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Hartmann et al.(10) **Pub. No.: US 2005/0041893 A1**(43) **Pub. Date: Feb. 24, 2005**(54) **METHOD FOR THE PRODUCTION OF A
FLEXIBLE BULK-MATERIAL CONTAINER
AND BULK-MATERIAL CONTAINER
PRODUCED ACCORDING TO SAID
METHOD**(30) **Foreign Application Priority Data**

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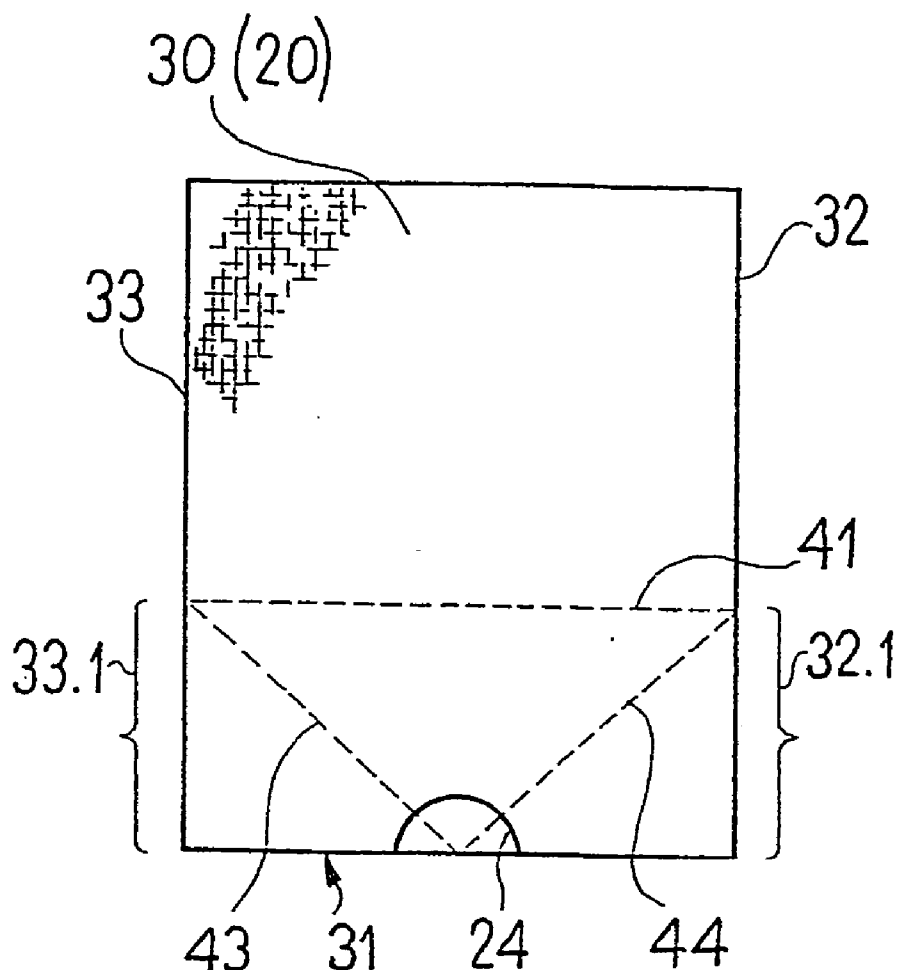
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Wolff, Herdecke (DE); U. Glotzbach,
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Karl F Milde Jr**Milde & Hoffberg****Suite 460****10 Bank Street****White Plains, NY 10606 (US)**(57) **ABSTRACT**

The invention relates to a flexible bulk-material container made of at least one woven blank of a synthetic strip-type material and to a method for the production thereof. In the seam areas (25), the woven blank (20.1) is provided with an overlapping or another woven blank (20.2) placed on top. An energy conversion agent (24) is inserted into the boundary layer (22) which is disposed between the overlapping and/or woven blanks placed on top (20.1, 20.2). The woven blank or blanks (20.1, 20.2) is/are melted by means of laser beams acting upon the energy conversion agent (24).

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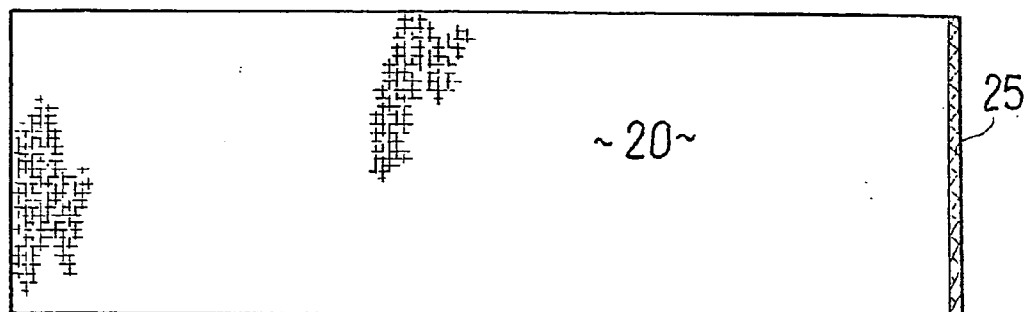


Fig.1a

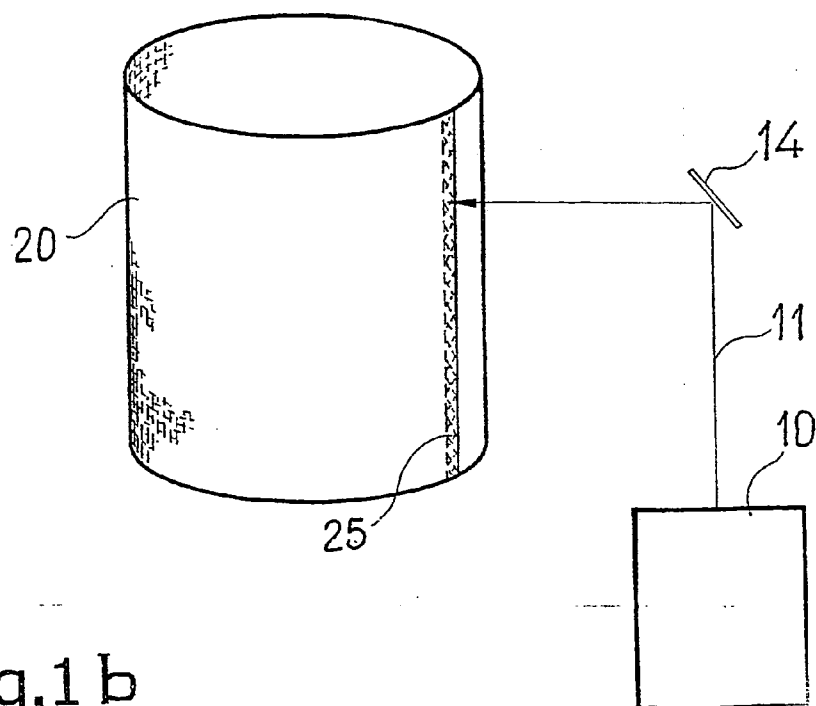
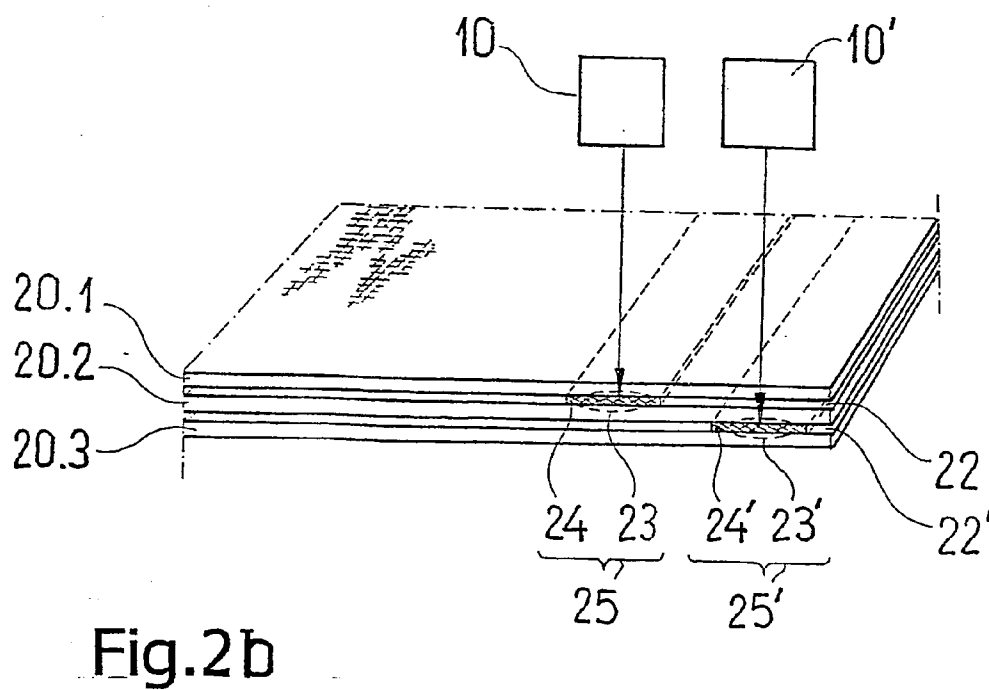
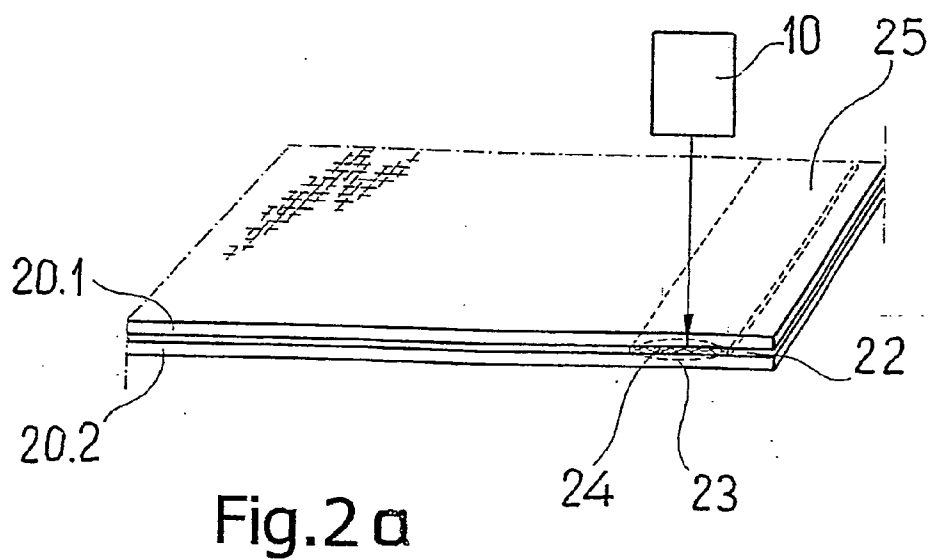


Fig.1 b



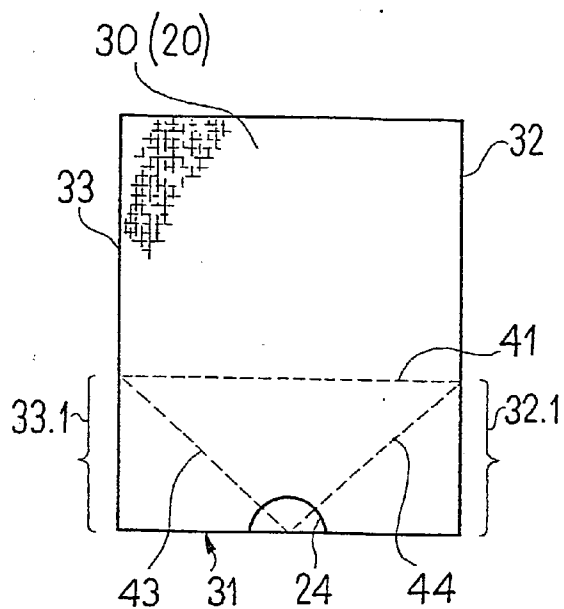


Fig.3a

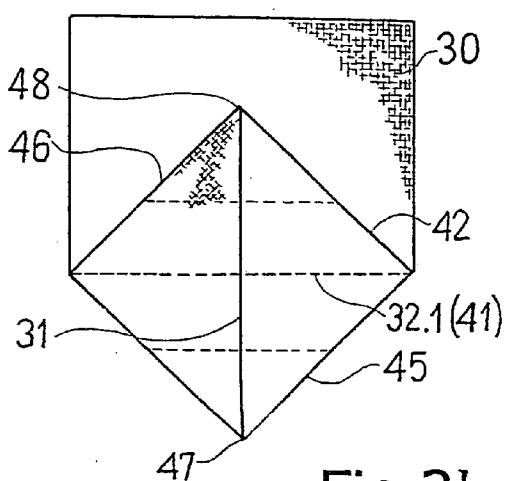


Fig.3b

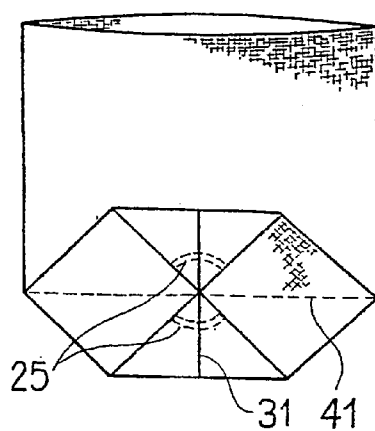


Fig.3c

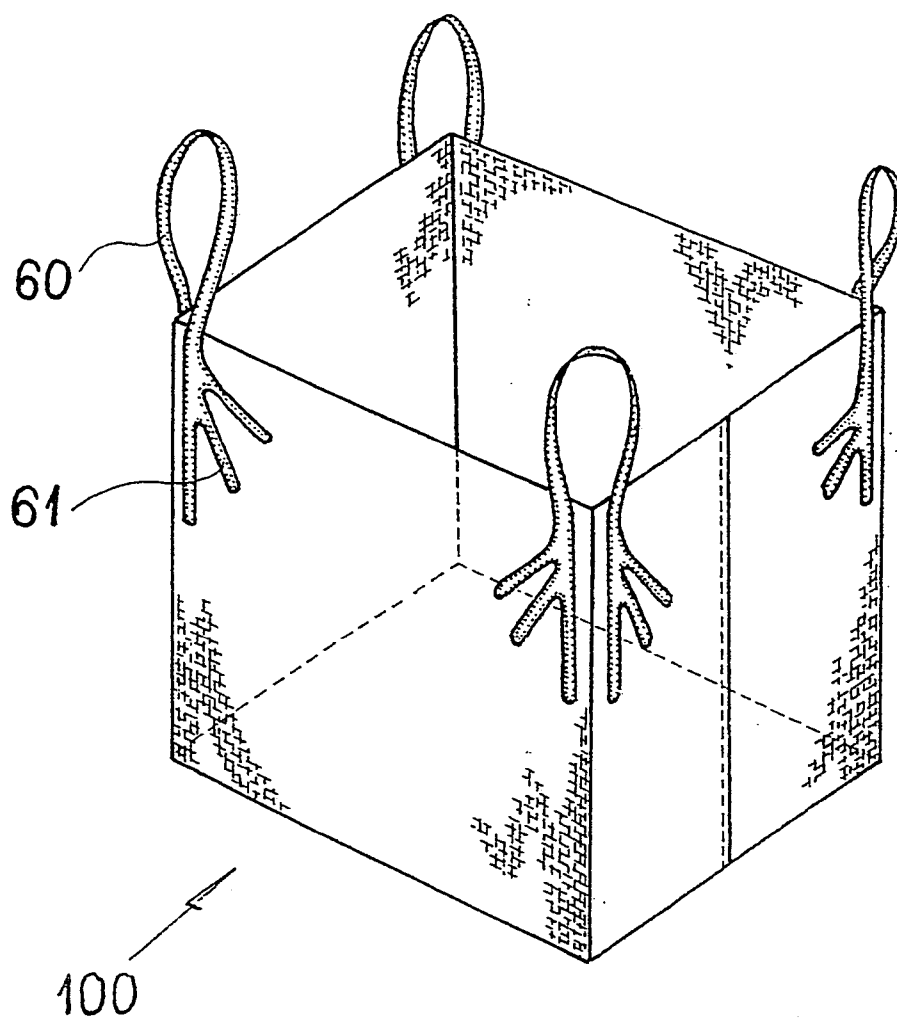


Fig.4

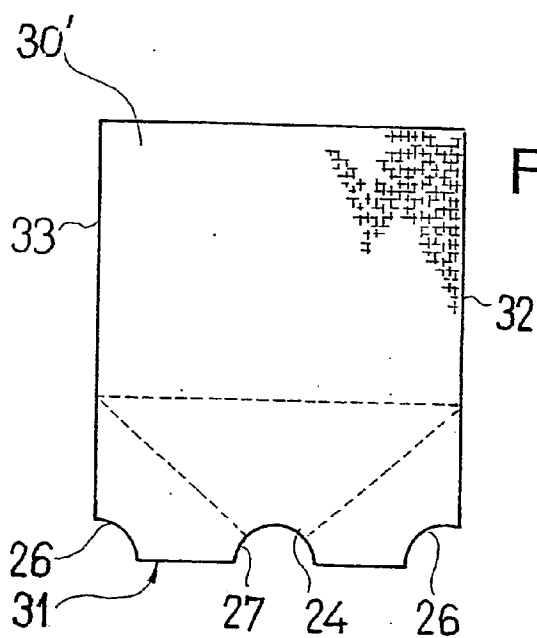
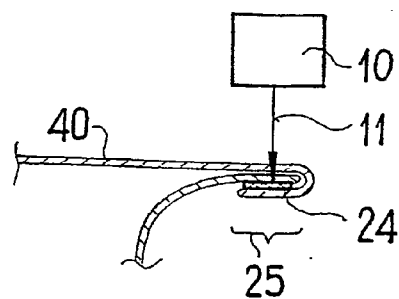
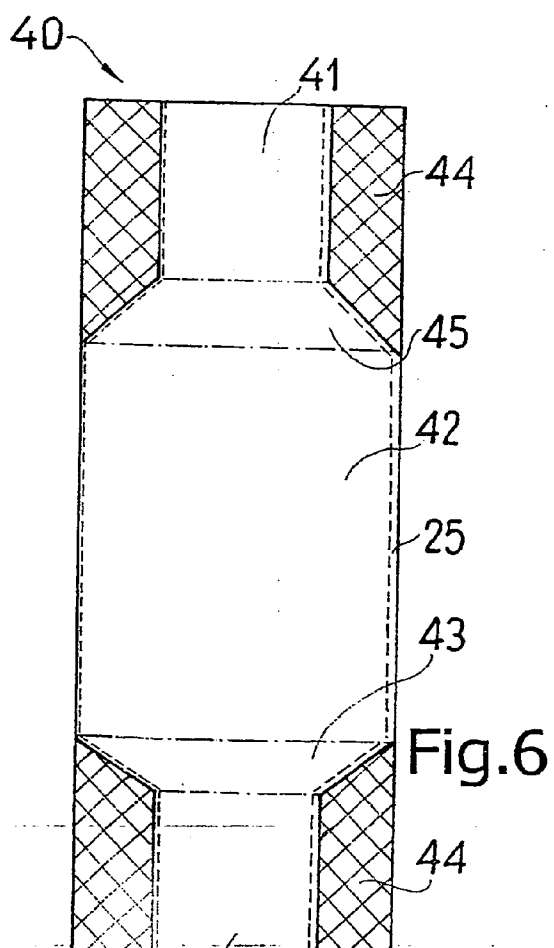
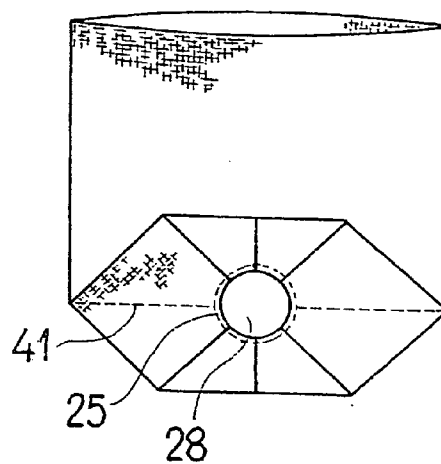


Fig. 5b



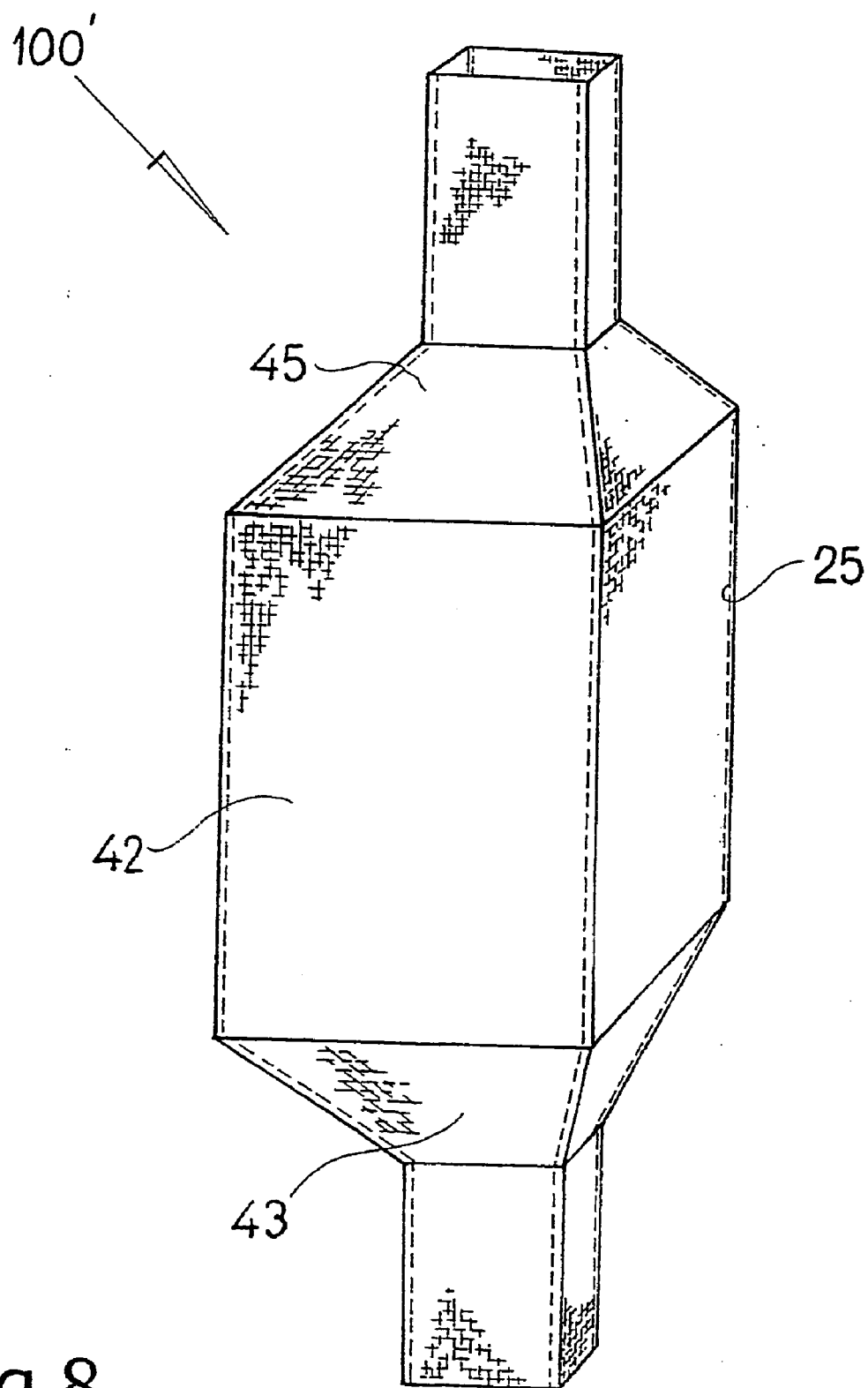


Fig.8

**METHOD FOR THE PRODUCTION OF A
FLEXIBLE BULK-MATERIAL CONTAINER AND
BULK-MATERIAL CONTAINER PRODUCED
ACCORDING TO SAID METHOD**

[0001] The invention relates to a method produce a flexible bulk-goods container.

[0002] Also, the invention relates to flexible bulk-goods containers that are internationally designated as Flexible Intermediate Bulk Containers (FIBC) of a plastic strip fabric that includes at least a surrounding sidewall and at least one floor section or roof section.

[0003] DE 39 38 414 A1 shows a bulk-goods container that is conventionally made of several cutouts to form a quadrilateral-based container that, in filled condition, may approach the cylindrical because of internal pressure by the bulk material. Four side parts are provided that are seam-stitched together along side edges. The sidewalls are seam-stitched with a floor section that may also be provided with emptying aids such as supports or similar. An additional roof section may be provided at the top of the container so formed that it may be provided with filling aids. Additionally, hoisting loops are attached to the upper edges of the container in order to facilitate use with hoists.

[0004] Production of a bulk-goods container by bonding individual sections includes several disadvantages. Thus, needle penetration weakens the material, which is usually a plastic fabric composed of strips of polypropylene, polyethylene, or HD-polyethylene film so that a perforation line occurs in the area of the stitches along which stitch holes may be stretched when the container is filled with a full load. Because of these perforations, the bulk-goods container must be provided with an inner lining or seam covering when fine bulk materials are to be transported, or when the bulk-goods container is to be suitable for foodstuffs, so that a hermetic seal of the bulk material is protected against environmental influences.

[0005] In order to prevent spreading of the stitch holes, a thick flat piece must be used that is over-dimensioned with respect to the theoretical forces acting on the unweakened fabric. Additional reinforcement layers must be stitched into the stitched-seam area.

[0006] Also, production according to the state of the art requires numerous production steps from cutting to size and pre-decoration of the individual parts, the subsequent stitching, and to the final visual inspection. Production must largely be manual.

[0007] In order to weaken the strong forces on the side stitched seams, it is known to stitch edge reinforcements along the entire height of the container in order to prevent the bulk goods from flowing into the lateral stitched-seam areas, thus producing large forces directly on the side stitched seams. According to the state of the art, such edge reinforcements may only be stitched up to a certain height of the container since the stitch length to be bridged is more than one meter itself, and industrial sewing machines do not allow stitching of such a seam.

[0008] U.S. Pat. No. 5,845,995 describes a packaging sack formed by folding a polyolefin tubular fabric. Next a molten intermediate layer of a thermoplastic polymer is inserted in the area of the folded layers to which the folded layers

adhere, resulting in a tightly-sealed floor area. The injection of the intermediate layer is difficult, however. There is also the disadvantage that the fabric is partially melted by the heat transfer, the infiltrating molten mass from the intermediate layer, and the full-surface adhesion, thus losing its flexibility. The so-called "memory effect" occurs to a fabric of stretched plastic strips as a result of the heat influence, i.e., the stretching causes a breakdown whereby the strength of the fabric is reduced.

[0009] It is thus the principal objective of the invention to provide a manufacturing method for a flexible bulk-goods container that allows significantly simpler and lower-cost manufacturing than does the state of the art. Also, its load-bearing capacity should increase, or the use of fabrics with lower weight per surface area would be allowed.

[0010] This objective is achieved in accordance with the invention by a method to manufacture a flexible bulk-goods container that possesses the following steps:

[0011] a) inserting of an energy-conversion medium that absorbs the light energy from a laser beam with wavelength λ and converts it into thermal energy at a seam area of at least one of the fabric sections, whereby the fabric section comprises a plastic that is light permeable to the laser;

[0012] b) producing an overlap of the fabric section at a seam area thereby forming a boundary layer between the overlapping fabric layers;

[0013] c) penetrating at least one of the fabric layers with a laser beam having a wavelength λ at a seam area;

[0014] d) allowing partial melting of the fabric layers in the surface area at the boundary layer, and allowing them to cool under formation of a weld seam location as a homogeneous bond between the fabric layers; and

[0015] e) repeating steps b) through d) until all seam areas are bonded.

[0016] The laser beam passes through the polypropylene fabric of the outer layer, penetrates in the area of the boundary surface between the adjacent fabric layers, and strikes energy-conversion medium embedded in the boundary layer. Here, the emitted light energy is converted into thermal energy that leads to local warming and partial melting of the fabric. The partial melting of both matching pieces in the area of the boundary layer leads to melting, and thus to a fused bond. It is even possible to pass the laser beam through several layers of fabric to an inner boundary layer not light permeable to create a weld seam for which an energy-conversion medium is provided at this boundary layer at least in the area of the seam. The method according to the invention may be automated, and thus may be performed at low cost. It is also possible using penetrating-laser welding to position weld seams anywhere functionally useful. Seams may also be created at locations not accessible to a sewing machine. It is thus possible to re-conceive a bulk-goods container, and sharply to reduce the number of parts required for its production.

[0017] It is also advantageous for the strength of the stretched plastic strips most often used for the manufacture of flexible bulk-goods containers to remain high, since, in

contrast to welding by a heated element, the fabric is not completely warmed and reduction in stretch capability is not reduced.

[0018] Since, in contrast to a process using a needle, no weakening of the fabric because of perforation ensues, a fabric may be selected that possesses a lower weight per surface area than is required for stitched containers.

[0019] It is further advantageous for the position of the stitches to be simply matched to the forces within the fabric, and complicated shapes of the cut sections may be undertaken without significant increase in production costs.

[0020] Further, it is possible to bond rigid and flexible fabrics together. This is possible with all combinations of thermoplastic materials in which mixture of the molten mass is possible. If, for example, a polypropylene-strip fabric is used, then injection-molded polypropylene parts may be bonded to the fabric without difficulty. This allows welding of supporting tubes in the floor or ceiling area that considerably simplify docking to a filling or emptying station. Also, additional parts may be welded on that allow automated gripping of the filling or emptying fittings of the bulk-goods container, e.g., those formed in the shape of a bayonet fitting.

[0021] Use of corner reinforcement is also possible without difficulty using penetrating-laser welding since merely the laser head need be led along the inner wall of the container in order to attach the corner reinforcement to the sidewall. Limitation to seal length as with sewing machines does not occur here.

[0022] It may be provided that the fabric be coated with an energy-conversion medium that absorbs the light energy of a laser at a specific wavelength, or to mix the plastic with an energy-conversion medium before fabric production.

[0023] It is preferred that the prepared fabric section is provided with an energy-conversion medium only in the region of the subsequent weld seams, e.g., by pressing.

[0024] The energy-conversion medium may further be prepared in the form of a welding film that is inserted into the boundary layer in the area of the desired seams. The welding film consists of a carrier plastic mixed with light-absorbing pigment. The thickness of the welding film whose melting temperature or degree of absorption of the pigment is so selected that either the welding film melts completely in the region of the weld seam creating a molten mass of plastic that causes local partial melting of the fabric to be welded, or that the welding film is merely heated and both fabric layers adhere to each other or are intensively bonded by means of the intermediary welding film.

[0025] It is possible to weld a first cut fabric section into a cylinder that is subsequently welded to a second cut fabric section as a floor, and to cut other fabric sections such as ceiling sections and filling and emptying aids.

[0026] Using the method according to the invention, one preferably starts with a stretched fabric tube so that the cutting is further simplified. The cut fabric section is then folded several times, and is welded in the area of the overlap of the folds by the effects of a laser beam.

[0027] It is also recommended to perform a micro-perforation by pulsed laser energy. Micro-perforations may be

simply created at least in regions of lower loading using a sharply focused laser beam that contributed to controlled ventilation of the interior of the container without allowing escape of the bulk material.

[0028] One may dispense with the previously required mounting of reinforcement areas in the area of the hoisting loops. It is recommended for heavily loaded containers here to compartmentalize the flap area welded to the container and to weld on the individual fingers of the compartments to the container in order to achieve a higher degree of force distribution. The larger number and length of the weld seams no longer presents a disadvantage to an automated process based on the invention.

[0029] Mounting of conventional welding surfaces with almost perpendicular cut sections is also possible.

[0030] In the following, the invention is described in further detail by embodiment examples and with reference to the illustrations, which show:

[0031] FIGS. 1a, 1b are schematic views of welding a cut-fabric section into a cylinder;

[0032] FIGS. 2a, 2b are schematic cutaway views of welding two or three fabric layers by means of laser penetration welding;

[0033] FIGS. 3a-3c show preparation of a section of fabric tubing by means of folding and positioning at various stages of the procedure;

[0034] FIGS. 5a, 5b show an additional section of fabric tubing before preparation for the manufacture of a bulk-goods container by folding and positioning;

[0035] FIG. 6 is an additional section of fabric tubing before decoration for the manufacture of a bulk-goods container by edge welding;

[0036] FIG. 7 is a schematic cutaway view of welding of an overlap area; and

[0037] FIG. 8 is a perspective view of another embodiment form of a bulk-goods container.

[0038] FIG. 1a shows a cut-fabric section 20 onto which an energy-conversion medium is pressed or otherwise mounted. The energy-conversion medium may consist of carbon, particularly in the form of soot. Since carbon absorbs light of all wavelengths, various lasers may be used, particularly low-cost semi-conductor lasers.

[0039] In FIG. 1b, the cut-fabric section 20 is rolled into a cylinder by means of formation of an overlap at the seam area 25. The laser beam 11 from a laser 10 is deflected using an optical device 14 and is projected along the seam area 25.

[0040] Welding of the cut-fabric sections using laser penetration welding is explained with reference to FIG. 2. There, two adjacent fabric layers 20.1, 20.2 are shown in whose boundary layer 22 an energy-conversion medium 24 is partially embedded. The artist-rendered dimensional relationships in FIG. 2 are not to scale, and serve merely for elucidation.

[0041] The energy-converting medium 24 is usually applied with a thickness of about 1-100 μm so that the boundary layer 22 also possesses the same thickness. The thickness of the upper fabric layer 20.1 to be penetrated may

possess any light permeability for the laser beam 11 as long as the light damping within the fabric layer 20.1 is not so strong that partial melting of the boundary layer 22 is no longer achievable. The thickness of the non-penetrated lower plastic part 20.2 is not significant.

[0042] The laser beam penetrates the plastic part 20.1, strikes the energy-conversion medium 24 embedded in the boundary layer 22, whereby the light energy is converted into thermal energy. Based on the laws of thermodynamics, and with respect to environmental influences, e.g., by cooling, the amount of heat per time may be calculated that must be input to the boundary layer in order to cause partial melting of the fabric layers 20.1, 20.2 but without causing complete melting, softening, or destruction of the fabric layers 20.1, 20.2.

[0043] For all welding process based on the invention, a lens-shaped weld seam location 23 is formed by the welding step that becomes molten and then cools and hardens after termination of the irradiation. The plane of symmetry of the weld seam location 23 lies approximately within the boundary layer 22, whereby even force progression and a high degree of load-bearing capacity is achieved.

[0044] Based on the method presented by the invention, the following option shown schematically in FIG. 2b is presented:

[0045] An additional laser 10' with a wavelength λ_2 can be provided. An energy-conversion medium 24' additional to the one in the existing seam area 25 is inserted into the boundary layer 22, or with more than two fabric layers 20.1, 20.2, 20.3, into an additional boundary layer 22' that absorbs light at wavelength λ_2 , but not to the extent that partial melting is caused. Thus, an additional seam area 25' is formed. It is thus possible to create two or more adjacent seams simultaneously by means of laser penetration welding.

[0046] It is further possible to use an energy-conversion medium that absorbs only a component of the energy at each of the wavelengths λ_1 and λ_2 . Upon irradiation by a only one of the laser beams 10 or 10', only local warming occurs, but not partial melting and welding. Only when several laser beams 11, 11' with wavelengths λ_1 and λ_2 are used is the energy contribution sufficient to create a weld seam location 23, 23'. It is thus possible to weld only the cross-points in a fabric if the weft yarn is coated with a first energy-converting medium 24, and the woof yarn with a second energy-conversion medium 24'. In the overlap at the node points, both energy-converting media 24, 24' are adjacent, so that a laser beam with wavelength λ_2 can only cause a weld at those positions while it otherwise may shine over the surface of the fabric without causing partial melting. The fabric remains flexible because of the connections only at the node points.

[0047] A flexible fabric is also obtained if an individual laser is coupled with an image-processing system and a control device through which switching the laser beam on only occurs at the node points of the weft and woof threads. In such case, it is adequate to apply an energy-conversion medium to the woof or weft threads.

[0048] FIGS. 3a through 3c show the preparation of a section of fabric tube for the manufacture of a bulk-goods

container. Either a tubular fabric is selected or, as shown above under FIGS. 1a, 1b, a flat cut-fabric section 20 is formed into a tube.

[0049] A polypropylene strip fabric is preferably selected where the strip width is preferably 1 to 4 mm, and preferably stretched to a ratio of 1:7 or 1:6. Fabric tension strengths of about 250 N/mm² have been achieved particularly by the use of mono-axial stretching. The polypropylene strips may be composed as follows, for example:

[0050] 95% polypropylene

[0051] 1.5% UV stabilizer

[0052] 3.5% anti-split medium, e.g., calcium carbonate, titanium oxide, talc, etc.

[0053] In addition, fabrics of polyethylene, HDPE, and PET may be processed by the invention.

[0054] The cut-fabric section 20 is provided with an impression of an energy-conversion medium 24 that corresponds to the subsequent seam.

[0055] As FIG. 3a shows, the tube section is flattened to a flat piece 30. Subsequently, several fold marks 41, 43, 44 are mounted and corners are reinforced until a folded floor or roof section of the bulk-goods container is formed.

[0056] The folding of a floor and/or roof section results from further procedure steps (see FIG. 3a).

[0057] Then, a first fold marking 41 is produced on both fabric layers along the entire width of the flat piece 30, namely at a distance from the lower edge 31 corresponding to the half-width of the flat piece 30.

[0058] A second and a third fold marking 43, 44 are produced starting from the middle of the lower edge 31 to the intersection point with the first fold marking 41 with a side edge 32, 33 of the flat piece 30.

[0059] A first and a second side edge section 32.1, 33.1 that extends between the lower edge 31 and the first fold marking 41 are pushed into the interior of the two-layered flat piece 30. Thus, the fabric is bent along the second and third fold markings 43, 44. In the final position of this production step, the side edge sections 32.1, 33.1 lie within the interior of the two-layered flat piece 30 at the first fold marking 41.

[0060] A configuration shown in FIG. 3b arises that possesses a clearly visible triangular area 45, 46. These are approximately bent in half so that their corners 46, 47 rest in the area of the first fold marking 41, and the final condition shown in FIG. 3c is achieved.

[0061] Only very low tensile forces act on the free corners 46, 47 of the bulk-goods container so formed, so that a very short weld seam is adequate to bind the corners 46, 47 to the fabric 20. For example, the corners may be connected using an arc-shaped weld seam area 25.

[0062] The illustrated simple production of a bulk-goods container 100 by folding and repositioning is essentially based on the laser welding method used here, because it would not be possible with conventional stitching equipment to stitch seam sections 25 with a sewing machine in the area of the floor or ceiling sections.

[0063] FIG. 4 shows a completed bulk-goods container 100 provided with hoisting loops 60. The welded flaps 61 of the hoisting loops 60 are also divided into compartments; the individual compartments are welded to the sidewalls in such manner that they are positioned approximately along the anticipated force directions. Laser beam welding using an energy-conversion medium pressed in place allows the provision of numerous complex weld steps, even with the compartmentalized weld flaps. No production cost increase results since the pressing of the energy-conversion medium for all seam areas may be performed in one step, and the welding may be automated using laser beams and electronic assembly-line control.

[0064] Welding of conventional hoisting loops with approximately rectangular weld flaps is also possible based on the invention. Such weld flaps are adequate under normal loading. Here also, rapid production of seams may be achieved via the invention.

[0065] FIG. 5a shows another flat piece 30 that includes quarter-circle arc cutouts at the edges of the lower edge 31. Also, an additional semi-circular cutout shape defined by the impression of the energy-conversion medium 24 is present. By use of the procedure steps explained previously with reference to FIGS. 3a through 3c, a bulk-goods container is produced with which the quarter- or semi-circular arc-shaped cutouts 26, 27 on the floor or ceiling section are expanded to a circular cutout 28 shown in FIG. 5b to which filling or emptying fittings may be mounted.

[0066] Another production method of a bulk-goods container with, for example, impressed energy-conversion medium, is first made possible using application of laser-beam welding based on the invention that is described with reference to FIG. 6 through 8 as follows:

[0067] At least one cut-fabric section 40 (see FIG. 6) is formed by corner cutouts of two symmetrical, mirror-reflected trapezoidal sections 44 opposing an edge. The cut fabric piece 40 thus produced, includes at least:

[0068] a right-angled sidewall area 42;

[0069] a trapezoid-shaped floor or ceiling area 43, 45 connected to the sidewall area 42, and

[0070] a right-angled support area 41 adjacent and connected to the floor and/or ceiling area 43, 45.

[0071] Either a tubular fabric may be correspondingly be processed, or four identical cut-fabric sections 44 are combined. If a tubular fabric is provided with cutouts 44, an endless tubular body is formed in the sidewall area. In both cases, the preferred embodiment per FIG. 7, a cut-fabric section 40 is folded over in the seam area 25. The short overlaid end is welded since the boring effect on the weld seams is minimized. Using the method based on the invention, the weld seam at the covered folded-over seam area may be produced by irradiation from a laser 10. The laser beam 11 passes through the outer fabric layers until it strikes the energy-conversion medium 24, thus causing melting of the overlapping cut-fabric sections 40 there.

[0072] FIG. 8 shows a bulk-goods container 100' formed out of four cut-fabric sections 40. The sidewall areas 42 are connected together in the edge-side seam areas 25 shown in the Figure with a dashed line so that an approximately quadrilateral, flexible container is formed that is limited at

the bottom by the connected trapezoid-shaped floor areas 43, and at the top by the connected trapezoid-shaped ceiling areas 45. A filling or emptying fitting is connected in the center of each floor or ceiling. Based on the invention, this bulk-goods container 100' is formed by seams created by only four automated passes with the laser, while a similar, conventional bulk-goods container assembled using manual stitching required 20 cut sections and 36 individual seams.

What is claimed is:

1. Method for producing a flexible bulk-goods container from a plastic strip fabric comprising the following steps:

a) introducing of the energy of a laser beam with an energy-conversion medium that absorbs wavelength λ_1 and converts it into thermal energy into a seam area of at least one cut-fabric section, the cut fabric section comprising a plastic that is light permeable to the laser beam;

b) producing an overlap of the cut-fabric section in a seam area thereby forming a boundary layer between the overlapping fabric layers;

c) penetrating at least one of the fabric layers with a laser beam having a wavelength of λ_1 in the seam area;

d) allowing partial melting of the fabric layers in their surface area under formation of a weld seam location as a homogeneous bond between the fabric layers (20.1, 20.2); and

e) repeating steps b) through d) until all seam areas are welded.

2. Method as defined in claim 1, wherein the energy-conversion medium is impressed onto at least one of the fabric layers.

3. Method as defined in claim 2, wherein the energy-conversion medium is impressed onto the seam area.

4. Method as defined in claim 2, wherein the energy-conversion medium is impressed onto the entire area.

5. Method as defined in claim 1, wherein the energy-conversion medium is inserted between the fabric layers in the form of a light-energy-absorbing welding film.

6. Method as defined in claim 1, wherein the energy-conversion medium is mixed into the plastic of at least one of the fabric layers.

7. Method as defined in claim 1, wherein a first cut-fabric section is welded into a cylinder that is welded to a second cut-fabric section as a floor section.

8. Method as defined in claim 1, wherein a first cut-fabric section is welded into a cylinder, and wherein a floor section is formed by multiple folding and repositioning of partial areas of the cut-fabric section, whereby the folds are fixed by laser beam welding.

9. Method as defined in claim 8, wherein a floor and/or roof area is formed using the following process steps:

a) folding the cylindrical cut fabric section flat into a two-layer flat piece;

b) producing a first fold mark on both fabric layers over the entire width of the flat piece at a distance to the lower edge corresponding to half the width of the flat piece;

c) producing a second and third fold mark starting from the center of the lower edge to each cutting point of the first fold mark with a side edge of the flat piece;

- d) inserting a first and second side-edge section that extends between the lower edge and the first fold mark into the interior of the two-layer flat piece by folding the fabric along the second and third fold marks up to the overlay of the side-edge sections on the first fold mark in the interior of the two-layer fabric;
- e) folding the triangular sections thus formed and overlaying the corners into the area of the first fold mark; and
- f) affixing the triangular sections and/or by penetrating laser-beam welding of the seam areas.

10. Method as defined in claim 1, wherein at least one cut fabric section is formed by corner extraction of two asymmetrical, mirror-reflected along one edge trapezoidal sections, whereby the cut fabric section thus obtained includes at least:

- a rectangular sidewall area;
- a trapezoid-shaped floor or roof area adjacent to the sidewall area; and
- a rectangular reinforcement area adjacent to each floor and/or roof area whose sidewall, floor, roof, and/or reinforcement areas each are welded in edge seam areas.

11. A flexible bulk goods container comprising at least one cut fabric section made of plastic fabric band, wherein the cut fabric section overlaps in the seam areas or is provided with an additional cut fabric section laid on it, and wherein an energy-conversion medium is inserted into the border layer, and the cut fabric sections is/are melted by laser beams acting on the energy-conversion medium(s).

12. A flexible bulk goods container as defined in claim 12, further comprising a surrounding sidewall and at least one floor section and/or roof section wherein the sidewall and floor section and/or roof section is/are formed of the same cut fabric section, and wherein the seam areas of the cut

fabric section are formed in the seam areas overlapping with the energy-conversion medium inserted into the intermediary border layer, and is melted by the laser beams (**11**, **11'**) acting on the energy conversion medium.

13. A flexible bulk goods container as defined in claim 12, wherein the floor section and/or roof section includes a round recess that is formed by means of quarter-circle shaped recesses near at least two corners of the cut fabric section that has been folded into a flat piece, and by at least one half-circle recess positioned in the center of an open edge of the flat piece.

14. A flexible bulk goods container as defined in claim 12, further comprising at least one surrounding sidewall and at least one floor or roof section, and by four cut fabric sections that are welded at seam areas near the edges, wherein each cut fabric section includes at least:

- a rectangular sidewall area;
- a trapezoid-shaped floor or roof area adjacent to the sidewall area; and
- a rectangular reinforcement area adjacent to each floor and/or roof area.

15. A flexible bulk goods container as defined in claim 10, wherein at least one carrying handle is positioned on the sidewall that is connected to it by means of a separate finger-shaped welding flap.

16. A flexible bulk goods container as defined in claim 10, wherein the cut fabric section is at least partially provided with micro-perforations that are spot-melted by laser beams.

17. Method as defined in claim 1, wherein the cut-fabric section comprises a stretched tubular fabric, and wherein a floor section is formed by multiple folding and repositioning of partial areas of the cut-fabric section, whereby the folds are fixed by laser beam welding.

* * * * *