Sept. 16, 1969 E. I. ROBINSKY 3,466,685

CONTINUOUSLY EXTENSIBLE AND ROLL-UP REINFORCED STRUCTURE

Filed Aug. 28, 1967

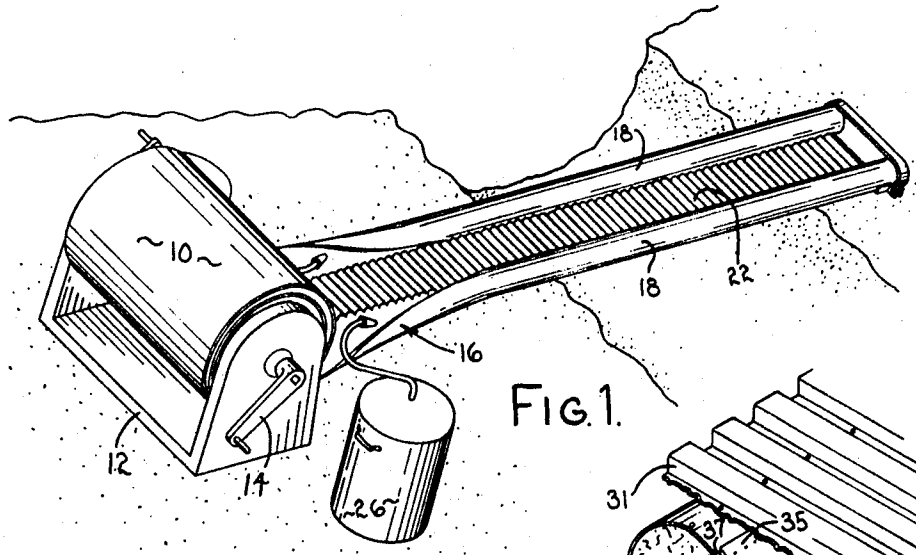



FIG. 1.




FIG. 4.

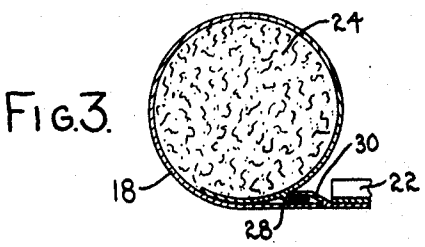



FIG. 3.

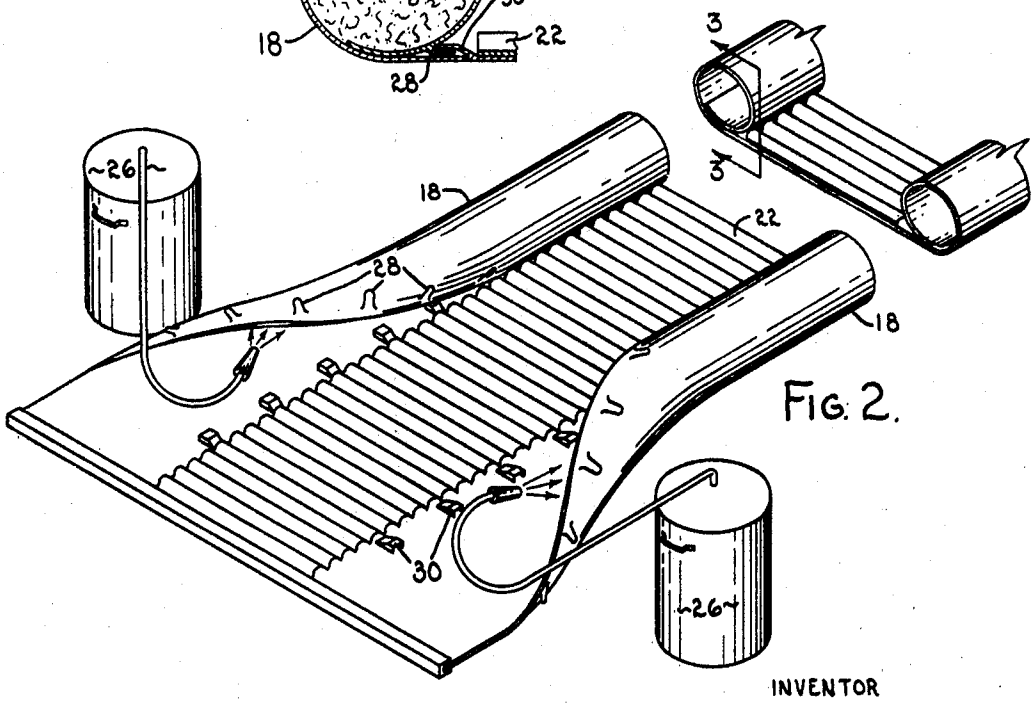



FIG. 2.

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# CONTINUOUSLY EXTENSIBLE AND ROLL-UP REINFORCED STRUCTURE

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U.S. Cl. 14—27 11 Claims

## ABSTRACT OF THE DISCLOSURE

A tubular member filled with a foamed material which is foamed in situ during the forming of the tubular member; said tubular member being formed from a resilient flat strip of material, such as spring steel, prestressed to form into a tube, when such strip is unwound from a coil.

## BACKGROUND OF INVENTION

The present invention relates to a structure made of tubular members of the kind which can be transported in a rolled-up or in a flat condition and then extended in tubular form to act as a beam, column or floating member.

In my prior Patents 3,252,173, dated May 24, 1966 and 3,258,800, dated July 7, 1966 and in my United States application Ser. No. 566,076 now Patent No. 3,385,397, I have described continuously extensible and roll-up structures which are particularly useful as ladders, towers and floating bridges. In such uses, the longitudinal tubes provide longitudinal rigidity for the structure.

I have discovered that the longitudinal rigidity of the tubular members of the structures described in my preceding patents and application can be substantially increased without sacrificing the advantages of the structure set forth in my said patents and application.

The invention comprises the introduction of a foam material into the tubular members during the extension of the structure; the foam material being allowed to expand and solidify as the tubular members are extended. The foam material expands to completely fill the tubular members and, as the members are made of spring steel, they will limit the expansion of the foam material to assure filling the void. This will retard the tendency for tubular members to buckle under load.

Under certain conditions it may be desirable to (a) retain a designed diameter for the tubular members, or (b) increase the density of the foam material. In such case, it is desirable to provide a means for locking the tubular members against expansion beyond a preset diameter.

## DESCRIPTION OF INVENTION

An illustrative embodiment of the novel structure will now be described in detail with reference to the appended drawings wherein:

FIGURE 1 is a perspective view illustrating the structure according to the present invention spanning a gully.

FIGURE 2 is an enlarged view, in perspective, further illustrating automatic coiling of the tubes and injection of the plastic foam.

FIGURE 3 is a cross-section view, on the line 3—3 of FIGURE 1 to show the tube filled with foam and with tube retainer means locked in operative condition.



FIGURE 4 is a fragmentary view of a roll-up structure similar to that shown in my U.S. Patent No. 3,258,800 in which an alternative locking means is shown.

With reference to FIGURE 1 before extension, the structure therein disclosed and as more particularly described in my U.S. Patent No. 3,252,173 comprises sheet material **10** of thin gauge material (e.g., spring steel), which is wound into a coil on a drum mounted for rotation in a cradle or supporting structure **12**. Means are provided for unwinding the sheet material **10** from the drum such as the crank **14**. Of course, any other suitable means, whether manual or motorized, could be employed.

The longitudinal border portions of the substantially continuous strip of material **10** are laterally prestressed such that, upon unwinding, the respective longitudinal edges of the latter coil as indicated at **16** to form laterally spaced, integral hollow tubes **18, 18'**.

To provide lateral rigidity, an elongated, corrugated members **22** is secured, as by riveting, bolting, spot-welding or the like, to that area of the strip material extending longitudinally between the parallel tubes **18, 18'**. This member **22** in accordance with preference and/or requirements, can be fastened to either side of the main strip without detracting from its primary function. Naturally, the corrugated surface assists in providing increased traction for traffic and should preferably be located on that side of the main strip over which traffic will move.

Referring to FIGURE 3 it will be seen that the entire volume defined by each tube is completely filled with a foamed plastic material **24**, such as styrene foam or urethane foam. The selection of the foam material will depend on the particular characteristics desired to meet the specific requirements of the tubular members and conditions under which the plastic is to be foamed. It is important that the material must be a plastic capable of being foamed-in-place and the expansion controlled to provide the best mechanical strength possible for the tubular member.

The foam **24** is injected or sprayed into the tubes **18, 18'** at the point where the sheet material starts to form into tubes **18, 18'** during unwinding of drum. Standard foam generating equipment, schematically illustrated at **26, 26'**, is well known and is suitable for the purposes of the present invention. As the foam generating device is well known to those skilled in the art, description of the same is unnecessary.

The resistance of the tubular members to expansion beyond their preformed shape may, for some uses, be sufficient to limit the expansion of the foaming plastic material and confine the tubular members approximately to the pre-set dimensions. However, in the event that it is desirable to restrict the expansion of the foamed material to obtain an exact diameter of the tubular member and to ensure a better bond between the foam and the tubular members, I provide the members with means for permanently or releasably locking the coiled tube at a predetermined diameter.

One of the locking means is illustrated in FIGURE 3 and comprises a series of longitudinally-spaced cantilever lugs **28** formed on the sheet **10** for engagement with complemental members **30** formed along the sheet **10** and located so that when the tubes are formed by extending the sheet **12** the lugs **28** and complemental members **30** lock together and preclude any increase in tube diameter due to the internal pressure of the foam material **24**.

In FIGURE 4 I have shown an alternative locking means. The roll-up structure which is fragmentarily illustrated is similar to that shown in my United States Patent 3,258,800. The structure herein illustrated, in part, comprises a corrugated deck **31** and tubular member **32** formed from thin metal strip as described in my said Patent 3,258,800. Along each edge of the tubular member **32** there is provided a pair of continuous abutments **33, 34** in parallelism. When the strip forms into a tube the abutments pass over each other and then when the free edge **35** of the tube jambs as described in my said prior patent the trailing edges of the abutments are brought into engagement as shown. The tube is then retained at its preset diameter against the expansion of the plastic foam.

To assist the abutments in passing each other, the leading edge of each abutment is levelled as indicated at **36, 37.**

The invention herein disclosed is also applicable to vertical tubular members. By way of illustration, I refer to my pending United States application Ser. No. 566,076. The upright rails can be reinforced by the invention herein described.

In this way, it is possible to substantially prevent buckling of the tubes **18, 18'** when engineered to carry a predetermined load without unduly increasing the overall weight of the structure per se.

The invention also consists of a method of filling a hollow tubular member apart from the particular structure shown, with a reinforcing member. It is apparent that a hollow tubular member of substantial length once it is formed, would be difficult to fill with a reinforcing material. The present invention provides a practical means for introducing the reinforcing material contemporaneously with the formation of the tubular member. If it is desired to produce a reinforced tubular member having a permanent form, the overlapping edges of the sheet material forming the tube can be permanently united.

It is contemplated that the reinforced tubular member or the portable bridge when they have been completed will not be rewound onto a drum for transporting to another site. However, it is to be noted that such rewinding is possible. During such rewinding the plastic core will be expelled at the point where the tubular member flattens into a strip and rewinds onto the drum. A new core will, of course, have to be formed when the strip is unwound again.

The foregoing embodiment of my invention is given by way of illustrating the construction and use of my invention and not by way of limiting the invention to the particular structures shown and described.

What I claim as new and desire to protect by Letters Patent of the United States is:

**1.** The method of forming a reinforced tubular member comprising the steps of:

(a) preforming a thin strip of material to form a tube with overlapping edges when unwound from a flat condition;

(b) winding said strip in a flat condition onto a roll;

(c) unwinding said strip from said roll and permitting said strip to automatically resume its tubular form;

(d) introducing a plastic foaming material into said strip at the commencement of the formation of the tube and allowing said foaming material to expand in situ against the resistance afforded by said tubular member; and

(e) locking the tubular member to prevent an increase in diameter beyond a predetermined diameter to ensure an increase in bond between the plastic foam and the tubular member and to ensure a complete filling of the void of the tubular member.

**2.** A reinforced tubular member comprising a substantially continuous strip of thin gauge resilient material capable of being wound in a flat condition into a roll, said material being prestressed to automatically form the tubular member when the strip is unwound from the roll and a filling of foamed plastic material under pressure-expanded against the inner wall of said tubular member and means locking the tubular member against expansion beyond a predetermined diameter.

**3.** A reinforced tubular member according to claim **2** wherein said complemental members comprise a plurality of longitudinally spaced, complementary, upset lugs, formed adjacent to the strip edges, which lugs engage with lug receiving elements positioned on the strip to be engaged thereby when the tube is formed.

**4.** A reinforced tubular member according to claim **2** wherein said complemental members comprise a pair of first and second continuous complemental abutments extending longitudinally in parallel relationship along said continuous strip, the first abutment being positioned adjacent to one of the longitudinal edges of the tubular member and the second abutment being positioned adjacent to the other longitudinal edge of the tubular member, said abutments clasping each other when said strip forms into a tube to retain said tube at its preset diameter against expansion.

**5.** A reinforced tubular member according to claim **4** in which said abutments have bevelled edges along the leading edge thereof to thereby assist the said abutments to pass over each other as the strip forms into a tube and bring the trailing edges into engagement.

**6.** A portable bridge comprising a continuous strip of thin resilient material formed with the longitudinal edges preformed to form an integral hollow tubular member along each lateral edge of the strip when unwound from a roll in which said strip is wound in a flat condition, said tubular members being capable of uncoiling to resume a flat position when said strip is rolled up and to resume the tubular shape when unwound and a filling of foamed plastic material under pressure-expanded against the inner wall of said tubular member and means locking the tubular member against expansion beyond a predetermined diameter.

**7.** A portable bridge according to claim **6** in which said locking means comprises a series of pairs complemental members which interlock when the tubular members form during unwinding to thereby prevent expansion of the tubes beyond a predetermined diameter by the in situ foamed plastic material which forms the reinforcing core, one of said pairs being located on one surface of the strip adjacent one edge of the strip and the other of said pairs being located, in parallelism thereto on the opposite surface and spaced inwardly from said one edge a distance which will bring said members into interlocking engagement at the predetermined diameter.

**8.** An extensible tubular structure adapted to be wound in a flat condition into a roll and form into a tubular member when unwound from the roll comprising a thin strip of resilient material of substantial length preformed to coil about its longitudinal axis to form the tubular shape when extended from the roll and a filling of foamed plastic material under pressure-expanded against the inner wall of said tubular member and means locking the tubular member against expansion beyond a predetermined diameter, said means comprising one of said pairs being located on one surface of the strip adjacent one edge of the strip and the other of said pairs being located, in parallelism thereto on the opposite surface and spaced inwardly from said one edge a distance which will bring said members into interlocking engagement at the predetermined diameter.

**9.** An extensible tubular structure according to claim **8** in which said complemental members comprise a plurality of longitudinally spaced, complementary, upset lugs, formed adjacent to the strip edges, which lugs engage with lug receiving elements positioned on the strip to be engaged thereby when the tube is formed.

10. An extensible tubular structure according to claim 8 wherein said complemental members comprise a pair of first and second continuous complemental abutments extending longitudinally in parallel relationship along said continuous strip, the first abutment being positioned adjacent to one of the longitudinal edges of the tubular member and the second abutment being positioned adjacent to the other longitudinal edge of the tubular member, said abutments clasping each other when said strip forms into a tube to retain said tube at its preset diameter against expansion.

11. An extensible tubular structure according to claim 10 in which said abutments have bevelled edges along the leading edge thereof to thereby assist the said abutments to pass over each other as the strip forms into a tube and bring the trailing edges into engagement.



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