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(54) Titre : RESERVOIRE SOUPLE POUR UN CONTENEUR D'EXPEDITION
(54) Title: FLEXIBLE TANK FOR 40-FOOT SHIPPING CONTAINER

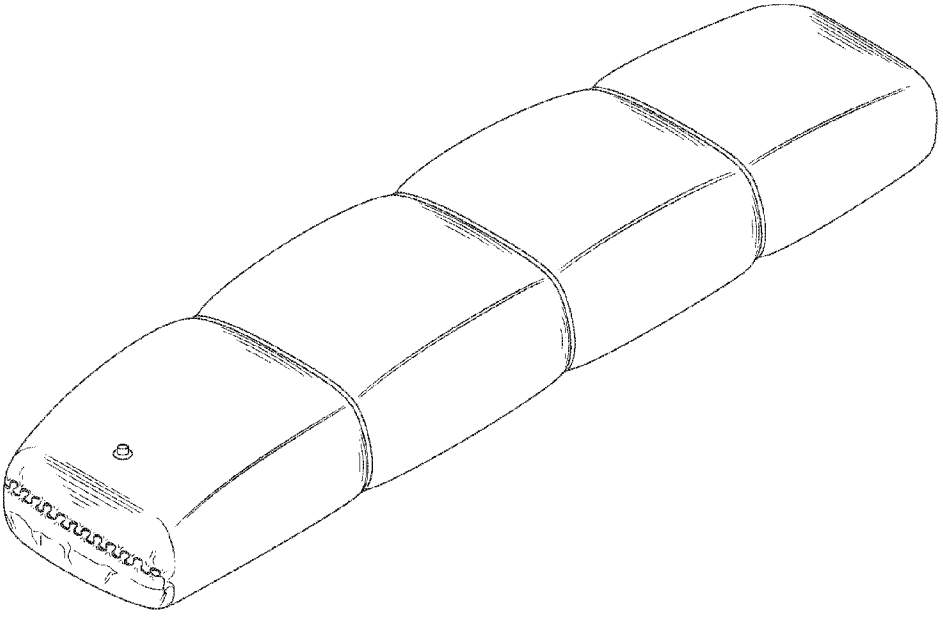


FIG. 1B

(57) Abrégé/Abstract:
A flexible tank is used to transport liquids or semi-liquid material in a shipping container on a railroad car. It has an inner tank ancl at least one end closure with alternating interlaced hollow loops from two separate exterior layers. A nylon rope or similar securing element is passed through the hollow loops to use the exterior layers in an end closure to constrain the inner tank. An end flap may be welded to an exterior layer and positioned between the inner tank and the end closure. The hollow loops may be formed by folding over the exterior layers and cutting out complementary portions so the loops are in an alternating interlaced pattern. Capacity bands located around the periphery of the flexible tank suppress expansion of the flexible tank at their respective locations.

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(54) **Title:** FLEXIBLE TANK FOR A SHIPPING CONTAINER

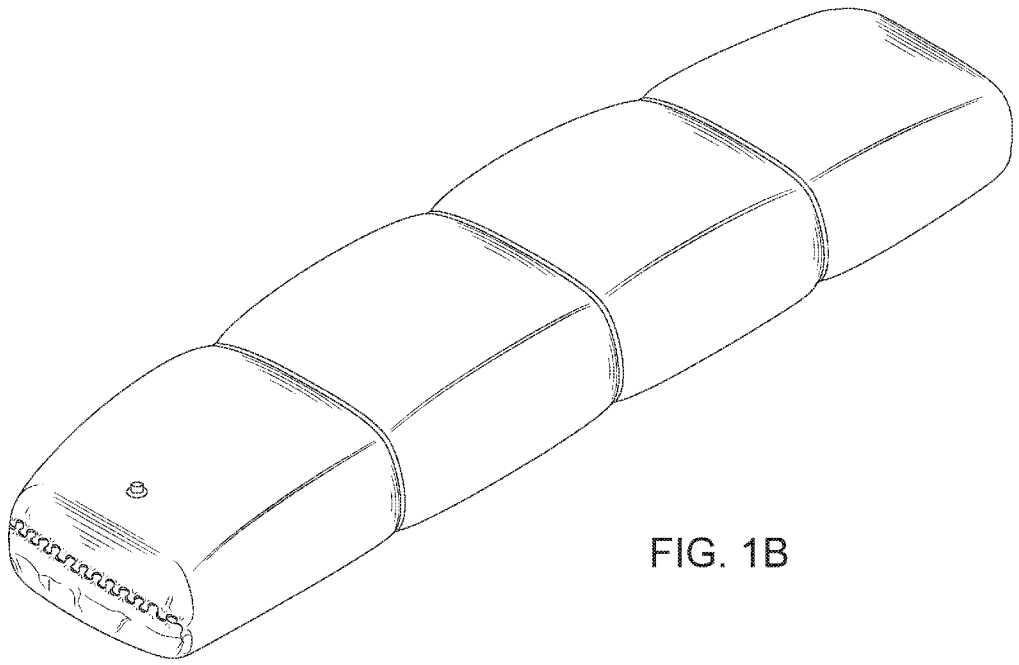


FIG. 1B

(57) **Abstract:** A flexible tank is used to transport liquids or semi-liquid material in a shipping container on a railroad car. It has an inner tank and at least one end closure with alternating interlaced hollow loops from two separate exterior layers. A nylon rope or similar securing element is passed through the hollow loops to use the exterior layers in an end closure to constrain the inner tank. An end flap may be welded to an exterior layer and positioned between the inner tank and the end closure. The hollow loops may be formed by folding over the exterior layers and cutting out complementary portions so the loops are in an alternating interlaced pattern. Capacity bands located around the periphery of the flexible tank suppress expansion of the flexible tank at their respective locations.

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Flexible Tank for 40-foot Shipping Container

Background

Lengthy shipments of goods frequently involve multiple modes of transport, such as ocean going vessels, railroad cars and trucks. Standardized intermodal shipping containers facilitate intermodal transport as they allow a variety of goods to be easily moved from place to place in ports and warehouses, and between ships and railroad cars. Some organizations, such as the International Standards Organization (ISO), have developed and continue to maintain standards for shipping containers such as size, location of doors, and the use of specific corners or fittings so that a container can be securely gripped and moved by lifting equipment. The ability to use a standardized shipping container is an advantage because the container handling equipment and logistics of making shipments of special kinds of goods is simplified when a particular customized shipping container is not necessary. For example, a large quantity of liquid can be transported by placing the liquid inside of a flexible tank in a shipping container also usable for dry goods and then that container can preferably be treated like any other shipping container without regard to the nature of its contents.

There is specialized equipment used for transport by road, rail and ship of bulk liquid products. However, it is desirable to take advantage of standard container equipment to realize cost savings. Standardized shipping containers are prevalent in both domestic and international trade lanes, and thus cheaper to use. For example, 40' or 53' shipping containers are readily and commonly available in North America. The prevalence or ubiquity of such larger shipping containers in some multimodal transport routes is such that it can be economically beneficial to use a flexitank in them with the same capacity as used in smaller 20' shipping containers.

These larger containers have a much higher internal volume than smaller 20' shipping containers. Due to weight restrictions, it can be difficult to take full advantage of the larger internal volume. The liquids to be shipped can have vastly different specific gravity (weight per gallon), and the volume of the liquid that can be shipped within the weight restriction varies accordingly. Conventional flexitanks are typically mass produced and are of a single capacity. This is a disadvantage for a larger shipping container with high internal volume where it is somewhat more possible to ship different volumes of liquids while remaining within the weight restriction. There are also other disadvantages to larger shipping containers that must be solved when shipping liquids.

For example, a 40 foot container may not always facilitate the use of a bulkhead. Flexible tanks designed for a 20 foot container with a bulkhead are typically longer than the internal length of the container so that the ends of the flexitank are supported by the front inside wall of the container and a bulkhead panel placed across the door opening at the rear wall. Therefore, the flexitank for a 20 foot shipping container may be, for example, 23 feet long. A 40 foot shipping container may not facilitate use of a bulkhead and the front wall, so the flexible tank must be freestanding, without relying on the availability of any end wall or bulkhead support.

The flexible tank should not deform any of the side or end walls of the container in which it is placed. Intermodal shipping containers are sometimes stacked or placed very close together in cargo holds of vessels or ports, with only a few inches of tolerance, and an outwardly deformed wall may interfere with or prevent placement of the container. The side walls of a 40-foot container are generally more susceptible to deformation than the side walls of a 20-foot container if for no other reason that they are longer and have no additional support. There is a limit to the amount of force that should be placed on the side wall of a 40-foot container by a flexible tank full of liquid.

But the largest disadvantage associated with the use of flexible tanks inside of larger shipping containers is the increased possibility of leak or rupture if the flexible tank for a 20-foot container is simply "lengthened" or made larger for a 40-foot container. Sudden movement can cause a rupture of a flexitank (even if there is no manufacturing defect or "weakness" in the flexitank). Sudden starts, stops or impacts can result in large waves that produce enormous pressure on the ends of the flexible tanks. The danger of a flexible tank rupture or leak depends greatly on the volume of the liquid inside of it and the length of the flexible tank from end to end. The liquid dynamics are dramatically different depending on the shape, proportion and volume of a flexitank. In particular, the flexitank for a 40' container will typically have a lower profile (height) than the flexitank for a 20' foot container. Figs. 3(a)-3(c) show the sewn end seams in a prior art flexitank. These end seams are susceptible to liquid dynamics (shown by the arrow in Fig. 3(c)) that impact the end seams at the intersection where they are sewn together, forcing the two halves to separate apart and away from each other.

So even when a larger shipping container is available, a larger version of a known flexible tank has historically not been practical due to the risk of rupture. For example, in U.S. Patent Application Publication No. 2017/0144833 filed by Environmental Packaging Technologies, Inc., three different flexible tanks are used in a 40-foot or 53-foot container rather than one larger flexible tank. Such a system has the disadvantages that each flexible tank has to be individually loaded and unloaded, and

the cost of the three flexible tanks is more than it would be if there were but a single flexible tank. A single larger flexible tank has historically not been possible in larger shipping containers because of the likelihood of rupture or leak.

This risk of leakage of flexible tank rupture is even greater for a multimodal shipment where the larger shipping container will be partly transported by railroad. Railroad cars are large and heavy, especially when loaded. Railroad cars are typically interconnected to each other by running them into each other to cause them to be hooked together in a process sometimes referred to as shunting. Even at a low speed, these collisions create very large and very sudden forces of deceleration, such as 2G's, that are similar to those experienced in a sudden and complete full stop. But this problem has been solved by the preferred embodiments of the invention. In particular, the flexible tanks of the preferred embodiments of the invention, although freestanding, disposable, and made especially for use in 40-foot shipping containers, will not leak or rupture even when repeatedly subjected to the impacts of railroad car collisions.

Brief Description of the Drawings

Fig. 1(a) shows a flexitank for a 40-foot shipping container, according to a preferred embodiment of the invention, when it is partially filled with liquid.

Fig. 1(b) shows an optional preferred embodiment utilizing capacity bands.

Fig. 2 is an illustration of a railroad car impact which the preferred embodiment of the invention undergoes without leaking, rupturing, or damaging the container in which it is placed.

Figs. 3(a) – 3(c) show the end seam of a prior art flexitank.

Fig. 4 shows an improved strength end closure of the preferred embodiments.

Fig. 5 shows is an illustration of the assembly of the end closure in Fig. 4.

Fig. 6 is an exploded view of the end closure in Fig. 4.

Figs. 7(a) - 7(e) show the steps of forming a flexitank according to the preferred embodiment.

Fig. 8 is a perspective view of an end closure in the preferred embodiment of the invention.

Fig. 9 shows an optional preferred embodiment in which an end cap is used to further strengthen the end closures of the flexitank.

Fig. 10 shows an end view of an exemplary bulkhead used in conjunction with the flexitank of one of the preferred embodiments.

Fig. 11 shows a side view of an exemplary bulkhead used in conjunction with the flexitank of one of the preferred embodiments.

The Preferred Embodiments of the Invention

Of course, the actual impacts on a larger shipping container when it is on a railroad car during part of a particular multi-modal shipment cannot be known in advance with certainty. However, they can be predicted and simulated. The preferred embodiments of the invention are believed to be the first to satisfactorily survive these impacts without leak, rupture, buckling of the bulkhead securement bars, damage or deforming of the container walls. A typical simulated impact test is shown in Fig. 2.

The railroad car with the shipping container and flexible tank is released on an approximate 0.8% downgrade of railroad track toward a string of empty anvil cars with standard draft gears and a combined weight of 250,000 lbs (113.40 metric tons), with the airbrakes set on all impact vehicles, and the handbrakes set on the first and last cars. The predetermined location is selected such that, at the point of impact, the railroad car carrying the flexitank has a speed of approximately 4-6 miles per hour (mph).

Fig. 1(a) shows a preferred embodiment of a flexitank according to the invention resting on the floor of the shipping container (horizontal cut away view). The flexitank is shorter than the internal length of the shipping container and its ends fall short of the end walls of the container. It consists of three layers of low density polyethylene (preferably 125 x 2 microns thick) plus an outer layer of woven polypropylene outer sleeve or cover (preferably 550 x 2 microns thick). The cover provides additional strength along the length of the flexitank that will absorb and control the internal liquid dynamics during transport. The cover for the flexitank is constructed from one layer of a 610 gram per square meter vinyl fabric on a base reinforcing scrim of either a 14 x 14 or 20 X 20 per centimeter polyester thread. Such a relatively high thread count of the scrim provides added strength for the carriage of liquids with a specific gravity higher than water. The diameter of the covering external layers is dependent on the

desired capacity of the flexitank. There may be a single fill/discharge port on the top of the flexitank or there may a top fill port and a discharge valve at an end of the flexitank.

The preferred dimensions of a flexitank for a 40-foot container according to the preferred embodiments of the invention is 40.5 feet in length and 9.6 feet wide, and approximately 27 inches in height when loaded so as to have a capacity of 5,812 US gallons (22,000 liters). When filled to capacity, the top is somewhat dome-shaped, being higher in the middle than it is at its ends and sides. See Fig. 1(a). Another important aspect of the preferred embodiments is that the flexitank is not filled to capacity. This is counter-intuitive given the known concern over waves causing ruptures at the ends of flexitanks. The prior thinking was that, if the flexitank was completely filled such that was no empty air space, waves could not form that would travel from end to end, potentially causing ruptures. But the inventors have surmised that liquid dynamics are still created by sudden impacts that stress the ends. In addition to the improved end closures, the preferred embodiments also take a different approach with respect to capacity. The flexitank is intentionally not filled to capacity. For example, for a flexitank with a capacity of 5,812 US gallons (22,000 liters), it is only partially filled, preferably with 5,425 US gallons (20,560 liters).

Capacity bands can optionally be used at various points along the length of the flexitank to adjust the capacity of the flexitank to, for example, permit the shipping of liquids of different specific gravities while remaining within the weight restriction. The lengths of the bands are somewhat less than the circumference of the flexitank when it is completely filled to capacity. The bands thus "squeeze" the flexitank imparting a sort of four hump camel shape to the flexitank and affecting the capacity of the flexitank as shown in Fig. 1(b). The number and length of the bands affect the flexitank capacity to different extents. The number of bands can be increased and/or the bands can be made shorter to reduce the capacity. The preferred connection length of the bands for the dimensions provided above accommodates a circumference of 122 inches. Preferably, the bands are disposed in a symmetrical fashion along the length of the flexitank so as to avoid any disproportionate effect on the liquid dynamics. There may be three bands with the middle band positioned at the center. Or there could be an even number of bands spaced proportionally along the length of the flexitank.

An important aspect of the capacity of the bands is that they are a separate piece from the main part of the flexitank, and selected at the time of installation according to the liquid to be shipped. This allows the main part of the flexitank to be mass produced and the capacity thereof optionally decreased by selective use of bands. The capacity bands are not sewn into or otherwise secured on the main part

of the flexitank. They surround the exterior and act somewhat like a belt for a person's waist, relying on the squeezing to keep them in place. It is important that the bands to do not have buckles, or other items with edges, to set their length or keep them in place. Testing has shown that there is significant abrasion between the capacity bands and the flexitanks during shipment, and care must be taken that the capacity bands themselves do not cause a leak or puncture. Preferably, the ends of the capacity bands are sewn together to form a continuous loop. A suitable construction of the capacity bands is a two inch width fabric constructed from a mixture of polyester and nylon materials.

Another key feature of the preferred embodiments are improved end closures shown in Figs. 4-8. They seal both ends of the tank and provide additional strength to the heat sealed end seams of the inner tank when compared to the prior art sewn ends shown in Figs. 3(a) to 3(c), preventing any bursting of the of the seam when under pressure from the liquid forces placed upon it. The result is a flexitank that is overall much stronger on the ends than the conventional flexitank.

A process of forming a flexitank according to a preferred embodiment of the invention is shown in Figs. 7(a) – 7(e).

In the first step, long and narrow fabric layers are welded together longitudinally, preferably by radio frequency (RF) welding, to form the top and bottom external layers. The ends of the top and bottom layers are welded back onto itself as shown in Fig. 7(a) to form a loop sufficiently large to accept a nylon rope.

In the second step, the end flap is welded to the inside of the bottom layer about 30 to 36 inches from each end of the bottom layer. This end flap is preferably the same fabric as the top and bottom outer layers. The end flap has the same width as the top and bottom layers and a length of approximately 7 to 8 feet. At this point, the end flap extends past the end of the bottom layer as shown by dashed line A in Fig. 7(b). When manufacture of the bag is complete, the end flap will be positioned as shown by dashed line B in Fig. 7(b). It is to be understood that, although not shown in the cross-section view, the longitudinal sides of the top and bottom layer are welded to each other so as to form an open ended tube.

In the third step, the looped ends of the top and bottom layers are cut at the same points to form corresponding equal sized sections of the looped ends as shown in Fig. 7(c). Odd loops are removed from one of the layers and even loops are removed from the other layer so that the layers have alternating interlaced loops in the manner of a door hinge. The number of loops is dependent on

the width and, preferably, each loop is 6 centimeters long. The loops are positioned in such a way that in a lay-flat position, the loops of the top and bottom external layers will be adjacent to and alternating with each other in an interlaced manner. See Figs. 4-6.

In the fourth step, a top mounted load/discharge valve is attached to the inner liner through an opening on the top external layer centrally placed widthwise and near one end seam lengthwise, preferably about 30 to 36 inches from the end seam. The valve is preferably secured using a clamp. The inner liner, with its 2-4 layers already formed and welded together at the ends, is inserted through the open end of the bag nearer the valve and positioned between the top and bottom layers. Any "coupon" of the inner liner at the closed end of the bag is tucked so that it lays flat against the outer layers. Any "coupon" of the inner liner at the open end of the bag is tucked and then the additional layer of fabric is moved from the position of dashed line A in Fig. 7(b), so as to cover the end and the coupon of the inner liner as shown in Fig. 7(d) and be positioned over the top of the inner liner.

In the final step, the nylon rope is threaded through the alternating interlaced loops of the open ends of the bag completely across the seams. The rope closes the seams and secures the flexitank into the cover. Alternatively, grommets may be used in place of the alternating loops to lace it together. When the bag is filled with liquid as shown in Fig. 7(e), the inner liner expands pushing against the end flap and against the end closures with the loops. It is to be noted that the loops in the end closure are not watertight and are not intended to be watertight. The end flap provides some protection against leakage but primarily provides additional strength to the end closure. The end flap contains the inner liner inside the external layers of the cover, stopping it from coming into direct contact with the end closure. As shown in Fig. 8, the loops do not remain in alignment and the rope does not remain straight when the flexitank is filled, but they do provide end-closures of significant strength.

The closure provides an extremely high strength which is particularly useful for the end closures of flexitanks. However, the closure is limited in its use to the preferred embodiments described herein. It can also be used for the sides of a rectangular shaped flexitank, or anywhere a higher strength replacement for a sewn seam is desired. The end closures here are based on those disclosed in PCT International Application No. PCT/US2018/058530 filed on October 31, 2018, and US Provisional Patent Application 62/579,612 filed on October 31, 2017, those disclosures being incorporated by reference herein.

An alternative preferred embodiment of the end closure is shown in Fig. 9. In addition to the inner and outer layers, and end flap C, of the preferred embodiment shown in Figs. 7(a)-7(e), an additional end cap C is secured to the end of the inner layer. End cap C is formed from a layer of PVC fabric in a rectangular shape that is, for a flexitank having the preferred dimensions noted above, about 116" wide x 60" long. It is folded in half making it 116" wide x 30" overall. The folded over material is then welded on each of the 30" long sides making the product shaped like a canoe if filled with water. This additional layer at a critical point adds strength overall to the end closure system. The end cap C helps to form the shape of the flexitank and further strengthen it against the large liquid dynamic forces resulting from the sudden starts, stops and jolts of a railroad car.

In addition to the above features, where a container has a door recess channel directly inside its doors, a bulkhead system may be inserted into that recess channel. The bulkhead system may be the bulkhead system shown in the end view of Fig. 10 and the side view of Fig. 11. There are multiple square bars 5 of $3/16^{th}$ steel tube stock that fit into the door post slots. Although five bars are shown in Figs. 10 and 11, there may be four or six such bars. A bottom telescopic bar 2 is preferably formed of a steel tube and includes an inner telescopic steel tube 3. Two vertically oriented short-straps 4 are preferably steel flat bars that secure steel bars 5 and telescopic bar 2 together, such as with hexagonal bolts at the overlap of the bars and each short-strap. The steel bars 5 and telescopic bar 2 protrude horizontally to secure the bulkhead into the recess channel and provide 2 inches of clearance from the bulkhead to the door. A corrugated polypropylene fluted panel board 1 is secured to each bulkhead bar 5 and telescopic bar 2 by passing zip ties through the corrugated board 1 and around the respective bar. The board is preferably thick, such as 10 - 12mm. The container walls are also lined with single wall corrugated paper, preferably without any additional side or wall reinforcement.

Claims:

1. A flexible tank for transporting bulk liquids or semi-liquid materials in a shipping container on a railroad car, comprising:

an interior tank made of a flexible water-proof polymeric material, said interior tank being generally rectangular in shape with a width of at least one end of the interior tank being less than the length of the interior tank, the interior tank enclosing within it the bulk liquid or semi-liquid materials being transported;

a first exterior layer made of a flexible polymeric material in a generally rectangular shape, a first end of the first exterior layer having a series of hollow loops and spaces between the hollow loops in a widthwise direction along the first end, the hollow loops and spaces alternating in sequence;

a second exterior layer made of a flexible polymeric material in a shape and size substantially similar to the first exterior layer, a first end of the second exterior layer having a series of hollow loops and spaces between the hollow loops, the hollow loops and spaces alternating in sequence in the widthwise direction of the first exterior layer, the first end of the second exterior layer being matched up with the first end of the first exterior layer such that the hollow loops of the second exterior layer occur at the positions of the spaces of the first exterior layer and the spaces of the second exterior layer occur at the positions of the hollow loops of the first exterior layer;

a plurality of capacity bands located around the outer periphery of the second exterior layer, each one of said plurality of capacity bands constraining the expansion of the flexible tank at its location during movement of the railroad car; and

a rope, the rope passing through the alternating hollow loops of the first and second exterior layers and connecting the first and second exterior layers to each other, the interior tank being constrained within the first and second exterior layers connected by the rope.

2. The flexible tank of claim 1, wherein the flexible tank is less than the length of the shipping container and is not supported by the end walls of the shipping container.

3. The flexible tank of claim 1, wherein the flexible tank has a capacity of more than 8,000 liters.

4. A method of transporting bulk liquids or semi-liquid materials in a flexible tank in a shipping container on a railroad car, comprising:

folding over the ends of rectangular shaped first and second layers of flexible polymeric material to form a continuous loop over the entirety of the width of said ends of said first and second layers;

connecting the longitudinal sides of the first and second layers to form an open ended tube;

attaching a first end of a first end flap to the inside of one of the first and second layers near a first end of the open ended tube and a first end of a second end flap to the inside of one of the first and second layers near a second end of the open ended tube, the length of the first end flap being greater than the distance from its point of attachment to the first end of the open ended tube and the length of the second end flap being greater than the distance from its point of attachment to the second end of the open ended tube;

cutting portions from each one of the continuous loops of said ends of said first and second layers so as to become a sequence of alternating hollow loops and spaces, the hollow loops and spaces of the first layer interlacing with the hollow loops and spaces of the second layer;

inserting an inner liner into the interior space of the open ended tube formed by connecting the longitudinal sides of the first and second layers, the inner liner made of a flexible water-proof polymeric material so as to enclose within it the bulk liquid or semi-liquid materials being transported ;

moving the respective second ends of the first and second end flaps to cover the ends of the inner liner;

closing the first and second ends of the flexible tank with the inner liner and end flaps constrained therein by threading a rope between the interlaced hollow loops of the first and second layers; and

placing a plurality of capacity bands at locations around the outer periphery of the flexible tank, each one of said plurality of capacity bands constraining the expansion of the flexible tank at its respective location during movement of the railroad car, the flexitank reliably not leaking during accelerations and decelerations of the railroad card.

5. The flexible tank of claim 4, wherein the flexible tank is less than the length of the shipping container and is not supported by the end walls of the shipping container.

6. The flexible tank of claim 4, wherein the flexible tank has a capacity of more than 8,000 liters.

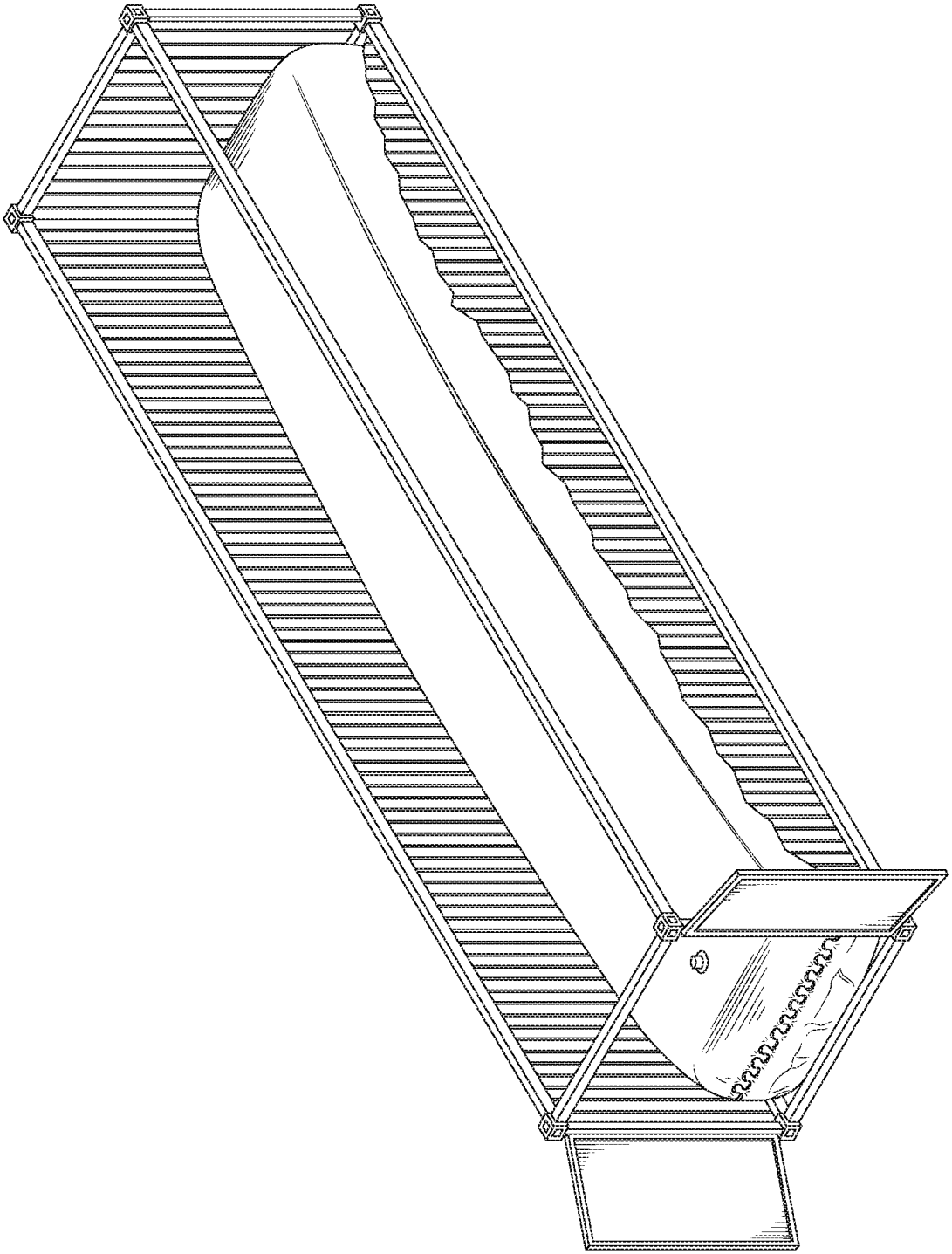


FIG. 1A

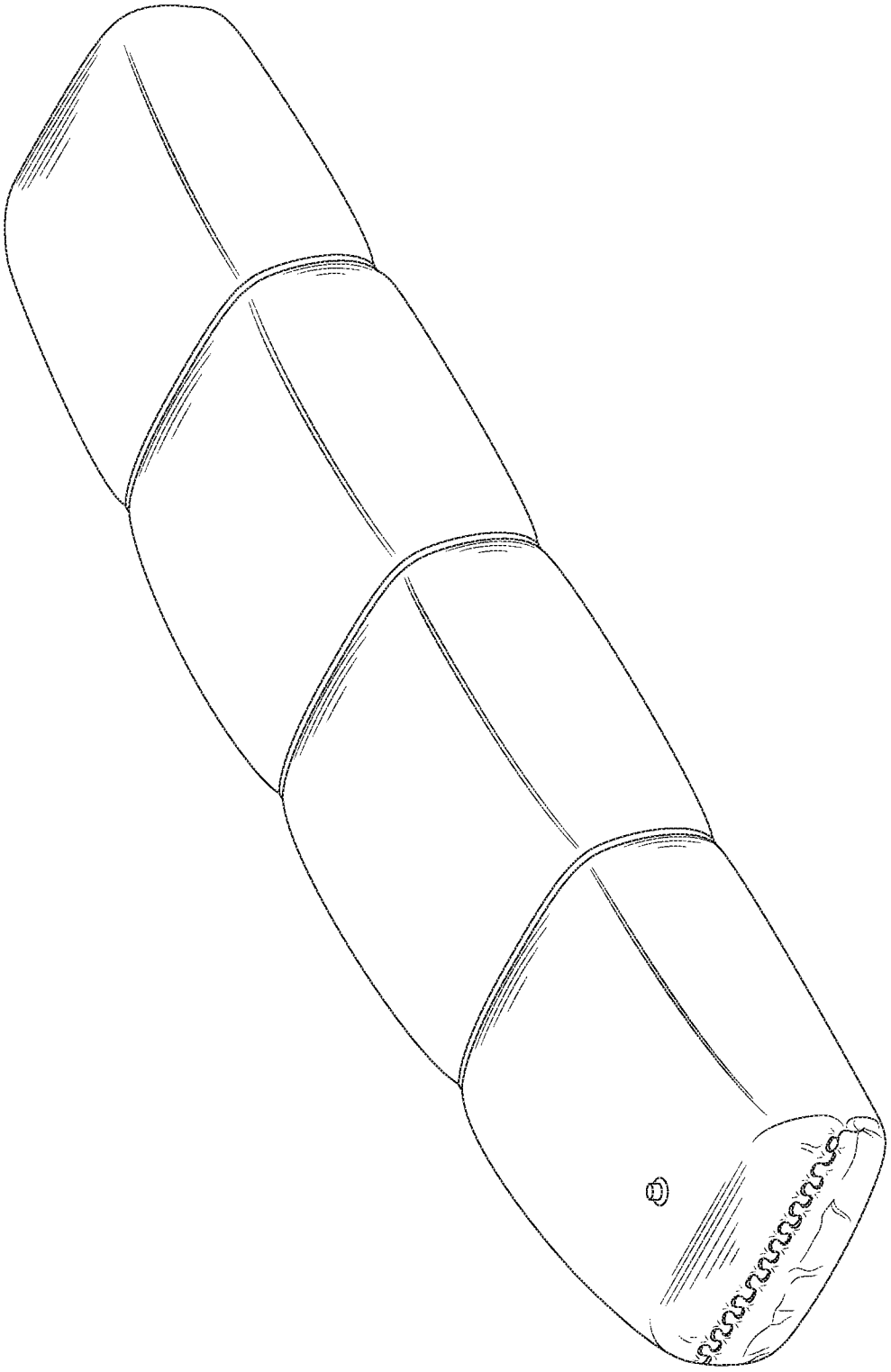


FIG. 1B

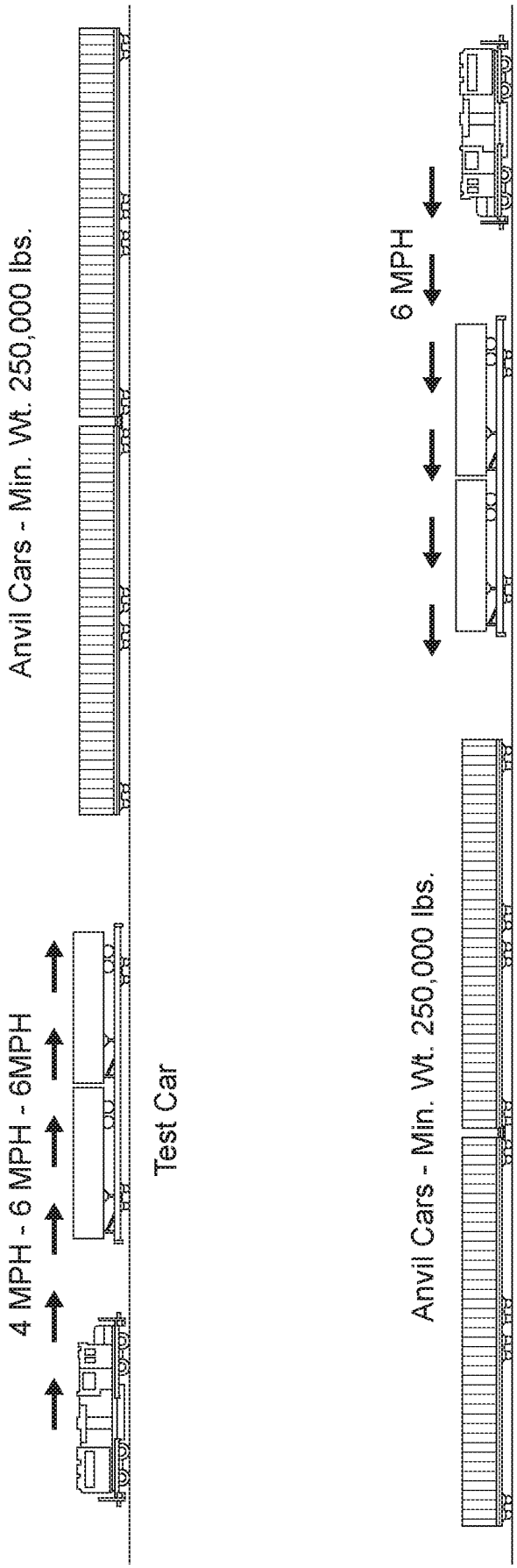

Anvil Cars - Min. Wt. 250,000 lbs.
4 MPH - 6 MPH - 6MPH
Test Car
6 MPH
Anvil Cars - Min. Wt. 250,000 lbs.

FIG. 2

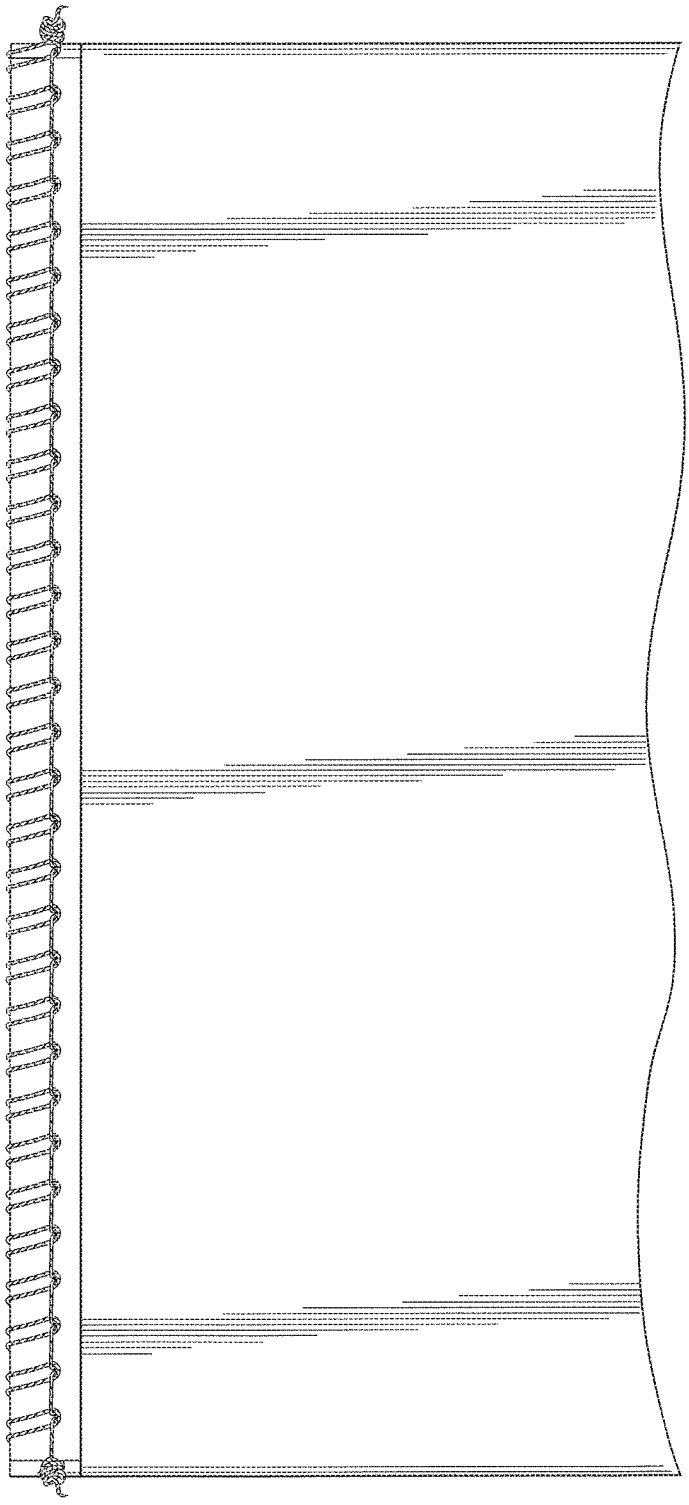


FIG. 3A
(Prior Art)

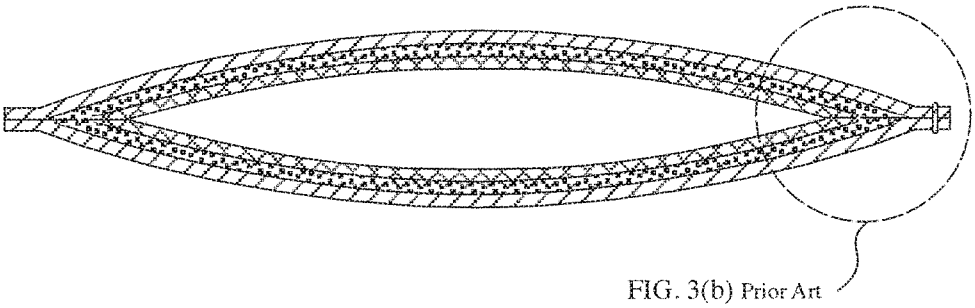


FIG. 3B
(Prior Art)

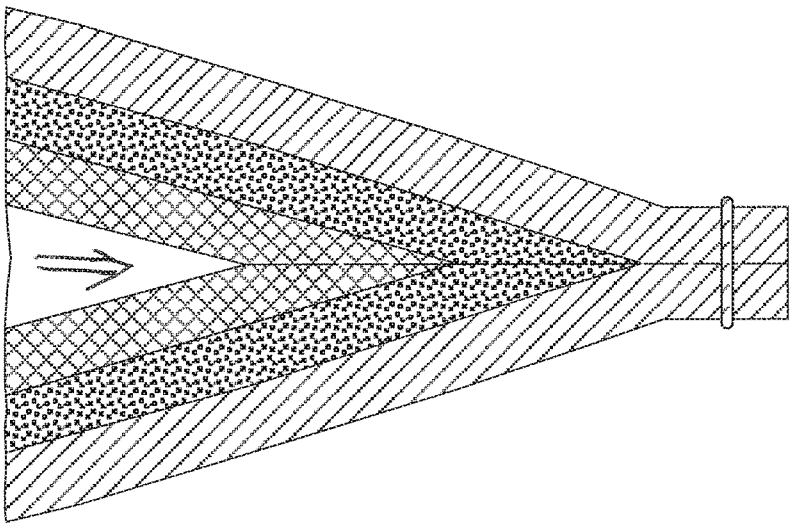


FIG. 3C
(Prior Art)

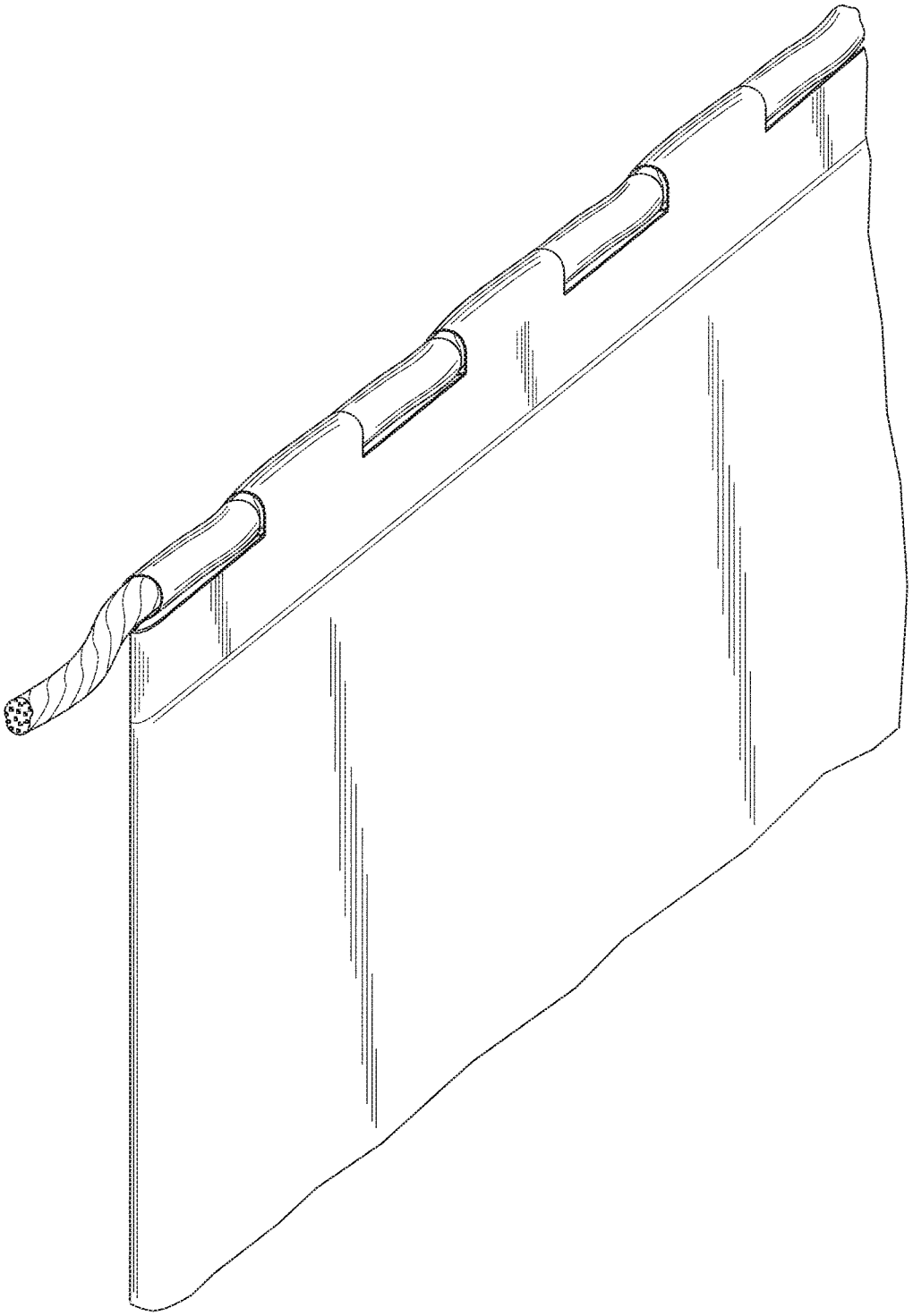


FIG. 4

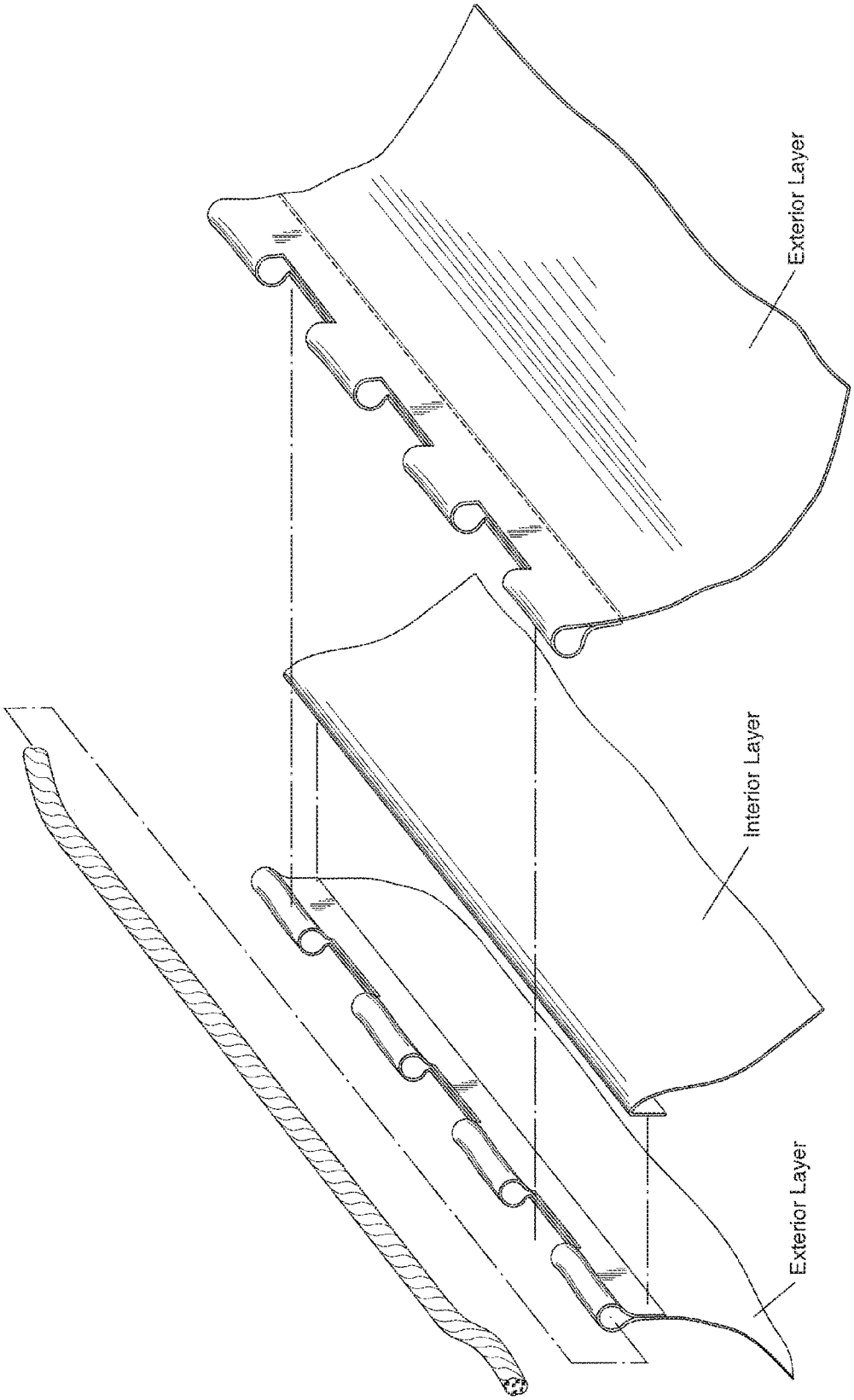


FIG. 5

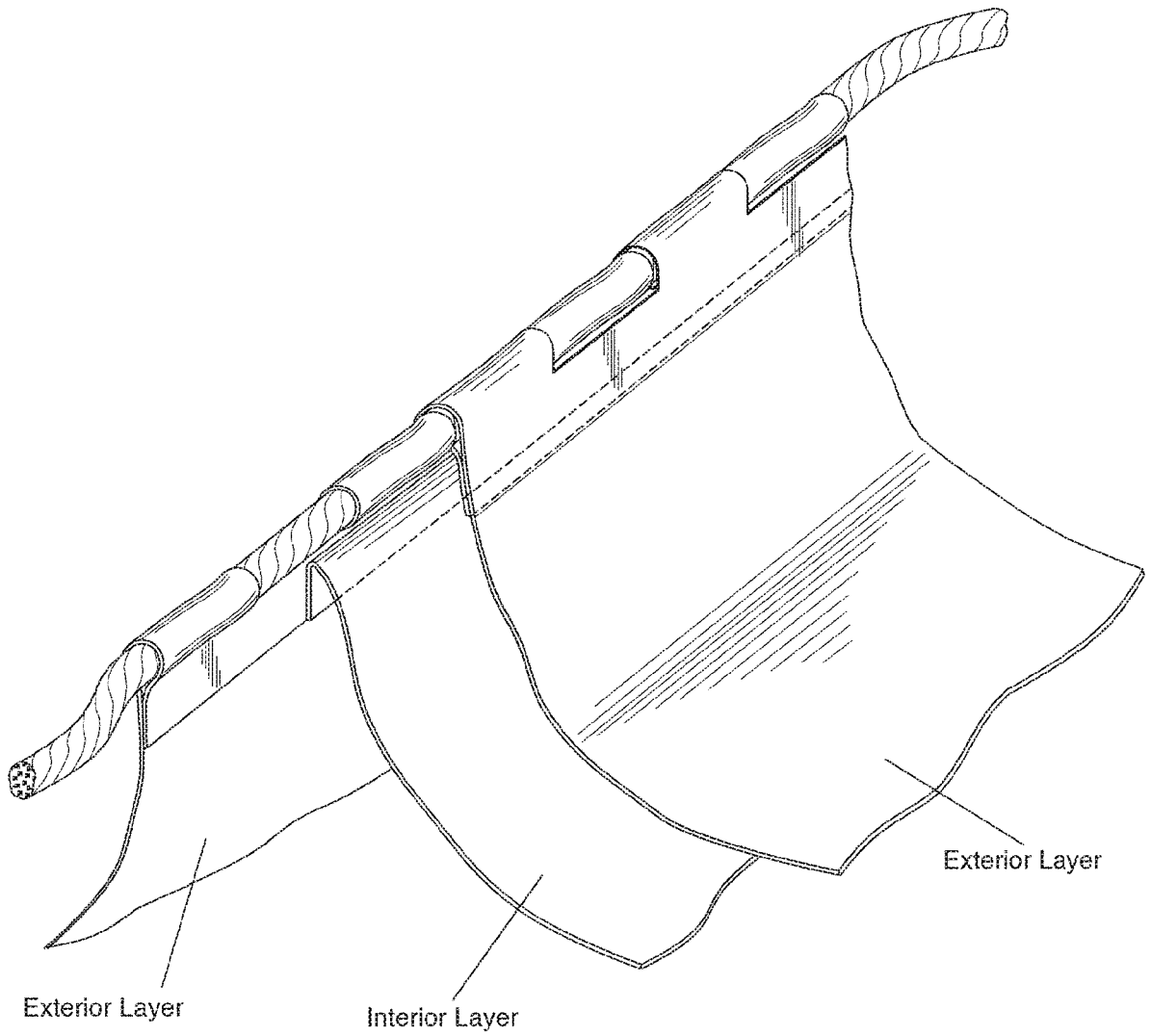


FIG. 6

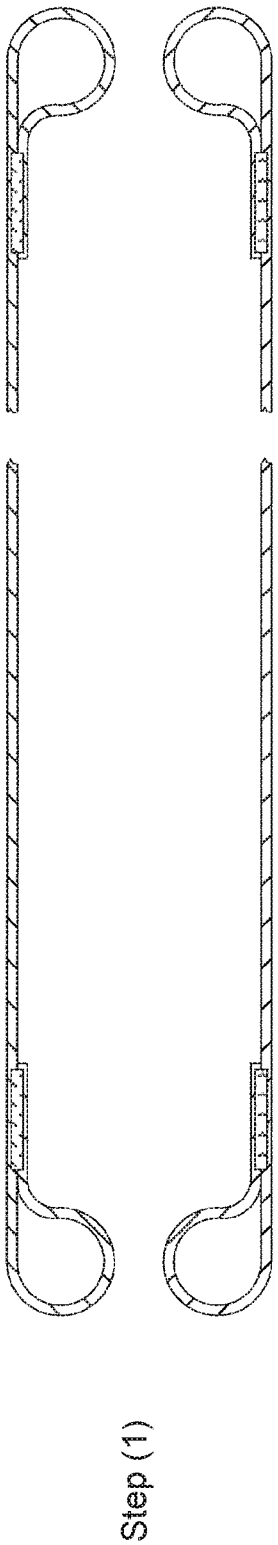


FIG. 7A

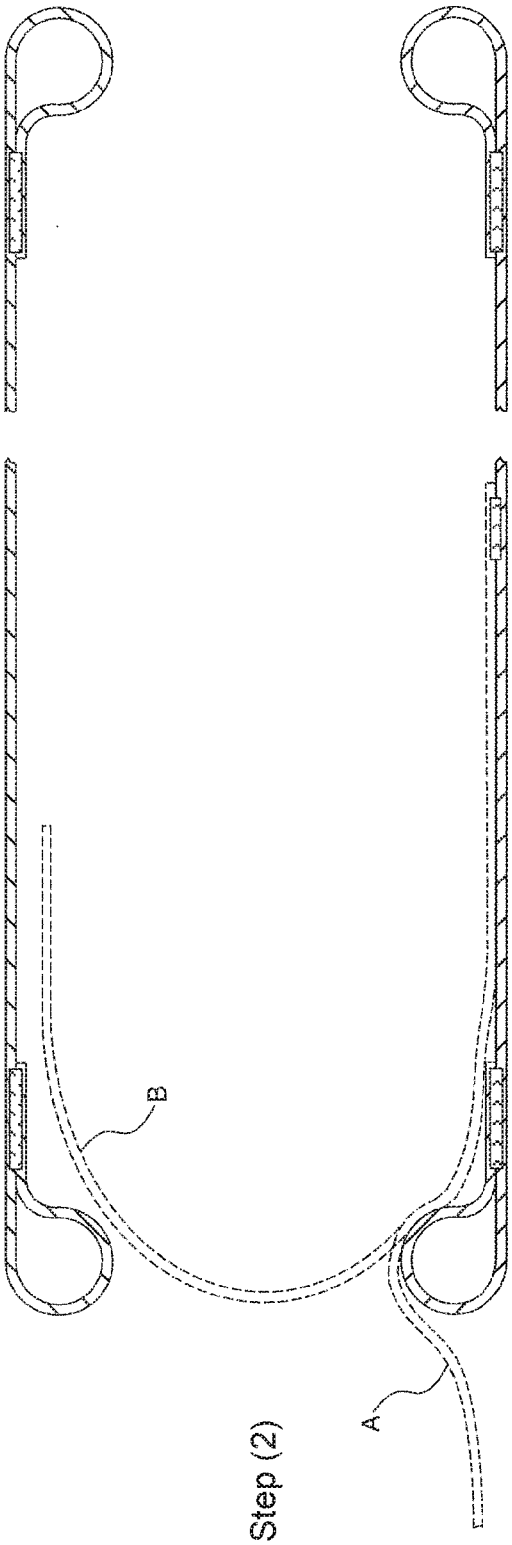
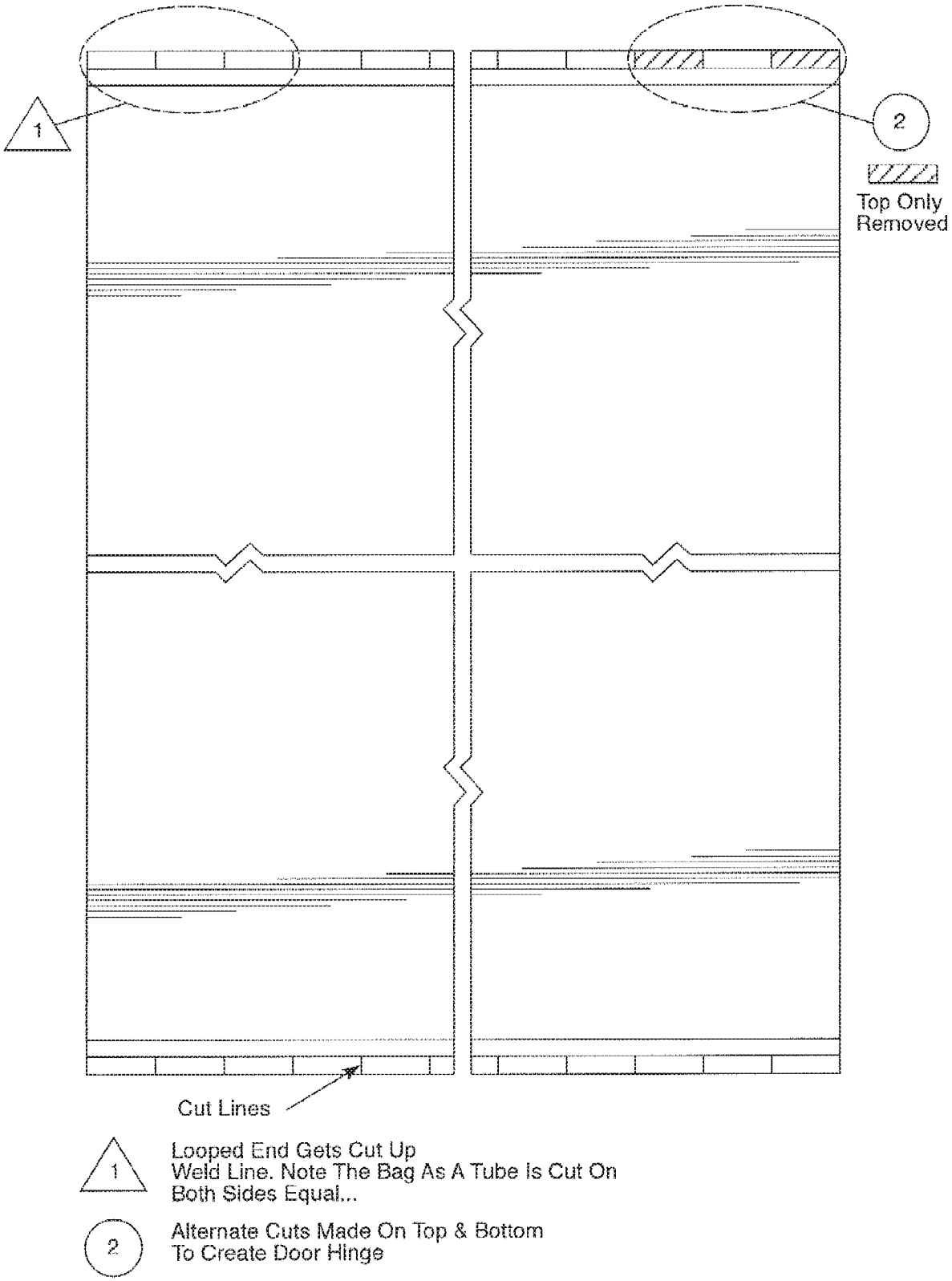


FIG. 7B


1
2
Top Only
Removed
Cut Lines
1
Looped End Gets Cut Up
Weld Line. Note The Bag As A Tube Is Cut On
Both Sides Equal...
2
Alternate Cuts Made On Top & Bottom
To Create Door Hinge

Step (3)

FIG. 7C

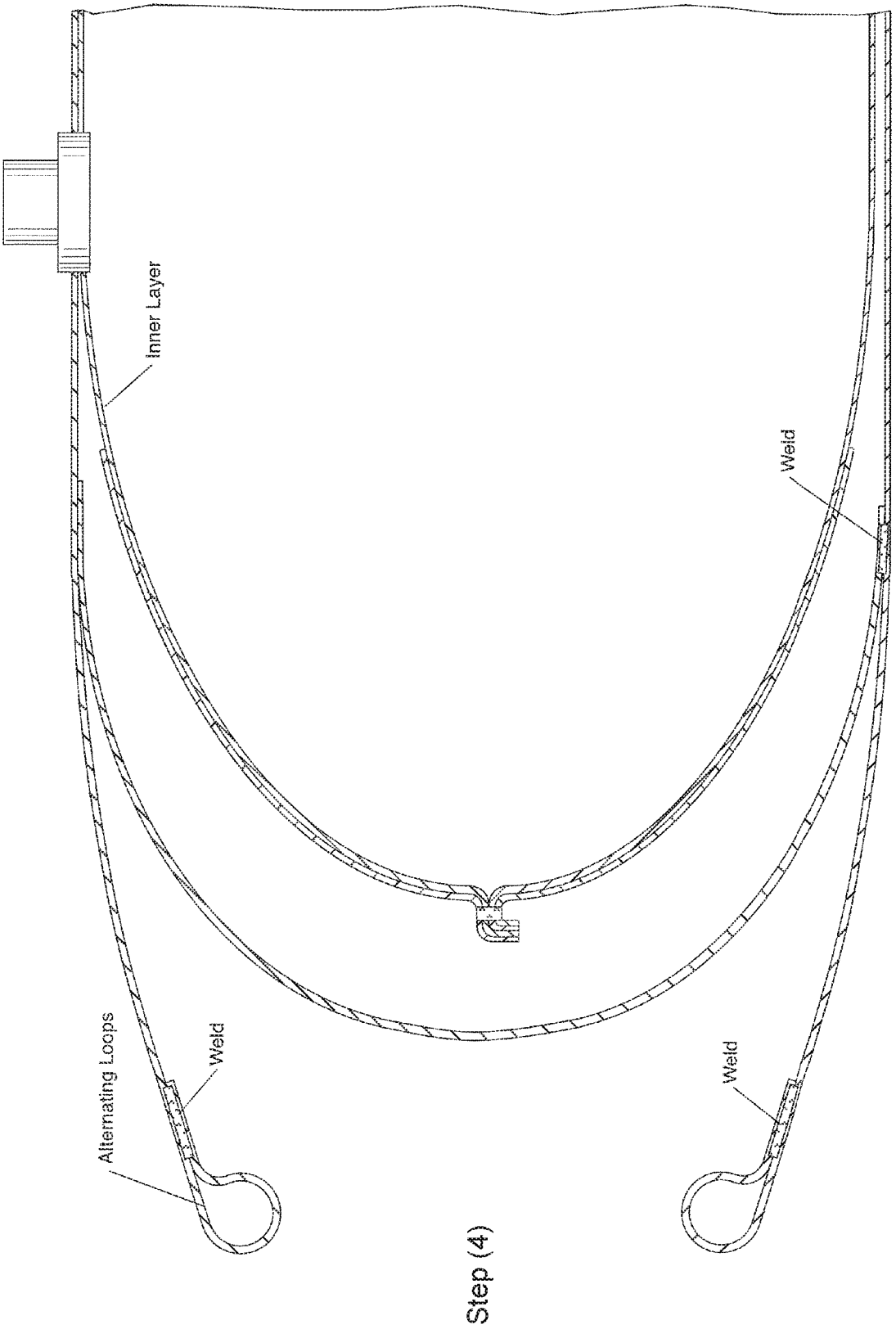


FIG. 7D

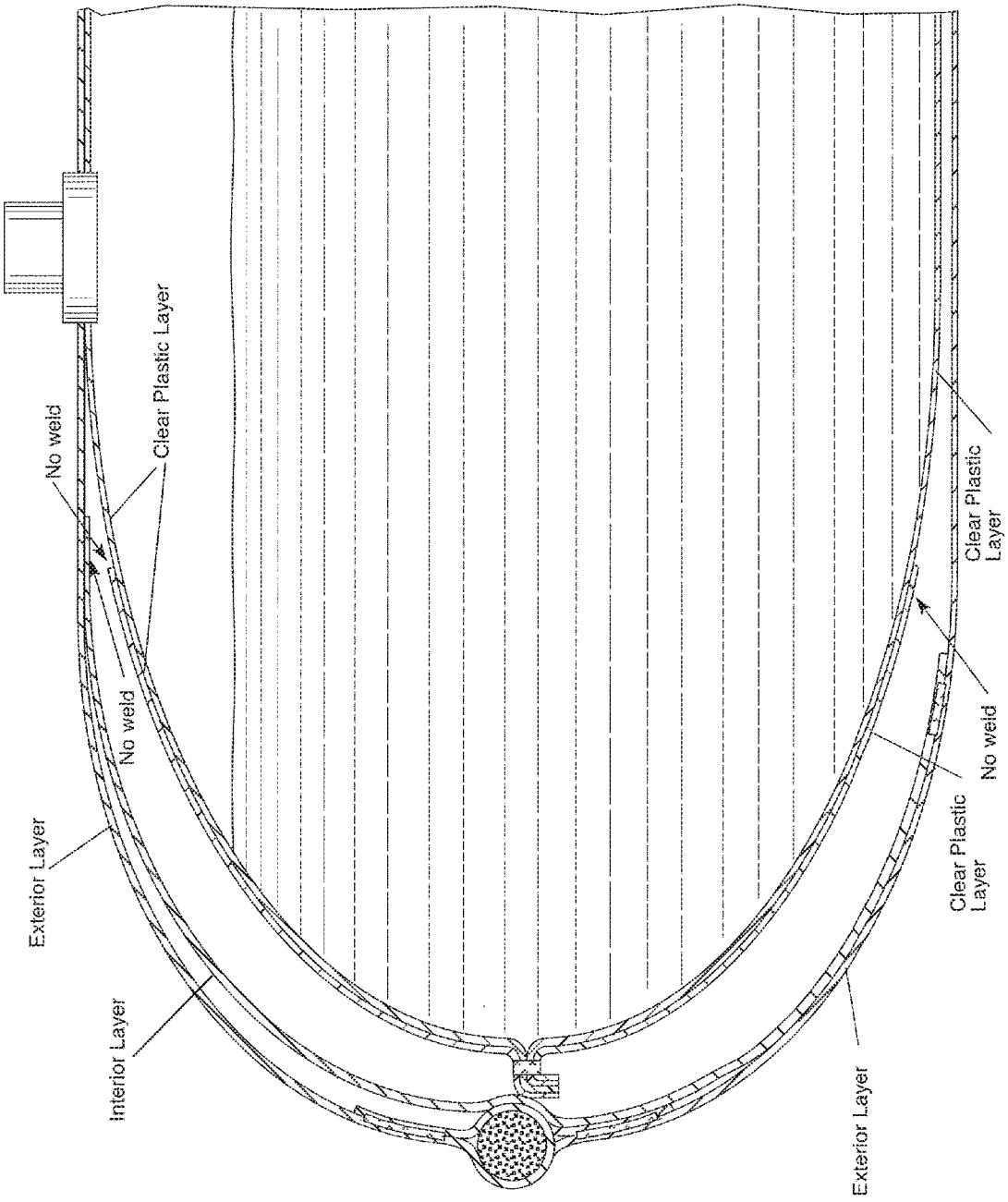

No weld
Clear Plastic Layer
No weld
Exterior Layer
Interior Layer
Clear Plastic Layer
No weld
Clear Plastic Layer
Exterior Layer

FIG. 7E

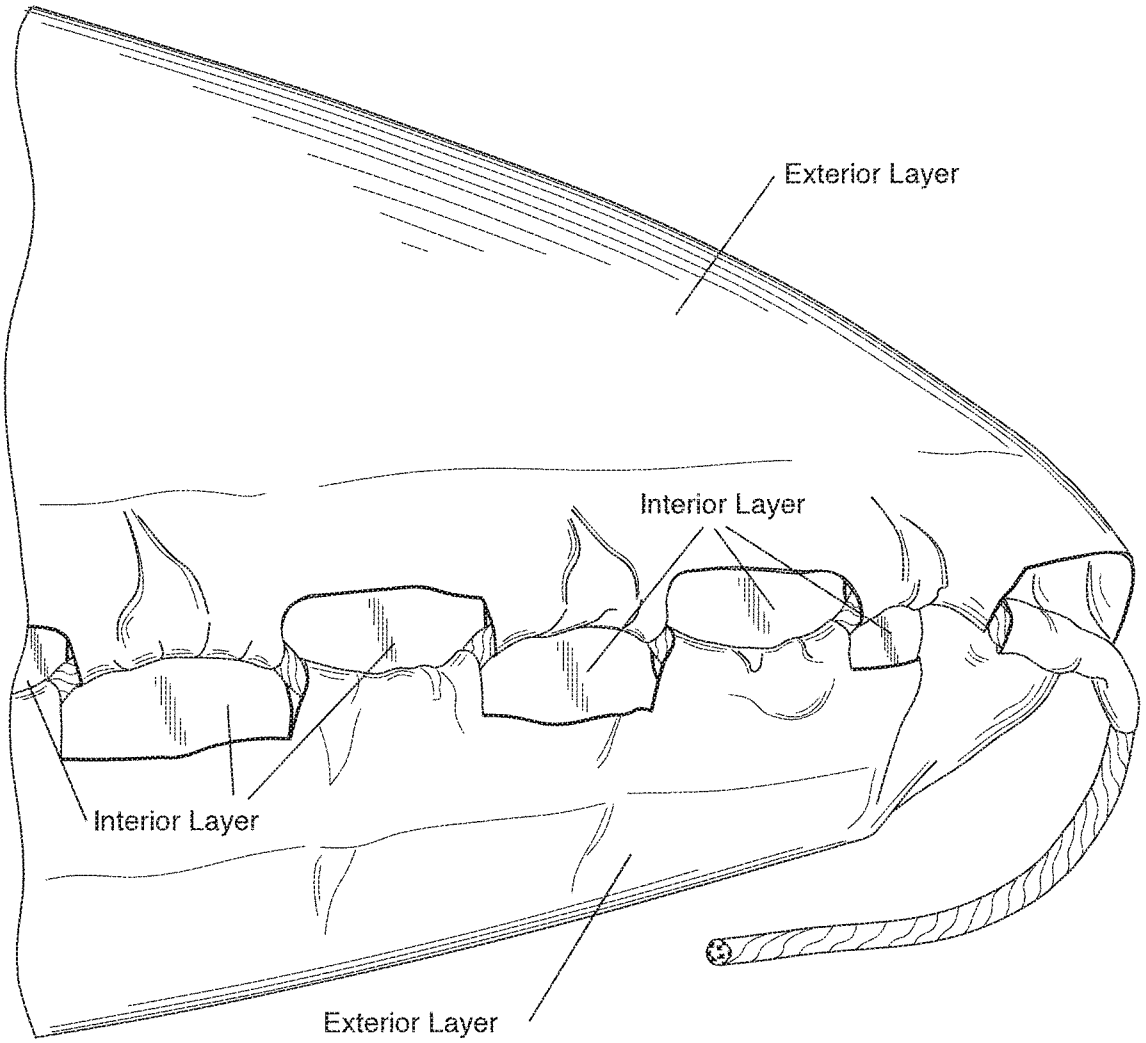

Exterior Layer
Interior Layer
Interior Layer
Exterior Layer

FIG. 8

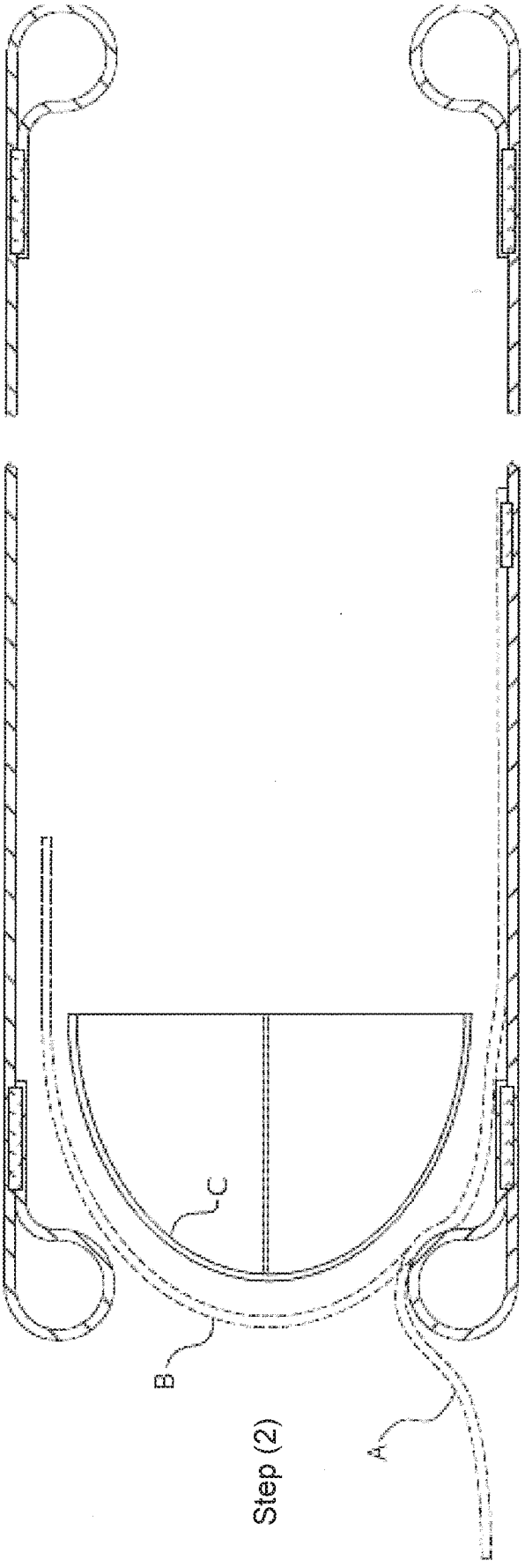


FIG. 9

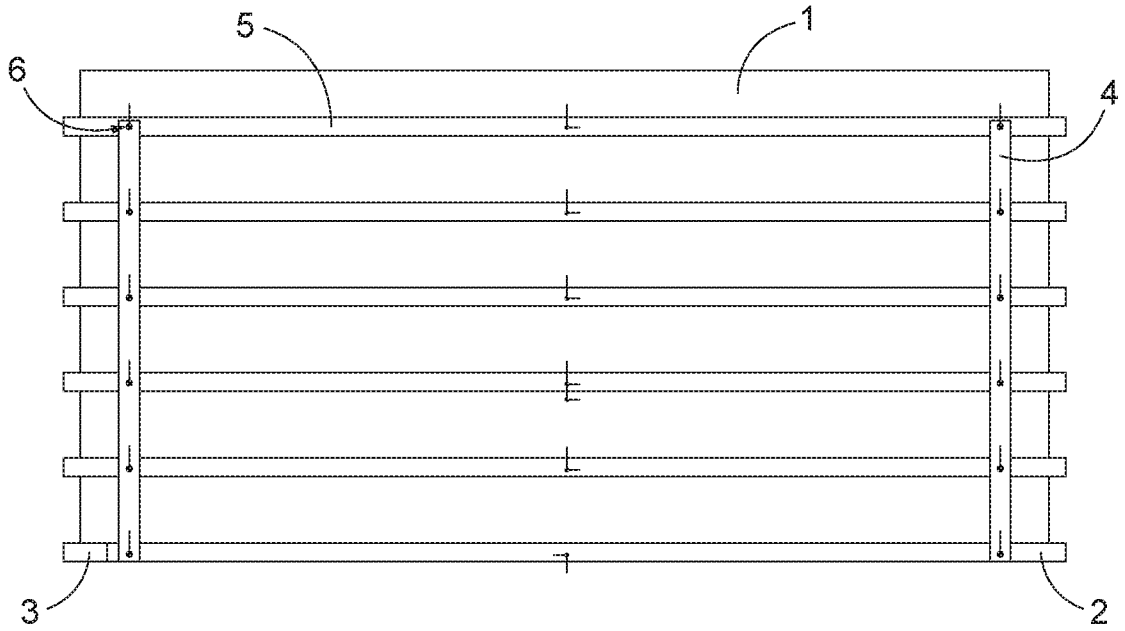


FIG. 10

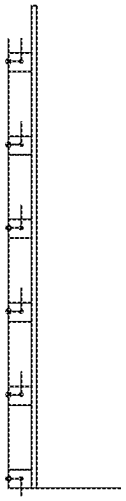


FIG. 11