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(54) **Title:** UTILITY POLE AND METHOD FOR MAKING THE SAME

(57) **Abstract:** Utility poles can be used as, electrical power poles, light poles, telephone poles and the like. A composite utility pole includes a tapered elongated body having a top end and a base end, where a cross section of the base end is larger than that of the top end. An elongated body can be made by diagonally cutting a common composite member into at least two tapered elongated segments. Each tapered elongated segment includes a larger end having a larger cross section area and a smaller end having a smaller cross section area. At least one tapered elongated segment is then rotated 180 degrees about an axis transverse to a longitudinal axis of the hollow member such that all the larger ends are placed toward each other. The tapered elongated segments are then assembled together into an elongated body.

UTILITY POLE AND METHOD FOR MAKING THE SAME

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FIELD

This document relates generally to poles, and particularly, but not by way of limitation, to a utility pole including a tapered elongated body and a method for making the same.

BACKGROUND

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Utility poles include electrical power poles, light poles, telephone poles and the like. Traditionally, utility poles are made from wood, steel and reinforced or prestressed concrete.

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Wooden utility poles consist of a natural substance. The continuous exposure to harsh environmental conditions can cause the wood poles to rot and decay. To prevent rotting, the wood is sometimes treated with a carbon base material. It has been found that most conventional wood treating material is harmful to the environment. Additionally, it has been found that a significant amount of electrical current drains to the ground, thereby reducing the energy efficiency of the power grid.

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Metal poles have been installed to increase the life of the utility poles. However, metal poles are substantially more expensive. Metal poles also are highly conductive, heavy and generally create an unsafe environment for the utility personnel that maintain and repair the pole.

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Reinforced or prestressed concrete utility poles alleviate the conductivity problem of metal utility poles and alleviate the environmental problems of wooden poles. But concrete utility poles are significantly heavier than metal or wooden utility poles and the freight cost in transporting concrete utility poles throughout the countryside limits their use to areas close to the manufacturing plant where they are made.

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Composite utility poles are used to resolve the above problems. Composite poles are formed from a combination of different materials each of which maintains their identities in the combination to produce a superior result than what could be achieved from individual materials acting alone. The composite for making poles is generally fiber-reinforced plastic or a fiber-reinforced polymer (FRP). A process for making composite poles is pultrusion, which is a continuous process including pulling a fiber reinforcing material through a resin impregnation bath and into a shaping die where the resin is subsequently cured. Typically,

the dies used in the pultrusion process can only make a structure having a constant cross-sectional or two-dimensional shape resulting in the material use to be less than the optimum.

For these and other reasons, there is a substantial need for an improved and simplified method for constructing composite poles so that less expensive and long lasting composite poles can be produced.

SUMMARY

Disclosed herein is a composite utility pole, which can be used to support a utility line, a light, a signal light, or any other components of a utility system. The pole may also be used for other products that require elevated support by a pole type structure. The composite utility pole includes a tapered elongated body having a top end and a base end, where a cross section of the base end is larger than that of the top end. The elongated body can be made by diagonally cutting a common composite member into at least two tapered elongated segments. Each elongated segment includes a larger end having a larger cross section area and a smaller end having a smaller cross section area. At least one tapered elongated segment is then rotated 180 degrees about an axis transverse to a longitudinal axis of the composite member such that all the larger ends of the tapered elongated segments are placed together. The tapered elongated segments are then assembled together into the tapered elongated body. The composite utility pole can be made by a pultrusion process. The assembled utility pole has a high strength to cost ratio and stiffness to cost ratio as compared to a non-tapered pole. Therefore, material costs are reduced since the assembled utility pole can have a thinner wall and maintain the same or better strength and stiffness as compared to a non-tapered pole.

The common composite member to be cut to form the utility pole can further include at least two opposite indentations. After the diagonal cutting, the indented walls can be snugly fit and bonded with each other to form overlaps. Each overlap has an inner surface and an outer surface that tracks an inner surface and an outer surface of an adjacent wall of the assembled utility pole, respectively. The opposite indentations help provide larger bonding surfaces and therefore stronger bonding between the different segments of the elongated body of the assembled utility pole.

By changing the dimensions of the sizes and thicknesses of its walls, a composite utility pole with desired strength to weight ratio can be obtained. For example, special dimensions of the cross section of the utility pole may be designed to maximize the pole's strength per weight ratios. Composite utility poles are significantly lighter than those made

of wood, metal or concrete, making them much easier to transport and install and thus reducing transportation and installation costs. In addition, the composite utility pole is resistant to all forms of degradation, such as ultraviolet light, rust and rot.

This summary is an overview of some of the teachings of the present application and not intended to be an exclusive or exhaustive description of the present subject matter. Further details about the present subject matter are found in the detailed description and appended claims. Other aspects will be apparent to persons skilled in the art upon reading and understanding the following detailed description and viewing the drawings that form a part thereof, each of which are not to be taken in a limiting sense. The invention is defined by the claims and their equivalents.

DESCRIPTION OF THE DRAWINGS

The drawings, which are not necessarily drawn to scale, illustrate generally, by way of example, but not by way of limitation, various embodiments discussed in the present document.

Fig. 1A is a perspective view of an embodiment of a composite utility pole including a tapered elongated body.

Fig. 1B is an enlarged view showing a top end of the tapered elongated body shown in Fig. 1A.

Fig. 2A is a cross section view of an elongated body of the utility pole of Fig. 1A along line 2D-2D.

Fig. 2B is a cross section view of the elongated body of Fig. 1A along line 2B-2B, illustrating the shape of a top end of the elongated body.

Fig. 2C is a cross section view of the elongated body of Fig. 1A along line 2C-2C, illustrating the shape of a base end of the elongated body.

Fig. 2D is a cross section view of the elongated body of Fig. 1A along line 2A-2A.

Fig. 3 is a diagrammatic view of a typical pultrusion production line for making a composite member.

Fig. 4A is an enlarged front side view of a composite member.

Fig. 4B is a bottom view of the composite member of Fig. 4A.

Fig. 4C is a smaller scale front side view of the composite member of Fig. 4A.

Fig. 4D is a cross-sectional view of an embodiment of an oval composite member.

Fig. 5 is a front view of the composite member being diagonally cut into first and

second tapered elongated segments at an angle with the vertical axis b-b' of the composite member.

Fig. 6A is a front side view of the first and second tapered elongated segments being separated from each other.

5 Fig. 6B is a cross section view of the first and second tapered elongated segments of Fig. 6A along line 6B-6B, illustrating the top ends of first and second tapered elongated segments cut from the composite member.

10 Fig. 6C is a cross section view of the first and second tapered elongated segments of Fig. 6A along line 6C-6C, illustrating the bottom ends of first and second tapered elongated segments cut from the composite member.

Fig. 7A is a front side view of the first and second tapered elongated segments after the second tapered elongated segment being rotated 180 degrees.

15 Fig. 7B is a cross section view of the first and second tapered elongated segments of Fig. 7A along line 7B-7B, illustrating the new top ends of first and second tapered elongated segments after the second tapered elongated segment being rotated 180 degrees.

Fig. 7C is a cross section view of the first and second tapered elongated segments of Fig. 7A along line 7C-7C, illustrating the new bottom ends of first and second tapered elongated segments after the second tapered elongated segment being rotated 180 degrees.

20 Fig. 8A is a front side view of an assembled structure formed by the first and second tapered elongated segments.

Fig. 8B is a cross section view of Fig. 8A along line 8B-8B, illustrating a top end of the assembled structure.

Fig. 8C is a cross section view of Fig. 8A along line 8C-8C, illustrating a bottom end of the assembled structure.

25 Fig. 9A illustrates unidirectional, longitudinally oriented fibers of the composite member adjacent an end of the composite member.

Fig. 9B illustrates the fibers adjacent the top ends of the tapered elongated segments after cutting at the angle and rotating 180°.

30 Fig. 9C illustrates the elongated body of the assembled utility pole with the unidirectional, longitudinally oriented fibers crossed at an angle in an overlap and the fibers at an angle to the vertical dimension.

Fig. 10A illustrates one embodiment of a composite member with free ends of indented walls being beveled to form slanted surfaces.

Fig. 10B illustrates the two segments of the composite member as in Fig. 10A, with one segment being rotated 180 degrees.

Figs. 11A-D illustrate another embodiment of a utility pole made from a composite member without indentations resulting in a tapered pultruded pole.

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DETAILED DESCRIPTION

In the following detailed description, reference is made to the accompanying drawings which form a part hereof, and in which is shown, by way of illustration, specific embodiments and examples. For purposes of illustration, the relationship between the width and length of the tapered elongated segments, as shown in the figures, has been exaggerated, as it will be appreciated that in reality normally the ratio between the length and width of the tapered elongated segments will be much greater than that illustrated.

It should be noted that references to “an,” “one,” or “various” embodiments in this disclosure are not necessarily to the same embodiment, and such references contemplate more than one embodiment. The terms “above,” “on,” “under,” “top,” “bottom,” “up,” “down,” “front,” “rear,” “left,” “right,” “horizontal,” and “vertical” used in this document are in reference to the relative positions of the compression sealing apparatus in use when oriented as in the figures.

Composite utility poles disclosed herein are used for many different applications, such as telephone poles, electrical power poles, light poles, and supporting structures. Disclosed herein is a utility pole which includes a tapered elongated body having a top end and a base end, where a cross section of the base end is larger than that of the top end. The elongated body is made by diagonally cutting a common composite member into at least two tapered elongated segments. Each tapered elongated segment includes a larger end having a larger cross section area and a smaller end having a smaller cross section area. At least one tapered elongated segment is then rotated 180 degrees about an axis transverse to a longitudinal axis of the composite member such that all the larger ends are placed together. The tapered elongated segments are then assembled together into an elongated body.

The cross section of the composite member for making the utility pole can be of any shape, for example, rectangular, square, hexagonal, circular, ellipse, etc. As a result, the cross section of the utility pole formed by cutting the composite member into segments and assembling the segments together can be of many shapes depending on the initial profile and the angle of the diagonal cutting. The utility pole will typically be hollow. It will be

appreciated that the segments formed by cutting the composite member can be various as long as when rotated, the larger ends of the segments can be placed together and assembled to form the utility pole. It will also be appreciated that the cuttings are from a top end to a bottom end of the composite member and are diagonal cuttings. It will also be appreciated
5 that the shape of the segments cut from the common composite member can vary from one to another.

For sake of convenience, the utility pole described herein is formed by diagonally cutting a hollow rectangular composite member into two identical tapered elongated segments and assembling the two identical tapered elongated segments into the pole.

10 Fig. 1A is a perspective view of an embodiment of a composite utility pole 10 including a tapered elongated body 12. Fig. 1B is an enlarged view showing a top end of the tapered elongated body 12 shown in Fig. 1A. The tapered elongated body 12 includes a top end 14 and a base end 16, where the cross section of the base end 16 is larger than that of the top end 14. Fig. 2A is a cross section view of the elongated body 12 of the utility pole 10 of
15 Fig. 1A along line 2D-2D. Fig. 2B is a cross section view of the elongated body 12 of Fig. 1A along line 2B-2B, illustrating the shape of the top end 14. Fig. 2C is a cross section view of the elongated body 12 of Fig. 1A along line 2C-2C, illustrating the shape of the base end 16. Fig. 2D is a cross section view of the elongated body of Fig. 1A along line 2A-2A.

The elongated body 12 has a height H. It is to be understood that the height H can
20 vary depending on the required height and strength of the utility pole. In some embodiments, the height H is in the range of 30-180 feet, and preferably 35-140 feet. It has a front side 18, a rear side 20, a left side 22 and a right side 24. The front side 18 and the rear side 20 are parallel to each other. The front side 18 also has a top edge 34 and a bottom edge 36 parallel to each other. The left side 22 makes an acute angle α with the bottom edge
25 36. The right side 24 makes an acute angle β with the bottom edge 36. Depending on the application, the angles α and β may or may not be identical. It will be appreciated that the angle α or β can vary depending on the dimension of the elongated body of the utility pole and the demands on the pole. In one embodiment, the angle α or β is in the range of 80° to 90° degrees, and preferably in the range of 87° to 90° degrees. In another embodiment, the
30 angle α or β is in the range of 86° to 90° degrees, and preferably in the range of 88° to 90° degrees.

The elongated body 12 is hollow and has a vertical axis a-a'. Each cross sectional configuration taken at a plane parallel to the front side 18 encloses an area that is in a shape of

trapezoid and identical to the configurations of the front side 18 and rear side 20. For example, Fig. 2A illustrates a cross section through the axis a-a' and parallel to the front side 18. Each cross sectional configuration taken at a plane parallel to the a-a' axis and perpendicular to the front side 18 encloses an area that is in a substantially rectangular shape. For example, Fig. 2D illustrates a cross section through the axis a-a' and perpendicular to the front side 18. In one embodiment, angle α is equal to angle β so that the configurations of the front side 18 and the rear side 20, as well as the area enclosed by each cross sectional configuration taken at a plane parallel to the front side 18 is a regular trapezoid.

An area enclosed by a cross sectional configuration of the elongated body 12 taken at any plane perpendicular to the vertical axis a-a', including an area enclosed by the cross section configuration of the top end 14 or base end 16, is substantially rectangular. In one embodiment, the area enclosed by a cross sectional configuration increases continuously from the top end 14 to the base end 16. For example, Fig. 2B illustrates the shape of the top end 14 and Fig. 2C illustrates the shape of the base end 16. It is to be understood that the area enclosed by the outer edge of the top end 14 or the outer edge of the base end 16 can vary as desired. In one embodiment, the area enclosed by the outer edges of the top end 14 is in the range of approximately 16 square inches to approximately 300 square inches. The area enclosed by the outer edges of the base end 16 is in the range of approximately 50 square inches to approximately 1500 square inches. The maximum ratio between the area enclosed by the outer edges of the base end 16 and that of the top end 14 can be over 30:1.

As illustrated in Figs 1, 1A, and 1B, the elongated body 12 includes a first tapered elongated segment 172 and a second tapered elongated segment 174. The first tapered elongated segment 172 includes a front inner indented wall portion 212 and a rear outer indented wall portion 182. The second tapered elongated segment 174 includes a front outer indented wall portion 190 and a rear inner indented wall portion 214. The front inner indented wall portion 212 of the first tapered elongated segment 172 and the front outer indented wall portion 190 of the second tapered elongated segment 174 form a first set of indented wall portions, which snugly fit with each other and form the smooth inner and outer surfaces for the front side 18. The rear outer indented wall portion 182 of the first tapered elongated segment 172 and the rear inner indented wall portion 214 of the second tapered elongated segment 174 form a second set of indented wall portions, which snugly fit with each other and form the smooth inner and outer surfaces for the rear side 20.

The thickness t_c of the sides 18, 20, 22, 24 of the elongated body 12 varies and is

determined in view of the height of the elongated body 12 and the loads expected to be applied to the pole. In one embodiment, the thickness t_c is in a range from 0.2 to 2.0 inches. In one embodiment, the sides 18, 20, 22, 24 have a constant thickness t_c . In a preferred embodiment the thicknesses of the indented wall portions 182, 190, 212, 214 can vary as long as when assembled together they form smooth inner and outer surfaces for the front and rear side. In one embodiment, the overall thickness t_{fi} of the first set of indented wall portions as well as the overall thickness t_{fo} of the second set of indented wall portions when assembled together equals a constant thickness ($t_{fi} + t_{fo} = t_c$) of the elongated body 12. In another embodiment, the thickness t_{fi} , t_{fo} of indented wall portions 182, 190, 212, 214 can vary and may not form smooth inner and outer surfaces.

By changing the dimensions of the lengths, cross sections, and thicknesses of the segments, a utility pole with desired strength to weight ratio can be obtained. For example, special dimensions of the cross section of the utility pole may be designed to maximize the pole's strength per weight ratios. The composite utility poles are significantly lighter than those made of wood, metal or concrete, making them much easier to transport and install and thus reducing transportation and installation costs. In addition, the utility pole is resistant to all forms of degradation from ultraviolet light, moisture, insects, birds, and other creatures.

The elongated body further includes four corners each has an inner radius 26 and an outer radius 28. It is to be understood that the inner radius 26 or the outer radius 28 each can vary as long as the stress at the corner is distributed and minimized.

The utility pole 10 can be made by cutting a composite member 50 as shown in Figs. 4A-8C, in the following manner. The composite member for making the utility pole can be made of fiber-reinforced plastic (FRP). Fiber-reinforced plastic is a composite material comprising a polymer matrix reinforced with fibers. The fibers include, but are not limited to fiberglass, jute, sisal, aramid fibers, carbon fibers, boron and other synthetic fibers. The polymer can be any polymer that is the matrix for a composite, such as epoxies, polyesters, urethanes, acrylics and other polymers.

A composite member can be manufactured by a pultrusion process by pulling a plurality of rovings through a resin impregnator and then through a pultrusion die. The resin is typically hardened by heat from the die and forms a rigid, cured profile that corresponds to the shape of the die. Those skilled in the art will recognize that a variety of shapes and sizes of pultruded profiles with constant cross sections can be made by the pultrusion processes, for example, rectangular, square, hexagonal, oval, circular, ellipse, hollow, solid, etc. The

shape of the cross section is determined by the shape of the die.

With reference to Fig. 3 and 4A, a composite member 50 can be made through a typical pultrusion production line 300. One example of a suitable pultrusion production line is described in U.S. Patent No. 5,492,583, filed on July 6, 1994, entitled "Apparatus and Method for In-Line Coating of Pultrusion Profiles" which is incorporated herein by reference. As described in that patent, and illustrated herein in Fig. 3, one embodiment of the pultrusion process begins by pulling a plurality of rovings 310 through a resin impregnator 312 and then through a pultrusion die 314. Another embodiment may also incorporate fiberglass mats or other mats to the inside and/or outside of the composite member to provide cross strength. For example, the pultrusion process begins by pulling a plurality of rovings 310 and at least one mat, with a thickness of approximately 20 mil, through a resin impregnator 312 and then through a pultrusion dies 314. The mats can be formed on the outside or the inside of the pultruded profile, but in a preferred embodiment, one mat is formed on the outside of the pultruded profile and another mat is formed on the inside of the pultruded profile. The benefit of the mats is to provide an additional layer of cross strength to the utility pole. It will be apparent to those skilled in the art that the number of mats is a design choice and based on the calculated required cross strength of the utility pole, one or several may be necessary.

The resin is hardened by heat from the die 314 and forms a rigid, cured profile having a constant cross section that corresponds to the shape of the die 314. A roving 310 typically consists of approximately 4000 glass fibers. While the sizes and numbers of rovings 310 used could vary, the use of rovings 310 with a yield of 113 yards per pound are preferred for this application. It should be recognized that other types of reinforcements such as carbon, aramid or a variety of man made or natural fibers can be used as the rovings 310. In addition, a portion of these fibers as well as the previously described glass fibers can be used in different forms such as in continuous strand mats, chopped strand mats, woven rovings or the like. A polyester thermoset resin could be used with the preferred embodiment; however, those skilled in the art would recognize that other types of resins including vinyl esters, epoxies, phenolics and a variety of thermoplastic resins could be used with the invention. It is to be understood that resin can comprise any percentage of the total material of the pultruded profile. In some embodiments, resin comprises 35% to 80% of the total material by weight of the pultruded profile. In other embodiments, resin comprises 30% to 60% of the total material by weight of the pultruded profile.

The pultrusion die 314 is typically heated to a temperature of 300°F to 400°F and has a length from about 48 to 72 inches to assure that the resin is cured or gelled before exiting the pultrusion die 314 at run speeds that allow economical processing of pultruded profiles, typically in excess of 30 inches per minute. However, any type of die and heating method that will cure and harden or gel (semi-cure) the resin before it exits the pultrusion die 314 could be used. Those skilled in the art would recognize that other types of resins may require other impregnation methods, die configurations or curing methods. Upon exiting the pultrusion die 314 the pultruded profile 318 enters a coating die 320. The coating die 320 applies, for example, a weather protective coating to prevent surface degradation from ultraviolet rays to the outer surface of the pultruded profile 318. However, many types of thermoset type coating materials can be used with the coating die 320. Application of the coating material is not limited to use of the coating die 320 and can be applied by many types of machines made for this purpose, by spray processes, or by hand. At the end of the pultrusion process, a strong, yet light weight, pultruded profile 318 exits the pultrusion production line 300, where it can be cut to any desired length and further operations performed on it.

A pultruded profile manufactured by the pultrusion process can include thousands of unidirectional longitudinally oriented fibers. It is to be understood that the unidirectional, longitudinally oriented fibers can constitute any percentage of the fibers. In some embodiments, the unidirectional, longitudinally oriented fibers constitute approximately 20% to 65% by weight of the fibers. Those skilled in the art will recognize that a variety of shapes and sizes of pultruded profiles 318 with constant cross sections can be made by the pultrusion processes, determined by the shape of the die 314.

In one embodiment, the average time to pull a composite member 50 is about 20 minutes and the average time to assemble, including cutting, trimming, turning and bonding, is about 20 minutes. It will be appreciated that the times given are only approximations for a specific embodiment. The time can vary depending on the size of the composite member, the materials used, and the methods used.

In one embodiment, a utility pole can be made to be more resistant to surface degradation from ultraviolet (UV) light by adding a UV additive to the polymer. In addition, during the pultrusion process, a UV resistant polyester mat can be applied to the outside surface of the utility pole. To further protect the utility pole from UV degradation, a UV weather protective coating can also be applied during the pultrusion process, as shown at a coating die 320 in Fig. 3.

Fig. 4A is an enlarged front side view of one embodiment of the composite member 50. Fig. 4B is a bottom view of the composite member 50 of Fig. 4A. Fig. 4C is a smaller scale front side view of the composite member of Fig. 4A. As shown in this embodiment, the composite member 50 is hollow and in a generally rectangular shape. In another
5 embodiment, the cross section of the composite member 50 can be an oval as shown in Fig. 4D where the indentations 130, 132 are essentially flat. Other embodiments can include cross sections that are multi-sided or other polygonal shapes, e.g. hexagonal, octagonal, square, etc., or whatever the application dictates as long as the indentations are essentially flat.

10 In one embodiment, a cross section of the composite member 50 has a constant generally rectangular shape as it exits a die made by a pultrusion process, because the typical die used in the pultrusion process can only make a structure having a constant cross section. The composite member 50 has a front side 56 and a rear side 57 parallel to each other, a left side 58 and a right side 59 parallel to each other, a top end 52 and a bottom end 54. The
15 composite member 50 has a geometry center O, a vertical axis b-b' across the center O and parallel to the front side 56, rear side 57, left side 58 and right side 59 of the composite member 50, and a horizontal axis c-c' across the center O and perpendicular to the left side 58 or right side 59 of the composite member.

The composite member 50 has an overall height H_c , a constant width W_c and a
20 constant thickness T_c . It is to be understood that the height H_c , the width W_c and the thickness T_c can vary to the extent the dimension and strength of the assembled elongated body of the utility pole allows. In some embodiments, the height H_c can be over 160 feet and preferably between 35 feet and 120 feet, the width W_c is in the range of from 6.0 inches to 72 inches and the thickness T_c is in the range from 3 inches to 60 inches. In another
25 embodiment, the height H_c is between 40 feet and 160 feet. A composite member having a length of between 30 feet and 180 feet, can easily be fabricated to be used to make assembled utility poles that match or exceed the properties of poles made from other materials, such as wood, steel, or cement. In addition, each of the sides 54, 56, 57, 60 will have a similar profile and sides 58, 59 will have a similar shape and thickness t_c . It is to be understood that
30 the thickness of the sides can vary depending on the strength and dimension requirement of the utility pole. In some embodiments, the thickness chosen for the sides can range from 0.1 inch to 3.0 inches.

In one embodiment, the front side 56 includes an outer surface 60 having a front

indentation 61 formed therein defined by a front left indentation edge 68 and a front right indentation edge 70. The rear side 57 includes an inner surface 62 having a rear indentation 63 formed therein defined by a rear left indentation edge 69 and a rear right indentation edge 71. The centerline of the front indentation 61 and the centerline of the rear indentation 63 are in opposite positions. The front indentation 61 has a thicknesses t_{fi} and a width w_{fi} . The rear indentation 63 has a thickness t_{ri} and a width w_{ri} . It is to be understood that the thicknesses t_{fi} , t_{ri} can each vary depending on the strength or dimension requirements of the utility pole. In one embodiment, the thicknesses t_{fi} , t_{ri} of the indentations are each chosen from the range from 0.05 to 1.5 inches. In a preferred embodiment, the thicknesses t_{fi} and t_{ri} are each constant and equal to each other. It is to be understood that the widths w_{fi} and w_{ri} can each vary depending on the strength or dimension requirements of the utility pole. In one embodiment, the widths w_{fi} and w_{ri} are constant and equal to each other and are chosen from the range from 2.0 inches to 60 inches. In another embodiment, the widths w_{fi} and w_{ri} are constant and equal to each other and are chosen from the range from 0.5 inches to 60 inches.

Fig. 5 is a front view of the composite member 50 being cut into a first tapered elongated segment 72 and a second tapered elongated segment 74 by a diagonal plane at an angle θ with the vertical axis b-b' and perpendicularly to the front side 56 or rear side 57, within the widths of the front and rear indentations 61 and 63. The diagonal cutting is necessary for forming a tapered elongated body for a utility pole since profiles formed by a pultrusion process typically have constant cross sectional shape. The stresses at the corners of the elongated body 12 are high, therefore, it is preferred that the bonding joint not be located at the corners of the elongated body 12. The orientation and position of the diagonal line 66 determines the exact configuration of the resultant elongated body of the utility pole when assembled. The diagonal plane intersects with the front side at line 66 and the rear side 66' (not shown). The lines 66 and 66' are parallel to each other. The lines 66, 66' each has an upper end 64, 64' (not shown) and a lower end 65, 65' (not shown) spaced away from the indentation edges 68, 69, 70, 71 respectively. The minimum space between the ends 64, 64', 65, 65' and the indentation edges is 0.5 inch to 10 inches. It is preferred, but not required, that the diagonal plane passes through the center O so that the composite member 50 is bisected and the first and second tapered elongated segments 72 and 74 are identical segments of a uniformly varying width. The severing operation along the line 66 can be done by any tool which will accurately provide a linear cutting line, for example,

mechanical saws, laser cutters, or waterjet saws.

In one embodiment, the angle θ is an acute angle varying from 0.2° to 5° . It will be appreciated that the positioning of the diagonal plane can vary and does not have to cross the center O, or even parallel to the front side 56 or rear side 57. It will be further appreciated that the lower angle range varies to the extent that the indentation widths w_{fi} , w_{ri} of the composite member 50 allows.

Fig. 6A is a front side view of the first and second tapered elongated segments 72, 74 being separated from each other. Fig. 6B is a cross section view of the first and second tapered elongated segments 72, 74 of Fig. 6A along line 6B-6B, illustrating the top ends of first and second tapered elongated segments. Fig. 6C is a cross section view of the first and second tapered elongated segments 72, 74 of Fig. 6A along line 6C-6C, illustrating the bottom ends of first and second tapered elongated segments. The first tapered elongated segment 72 has a top end 92, a bottom end 94, a front side 100, and a rear side 108. In one embodiment, the front and rear sides 100 and 108 are parallel to each other and of the same size and dimension. The first elongated body 72 also has a front inner indented wall portion 112 cut from the front indentation 61, and a rear outer indented wall portion 82. In one embodiment, the front inner indented wall portion 112 and the rear outer indented wall portion 82 are of the same size and dimension.

The second tapered elongated segment 74 has a top end 96, a bottom end 98, a front side 102, and a rear side 110. In one embodiment, the front and rear sides 102 and 110 are parallel to each other and of the same size and dimension. The second elongated body 74 also has a front inner indented wall portion 114 cut from the front indentation 61, and a rear outer indented wall portion 90. In one embodiment, the front outer indented wall portion 112 and the rear inner indented wall portion are of the same size and dimension.

Fig. 7A is a front side view of the first and second tapered elongated segments 72, 74 after the second tapered elongated segment 74 being rotated 180 degrees about c-c', such as shown in Fig. 4B. Fig. 7B is a cross section view of the first and second tapered elongated segments 72, 74 of Fig. 7A along line 7B-7B, illustrating the new top ends 92, 98' of the first and second tapered elongated segments 72, 74 after the second tapered elongated segment 74 being rotated 180 degrees c-c', such as shown in Fig. 4B. Fig. 7C is a cross section view of the first and second tapered elongated segments of Fig. 7A along line 7C-7C, illustrating the new bottom ends 94, 96 of the first and second tapered elongated segments 72, 74 after the second tapered elongated segment 74 being rotated 180 degrees c-c', such as shown in Fig.

4B. The second tapered elongated segment 74 is rotated about the c-c' axis (shown on Fig. 4B), whereby the bottom end 98 of the second tapered elongated segment 74 is disposed upon the same plane and corresponds to the top end 92 of the first tapered elongated segment 72. The second tapered elongated segment 74 then has a new top end 98', a new bottom end 96', a new front side 110' and a new rear side 102'. In turn, the second tapered elongated segment 74 has a front outer indented wall portion 90' and a rear inner indented wall portion 114', which were the rear outer indented wall portion 90 and the front inner indented wall portion 114 of the second tapered elongated segment 74 respectively before the second tapered elongated segment 74 was rotated. The front inner indented wall portion 112 of the first tapered elongated segment 72 and the front outer indented wall portion 90' of the second elongated body 74 form a first set of indented wall portions. The rear outer indented wall portion 82 of the first tapered elongated segment 72 and the rear inner indented wall portion 114' of the second tapered elongated segment 74 form a second set of indented wall portions.

As shown in Fig. 9A, the composite member 50 is comprised of primarily unidirectional, longitudinally oriented fibers 51. Fig. 9B, details the fibers adjacent the top ends of the first tapered elongated segment 72 and the second tapered elongated segment 74. As shown in Fig. 9C, when the indented wall portions 90', 112 or 82, 114' are bonded to form the elongated body 150, the unidirectional, longitudinally oriented fibers 51 cross at an angle 53. In the overlap of the segments, as shown in Fig. 8B and 8C, the differential planes of the segments intersect creating a higher shear strength along the plane where 90' and 112 overlap and 114' and 82 overlap. This is the area, in Fig. 8A, where the shear from 8B to 8C is the highest. As a result, the unidirectional, longitudinally oriented fibers of the composite member cross at an angle. This significantly strengthens the longitudinal shear resistance of the utility pole due to bending.

Fig. 8A is a front side view of an assembled structure formed by the first and second tapered elongated segments 72, 74. Fig. 8B is a cross section view of Fig. 8A along line 8B-8B, illustrating a top end of the assembled structure. Fig. 8C is a cross section view of Fig. 8A along line 8C-8C, illustrating a bottom end of the assembled structure. The first and second tapered elongated segments are assembled together to form an elongated body 150 of the utility pole. The first set of indented wall portions 90' and 112 are equivalently dimensioned so that they fit together to form smooth inner and outer surfaces of a front wall 118 of the elongated body 150. Likewise, the second set of indented wall portions 82 and 114' are equivalently dimensioned so that they fit together to form smooth inner and outer

surfaces of a rear wall 120 of the elongated body 150.

It will be appreciated that the indented wall portions 112, 90' and 82, 114' are assembled by bonding, for example, by adhesives or fastening devices or a combination thereof. Fastening devices can be any type of device that can hold two separate components together, for example, but not limited to, rivets, screws, bolts, banding, plastic ties, etc. The adhesive can be, for example, a thermosetting adhesive, a chemical adhesive, a contact adhesive, a hot adhesive, or a pressure adhesive made of, for example, a polyester resin. The adhesive can be applied, for example, by machine or by hand as long as a substantially even coating of the adhesive is applied covering as much square area of the indented wall portions 90', 112 or 82, 114' as has been determined to be necessary to effectuate a secure and strong bond. Prior to application of the adhesive, it is preferable that steps be taken to ensure that a predominant amount of dust or impurities are removed from the surface of the indented wall portions 90', 112 or 82, 114' since dust and impurities can weaken the bond. In one embodiment, adhesives are applied between the indented wall portions 90', 112 or 82, 114' to bind them to each other.

For example, one embodiment of the cross section of the composite member 50 can have a width W_c of 33.25 inches and a thickness T_c of 15 inches. The sides 18, 20, 22, 24 have a constant thickness t_c of 1.0 inch. The indented wall portions 182, 190, 212, 214 have a constant thickness t_{ri} , t_{ri} of 0.5 inch. Once the composite member 50 is cut and assembled into an elongated body 12, the cross-section of the top end 14 has a width W_c of 16 inches and a thickness T_c of 15 inches. The sides 18, 20, 22, 24 have a constant thickness t_c of 1.0 inch. The indented wall portions 182, 190, 212, 214 have a constant thickness $t_{ri} + t_{ri}$ of 1.0 inch with an overlap of 2.0 inches. The cross-section of the base end 16 has a width W_c of 32 inches and a thickness T_c of 15 inches. The sides 18, 20, 22, 24 have a constant thickness t_c of 1.0 inch. The indented wall portions 182, 190, 212, 214 have a constant thickness $t_{ri} + t_{ri}$ of 1.0 inch with an overlap of 16 inches.

With reference to Figs. 10A-B, in one embodiment, the pultrusion die can be adjusted such that a joint between the indentations and an adjacent wall can include a slanted surface 195 during the pultrusion process. Also, after the diagonal cutting, each free end of the indented walls is slightly beveled to form a slanted surface 197 accordingly. The slanted surfaces 195, 197 are sized such that, after one segment is rotated 180 degrees about an axis transverse to a longitudinal axis of the composite member 150, the segments 172, 174 can be assembled together with the slanted surfaces 197, 195 being positioned to fit each other, as

shown in Fig. 10B. Thus, a more strongly bonded joint is formed between the slanted surfaces 195, 197 to bond the segments 172, 174 together. The angle λ between the slanted surface 197 and an unindented surface of an indented wall can vary depending on the requirements for the bonding strength between the slanted surfaces 195, 197. In one embodiment, the angle λ is in the range of 10 degrees to 80 degrees. In another embodiment, the angle λ is in the range of 10 degrees to 90 degrees. It is to be understood that the angles between the slanted surfaces 197 and the unindented surface of the indented walls can vary from each other. The angle between the slanted surface 195 and the unindented surface of the indented wall corresponds to the angle λ as long as after rotated 180 degrees, the two slanted surfaces are angled to match each other. The slanted surfaces 197 are cut by different machines, for example, an angled diamond cutter or a two blades cutter.

With reference to Figs. 11A-D, in one embodiment, the composite member 250 does not include indentations, as shown in Fig. 11A. After the composite member 250 is cut into two segments, Fig. 11B, the free ends 293 of the walls at one side of the composite member 250 are slightly beveled shorter than the free ends 291 on the other side of the composite member 250 such that after being rotated 180 degrees, the shorter free ends 293 are each positioned inside the assembled elongated body and fit snugly with the corresponding corner, as shown in Fig. 11C. The walls of the two segments overlap entirely with each other, as shown in Figs. 11C and 11D.

The embodiments disclosed in this application are to be considered in all respects as illustrative and not limitative. The scope of the invention is indicated by the appended claims rather than by the foregoing description; and all changes which come within the meaning and range of equivalency of the claims are intended to be embraced therein.

CLAIMS

What is claimed is:

1. A composite utility pole, comprising:

5 an elongated body formed by at least two elongated tapered segments that are formed by cutting a common composite member that has a constant cross section at an angle along a diagonal line from one end to another end of the common composite member,

each elongated tapered segment including a first end and a second end that is larger than the first end,

10 wherein the elongated body is formed by rotating at least one elongated tapered segment 180 degrees about an axis transverse to a longitudinal axis of the composite member such that all the second ends of the tapered elongated segments are placed together and all the first ends of the tapered elongated segments are placed together, and the elongated tapered segments are assembled together.

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2. The composite utility pole of claim 1, wherein the elongated body is formed by positioning a first free end of an elongated tapered segment inside another elongated tapered segment and positioning a second free end of the elongated tapered segment that is longer than the first free end of the elongated tapered segment outside the another elongated tapered
20 segment, whereby the first free end fits snugly with a corresponding inner corner of the another elongated tapered segment.

3. A composite utility pole, comprising:

25 an elongated body formed by at least two elongated tapered segments that are formed by diagonally cutting a common composite member that has a constant cross section and two opposite indentations, with the cutting line across each indentation such that each indentation is divided into at least two indented walls,

each elongated tapered segment including a first end and a second end that is larger than the first end,

30 wherein the elongated body is formed by rotating at least one elongated tapered segment 180 degrees about an axis transverse to a longitudinal axis of the composite member such that all the second ends of the tapered elongated segments are placed together,

wherein indented walls of one segment match and are overlapped with indented walls

of the other segment, respectively, such that outer and inner surfaces of an overlap track outer and inner surfaces of an adjacent wall of the composite utility pole, respectively.

4. The composite utility pole of claim 3, wherein the utility pole is comprised of a fiber-
5 reinforced plastic.

5. The composite utility pole of claim 3 or 4, wherein the fiber-reinforced plastic has a UV additive.

10 6. The composite utility pole of any of claims 3-5, wherein an outer surface of the utility pole includes a UV resistant polyester mat and/or a UV weather protective coating.

7. The composite utility pole of any of claims 3-6, wherein an inner or outer surface of the composite member includes a cross strength mat.

15

8. The composite utility pole of any of claims 3-7, wherein the cross section of the composite member is rectangular or oval.

9. The composite utility pole of claim 8, wherein the oval composite member has two
20 opposite indentations that are flat and are cut diagonally to allow a tapered pole with curved sides to be formed.

10. The composite utility pole of any of claims 3-9, wherein the first and second elongated tapered segments are substantially equal in dimension.

25

11. The composite utility pole of any of claims 3-10, wherein the first elongated segment and the second elongated segment are joined by an adhesive or fastener.

12. The composite utility pole of any of claims 3-11, wherein, at the overlap,
30 unidirectional, longitudinally orientated fibers of one indented wall intersect unidirectional, longitudinally orientated fibers of the other indented wall.

13. The composite utility pole of any of claims 3-12, wherein a joint between an

indentation and an adjacent wall is formed with a first slanted surface, and a free end of an indented wall is formed with a second slanted surface, whereby the two elongated tapered segments are assembled together, the first and second slanted surfaces are sized and angled to match each other to form a joint section.

5

14. A method for making a composite utility pole, comprising:

cutting a composite member that has a constant cross section and at least two indentations at an angle along a diagonal line from one end to another end of the common composite member such that the composite member is cut into at least two tapered elongated segments, each indentation being divided into at least two indented walls, each tapered elongated segment having a first end and a second end that is larger than the first end;

10

rotating at least one tapered elongated segment 180 degrees about an axis transverse to a longitudinal axis of the composite member such that all the second ends of the tapered elongated segments are placed together and all the first ends of the tapered elongated

15

segments are placed together;

assembling the elongated tapered segments together such that indented walls of one segment matches and are overlapped with indented walls of the other segment, respectively, and outer and inner surfaces of an overlap track outer and inner surfaces of an adjacent wall, respectively; and

20

bonding the overlapped indented walls together to form an elongated body of the composite utility pole.

15. The method for making a composite utility pole of claim 14, further comprising forming a first slanted surface at a joint between an indentation and an adjacent wall, forming a second slanted surface at a free end of an indented wall, matching the first slanted surface with the second slanted surface such that a joint section is formed by the first and second slanted surfaces at an end of an overlap.

25

Fig. 1A

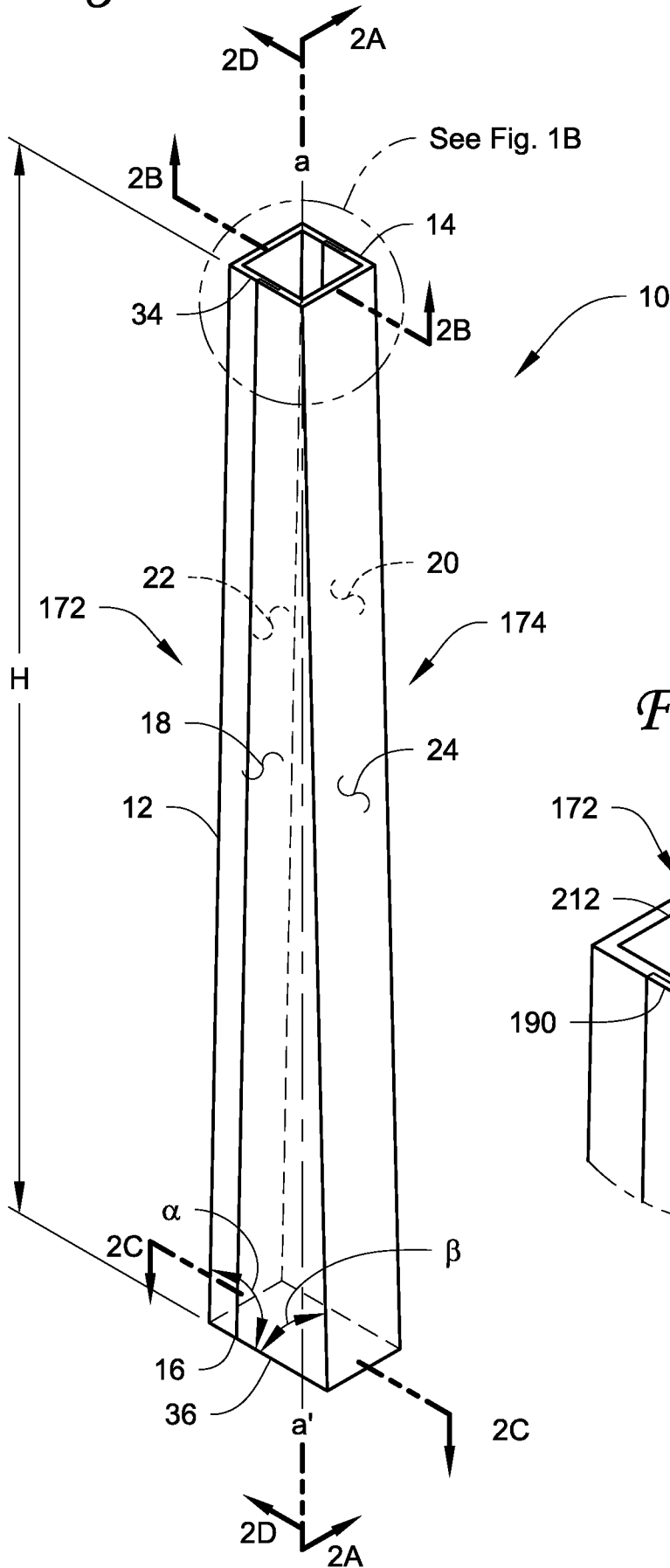


Fig. 1B

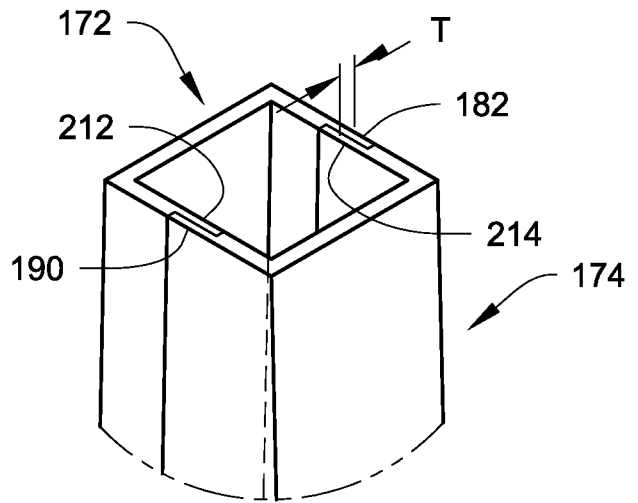


Fig. 2A

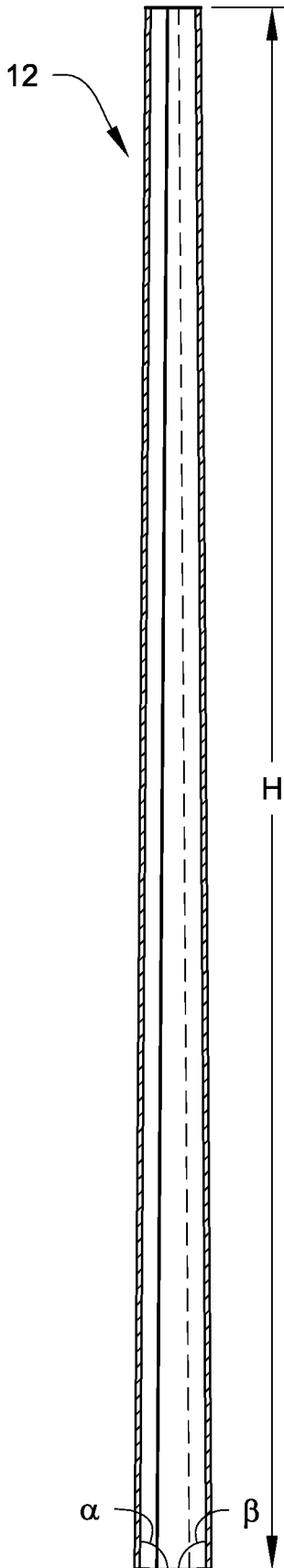


Fig. 2B

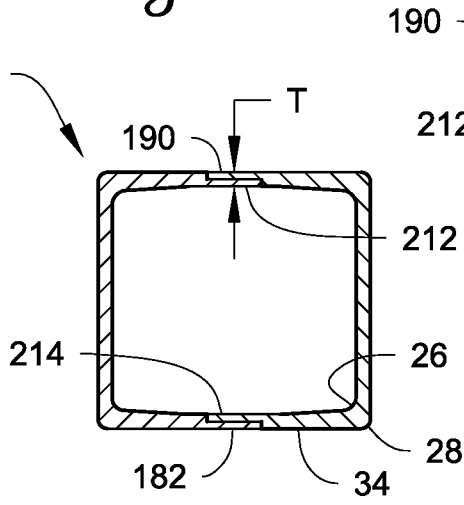


Fig. 2D

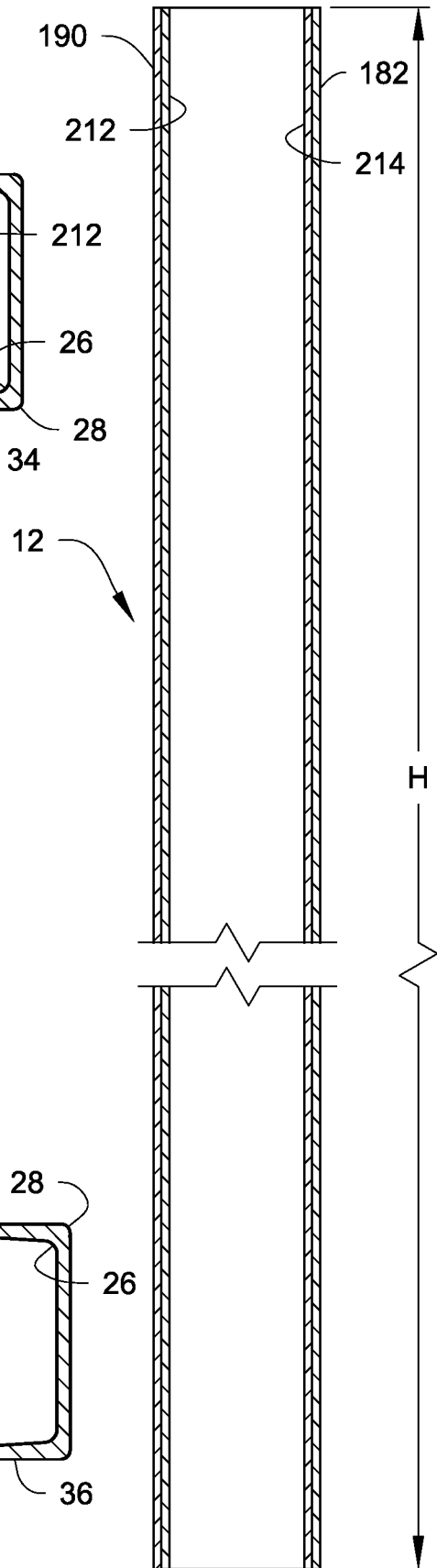


Fig. 2C

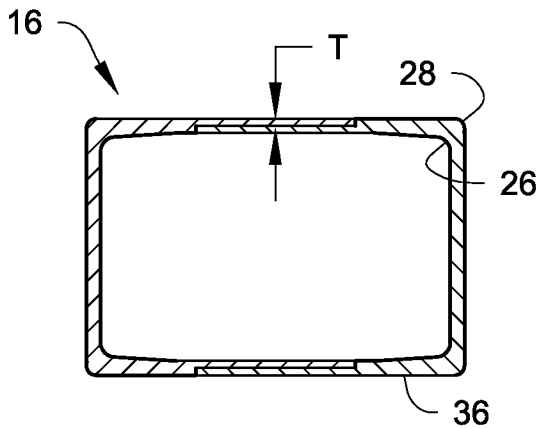


Fig. 3

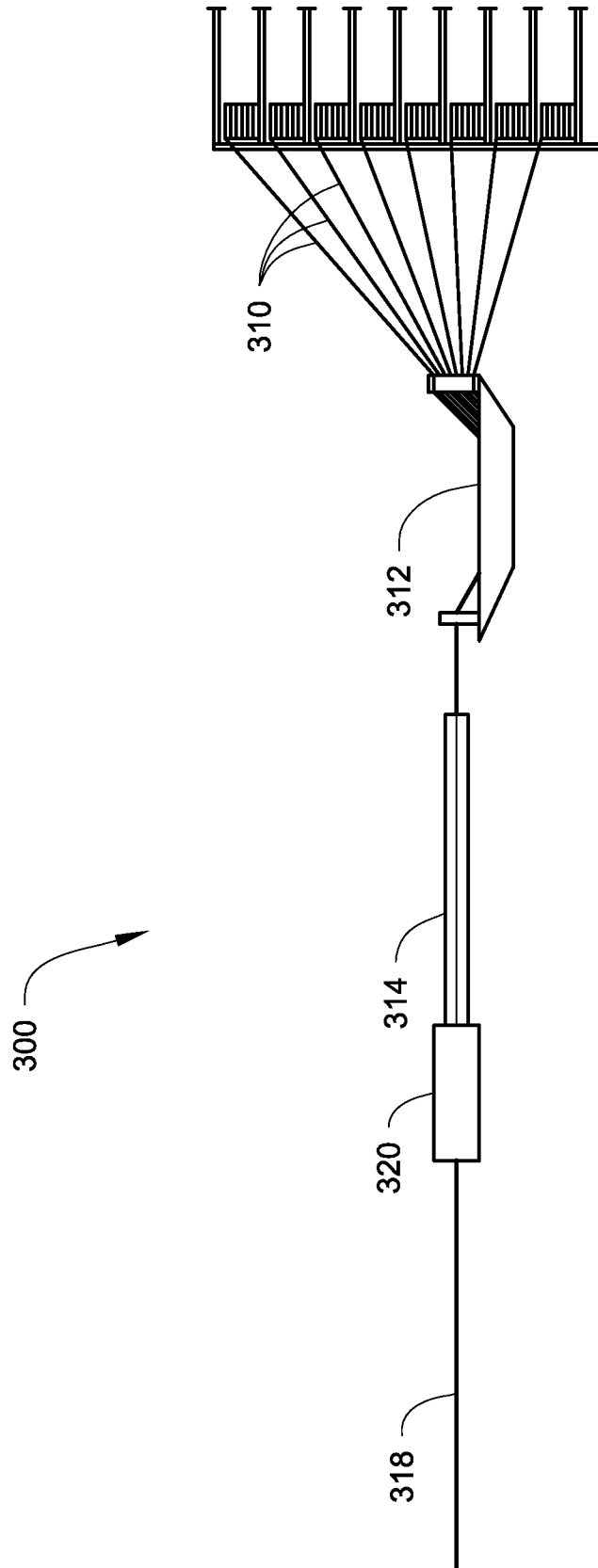


Fig. 4A

4/12

Fig. 4B

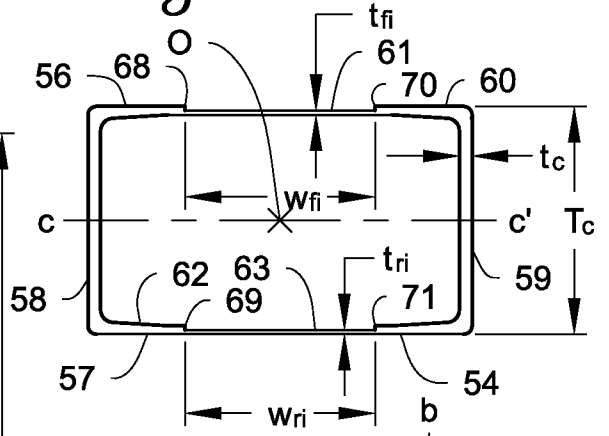
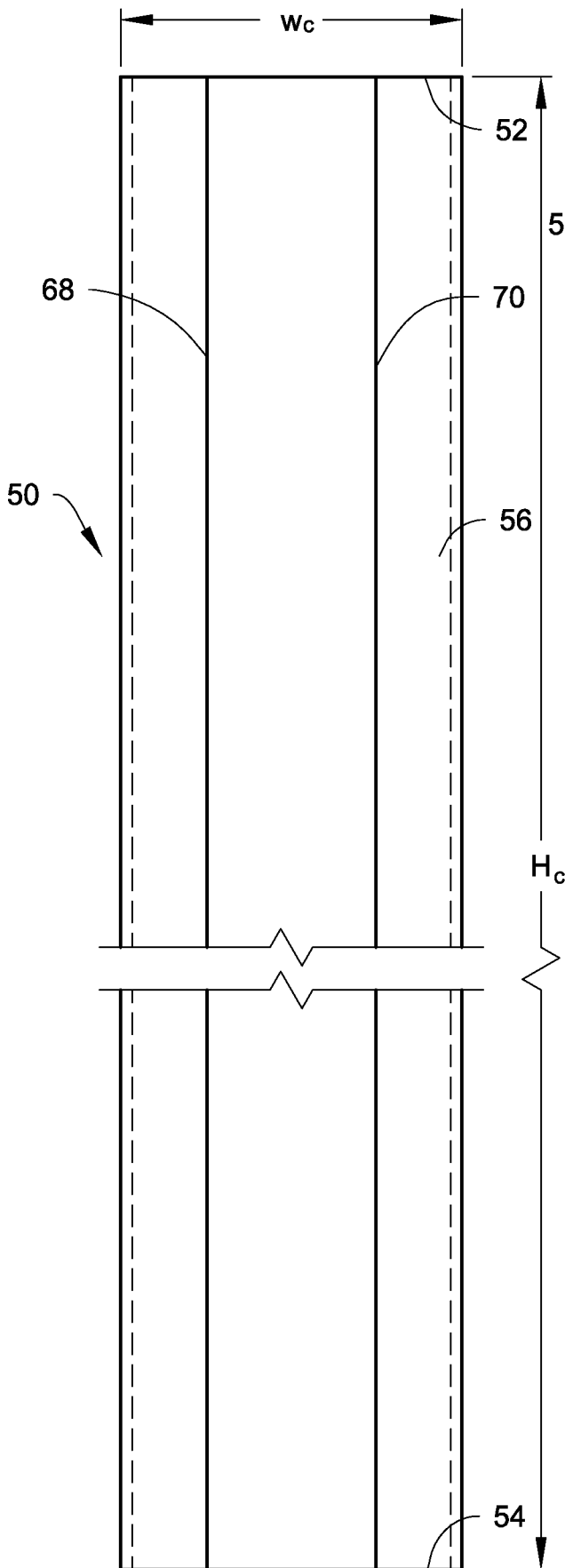


Fig. 4C

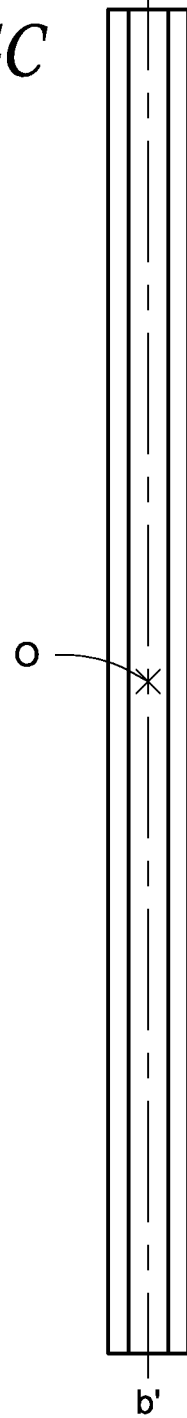


Fig. 4D

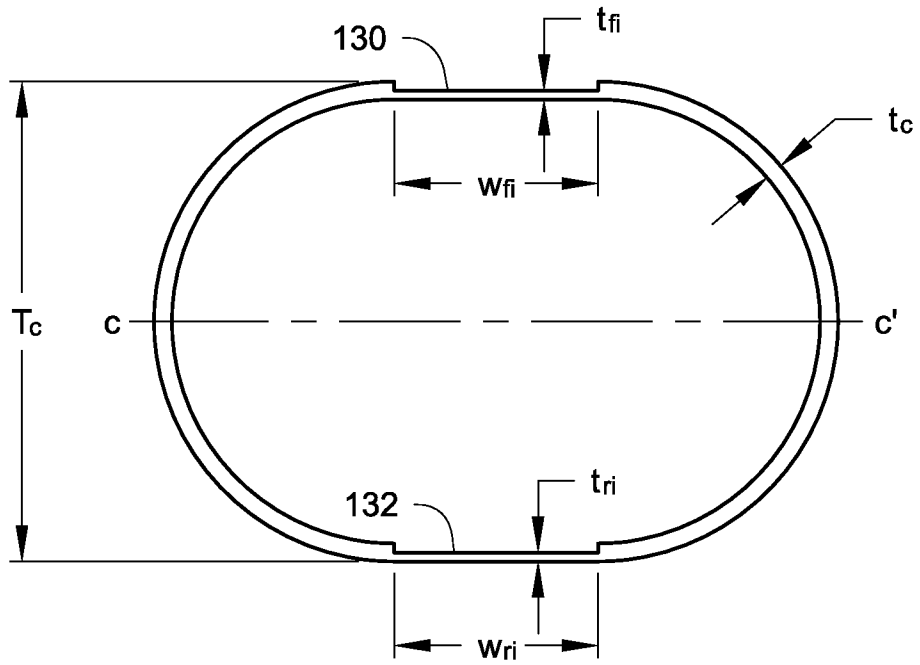


Fig. 5

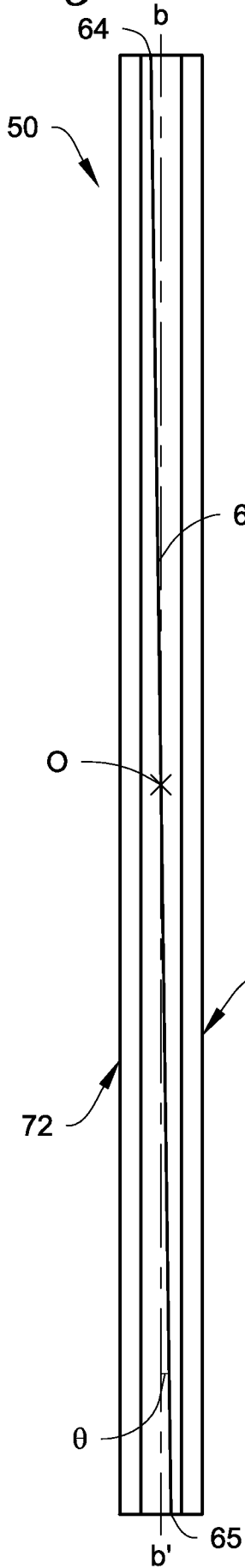


Fig. 6A

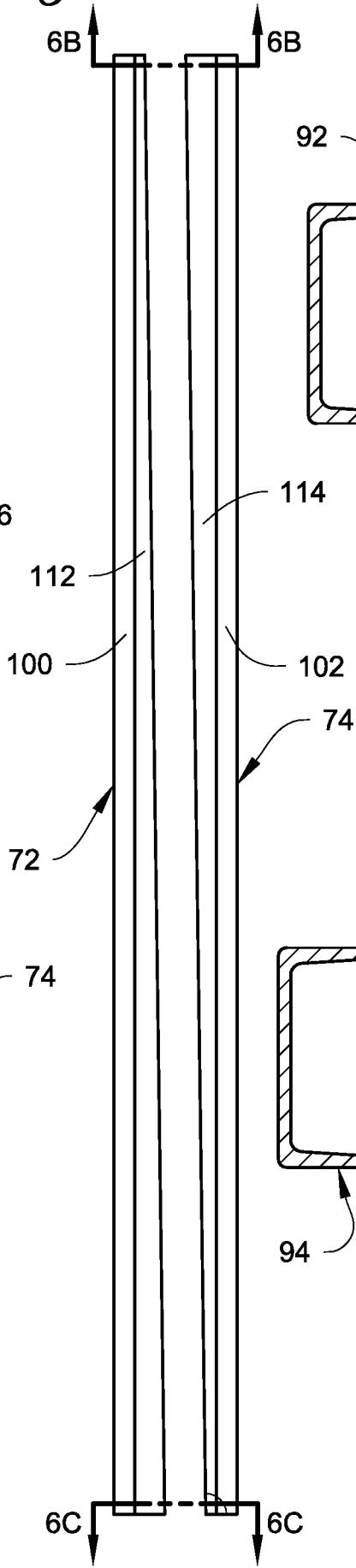


Fig. 6B

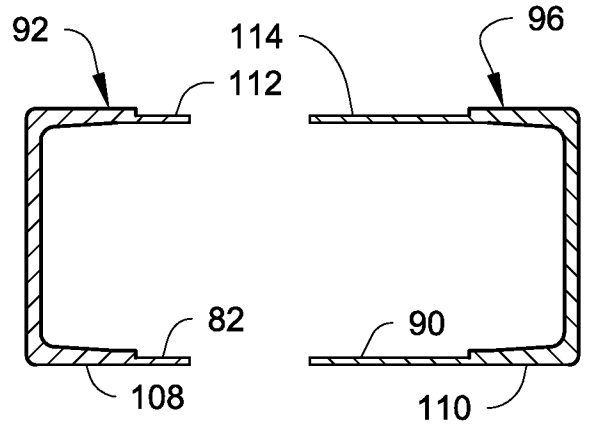


Fig. 6C

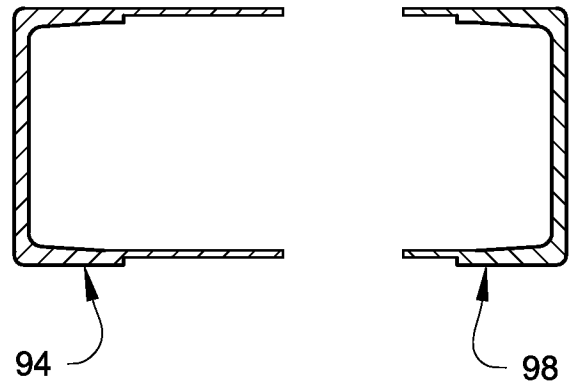


Fig. 7A

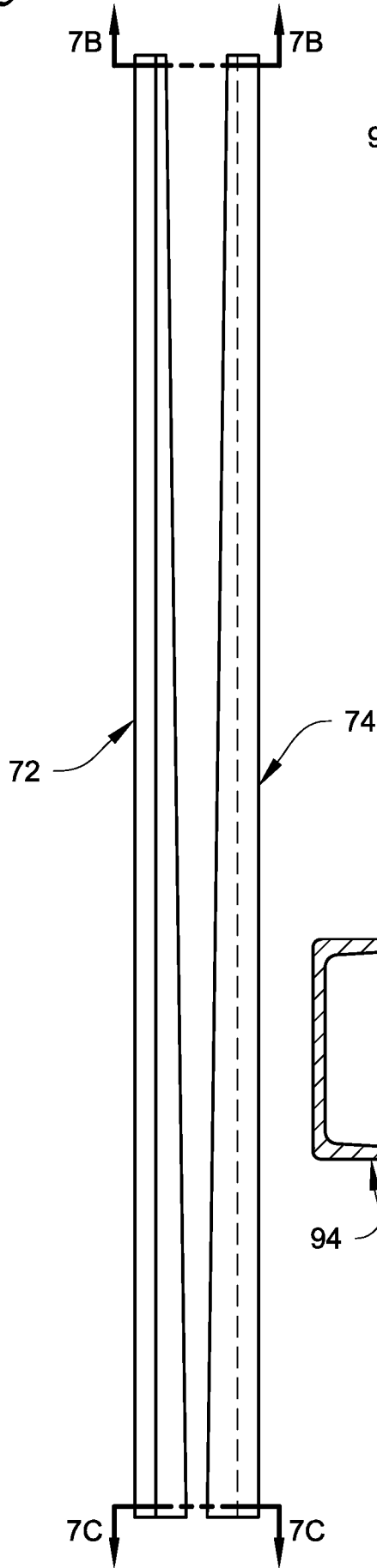


Fig. 7B

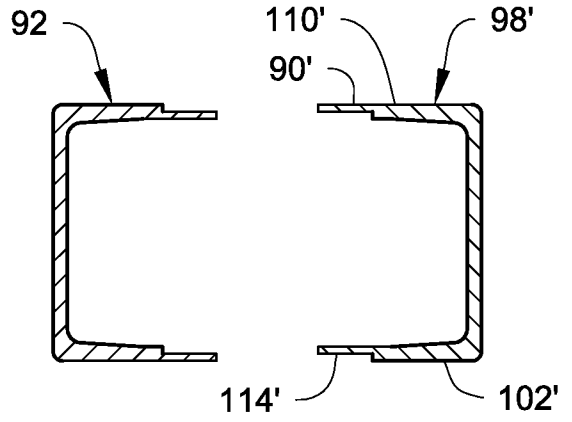


Fig. 7C

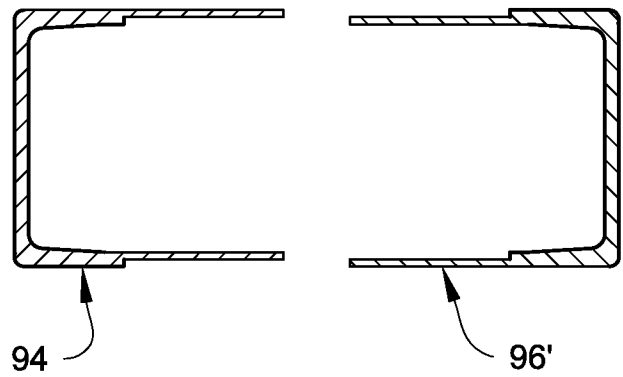


Fig. 8A

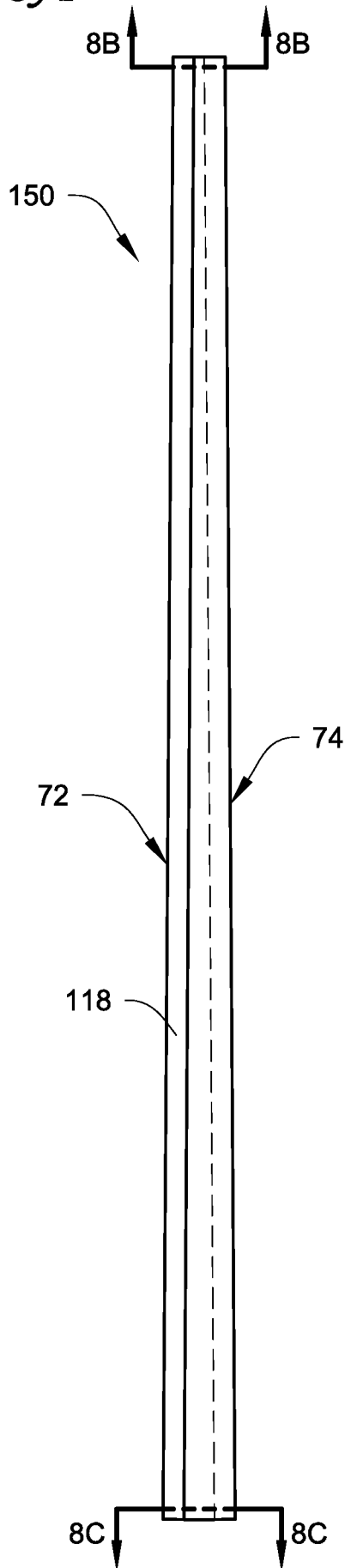


Fig. 8B

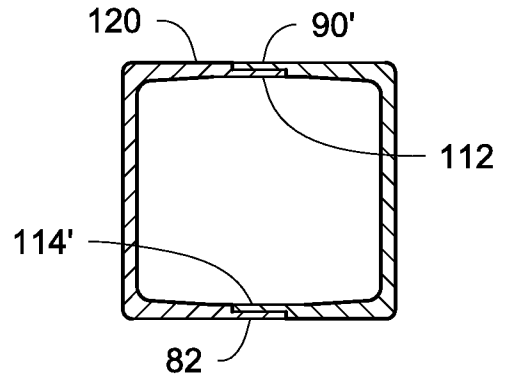


Fig. 8C

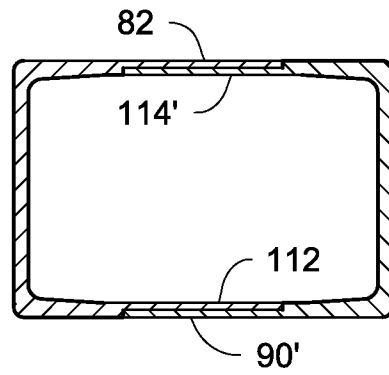


Fig. 9A

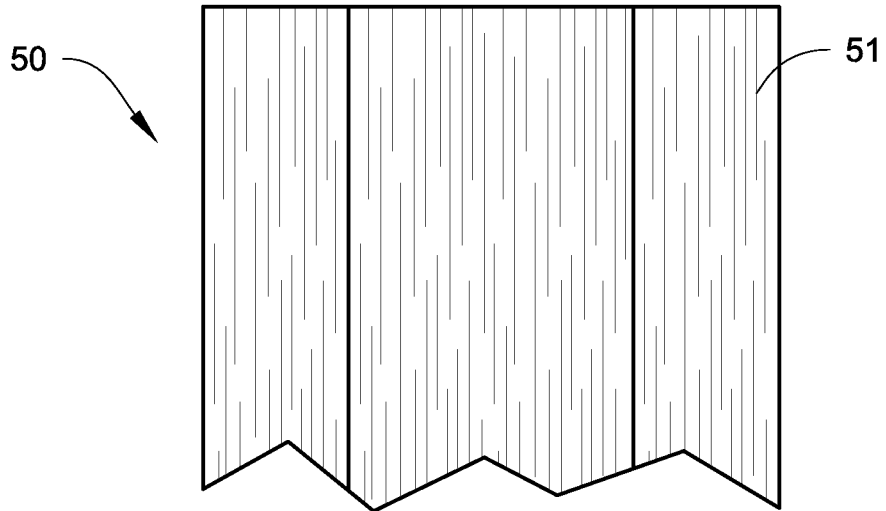


Fig. 9B

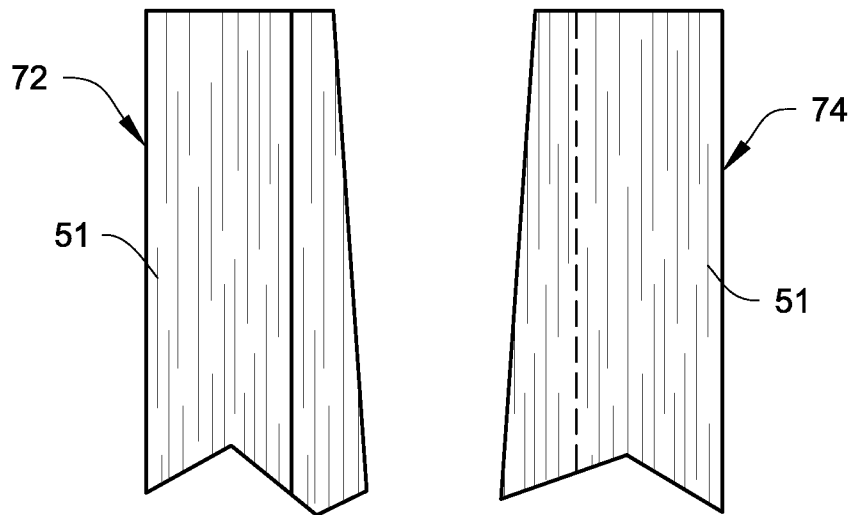
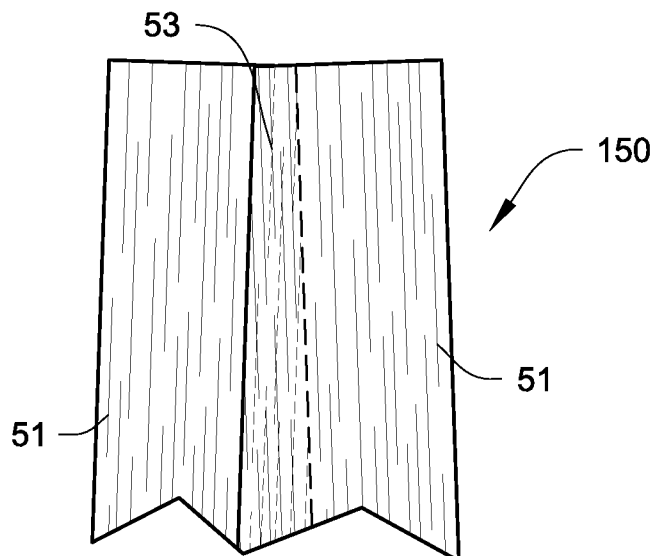
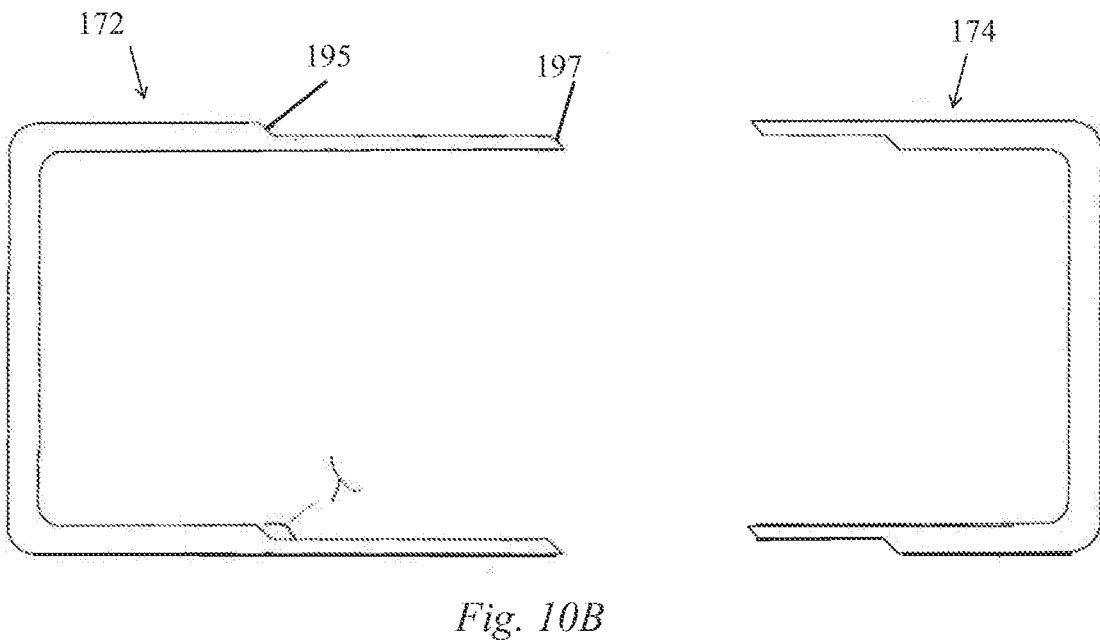
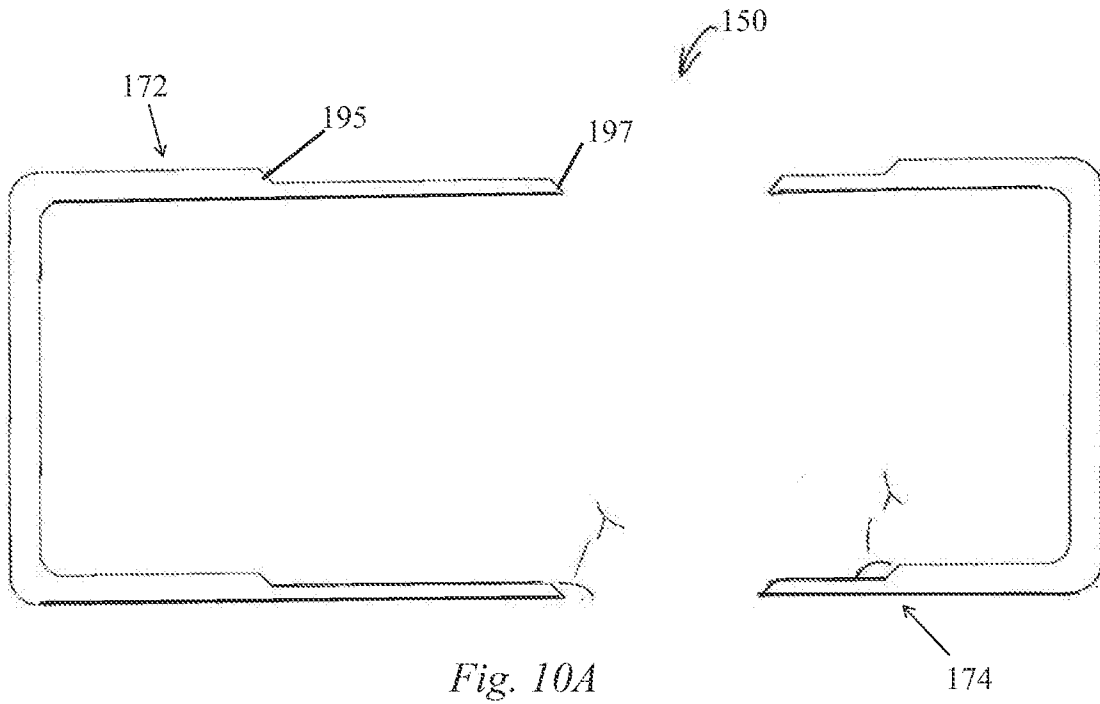


Fig. 9C





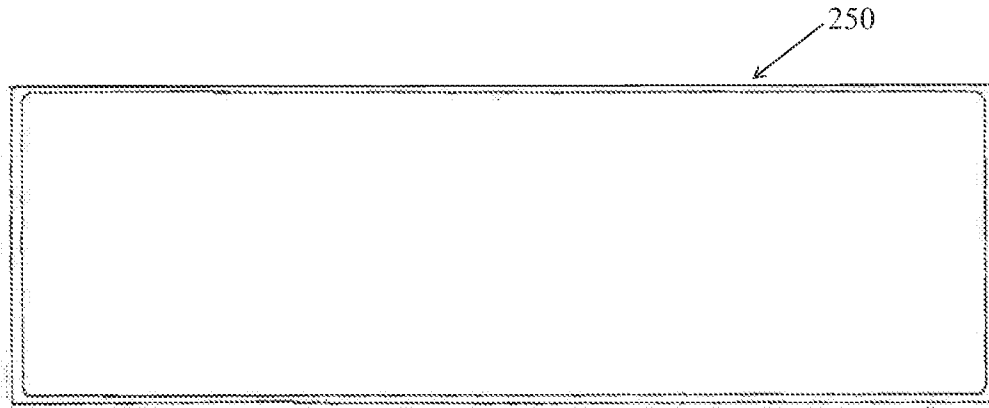


Fig. 11A

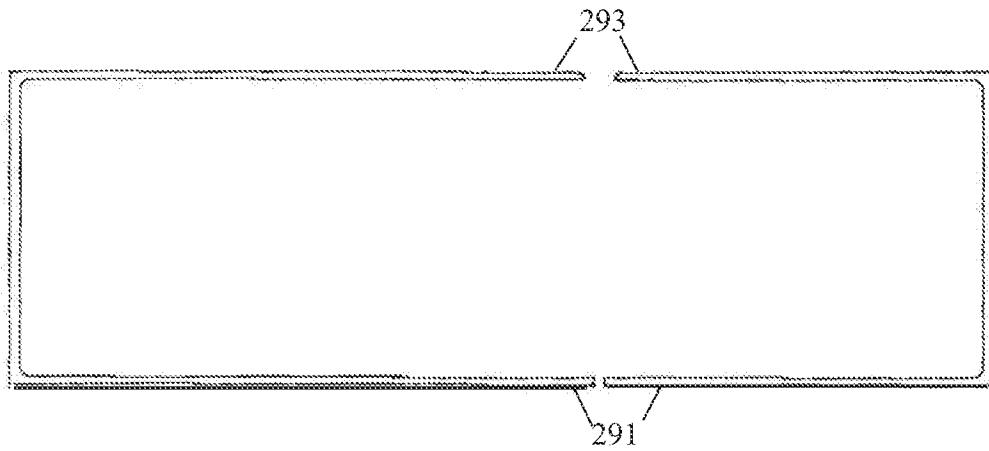


Fig. 11B

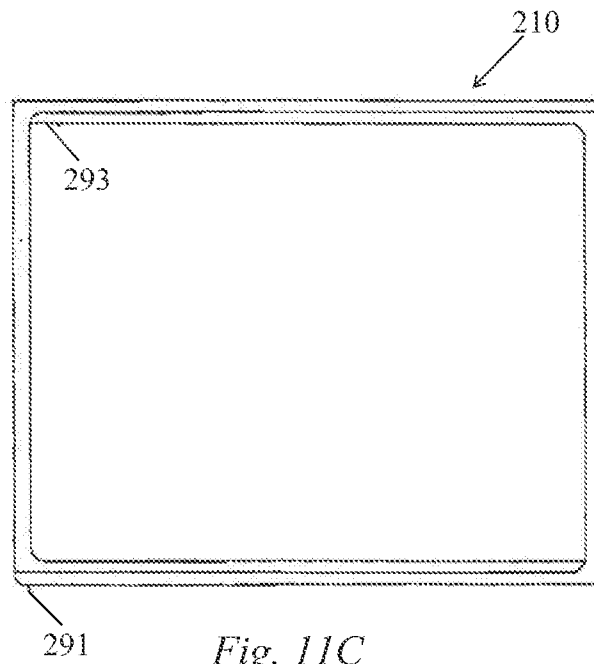


Fig. 11C

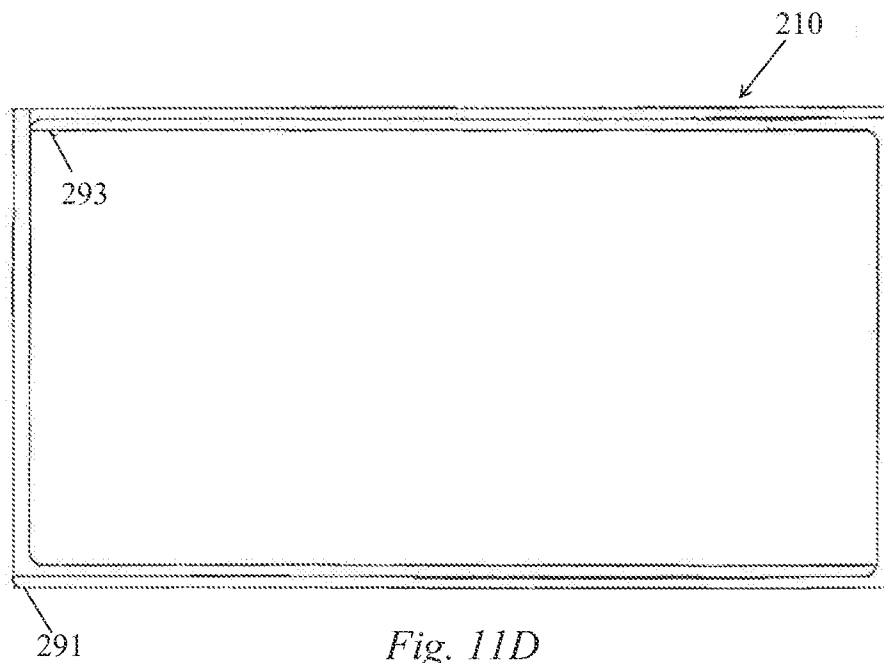


Fig. 11D