Feb. 25, 1969 E. C. YOUNG 3,429,758

METHOD OF MAKING FILAMENT WOUND STRUCTURAL COLUMNS

Filed Jan. 24, 1966

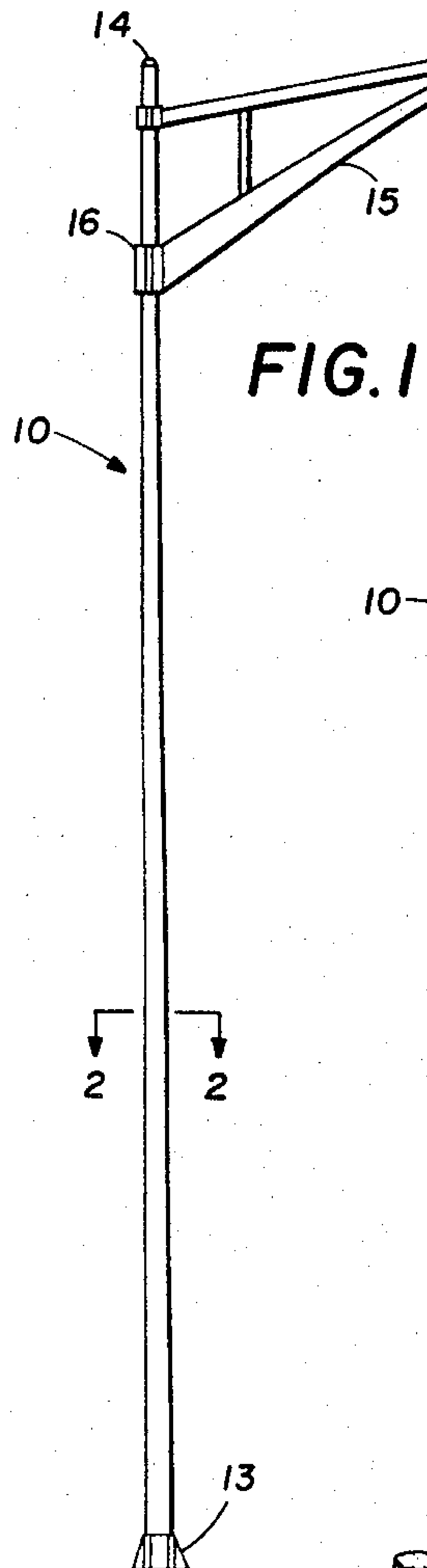

FIG. 1

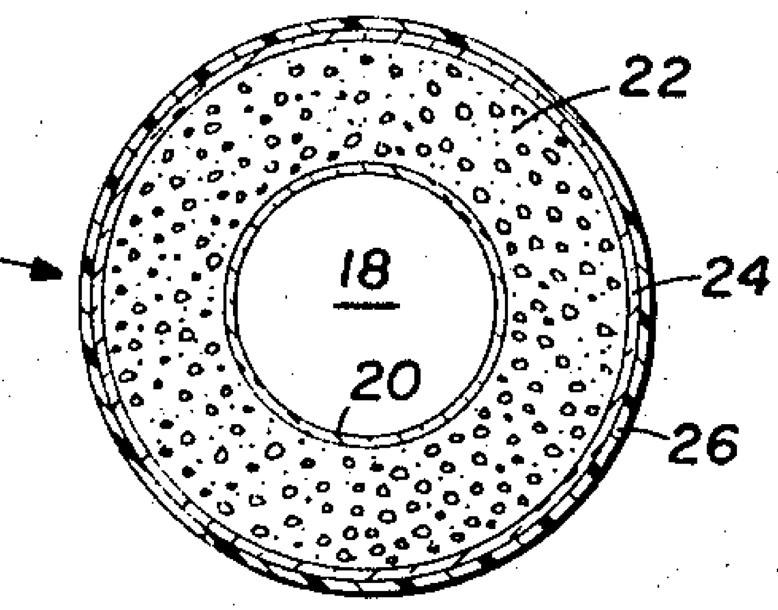

FIG. 2a

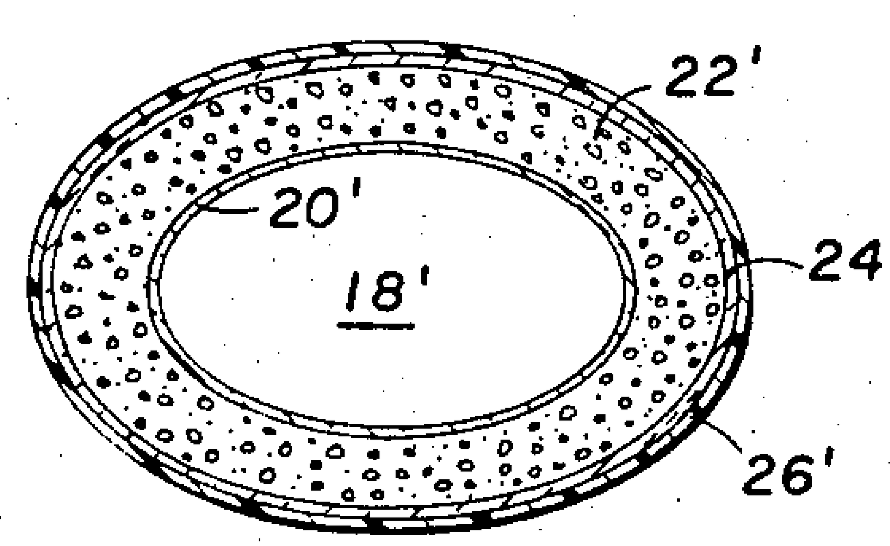

FIG. 2b

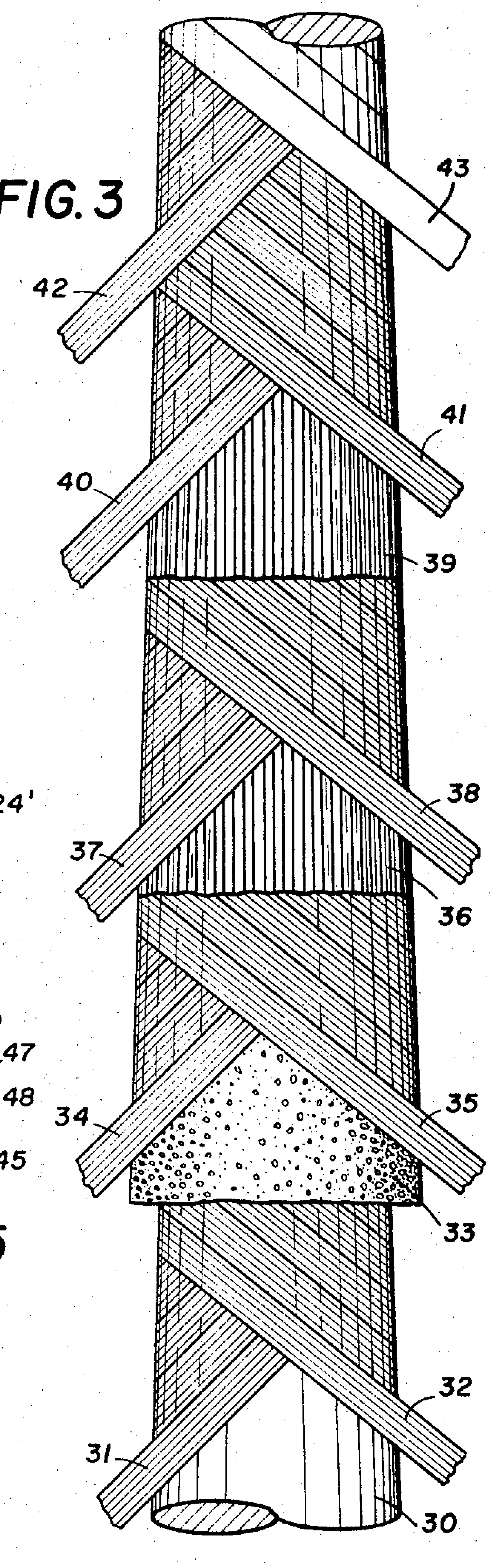

FIG. 3

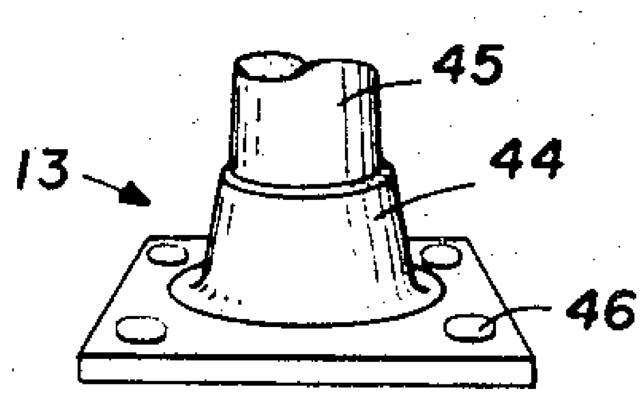

FIG. 4

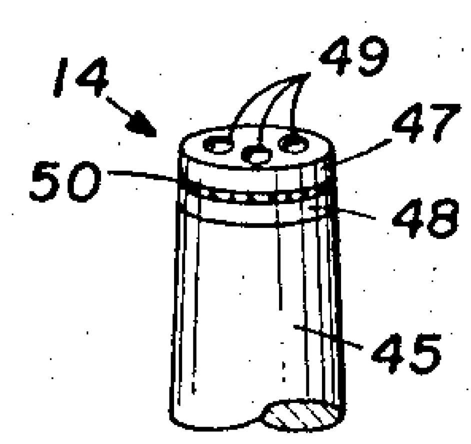

FIG. 5

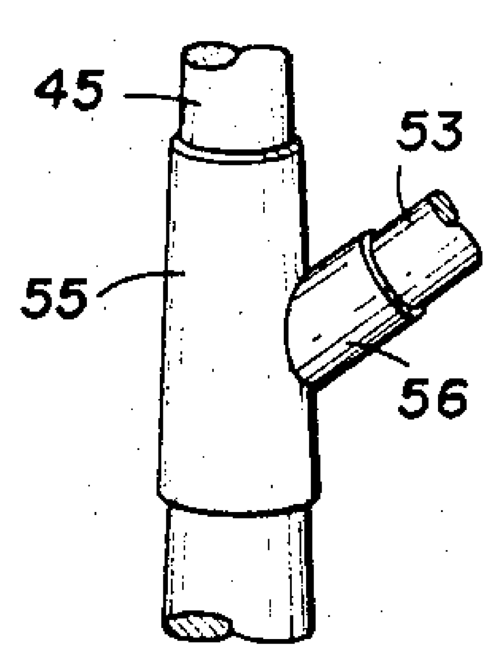

FIG. 7

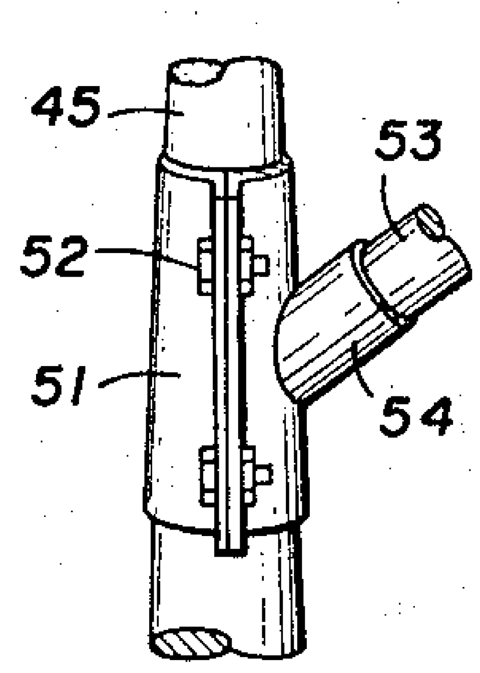

FIG. 6

INVENTOR
EDWIN C. YOUNG
Richards Harris & Hubbard
ATTORNEY

United States Patent Office 3,429,758
Patented Feb. 25, 1969

3,429,758

METHOD OF MAKING FILAMENT WOUND STRUCTURAL COLUMNS

Edwin C. Young, 7139 Dover Lane, Richland Hills, Tex. 76118

Filed Jan. 24, 1966, Ser. No. 522,644
U.S. Cl. 156—79 6 Claims
Int. Cl. B32b 5/20

ABSTRACT OF THE DISCLOSURE

A tube-like structural member is constructed about a mandrel by helically wrapping two resin-carrying warps of fibers about the outer surface of the mandrel in opposite senses and thereafter forming an integral cellular core about the outer surface of the layer formed by the two resin-carrying warps. Additional layers of resin-carrying warps of fibers are helically wrapped in opposite senses about the outside of the cellular core. When the warps and cellular cores are cured, the mandrel is then removed from within the inner layer of resin-carrying warps to provide a tube-like structural member having significant structural strength.

The present invention relates to filament wound structural columns and methods of forming the same and is particularly concerned with such columns for use as lighting poles or standards with hollow cores. There is presently a need for lighting poles of heights in excess of forty feet to produce lighting patterns of more uniform light distribution for the same lamp wattage. Such lighting installations are found principally where underground electrical service is used in such areas as interstate highway interchanges, municipal street and boulevard lighting, general automobile parking areas, sporting arenas and stadiums, industrial plants and the like. Ideally these poles should be constructed in one piece for maximum strength, using materials that produce an electrically insulated pole and which are inert to atmospheric conditions to reduce pole maintenance. It is also desirable that these poles be as light-weight as possible consistent with maximum strength to reduce the cost of installation and minimize possible personal injury and property damage resulting from vehicular collision.

Accordingly, it is an object of the present invention to provide such a pole which has all of the desirable characteristics enumerated above.

More specifically, it is an object of the invention to provide filament wound lighting poles to withstand compressive and bending loads.

Another object is to provide a lighting pole that is chemically resistant to the elements.

Still another object is to provide a lighting pole that is light-weight while yielding maximum strength.

A further object is to provide a lighting pole that has high strength continuous glass fibers positioned on the periphery of the circumference at the point of maximum fiber stress.

A still further object is to use a low strength, low cost core material to increase the section modulus and reduce the deflection due to bending.

Another object is to provide a method of fabrication of said pole in a simple and economical manner.

In accordance with these objects, the present invention provides a structural column with a filament wound inner layer which forms a hollow core with said inner layer being comprised of fibers, preferably continuous glass fiber filaments bonded together with a suitable catalysed resin as a bonding agent. A core material is sprayed over said inner layer which has the characteristic of forming a

bond with the inner layer of fiber glass and is expanded to a controlled density and thickness of rigid nature to provide structural stiffness. The core material is also overwound with continuous glass fiber filaments bonded together and to the core material with a suitable resin binder to provide additional structural strength for the column. In both the inner and outer layers of glass fibers, various layers of glass fibers are built up with a predetermined fiber orientation to provide maximum strength in all directions of compression, tension, bending or twisting.

Additional objects, features and advantages will in part be obvious and in part pointed out in the following description of the invention when taken in conjunction with the appended claims and the accompanying drawings wherein:

FIGURE 1 is a side elevational view of a lighting pole assembled with standard accessories;

FIGURES 2A and 2B are section views taken through section lines 2—2 shown in FIGURE 1 for lighting poles having circular and elliptical cross-sections, respectively, and constructed according to the invention;

FIGURE 3 is a fragmentary, side elevational view of a tapered structural column constructed according to the invention, with various layers broken away to show the details of construction thereof;

FIGURE 4 is a perspective view of a shoe base flange bonded to the lower end of the pole for attachment to the foundation;

FIGURE 5 is a perspective view of a cap used for sealing off the top end of the pole;

FIGURE 6 is a perspective view of a clamp-type bracket used for attaching the lamp arm to the pole; and

FIGURE 7 is a perspective view of an alternate bonded-type bracket for attaching the lamp arm to the pole.

In the following description of the invention, reference will be had in the application thereof to a lighting pole, although it will readily be apparent that the invention is adapted to many other applications for structural columns or for tubular members having various purposes, e.g., fluid conduit means. As applied to a lighting pole as shown in FIGURE 1, the structural column is comprised of a hollow tapered pole **10** with a base flange **13** for securing the pole to a foundation, and a cap **14** for sealing off the top of the pole. Both the base flange and the cap can be made from any suitable material. An arm **15** is secured to the pole by a suitable bracket **16** as described below.

Two different shaped cross-sections of the pole are shown in FIGURES 2A and 2B wherein FIGURE 2A shows a circular cross-section for most uses in structural column applications, and FIGURE 2B shows an oval or elliptical cross-section that is designed for reducing the fiber stress by loading along the major axis of the cross-section. The structural column as shown in FIGURE 2A has a hollow interior **18** and is comprised of an inner wall **20** of filament wound fibers, preferably fiber glass, forming a plurality of layers impregnated with resin which serves to seal off the inner surface of the pole and provide structural strength around the center hole through the pole. A core material **22**, such as a self-rising rigid foam (or similar inexpensive material) is used to build up the section modulus of the pole for the purpose of making the pole more rigid. An outer wall **24** comprising a plurality of filament wound layers is provided on the exterior of the core material and preferably comprises a combination of fiber glass of approximately 70% by weight impregnated with a catalysed resin of approximately 30% by weight and built up in sufficient layers of glass filaments to provide the desired strength, all as explained in detail hereinafter. The final layers of the outer wall can be wound with a resin pigmented to a desired color and overwrapped with a film of transparent plastic **26**, such as a fluorocarbon, to give the exterior of the pole a smooth surface to improve the esthetic appearance of the pole and to give the pole better weathering characteristics. The film may contain an ultraviolet absorber to protect the resin system used from ultraviolet attack. The film may also be colored to eliminate pigmentation of the outer fiber glass layer.

A similar structural column is shown in FIGURE 2B which differs only from that just described in the geometry of cross-section thereof for a different type of loading, wherein like reference numerals, plus the character prime, refer to like parts.

A typical fiber glass pole constructed according to the invention is shown in FIGURE 3 in the various stages of fabrication. A mandrel **30** is used which has dimensions which conform to the desired inner diameter of the pole and is tapered to facilitate the removal of the pole after completion. It will be understood, however, that the mandrel and pole do not have to be tapered. Before winding the inner wall of the pole over the mandrel, the mandrel is treated with a releasing agent to prevent the fiber glass material and resin from adhering to the mandrel and to facilitate the stripping of the pole from the mandrel. Any suitable releasing agent may be used for this purpose, such as a polyvinyl alcohol film, or alternatively, the mandrel may be wrapped with a protective covering.

The inner fiber glass wall is composed of two layers **31** and **32** of continuous glass filaments impregnated with resin and these layers are overwound with equal but opposite helix angles. The configuration shown consists of bands of filaments placed on the mandrel **30** adjacent the preceding band and of sufficient width to provide the desired helix angle. Other winding patterns, such as single circuit or multiple circuit patterns, can be used to achieve the same results. The method described herein is used for rapid production and to eliminate bending the glass filaments over previously wound filaments by allowing all filaments to be laid down straight to produce uniform stress under load. The inner fiber glass surface **31** acts as a protection to the core material (to be added later) against atmospheric conditions, especially moisture, and against damage in pulling electrical wires or cable through the center of the pole for electrical hook-up. Additional layers of fiber glass can be added to the inner wall but do not necessarily provide any useful advantage to the pole, while increasing costs; however, for other applications such additional layers may be desirable.

As mentioned earlier, the fiber glass filaments comprising the various warps or layers of the inner wall are impregnated with a resin which acts to reinforce the inner surface and serves as a medium for forming a unitary member of the inner wall when the resin has set-up or cured. There are many types of resins, such as thermosetting resins, that are suitable for this purpose and applicable to this process. As examples, the silicones, phenolics, polyesters and epoxies are all suitable, among many others that are well-known. In particular, the physical properties of the epoxies (condensation products of epichlorohydrin and bisphenol A) make them especially suitable. A low viscosity resin, such as "Epon 826" or "Epon 828," both being trade names of Shell Chemical Company, is especially suitable and desirable for filament winding of this nature. These particular epoxy resins are in liquid form and are polymerized by using a catalyst or hardener to produce a solid structure. Because of the nature of preferred foam core material to be discussed below, it is advisable to use a low temperature, e.g., 200° F. or below, cure system for the resin. Suitable curing agents for this purpose can be selected from the polyamine group, although others will readily come to mind, wherein consideration should be given to both pot life and cure times and temperatures. As specific examples only of low temperature curing agents for the epoxy resins, any of diethylenetriamine, triethylenetetramine and diethylamino propylamine can be used.

A core material **33** is then added and comprises a self-

rising rigid foam, e.g., such as a urethane foam, and is applied over the inner fiber glass wall **32** with a constant density and to a constant thickness. This core material must have good adhesive properties and adhere to the inner fiber glass surface after it rises and sets to a rigid condition. For fiber glass poles under consideration for use as lighting poles, for example, the core material is usually of a two lbs./ft.^{3} density and of one inch thickness, both properties being approximate for process variations and chosen on both an economic and physical property analysis. A suitable method of applying the core material is by spraying onto the fiber glass surface, although any method of application may be used which yields the desired results. It is obvious that alternate layers of foam and fiber glass can be combined to produce thicker structures of high strength.

Many different plastic foams can be used for the core material discussed above; among those is the group of polyurethanes, polystyrenes, epoxies, polyvinyl chlorides, phenolics, silicones, and urea-formaldehydes, to name examples only. Spraying of the foam material onto the inner fiber glass surface has been found especially suitable as being fast and adapted for controlling the density and thickness of the core. The most suitable foams for spraying are the polyurethanes, epoxies, and silicones, wherein these and the rest of the above-enumerated foams are all characterized by forming an adhesive bond with the fiber glass inner wall. In particular, the strength properties of the polyurethanes, coupled with their much lower costs, make them the prime candidate for the foam core material for this purpose. Basically, the polyurethane polymer is formed from polyol and polyisocyanate. In forming the core material, the polyurethane is mixed with a catalyst such as, for example, tertiary amines and tin salts in conjunction with a cell control agent such as, for example, a polyglycolsilicone polymer and a blowing agent, such as fluorotrichloroethane, all in the proper proportions (which are well-known) to produce a cell structure that yields the best physical properties at the lowest cost.

An outer surface or wall is provided over the core material to seal it off and to give the structural column a better appearance. The outer surface is also provided for the purpose of increasing the strength of the pole. A fiber glass-resin combination is also used for this purpose similar to the inner wall previously described, wherein the following description will also have reference to the use of the structural column as a lighting pole. The outer fiber glass surface is designed to take the compressive and tensile loadings of the installed pole as well as the bending and twisting loads encountered from normal atmospheric conditions and from high winds of hurricane magnitude. Glass filaments **34** and **35** impregnated with resin are wound over the core in a manner similar to that described above for the inner wall. These helically wound outer layers take the combined axial and longitudinal stresses and are designed accordingly. With the tapered pole construction as described herein and with the constant band width of filaments, the helix angle of the windings will gradually change from the top to the bottom of the pole. Since the longitudinal strength is important for the loads under consideration, longitudinal glass filaments **36** are formed on top of helical layers **34** and **35** to compensate for the lower longitudinal components of the helical windings. Additional helical windings **37** and **38** and another longitudinal layer **39** are continued in a similar manner and subsequent layers of this pattern may be added until the required thickness of outer windings is obtained to meet the load specifications. The winding pattern need not go the entire length of the pole. Since the bending moment increases towards the bottom or the larger diameter of the pole, additional thickness will be required to compensate for the increase in bending. Thus, the additional layers in the winding pattern need to go only as high as needed for obtaining the required strength. Helical windings **40** and **41** are wound over the entire length of the pole and put all layers previously wound under compression along the entire length of the pole. A final layer of helical fiber glass winding **42** may be used which has the resin impregnated with a pigment to meet whatever color might be required for the pole.

All filament windings described above are applied under tension to make the pole a prestressed structure.

A final outer winding **43** may be used which comprises a film of plastic with good weathering properties, such as a fluorocarbon. The side of the film contacting the outer winding **42** is treated, if necessary, to provide a good bonding surface for the resin system used on the pole. As pointed out previously, the purpose of the film is to improve the weathering properties and the esthetic appearance of the pole. In the case where the resin system used in the winding process is not affected by atmospheric conditions, or where the outer surface is not critical, the use of the film can be considered to be superfluous.

If the resin system used requires heat for adequate cure, the completed pole will be heated prior to stripping from the mandrel. Both ends of the pole can be machined perpendicular to the pole centerline for assuring vertical mounting on the flange base described hereinafter.

For purposes of explanation in the use of the structural column just described as a lighting pole, the following provides a description of mounting means that may be used therewith. There is shown in FIGURE 4 suitable means for attaching the pole to a foundation wherein, in almost all underground electrical installations, the pole is attached to a concrete base with anchor bolts as an integral part of this base. A flange **44**, used to make this attachment, has the same internal diameter as the outside of the pole **45**. The tapered joint formed by placing the flange over the pole provides a positive hold-down for the pole. To supplement this hold-down the flange and pole are bonded together in assembly with a catalysed resin similar to that used on the pole. Variations in the pole diameters will be small and the base flange or the pole can be machined to compensate for the variations and provide a tight fit between the flange and pole. The flange will be provided with holes **46** to match the bolting pattern of the foundation and be secured to it by conventional means. The flange is fabricated from a suitable material that satisfies the strength and weathering specifications. In the case where a transformer base is used between the pole and the foundation, the flange can be made adaptable by changing the bolting pattern.

For the case where the pole is buried as a permanent type of installation, the flange would be eliminated and the pole height increased to provide adequate underground support for the height of the pole above ground. In this case, the chemical inertness of the fiber glass construction would provide a long-life, maintenance-free installation.

As shown in FIGURE 5, the pole **45** is capped to seal off the top of the hollow core to protect the electrical wiring from atmospheric conditions. A cap **47**, of any suitable material, is attached to an insert **48** by means of machine screws **49** with a gasket **50** used as a seal between the cap and pole. Insert **48** can be imbedded in the pole top during fabrication, bonded to the pole top after the pole has been completed, or in any other manner attached permanently to the pole. In the event that a removable cover is not desired, the cap **47** can be bonded directly to the top of the pole.

The pole bracket arm for holding the lighting fixture must be securely attached to the pole. Two typical means are shown but are not to be construed as being the only type fastening devices possible; good engineering practice will normally dictate the type of attachment to be used. The clamp type attachment is shown in FIGURE 6 and comprises a split-type clamp **51** which conforms to the pole taper and is secured thereto with bolts and nuts **52**. The bracket arm **53** fits into a slip collar **54** which is a part of the clamp **51**. The arm **53** can be welded, bonded or clamped to collar **54**, depending on the nature of the material used. Since the electrical cable or wiring must be pulled from the base of the pole through the arm to the lighting fixture, the arm must be hollow and a hole must be made through the wall of the pole and aligned with the slip collar holding the arm.

An alternate means is shown in FIGURE 7 where the attachment is made by bonding a tapered sleeve **55** of appropriate diameter and taper to the pole to maintain proper lamp height. The arm **53** fits into a collar **56** that is an integral part of sleeve **55**. The attachment of the arm to the collar and the alignment of the hole through the pole are the same as described above.

In the foregoing description, fiber glass has been indicated as filament material for use with this invention. The economics, physical properties and availability make fiber glass the preferred material for use as filaments. It is to be understood, however, that the invention is not limited to fiber glass filaments, but embodies the use of any usitable filament material. Likewise, reference to the core material being a rigid foam should not be construed as being limited and is used herein for illustrative purposes and because of its economic, structural and physical assets, as well as its adaptability to the process and its availability.

The invention describes in detail a hollow tapered pole for use as a lighting pole and methods for forming same. This is to be construed as being only for the purpose of illustration and not to be limited to this one illustration. For those skilled in the art, it will be evident that this process and method can be used to produce a wide range of structural columns for use in many applications. Only one method of filament winding has been explained in detail and it is to be understood that there are several methods of winding filaments to specific patterns and that these could be adapted to the making of these structural columns as described in this invention. Likewise, changes may be made in the above method and modifications may be made in the structures and combinations of the same which embody the invention without departing from the scope thereof. Therefore it is intended that the invention be limited only as defined in the appended claims.

What I claim is:

1. A method of making a tubular structural member, comprising the steps of:

(a) forming a first layer of warps of resin reinforced with fibers about the outer surface of a tubular mandrel;

(b) spraying a foamable resinous composition including a catalyst onto said first layer of resin reinforced with fibers;

(c) forming a second layer of warps of resin reinforced with fibers about the outer surface of said foamable composition;

(d) permitting said composition to foam in situ until cured; and

(e) removing said mandrel from within said layer along the longitudinal axis thereof when said first and second layers and said cellular core have been rigidly formed into an integral tubular structure.

2. A method of making a tubular structural member as claimed in claim **1** including the additional step of applying a release agent to said mandrel prior to forming said first layer on said mandrel.

3. A method of making a tubular structural member as claimed in claim **2** wherein:

(a) said first layer of warps of resin reinforced with fibers is formed by helically wrapping a first resin-carrying warp of glass fibers about said mandrel and helically wrapping a second resin-carrying warp of glass fibers about said mandrel in an opposite sense to said first warp on top of said first warp; and

(b) said second layer of warp of resin reinforced with fibers is formed by helically wrapping a third resin-carrying warp of glass fibers about the outer surface of said cellular core and helically wrapping a fourth resin-carrying warp of glass fibers about the outer surface of said cellular core in an opposite sense to said third warp on top of said third warp.

4. A method of making a tubular structural member as claimed in claim 2 wherein said foamable composition is a thermosetting resin compound.

5. A method of making a tubular structural member as claimed in claim 2 wherein said foamable composition is a thermoplastic resin compound.

6. A method of making a tubular structure as claimed in claim 1 including the additional step of heating said mandrel and said structure formed thereon to cure the resins in said first and second warps.

References Cited

UNITED STATES PATENTS

2,747,616	5/1956	De Ganahl ------	156—175 XR
2,870,793	1/1959	Bailey.	
3,303,617	2/1967	Hessburg et al. ----	156—79 XR
2,642,920	6/1953	Simon et al. --------	161—161

FOREIGN PATENTS

558,633	7/1957	Belgium.

PHILIP DIER, *Primary Examiner.*

U.S. Cl. X.R.

138—144; 156—173; 161—161