body portion of Fig. 3 is subjected is less than the leverage to which that of Fig. 6 would be subjected when tensile strain is applied transversely of the strip.

The relatively greater width of the body portion and of the flanges in the improved strip not only affords strength where the same is needed, but it decreases the number of convolutions per unit of length of tubing.

The form of strip shown by Fig. 7 is the same as that shown by Figs. 1, 2 and 3 in the matter of proportions of the several parts, but is different in that the contiguous faces 14 of the flanges are undercut. As an incident to this arrangement of the faces 14, the other faces which extend from the top to the bottom of the strip are inclined to the same degree so as to facilitate the insertion of the flanges into the grooves. The purpose in arranging the faces 14 as described is to hold the convolutions interlocked in case the flanges are slightly flexed by tensile strain transverse with relation to the length of the strip. There is, of course, a possibility of slight flexure of the flanges when the tubing is subjected to great tensile strain, and when the contacting faces of the flanges are normally at right angles to the length of the tubing, as shown by Figs. 1, 2 and 3, these faces would be slightly inclined in such manner as to afford tendency of the flanges to slip off each other, and it is in order to counteract this tendency that the faces 14 are inclined as shown by Fig. 7. The term "undercut" as applied to the faces 14 pertains to their condition rather than the method by which they are formed.

The strip is preferably formed by being drawn through a die or through a series of dies instead of being passed between rolls. The reason for this preference is that the corners of the strip, as indicated at 13, may be formed more sharply by drawing than by rolling; and the sharper corners are desirable because they afford smoother surfaces upon the interior and exterior of the finished tubing, by lessening the width of the grooves between the convolutions. It is not intended, however, to limit the invention to a drawn metal strip, because for some purposes a rolled strip having the desired characteristics may serve as well.

We claim:

1. A flexible tube consisting of a helical strip of metal, said strip having a body portion, marginal flanges, and webs connecting the flanges with the body portion, the convolutions of said strip being interlocked with each other by said flanges and being capable of relative movement longitudinally of the tube, the width of said body portion being nearly equal to the thickness of the wall of the tube.

2. A flexible tube consisting of a helical strip of metal, said strip having a body portion, marginal flanges, and webs connecting said flanges with the body portion, the con-

volutions being movably interlocked with each other by said flanges and being capable of relative movement longitudinally of the tube, said body portion being relatively wide, said flanges being narrower than the body portion, and said webs being thinner than the width of said flanges.

In testimony whereof we have affixed our signatures, in presence of two witnesses.

ROLLIN ABELL.
WALTER P. ABELL.

Witnesses:
JOHN E. POVEY,
MARY A. HINES.