United States Patent [19]

Lambert

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[45] **June 3, 1975**

[54] **COLLAPSIBLE STRUCTURAL MEMBER**

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[51] **Int. Cl.** **E04b 1/343;** E04h 12/18

[58] **Field of Search** 52/108, 726

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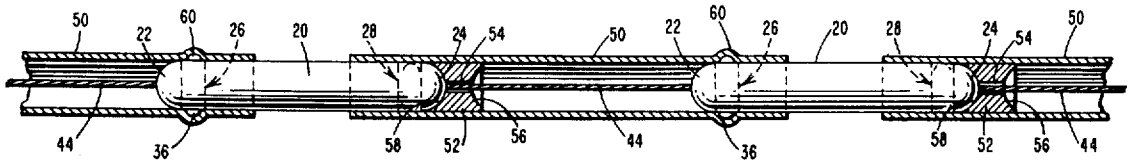
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Primary Examiner—Henry C. Sutherland

[57] **ABSTRACT**

A collapsible structural member comprises a plurality of elongated inner elements in spaced end-to-end relationship and attached together by a flexible strand, and a plurality of elongated open-ended outer elements coaxial with the inner elements and positioned in alternating relationship therewith. The outer elements are longer than the distance between adjacent pairs of inner elements and are slidable with respect thereto between extended positions engaging the ends of an adjacent pair of inner elements whereby a substantially rigid member is created, and retracted positions engaging only one inner element, whereby the structural member can be collapsed and folded. Limiting stops are provided in the interior of the outer elements, and means for locking the outer elements in the extended position is provided.

15 Claims, 13 Drawing Figures



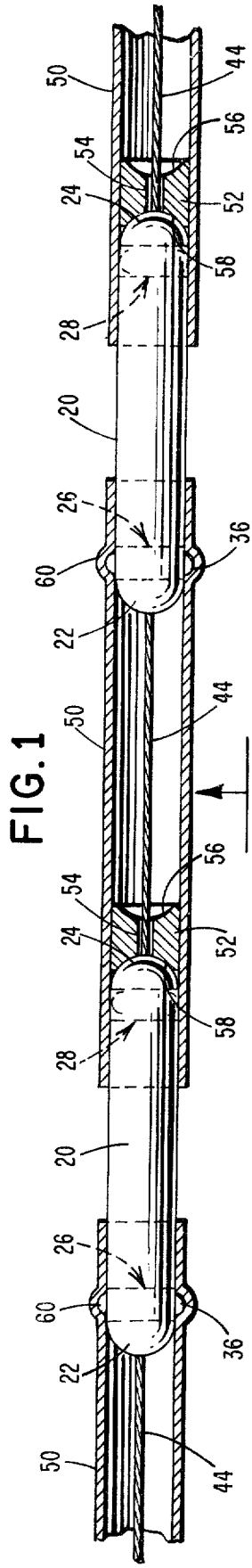


FIG. 1

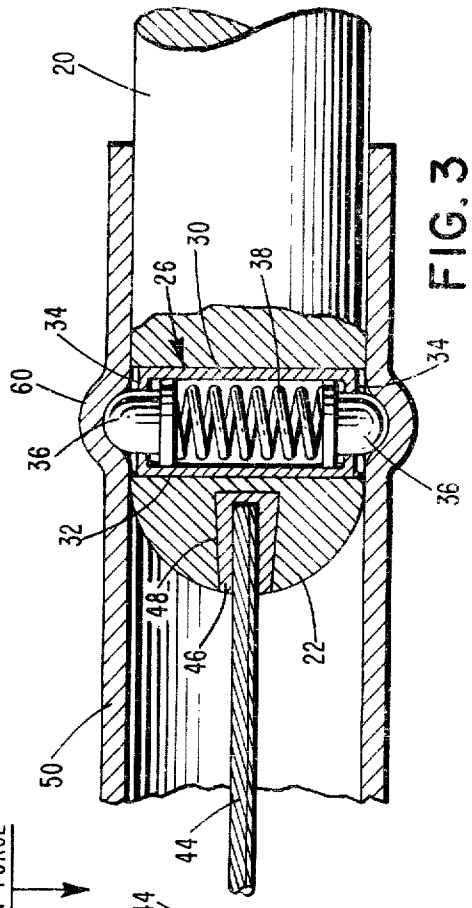


FIG. 3

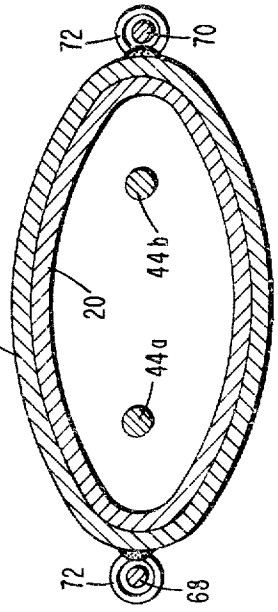
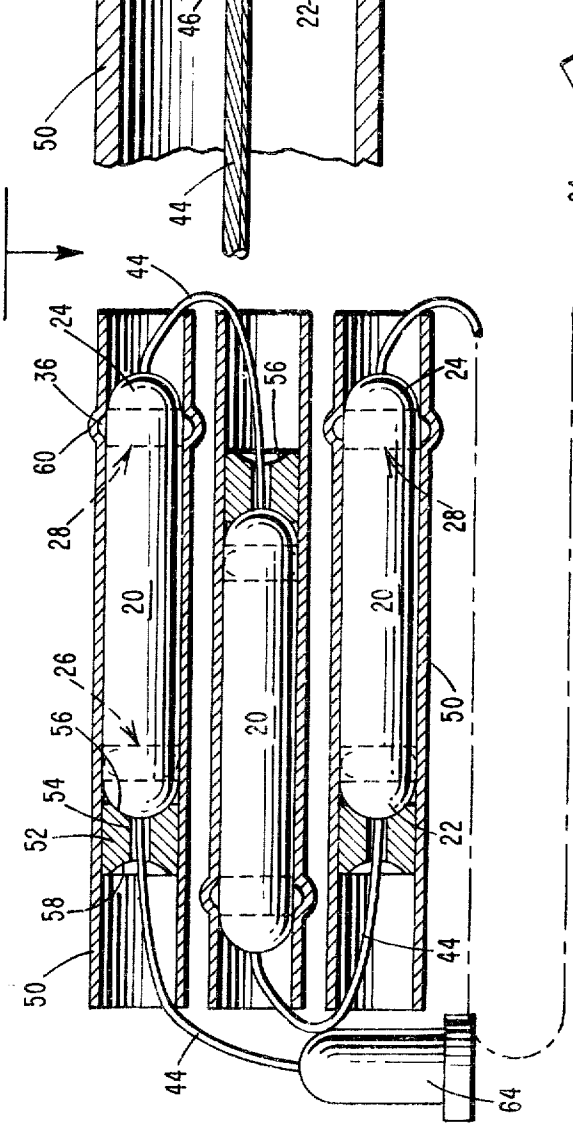


FIG. 4



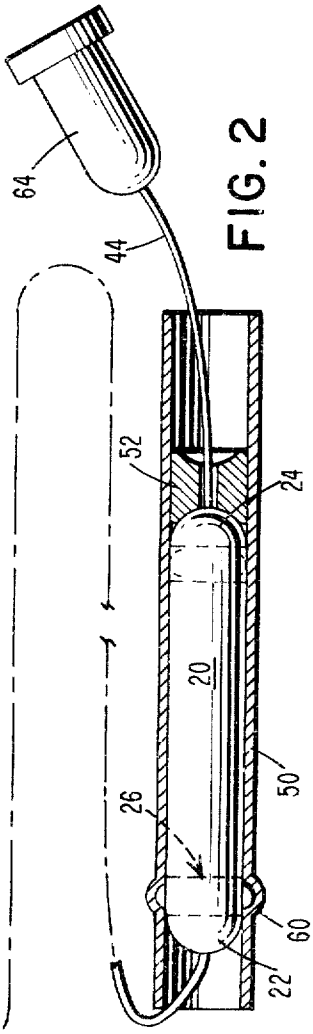


FIG. 2

FIG. 5

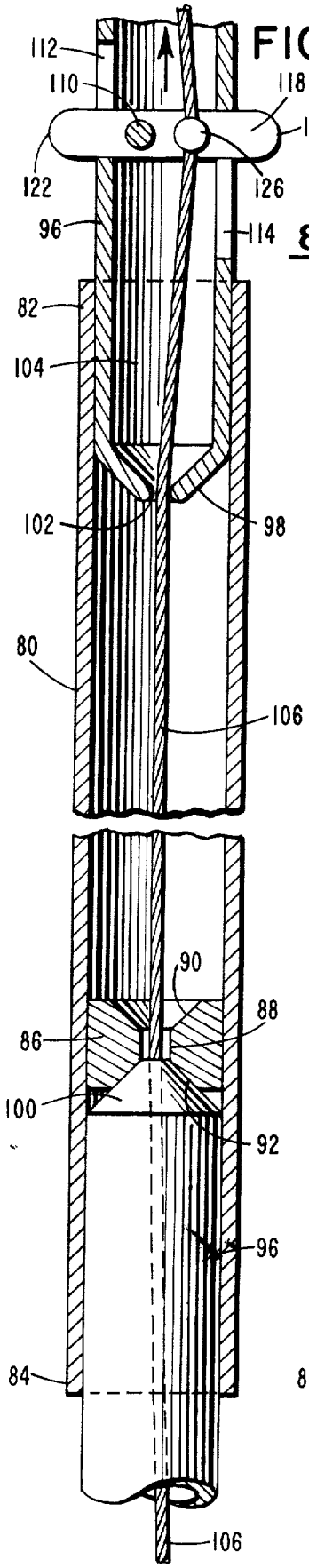


FIG. 6

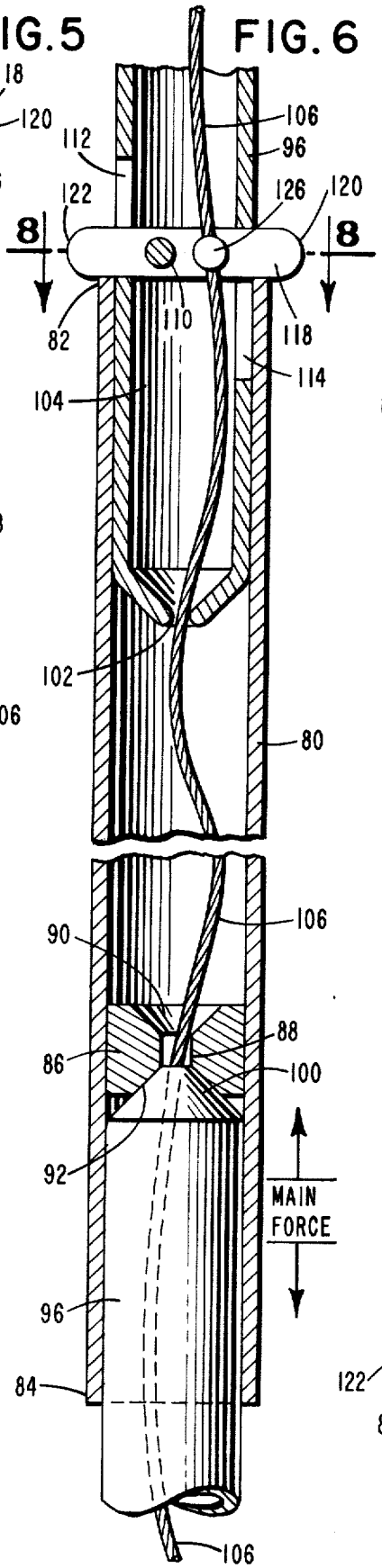


FIG. 7

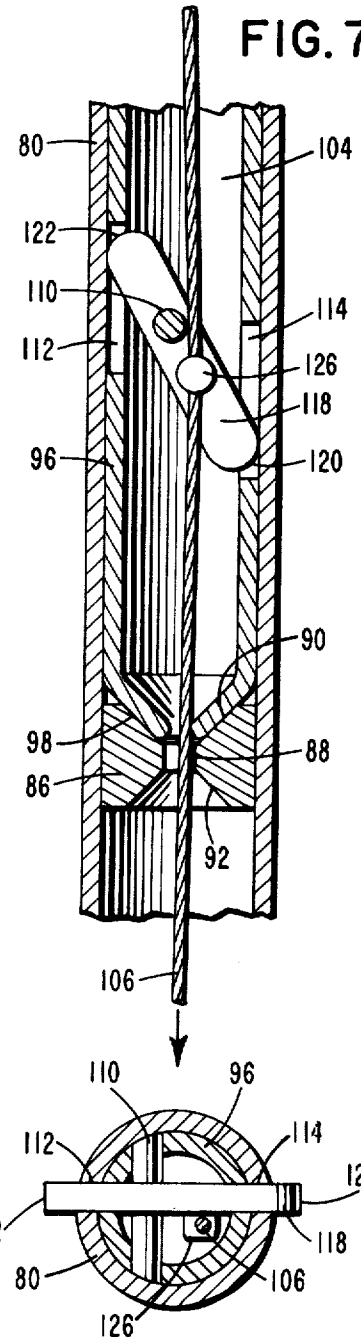


FIG. 8

FIG. 9

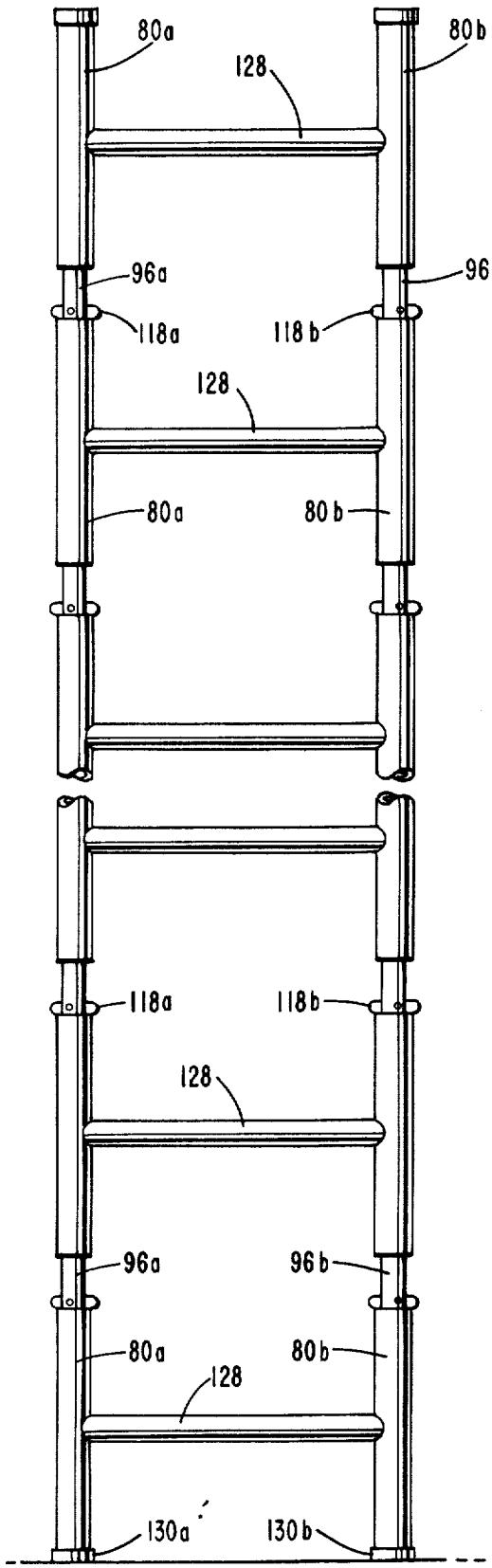
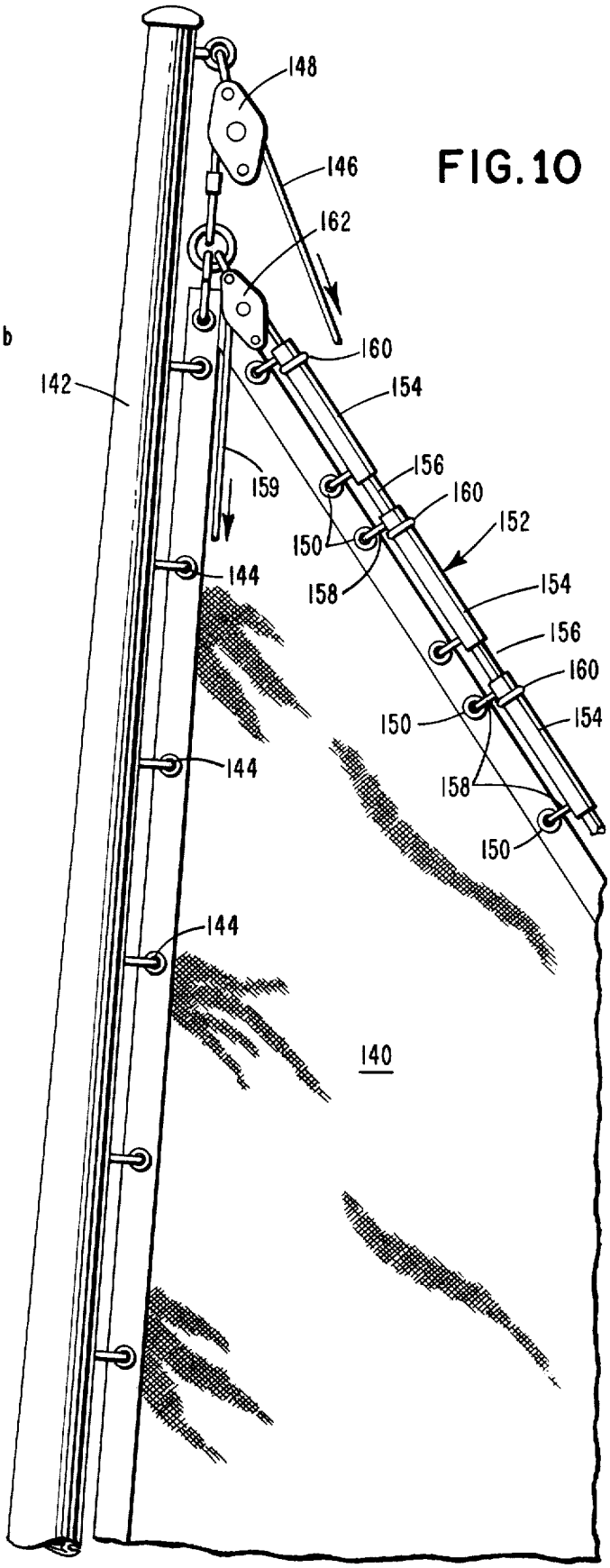

80a
80b
128
96a
96b
118a
118b
128
80a
80b
118a
118b
128
96a
96b
80a
80b
128
130a
130b

FIG. 10


148
146
162
160
142
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156
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150
152
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156
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158
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144
140

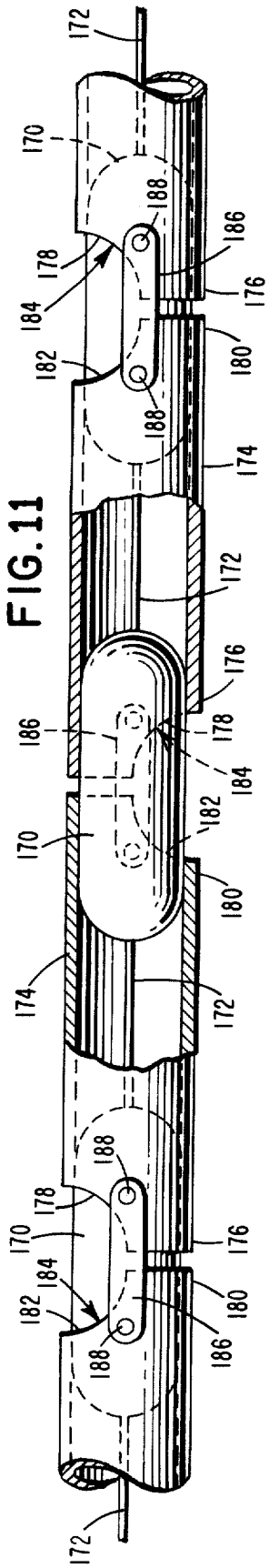


FIG.11

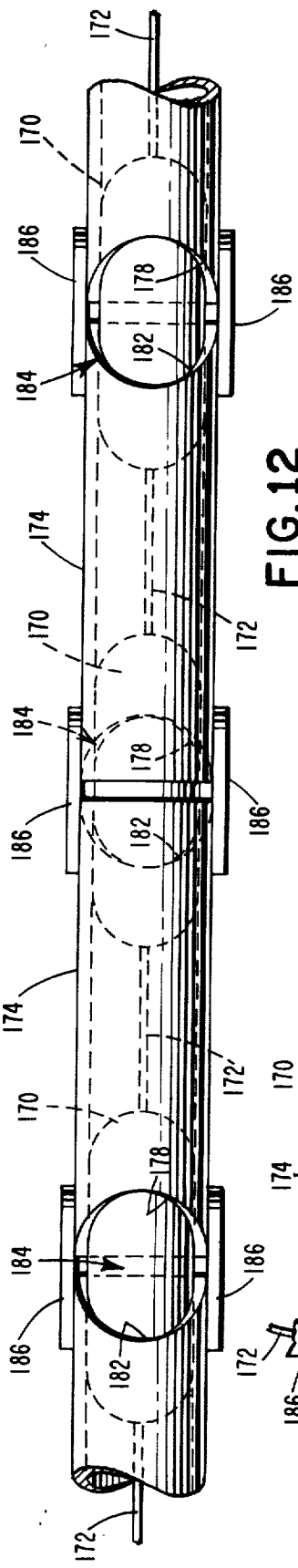


FIG.12

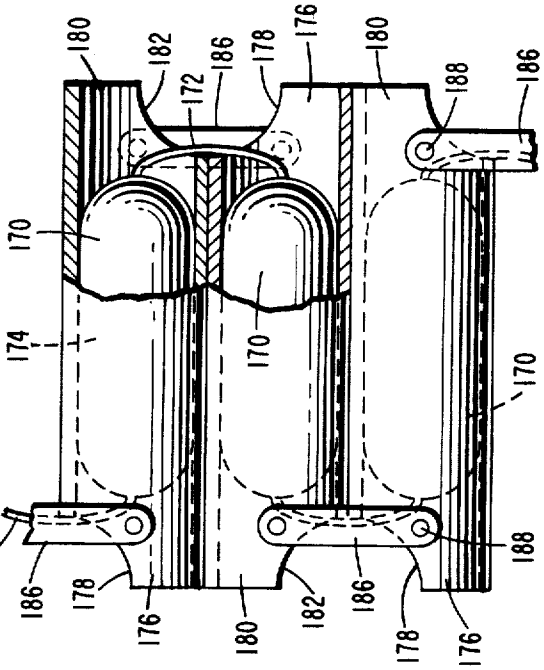


FIG.13

COLLAPSIBLE STRUCTURAL MEMBER

BACKGROUND OF THE INVENTION

This invention relates generally to the field of structural members and more particularly to a collapsible structural member that is usable for a variety of permanent and semi-permanent structures.

There exists an almost endless requirement for structural members that can be easily carried, set up, and taken down. Such members are used alone or in combination with other elements, and are loaded axially and transversely. There are many such devices in the prior art, but they have generally been manufactured of a number of parts, which immediately prior to use must be catalogued and organized, and then painstakingly assembled. Therefore, speedy assembly and disassembly is usually not a characteristic of the prior art devices. Furthermore, they are for the most part designed for a specific limited task, and their utility is thus limited. While some such prior art devices can support axial loads and others transverse loads, few can safely support both types.

SUMMARY OF THE INVENTION

The structural member of this invention is quite basic in design and can thus be adapted to a great number of uses. It is collapsible, has no loose parts, and can be quickly assembled. It can support both axial and transverse loads. It not only solves the problems present in prior art devices, but adds a new dimension to this type of device.

The structural member of this invention comprises only three basic parts: A plurality of spaced inner elements assembled in end-to-end relation; flexible strand means connected to and between the inner elements; and a plurality of open-ended outer elements coaxial with the inner elements, and movable with respect to the inner elements between extended positions engaging the end portions of a pair of adjacent inner elements to create a substantially rigid elongated member and retracted positions engaging only one of the inner members, wherein the rigidity is destroyed and the member can be collapsed and folded.

The basic structure can be used as a pole or a beam, alone or as a part of a device. Its uses are virtually unlimited, including to recite just a few, a support pole, a bridge member, a truss extension, a sail stiffener, and a ladder.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a longitudinal sectional view of a portion of a first embodiment of the structural member of the invention in the assembled position;

FIG. **2** is a sectional view of the embodiment of FIG. **1** in the disassembled folded position;

FIG. **3** is an enlarged sectional view of the details of the locking means of the embodiment of FIG. **1**;

FIG. **4** is a transverse sectional view of an alternative configuration of the structural member of the invention;

FIG. **5** is a longitudinal sectional view of a portion of a second embodiment of the invention in an intermediate position during assembly;

FIG. **6** is a longitudinal sectional view of the embodiment of FIG. **5** in the assembled position;

FIG. **7** is a longitudinal sectional view of the embodiment of FIG. **5** in the disassembled position;

FIG. **8** is a transverse sectional view taken through line **8**—**8** of FIG. **6**;

FIG. **9** shows the use of the embodiment of the invention shown in FIGS. **5**–**8** incorporated into a ladder;

FIG. **10** shows the embodiment of FIGS. **1**–**3** incorporated into a boat sail as a stiffener;

FIG. **11** is a side elevation, partially in section, of still another embodiment of the invention in the assembled position; and

FIG. **12** is a top plan of the embodiment of FIG. **11** in the assembled position.

FIG. **13** is a side elevation, partially in section, of the embodiment of FIGS. **11** and **12**, in the disassembled folded position.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A very basic embodiment of the invention is shown in FIGS. **1**–**3**.

In FIG. **1**, it is illustrated in the assembled position, and in FIG. **2** in the disassembled and folded position. The structural member of the invention is composed of a plurality of structural units, each unit comprising inner and outer elements that interlock and coact in a unique manner.

Each inner element **20** is an elongated cylinder, having a circular exterior cross-sectional configuration, and terminating in tapered ends **22** and **24**. Adjacent each end of inner element **20** is a locking means designated **26** and **28** in FIG. **1**, and shown in detail in FIG. **3**. Locking means **26** and **28** are identical, and each comprises a cylindrical bore **30** extending through inner element **20** perpendicular to its axis. Installed in bore **30** is a sleeve **32** having flanged ends **34**, through which protrude tapered locking pins **36**. A spring **38** biases pins **36** outwardly.

Adjacent pairs of inner sections **20** are attached together by sections of flexible strand **44**, such as wire rope of a particular length. Each strand section **44** terminates at both ends in locking plugs **46** that engage axial bores **48** in each of the inner element ends **22**, **24**. However, the flexible strand could be one continuous piece extending through the entire length of the structural member and passing through each inner element **20**, if so desired, with each inner element **20** being fixidly attached thereto.

Each outer element **50** is an open-ended cylinder having an internal cross-sectional configuration substantially identical to the external cross-sectional configuration of inner elements **20**. Outer element **50** is axially slidable with respect to its respective inner element **20**, in close-fitting relationship thereto. The more precise the fit between the inner and outer elements, the more rigid the resulting structural member. Installed internally of each outer section **50**, adjacent one end, is a limiting stop **52** having a central passage **54** and a pair of concave stop surfaces **56**, **58** which correspond in curvature to ends **22**, **24** of inner elements **20**. Strand sections **44** pass through passages **54**. An annular outwardly oriented groove **60** is provided in each outer element **50** adjacent the other end for receiving pins **36** of locking means **26** and **28**.

A structural member can be constructed in the desired length by assembling together the necessary number of structural units. The final sections of strand sections **44** are then provided with caps **64**.

The operation of the embodiment FIGS. 1–3 is as follows: Considering first the disassembled folded position shown in FIG. 2 within each structural unit the inner element 20 is in its left-most or retracted position relative to its associated outer element 50. End portion 22 of inner element 20 abuts limit surface 56 of limiting stop 52, and pins 36 of locking means 28 are engaged with groove 60. Pins 36 of locking means 26 have been cammed inwardly by the inner walls of outer element 50. Strand sections 44 are exposed, and the device can thus be folded over upon itself, as is the case in FIG. 2.

To assemble the structural member into the position shown in FIG. 1, the various elements are first oriented in end-to-end relationship, with the strand section 44 straightened. Then each outer section 50 is moved leftwardly as viewed in the drawings with respect to its associated inner element 20 to its extended position, wherein it slides over the tapered end 24 of the adjacent inner element 20. In the final orientation, each end portion 24 seats against limit surface 58 of the limiting stop 52 of the adjacent outer section 50, and the locking means 26 of each inner element 20 engages groove 60.

If the device is free standing, assembly is accomplished by sequentially sliding each outer element 50 into position spanning a pair of adjacent inner elements 20. However, if the outer elements are held in fixed, spaced relationship as, for example, when the device is used as a sail stiffener with the outer elements attached to the canvas, the inner elements can all be moved together by pulling on the last section of strand. This will be explained in detail with reference to FIG. 10.

It is apparent that the dimensional relationships of the various elements are of considerable importance. Outer element 50 must be of such length as to allow full retraction of inner element 20. The length of each strand section 44 is less than the length of outer element 50. For example, the outer element length can be about 9 inches, the inner element about 6 inches, the strand sections about 5 inches. In the assembled positions, each end of inner elements 20 would then extend 2 inches into the adjacent outer elements 50, with 2 inches between adjacent outer elements 50.

The axial load that can be placed upon the structural member of this invention depends upon the effectiveness of locking means 26. The transverse loading depends principally upon three factors: the strength of the components, the amount of overlap between adjacent inner and outer elements, and the closeness of the fit between engaged inner and outer components. Added lateral strength can be achieved by axially tensioning the member, with limits allowed by the locking means. The structural member pictured in FIGS. 1–3 is primarily for supporting transverse loads, because of the type of locking means utilized.

While a circular cross-sectional configuration lends itself exceedingly well to this device, others can be used. For example, in FIG. 4 an oval cross-section is shown. Note that the inner surface of outer element 50 conforms to the outer surface of inner element 20. When a non-circular cross-section is used, it is advantageous to provide means for insuring that the elements maintain their radial alignment, to facilitate speedy assembly. A pair of external cables 68, 70 are threaded through rings 72 attached to outer elements 50 to maintain their radial alignment. Other arcuate shapes, as well as straight-lined shapes, can be used. It is also possible to use a pair of strands 44*a* and 44*b*, as shown in FIG. 4.

An embodiment of the invention capable of handling axial loads is shown in FIGS. 5–8. Each outer member 80 terminates in ends 82, 84. Internally, near end 84, is a limiting stop 86 having a central opening 88 and a pair of limit surfaces 90, 92. Each inner element 96 has a pair of tapered ends 98, 100, each with a central opening 102 leading to a hollow interior 104. A flexible strand 106 extends the entire length of the structural member.

This embodiment is provided with a positive locking means that can support considerable axial load. A shaft 110 is installed within each inner element 96, offset from the axis of the element and perpendicular thereto. Located in the walls of inner element 96, opposite one another, are a pair of offset slots 112 and 114. Pivotally mounted on shaft 110 is a locking bar 118, having ends 120 and 122. The relationship of bar 118 and slots 112 and 114 is such that ends 120 and 122 can pass through slots 112 and 114 into interior 104 of inner element 96, as shown in FIG. 7, and when engaging the ends of slots 112 and 114 orient pin 118 perpendicular to the element axis, as shown in FIGS. 5 and 6. Strand 106 engages a pin 126 rotatably attached to bar 118 at a point offset from the axis of inner element 96.

The operation of the embodiment of FIGS. 5–8 is as follows: Looking first to FIG. 7, inner element 96 is nested within its associated outer element 80, with end 98 abutting surface 90. Strand 106 has been pulled downwardly in FIG. 7, thus causing bar 118 to pivot clockwise to the unlocked position retracted into interior 104. In this position the structural member can be collapsed and folded, as is shown in FIG. 2.

Outer elements 80 are now moved axially downwardly, as viewed FIG. 5, uncovering slots 112 and 114, until ends 100 are seated against surfaces 92 of the adjacent outer element 80, in the same manner as was done in the first embodiment, explained above. Strand 106 is then pulled upwardly, as seen in FIG. 5, pivoting all of the bars 118 counterclockwise, and thus moving ends 120 and 122 outwardly through slots 112 and 114. With the bars 118 thus extended as shown in FIG. 5, the entire member is compressed axially to move bar 118 into contact with end 82 of outer element 80, as seen in FIG. 6. Note that strand 106 is now relaxed. This embodiment is primarily for axial loading. Transverse loading can be accomplished, but it must be remembered that in the absence of some axially compressive force, the inner and outer elements can move to the point of disengagement with one another. Of course, the spring loaded locking means shown in FIGS. 1–3 could be added to this embodiment, to prevent slight tension loads from separating the elements.

To collapse the member, the adjacent inner and outer elements are moved axially apart, again to the position shown in FIG. 5, and strand 106 is then pulled downwardly to retract bars 118 so that the inner elements may again be moved into their respective outer elements, as shown in FIG. 7.

FIG. 9 shows a ladder constructed from a pair of structural members described above. A plurality of outer elements 80*a* and 80*b* and inner elements 96*a* and 96*b* comprise the ladder sides. Rungs 128 are attached to opposed pairs of outer elements 96*a* and 96*b*. The locking bars are designated 118*a* and 118*b*. Caps 130*a* and 130*b* are connected to the strand to facilitate

pulling the strands. The ladder is assembled and disassembled in the same manner as the single structural member of FIGS. **5–8,** described above.

FIG. **10** shows the structural member of FIGS. **1–3** installed as a stiffener in the leech of a boat sail. The sail **140** is attached to mast **142** by a series of fasteners **144** that slide in a track (not shown). Hoisting of sail **140** is accomplished by means of a line **146** passing through a block **148** attached to the top of mast **142,** and attached to the top corner of the sail. A series of grommets **150** are installed in the edge of sail **140.** The inventive structural member is utilized as a stiffener **152** comprising a plurality of outer elements **154** and inner elements **156.** Outer elements **154** are attached to sail **140** by means of links **158,** which hook through grommets **150.** Inner elements **156** are attached together by a strand (not shown) as described above. An operating line **159** has one end attached to the topmost inner element **156,** is threaded through a block **162** carried by the sail hoist line **146,** and has its other end attached to the lowermost inner element **156** (not shown). Sail **140** is hoisted in the normal manner, with all of inner elements **156** in the retracted position. Then operating line **159** is pulled upwardly, extending each of the inner elements **156** with respect to the outer elements **154,** since the outer elements **154** are held fixed in position by virtue of their spaced attachment to sail **140.** The spring loaded locks carried by the inner members engage grooves **160** in the outer members so that axial load can be applied, as described above. To lower sail **140,** operating line **159** is pulled downwardly, thus again retracting the inner elements **156,** and then sail **140** is lowered.

Many other arrangements of components are possible to accomplish the purpose of the structural member used as a sail stiffener. For example, the structural member could be sewn into a sleeve in the edge of the sail, and other arrangements of the various lines and blocks are foreseeable.

The embodiment shown in FIGS. **11–13** differs from the others in form but not in concept. A plurality of inner elements **170** of elongated shape with rounded ends are attached together by strands **172.** Inner elements **170** are axially slidably mounted within a corresponding plurality of outer elements **174,** which are of open-ended cylindrical shape. One end **176** of each outer element **174** has an arcuate cut-out portion **178,** and the other end **180** has a like cut-out portion **182** which is oriented **180** degrees from cut-out **178.** Adjacent pairs of outer elements **174** are oppositely oriented so that adjacent cut-out portions **178** and **182** combine to present a hemispherical opening generally indicated as **184.**

Adjacent pairs of outer elements **174** are attached together by pairs of rigid links **186** which are pivotally attached to outer elements **174** by means of pins **188.** The locking and limiting elements described above with regard to the embodiment of FIGS. **1–3** can equally well be used with this embodiment, although not shown therewith.

The operation of this embodiment is like that of the other embodiments, in that inner elements **170** are axially movable between a retracted position within their respective outer elements **174,** as shown in FIG. **13,** and an extended position, as shown in FIGS. **11** and **12.** Links **186** provide axial rigidity to the device, allowing the application of axial as well as lateral loads. The length of each link **186** is so related to the diameter of outer elements **174** as to allow the device to be folded as shown in FIG. **13.** The presence of cut-out portions **178, 182** is necessary to allow the folding action to take place, since the distance between adjacent outer elements **174** is considerably less than in the first embodiment, although such distance can be greater. Inner elements **170** need not be as long in this embodiment, since the distance they span in their extended position between adjacent outer elements is less.

Of course, the invention is not to be limited to the particular forms and uses described above. To those skilled in the art, this disclosure may bring to mind many variations and modifications of the embodiments of the invention described herein. However, the scope of the invention is limited only by the breadth of the appended claims.

I claim:

1. A collapsible structural member comprising:

a plurality of rigid elongated inner elements arrangeable in spaced end-to-end relationship and connected together by flexible connecting means attached to adjacent pairs thereof, each of said inner elements being of a first length,

a plurality of rigid elongated open-ended outer elements coaxial with said inner elements and arrangeable in alternating relationship with said inner elements, said flexible connecting means extending through the interior of said outer elements, said outer elements being axially relatively movable with respect to said inner elements between an extended position engaging opposite end portions of a pair of adjacent of said inner elements to create a continuous rigid structural member and a retracted position spaced from one of the said pair of adjacent said inner elements to allow said structural member to be collapsed and folded, each of said outer elements being of a second length at least substantially equal to said first length so that said inner elements are positionable substantially entirely within said outer elements when said outer elements are in said retracted position, whereby the effective combined length of all of said inner and outer elements in said retracted position is substantially less than the effective combined length of all of said inner and outer elements when said outer elements are in said extended position,

the cross-sectional configuration of said outer elements and said inner elements being so related to one another as to minimize lateral and angular movement between said inner and outer elements when said outer elements are in said extended position.

2. The structural member of claim **1** wherein the outer cross-sectional size and shape of said inner elements are substantially identical to the inner cross-sectional size and shape of said outer elements.

3. The structural member of claim **2** wherein both said cross-sectional shapes are circular.

4. The structural member of claim **2** wherein both said cross-sectional shapes are not circular, and further comprising alignment means for maintaining the proper radial alignment of said elements to facilitate movement of said outer elements to said extended position.

5. The structural member of claim **4** wherein said alignment means comprises flexible alignment strand

means connecting together adjacent pairs of said outer elements.

6. The structural member of claim **1** wherein said flexible connecting means establishes a particular maximum spacing between adjacent pairs of said inner members, and the length of said outer members is greater than the length of said spacing.

7. The structural member of claim **6** wherein the length of each of said outer elements is at least the length of said spacing plus two-thirds of the length of one said inner element.

8. The structural member of claim **7** wherein the length of each of said inner elements is less than the length of one of the respective said outer elements into which said inner element is retracted in said retracted position.

9. The structural member of claim **1** further comprising means for limiting the relative movement between said inner elements and said outer elements to define said extended position and said retracted position.

10. The structural member of claim **9** wherein said limiting means comprises a stop installed in the interior of said outer elements for engaging the ends of said inner elements, said stop having an opening through which said flexible connecting means passes.

11. The structural member of claim **1** further comprising releasable locking means for holding said outer elements in said extended position.

12. The structural member of claim **11** wherein said releasable locking means comprises a biased locking element and a receiving groove.

13. The structural member of claim **11** wherein said releasable locking means comprises a movable bar carried by each said inner element and extendable radially outwardly generally perpendicular to the axis of said inner element.

14. A collapsible structural member comprising:

a plurality of elongated inner elements arrangeable in spaced end-to-end relationship and connected together by flexible connecting means attached to adjacent pairs thereof,

a plurality of elongated open-ended outer elements coaxial with said inner elements and arrangeable in alternating relationship with said elements, said flexible connecting means extending through the interior of said outer elements, said outer elements being axially relatively movable with respect to said inner elements between an extended position engaging opposite end portions of a pair of adjacent of said inner elements to create a continuous rigid structural member and a retracted position spaced from one of said pair of adjacent said inner elements to allow said structural member to be collapsed and folded, the cross-sectional configuration of said outer elements and said inner elements being so related to one another as to minimize lateral and angular movement between said inner and outer elements when said outer element is in said extended position, and

releasable locking means for holding said outer elements in said extended position, said releasable locking means comprising a movable bar carried by each said inner element and connected to said flexible connecting means, said bar being extendable radially upwardly to a locked position generally perpendicular to the axis of said inner element by tension on said flexible connecting means when said outer element is moved to said extended position.

15. The structural member of claim **14** wherein said inner elements include an axial strand passage, and wherein said flexible connecting means comprises a strand extending the entire length of said structural member passing through said strand passages.

* * * * *