April 29, 1958 W. E. PHILLIPS 2,832,375

FLEXIBLE METALLIC TUBING

Filed May 14, 1954

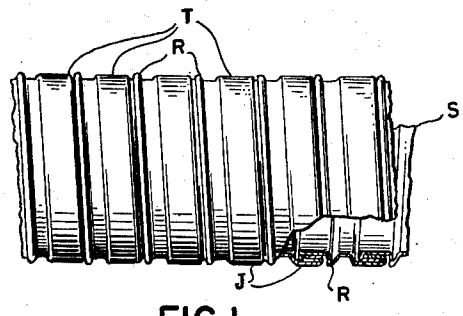


FIG.1

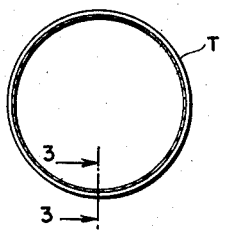
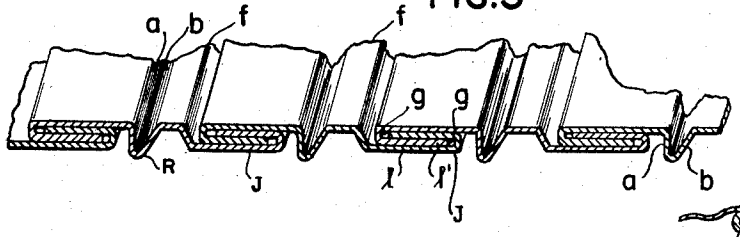


FIG.2

FIG.3



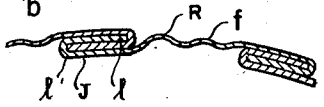


FIG.5

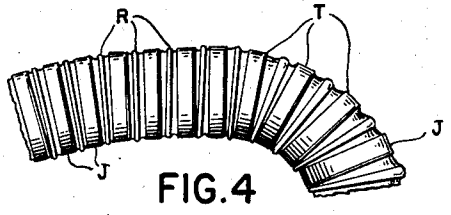


FIG.4

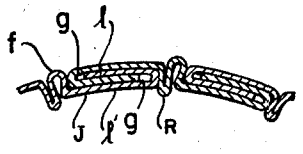
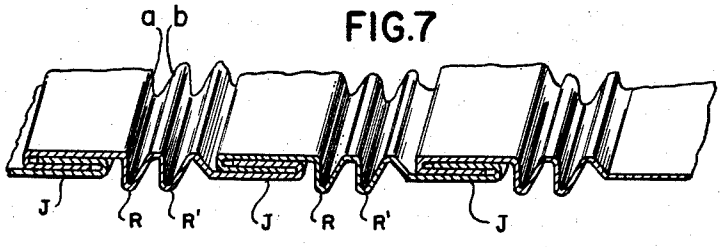


FIG.6

FIG.7



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FLEXIBLE METALLIC TUBING

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1 Claim. (Cl. 138—51)

This invention relates to flexible tubing and more particularly to flexible tubing comprised of metal and still more particularly to flexible metal tubing formed from metallic strip material wound spirally upon a mandrel with its abutting edges secured together in an interlocking joint with or without a sealing material disposed in said joint.

The object of the invention is to provide an improved flexible metal tubing. Another object is to provide a relatively light weight flexible metal tubing per unit of length having a high crushing strength and high bending properties. Still another object is to provide relatively large diameter flexible metal tubing comprised of relatively thin guaged metal strip, which has a high crushing strength and sufficient bendability to enable relatively long lengths of the tubing to be coiled up into small diameter coils for shipment. Other objects will be apparent as the invention is more fully hereinafter disclosed.

In accordance with these objects, I have discovered that by providing thin guaged strip material with from one to a plurality of longitudinally extending ribs in the area lying between the edge areas subsequently to be utilized in the forming of the interlocking joint, the crushing strength of the flexible metal tube formed therefrom is increased from a small amount to a large amount depending upon the size, shape and number of said reinforcing ribs. I have further discovered that by locating one of the said ribs in a position disposing said rib in closed spaced relation to the forward edge of the interlocking joint of the tubing and giving to said rib a heighth approximately but slightly greater than the thickness of the said joint the bendability of the said tubing is materially increased as well as is the strength of said joint and its resistance to deformation under bending stress. I have also discovered that the flexibility of the said tubing is further increased by increasing the heighth of at least one of the other reinforcing ribs provided in said strip as is also the crush resistance of the tubing.

On the basis of these discoveries I am able to design and fabricate a plurality of crush resistant flexible metal tubing from relatively thin guaged metal strip material each designed to meet some specific service use or utility for which prior art flexible metal tubing is either inadequate, too heavy or non-utilizable.

As one specific embodiment of the invention, but not as a limitation thereof, I will disclose and illustrate the same in the form of a relatively light weight crush resistant flexible metal tubing having sufficient bending properties permitting relatively long lengths or same to be wound up into small diameter coils suitable for shipment. The flexible metal tubing of this specific embodiment is one that has been designed for particular utility in association with the tensioning units and in the Lee-McCall system of placing concrete structures in a permanent state of compression greater than any tensile stresses would carry under load. In this system of pre-tensioning concrete structures steel bars or rods specially processed

to specified physical properties are embedded in the concrete structure with the opposite ends thereof enclosed by an engaging nut and plate resting against the exterior surface of the concrete structure holding the bar or rod under tension.

The problem involved in the use of these tensioning bars is to provide in the concrete structure a suitable opening through which the bars may be passed after the concrete structure has hardened. As the length of the bar increases this problem increases and is effectively solved by the specific embodiment of the present invention.

The flexible metal tubing of the instant specific embodiment herein disclosed is designed to solve this problem economically and practically.

Referring to the drawings illustrating the present invention in the specific embodiment—

Fig. 1 illustrates a length of spirally wound flexible metal tubing constructed in accordance with the present invention with said length shown partly in broken away section to enable one skilled in the art to recognize the improvement of the present invention;

Fig. 2 is an end view of the same;

Fig. 3 is an enlarged sectional view in perspective taken along plan 3—3 of Fig. 2;

Fig. 4 is a side view of a length of the tubing subjected to two (2) angles of bend;

Fig. 5 is an enlarged cross section indicating the flexible properties of the tubing under tensile stresses;

Fig. 6 is an enlarged cross section indicating the flexible properties of the tubing under compression stresses; and

Fig. 7 is an enlarged sectional view showing a modified form of the invention.

In the drawings, the tubing T (Fig. 1) which may have substantially any desired diameter, from relatively small to relatively large diameter, is in this example of a diameter of 1⅜ inches (inside) and 1½ inches (outside) and is comprised of a cold formable metal strip having a guage thickness of .008 inch and a width of 1 inch. The strip material of the instant specific embodiment is comprised of soft annealed cold rolled steel. Alternatively, the said strip may be comprised of substantially any suitable metallic material such as stainless steel, copper and its alloys, aluminum and its alloys, brass, bronze, and many other suitable cold formable metallic strip materials without departure from the present invention.

Referring to the drawings, the tube T is illustrated as a spirally wound product with the abutting edges of strip S bent over and folded together into an interlocking joint J. This interlocking joint J is, per se, old and well known in the art and, per se, forms no part of the present invention except as one of the necessary and essential elements thereof. Heretofore, however, such interlocking joints have had limited flexibility and have had low resistance to distortion under either compression or tensile stresses.

In accordance with the instant invention, the strength of this joint J and its resistance to distortion under tensile and compression stresses have been greatly increased by providing in the said strip S a longitudinally extending rib R prior to forming the strip into the tube T.

The rib R, as may be noted in Fig. 3, which is a perspective view taken along plane 3—3 of Fig. 2, is substantially V-shaped in cross section with one leg *a* lying in a plane substantially perpendicular to the surface of the strip S and with the other leg *b* lying in a plane at an acute angle thereto. The heighth of the rib R is preferably approximately but slightly greater than the thickness of the joint J and the rib R is disposed in the strip S in a position that will locate the rib R in relatively close spaced relation to the forward edge of the joint J.

The rib R, so constructed, materially increases the crushing resistance of the tube T, particularly in the area between the joint J, which is a factor of great importance when the tube T is comprised of relatively thin guaged material as in the specific embodiment shown. With a wider spacing between the joints J than shown in the drawings, one or more additional ribs R' (Fig. 7), can be provided in the strip S to further increase the crushing resistance of the tube if desired, without departure from this invention.

In addition to increasing the crushing resistance of the tube T, the rib R performs another important function. This additional function is illustrated in Figs. 4, 5 and 6, to which reference now should be made. As shown in Fig. 4, when the tube T is bent in an arc which may vary from a small angle to as much as 90°, the rib R increases the resistance of the tube T to mechanical deformation under the compression and tensile stresses applied and increases the bending properties of the tube T.

In Fig. 4 is shown a length of a tube T which is bent in one section about an arc having a radius of 5½ inches and in another section about an arc having a radius of 1¼ inches. The angle of bend in the second section is substantially sufficient to provide a 90° bend to the tube T.

In Figs. 5 and 6 is illustrated in enlarged cross section the effect obtained when the angle of bend of the tube T is substantially 90°. In Fig. 5 the effect of tensile stresses along the outer face of the tube T is shown. A comparison of the joint J and rib R of Figs. 3 and 5, should be made. It will be noted that when the tube T is bent the part of the tube subjected to tension stress will move substantially as follows:

The interlocking leafs *l*—*l'* of the joint J will first move relative to each other to close up the space gaps *g*—*g'* provided in the joint J for moderate flexibility in the tube T. As the tensile stress increases beyond that necessary to produce the result the rib R opens with the leg *a* moving out of the perpendicular to an angle to the perpendicular. When the tensile stress is further increased as by increasing the angle of bend, the rib R can open to the point where it is substantially concentric with the joint J. In this position, however, the flexibility of the rib R has been substantially destroyed and the tube T thereafter cannot be returned to its original position. However, until the elastic limit of the metal has been exceeded under such tensile stresses the tube T usually can be returned to first position.

Referring now to Fig. 6, the effect of compression stresses can be noted. The section of the tube T illustrated is that section diametrically opposite to the section shown in Fig. 5. As may be noted, the first effect of compression stress is to pinch the legs *a* and *b* together and to force the leg *a* downwardly and against the joint J pinching the interlocking leafs *l*—*l'* of the joint together and securing them in this position against relative movements. This movement of rib R brings the outer edge of the rib R in a position above and over the joint J further preventing the joint from opening up under extreme compression stresses.

As the rib R bears downwardly on and against the joint J the joint J is forced sideways against the fold *f* of the adjacent section which is pinched together and moved downwardly onto the opposite edge of the joint J to secure that side of the joint against opening up.

With sufficient compression stress, such as that present in a bend of 90°, the metal comprising the rib R and fold *f* may be mechanically deformed to the extent that a return to first position is not possible. However, it is apparent that there is a wide bending range within which the tensile and compression stresses will not seriously damage the tube T and that even when the full 90° angle of bend is applied, the joint J will remain intact. This

is of great importance where the joint J is desired to remain fluid tight, as in the instant specific embodiment.

Where the joint J is desired to be absolutely fluid tight, the said joint may be formed with a packing material disposed between the interlocking leafs of the joint, as heretofore done in the art, which will generally have the effect of severely limiting the relative movement of the leafs *l*—*l'* under tensile stress and throwing the flexibility factor under tensile stress substantially wholly upon the rib R.

Under these conditions it is desirable to provide one or more additional ribs R in the strip S substantially as indicated in Fig. 7.

In the modification shown in Fig. 7, a second reenforcing and flexing rib R' is provided to increase the crush resistance of the tube T and to increase the angle of bend of the tube T, and the flexibility of the tube T under tensile stress. If desired, a plurality of such ribs R' may be provided in the strip S without departure from the invention, the single rib R shown in Fig. 5 being shown for purposes of example and not for purpose of limitation. The additional rib R' normally is required where the width of strip S is increased materially or where the diameter of the tube T is increased materially or where the joint J is packed or sealed to fluidproof the joint, as above disclosed.

The said ribs R' may be substantially identical in size, shape and configuration to rib R, as shown, or may be of many other shapes, depending upon the main function in view, all as one skilled in the art will recognize as being without essential departure from the scope of the present invention which contemplates the use of from one to a plurality of such auxiliary ribs R' having a size, shape and configuration substantially that of rib R down to a size, shape or configuration relatively smaller than that of rib R, thereby to obtain varying reinforcing and flexing properties, in the tube T to meet varying service conditions.

Having hereinabove disclosed the present invention generically and specifically and having illustrated and disclosed one specific embodiment of same and a modification thereof, it is believed apparent that the present invention may be widely modified without essential departure therefrom and all such modifications and departures therefrom are contemplated as may fall within the scope of the following claim.

I claim:

A flexible helically wound metallic tube formed from an elongate strip of flexible metallic material, said strip having opposite marginal edge portions thereof folded back upon adjacent portions of the strip in opposite directions and the juncture of the folds defining outer side edges and with substantially identical folded marginal portions of the adjacent wound portion of the strip disposed between and engaged by said folded portions and with the free ends of the interengaged portions being spaced from the inner junctures of the folds whereby to provide a readily slidable interengaged joint, at least one expansible and contractable and deformable helical outwardly extending rib disposed between the inner and outer folds at the opposite ends of the strip, a portion of the rib being disposed opposite to and in alignment with the adjacent fold and in spaced relation therewith, the width of the space between the fold and the portion of the rib being greater than the said spacing of the free ends of the folds from the juncture of the folds, whereby the tube may be expanded due to the slidable joint while maintaining the engagement of that joint and further the tube may be contracted so that the fold engages the adjacent portion of the rib to limit the contraction and prevent disengagement of the slidable joint, and when the tube is bent the rib will be compressed on the inner side of the bend and will be gradually and increasingly expanded from the inner side to a point of maximum ex-

pansion substantially diametrically disposed on the outer side of the bend.

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