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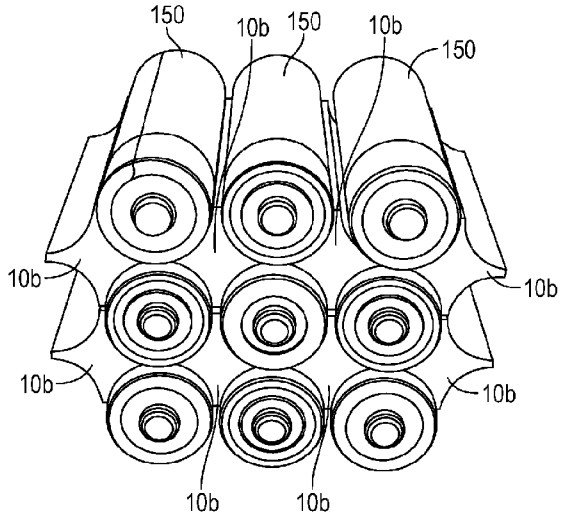

FIG. 16

(57) Abstract: A custom-shaped component for assembling cylindrical batteries, including: a first support that has been 3-D printed, wherein the first support has a first portion having a first length that is sized relative to the length of a first intended cylindrical battery, wherein the first support has a first cylindrical surface that aligns closely with the cylindrical surface of the first intended cylindrical battery.

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CUSTOM-SHAPED COMPONENT FOR ASSEMBLING BATTERIES AND METHODS FOR MAKING THE SAME

Background

Electric vehicles are becoming more popular and thus more in demand globally. Electric vehicles typically include an electric motor instead of an internal combustion engine. Electric vehicles use large traction battery packs to power the electric motor and must be plugged into a wall outlet or other charging equipment to store energy.

Potting adhesives are often used for bonding the cylindrical batteries to the base of battery pack for the electric vehicles. Alternatively, various battery modules or honeycomb structures are taught in the prior art for storing batteries for electric vehicles, including, for example, the following: European Patent No. 3824504 titled "Battery Module for an Electric Vehicle;" German Patent No. DE 102020119450 titled "Battery Module with Condensation and Propagation Protection, traction battery, and Electrified Motor Vehicle;" Japanese Patent No. 6749217 titled "Battery Outer Package and Battery Pack;' European Patent No. 1984964 titled "Spacer for Production of Battery Pack;" Japanese Patent No. 5899420 titled "Battery Module;" Chinese Patent No. 214227007 titled "Buffering Heat-Insulation Aerogel Sheet;" PCT Published Patent Application No. WO 2020223676 titled "Battery Thermal Management Strip;" and Chinese Patent No. 209487560 titled "Battery."

Summary

One aspect of the invention provides a custom-shaped component for assembling cylindrical batteries. The custom-shaped component comprises: a first support that has been 3-D printed, wherein the first support has a first portion having a first length that is sized relative to the length of a first intended cylindrical battery, wherein the first support has a first cylindrical surface that aligns closely with the cylindrical surface of the first intended cylindrical battery, wherein the first support has a second cylindrical surface that aligns closely with the cylindrical surface of a second intended cylindrical battery, wherein the first portion includes a thickness between the first and second cylindrical surfaces to electrically and thermally isolate the intended batteries from one another, and wherein the first and second cylindrical surfaces are tacky.

Another aspect of the invention provides an alternative custom-shaped component for assembling cylindrical batteries. This custom-shaped component comprises: a first support that has been injected molded, wherein the first support has a first portion having a first length that is sized relative to the length of a first intended cylindrical battery, wherein the first support has a first cylindrical surface that aligns closely with the cylindrical surface of the first intended cylindrical battery, wherein the first support has a second cylindrical surface that aligns closely with the cylindrical surface of a second intended cylindrical battery, wherein the first portion includes a

thickness between the first and second cylindrical surfaces to electrically and thermally isolate the intended batteries from one another, and wherein the first and second cylindrical surfaces are tacky.

Another aspect of the invention provides yet another alternative custom-shaped component for assembling cylindrical batteries. This custom-shaped component comprises: a first support that has been extruded, wherein the first support has a first portion having a first length that is sized relative to the length of a first intended cylindrical battery, wherein the first support has a first cylindrical surface that aligns closely with the cylindrical surface of the first intended cylindrical battery, wherein the first support has a second cylindrical surface that aligns closely with the cylindrical surface of a second intended cylindrical battery, wherein the first portion includes a thickness between the first and second cylindrical surfaces to electrically and thermally isolate the intended batteries from one another, and wherein the first and second cylindrical surfaces are tacky.

Another aspect of the invention provides an assembly of a plurality of batteries and a custom-shaped components for assembling cylindrical batteries. This assembly comprises: a plurality of batteries including at least a first cylindrical battery and a second cylindrical battery; a first support that has been 3-D printed, wherein the first support has a first portion having a first length that is sized relative to the length of a first cylindrical battery, wherein the first support has a first cylindrical surface that aligns closely with the cylindrical surface of the first cylindrical battery, wherein the first support has a second cylindrical surface that aligns closely with the cylindrical surface of a second cylindrical battery, wherein the first portion includes a thickness between the first and second cylindrical surfaces to electrically and thermally isolate the first and second batteries from one another, and wherein the first and second cylindrical surfaces are tacky; wherein the first cylindrical battery is releasably attached to the first support by contacting the cylindrical surface of the first cylindrical battery with the first cylindrical surface of the first support and wherein the second cylindrical battery is releasably attached to the first support by contacting the cylindrical surface of the second cylindrical battery with the second cylindrical surface of the first support.

Lastly, another aspect of the invention provides a method of manufacturing a custom-shaped component for assembling cylindrical batteries. This method comprises: providing UV-curable acrylate adhesive; providing a 3D printer; 3D printing a first support from the UV-curable acylate adhesive using the 3D printer, wherein the first support has a first portion having a first length that is sized relative to the length of a first intended cylindrical battery, wherein the first support has a first cylindrical surface that aligns closely with the cylindrical surface of the first intended cylindrical battery, wherein the first support has a second cylindrical surface that aligns closely with the cylindrical surface of a second intended cylindrical battery, wherein the first portion includes a thickness between the first and second cylindrical surfaces to electrically and thermally isolate the intended batteries from one another, and curing the support, wherein the first and second cylindrical surfaces are tacky.

Brief Description of the Drawings

Figure 1 is perspective view of one embodiment of a custom shaped component for assembling cylindrical batteries of the present invention;

Figure 2 is a top view of the custom shaped component of Figure 1;

Figure 3 is perspective view of another embodiment of a custom shaped component for assembling cylindrical batteries of the present invention;

Figure 4 is a top view of the custom shaped component of Figure 3;

Figure 5 is perspective view of another embodiment of a custom shaped component for assembling cylindrical batteries of the present invention;

Figure 6 is a top view of the custom shaped component of Figure 5;

Figure 7 is perspective view of another embodiment of a custom shaped component for assembling cylindrical batteries of the present invention;

Figure 8 is a top view of the custom shaped component of Figure 7;

Figure 9 is a perspective view of another embodiment of a custom shaped component for assembling cylindrical batteries of the present invention;

Figure 10 is a perspective view of another embodiment of a custom shaped component for assembling cylindrical batteries of the present invention;

Figure 11 is a top view of the custom shaped component of Figure 10;

Figure 12 is a perspective view of yet another embodiment of a custom shaped component for assembling cylindrical batteries of the present invention;

Figure 13 is a top view of the custom shaped component of Figure 12;

Figure 14 is a perspective view of another embodiment of a custom shaped component for assembling cylindrical batteries of the present invention;

Figure 15 is a perspective view of yet another embodiment of a custom shaped component for assembling cylindrical batteries of the present invention;

Figure 16 is a perspective view of an assembly of plurality of batteries with the custom shaped components of Figure 3; and

Figure 17 is a perspective view of an assembly of plurality of batteries with the custom shaped components of Figure 1, 14 and 15.

Detailed Description

The present invention provides custom shaped components in multiple shapes and configurations that are convenient to releasably store a plurality of cylindrical batteries. Such assembly of these components and batteries are suitable for easily grouping and shipping the batteries and ability to reuse the components, thus offering environmentally friendly options. The custom nature of the components are useful to pick and choose appropriate components with certain supports that will be especially useful for packing and shipping any number of batteries. The

components may be 3D printed, extruded, or injection molded. Lastly, the supports in the custom shaped components provide reliable shock absorbance, crash impact, vibration resistance for all of the batteries, and also provides reliable electrical and thermal isolation of the batteries from each other. Although primarily the custom shaped components described herein may be used in electric cars or other vehicles, they may also be used for any type of storage, shipping or transportation purposes.

Figures 1-15 illustrate multiple components that are all customized to provide certain supports for releasably storing cylindrical batteries to form assembly packs of batteries. Other configurations are contemplated, and the present invention should not be limited by the Figures illustrated.

Figures 1 and 2 illustrate a first embodiment of the support 10a which is useful for forming a customer shaped component for assembling cylindrical batteries of the present invention. In this embodiment, the first support 10a includes a first portion 12, a second portion 14, and a third portion 16, which provides a first cylindrical surface 20, a second cylindrical surface 22, and a third cylindrical surface 24. The surfaces 20, 22, and 24 and adjacent portions 12, 14, 16 are shown as all the same length L, but this is not absolutely necessary. In one embodiment, the first support 10a has a first portion 12 having a first length L that is equal to or is less than the height of a first intended cylindrical battery. In another embodiment, the first support 10a has a first portion 12 having a first length that exceeds the height of a first intended cylindrical battery. Likewise, in either embodiment, preferably the first portion 12 and second portion 14 have the same length L. The surfaces 20, 22, and 24 are preferably concave to align with the cylindrical surfaces of any intended batteries which are convex.

The support 10a includes a first end surface 28 extending between the first cylindrical surface 20 and the second cylindrical surface 22. The first support 10a also includes a second end surface 30 extending between the second cylindrical surface 22 and the third cylindrical surface 24. The first support 10a also includes a third end surface 32 extending between the third cylindrical surface 24 and the first cylindrical surface 20. The end surfaces 28, 30, and 32 are shown as all the same thickness t, but this is not absolutely necessary. The thickness t of each of the portions 12, 14, 16 may be chosen so as to electrically and thermally isolate the intended batteries from one another, when they releasably contact the cylindrical surfaces 20, 22, 24. The cylindrical surfaces 20, 22, 24 are tacky to the touch. The cylindrical surface materials that are tacky or sticky are easily identified by touch. This is normally done by holding the cylindrical surface material between the forefinger and thumb, and feeling how sticky and difficult it is to remove the material from the fingers, while at room temperature. To provide tacky surfaces the first support 10a may be manufactured using adhesive, more specifically cured adhesive, and in one particular embodiment using UV-curable acrylate adhesive. Alternatively, the cylindrical surfaces 20, 22, and 24 may be coated with a

pressure sensitive adhesive. 3M Company based in St. Paul, Minnesota sells a variety of pressure sensitive adhesives commercially that are suitable for this application.

The first support 10a includes a top surface 36 and a bottom surface 38 which is opposite the top surface 36. The first support 10a may be either solid or partially hollow. Figure 1 illustrates first support 10a as partially hollow. The inside surfaces 40a, 40b, and 40c generally align with the cylindrical surfaces 20, 22, and 24 accordingly.

The first support 10a including its first portion 12, 14, 16 may be made of an auxetic structure, particularly if made by 3D printing. Alternatively, the first support 10a may include a core of polymer of cured resin (thermoset) or of thermoplastic coated with a layer of adhesive. As another alternative, the first support 10a may include a core of non-woven structure coated with layer of adhesive.

Figures 3 and 4 illustrate an alternative support 10b useful for forming a custom shaped component for assembling cylindrical batteries of the present invention. Support 10b is just like the support 10a illustrated and discussed relative to Figures 1 and 2, except that it has four portions, named appropriately first portion 12, second portion 14, third portion 16, and fourth portion 18. Each portion 12, 14, 16, 18 has a corresponding end surface, shown as first end surface 28, second end surface 30, third end surface 32, and fourth end surface 34, respectively. Custom-shaped support 10b also includes a first cylindrical surface 20, a second cylindrical surface 22, a third cylindrical surface 24, and a fourth cylindrical surface 26. The first cylindrical surface 20 extends between the first end surface 28 and the fourth end surface 34. The second cylindrical surface 22 extends between the first end surface 28 and the second end surface 30. The third cylindrical surface 24 extends between the second end surface 30 and the third end surface 32. The fourth cylindrical surface 26 extends between the third end surface 32 and the fourth end surface 34.

The surfaces 20, 22, 24, 26 and adjacent portions 12, 14, 16, 18 are shown as all the same length L, but this is not absolutely necessary. In one embodiment, the first support 10a has a first portion 12 having a first length L that is equal to or is less than the height of a first intended cylindrical battery. In another embodiment, the first support 10a has a first portion 12 having a first length that exceeds the height of a first intended cylindrical battery. Likewise, in either embodiment, preferably the first portion 12, second portion 14, third portion 16, and fourth portion 18 have the same length L. The surfaces 20, 22, 24, 26 are preferably concave to align with the cylindrical surfaces of any intended batteries which are convex. The custom-shaped first support 10a may include the first and second cylindrical surfaces 20, 22 are configured at a 90-degree angle relative to each other. The custom-shaped first support 10a may also include third and fourth cylindrical surfaces 24, 26 are configured at a 90-degree angle relative to each other. Also, the first cylindrical surface 20, second cylindrical surfaces 22, third cylindrical surface 24, and fourth cylindrical surface 26 are all configured to be at a 90-degree angle relative to each other.

The end surfaces 28, 30, 32, 34 are shown as all the same thickness t, but this is not absolutely necessary. The thickness of each of the portions 12, 14, 16 may be chosen so as to electrically and thermally isolate the intended batteries from one another, when they releasably contact the cylindrical surfaces 20, 22, 24, 26. The cylindrical surfaces 20, 22, 24, 26 are tacky to the touch. For example, preferred measurement range of thicknesses t includes 0.1 mm to 1.5 cm, and more preferably 1 mm to 5 mm. The thickness of the portions 12, 14, 16 may be also tapered from example at its widest thickness of 2.6 mm and at its narrowest thickness 1.2 mm, for example. Preferable materials for support 10 depend of method of manufacture, and are listed below.

To provide tacky surfaces the first support 10b may be manufactured using adhesive, more specifically cured adhesive, and in one particular embodiment using UV-curable acrylate adhesive that is UV-cured. Alternatively, the cylindrical surfaces 28, 30, 32, 34 may be coated with a pressure sensitive adhesive.

The first support 10b includes a top surface 36 and a bottom surface 38 which is opposite the top surface 36. The first support 10a may be either solid or partially hollow. Figures 3 and 4 illustrate first support 10b as partially hollow. The inside surfaces 40a, 40b, 40c, 40d generally align with the cylindrical surfaces 20, 22, 24, 26 accordingly.

First support 10a illustrated in Figures 1 and 2 is designed to releasably attach three batteries to the cylindrical surfaces 20, 22, 24. First support 10b illustrated in Figures 3 and 4 is designed to releasably attach four batteries to the cylindrical surfaces 20, 22, 24, 26., which is shown in Figures 16 and 17.

Figures 5 and 6 illustrate a first support 10c useful for forming a custom shaped component for assembling cylindrical batteries of the present invention. Support 10c is just like the support 10b illustrated and discussed relative to Figures 3 and 4, except that support 10c is made entirely from a lattice structure 50 of interconnected filaments 52. The interconnected filaments 52 form the top surface 36, bottom surface 38, first cylindrical surface 20, second cylindrical surface 22, third cylindrical surface 24, and fourth cylindrical surface 26. The end surfaces 28, 30, 32, and 36 are formed from individual filaments 52 which run the length L of the support 10c. The thickness t is selected for each of the portions 12, 14, 16 so as to electrically and thermally isolate the intended batteries from one another, when they releasably contact the cylindrical surfaces 20, 22, 24, taking into the materials and spacing between the filaments 52.

First support 10c may be 3D printed using conventional 3-D printing apparatuses commercially available. One example of a suitable 3-D print apparatus for use in creating first support 10c is commercially available from Asiga which has a European office in Erfurt, Germany and is a stereolithographic printer sold under the Asiga-Pro4K brand. One suitable material to 3-D print to provide first support 10c is an adhesive, more specifically cured adhesive, and in one particular embodiment using UV-curable acrylate adhesive. Such material provides tacky surfaces to hold the batteries in place within the custom shaped component.

Figures 7 and 8 illustrate another first support 10d useful for forming a custom shaped component for assembling cylindrical batteries of the present invention. Support 10d is just like the support 10c illustrated and discussed relative to Figures 5 and 6, except that support 10d is made from a lattice structure 50 of interconnected filaments 52 in combination with four cylindrical surfaces, first cylindrical surface 20, second cylindrical surface 22, third cylindrical surface 24, and fourth cylindrical surface 26. The spacing between adjacent surfaces 20, 22, 24, 26, which is occupied by the filaments 52 form the respective portions, first portion 12, second portion 24, third portion 26, and fourth portion 28. The interconnected filaments 52 form the top surface 36 and bottom surface 38. In an alternative embodiment, not shown, the top surface 36 and bottom surface 38 could be solid surfaces, like the surfaces 20, 22, 24, 26. The length between the top surface 36 and bottom surface 38 is the length L of the support 10d. The thickness t is selected for each of the portions 12, 14, 16, 16 so as to electrically and thermally isolate the intended batteries from one another, when they releasably contact the cylindrical surfaces 20, 22, 24, taking into the materials and spacing between the filaments 52.

Figure 9 illustrates a first support 10e useful for forming a custom shaped component for assembling cylindrical batteries of the present invention. Support 10e is just like the support 10b illustrated and discussed relative to Figures 3 and 4, except that support 10c additionally includes channels 60 that extend from the end surfaces 28, 30, 32, 34 to the inside surfaces 40a, 40b, 40c, 40d, respectively. Similar to the other first supports 10a-10d, the first support 10e includes a length L extending between the top surface 36 and bottom surface 38. The thickness t is selected for each of the portions 12, 14, 16, 18 so as to electrically and thermally isolate the intended batteries from one another, when they releasably contact the cylindrical surfaces 20, 22, 24, 26 taking into the materials and channels 60.

Figures 10 and 11 illustrates yet another first support 10f useful for forming a custom shaped component for assembling cylindrical batteries of the present invention. Support 10f is just like the support 10b illustrated and discussed relative to Figures 3 and 4, except that support 10f additionally includes connectors 56a, 56b that extend from at least one of the end surfaces 28, 30, 32, 34. Other end surfaces 28, 30, 32, 34 include specialized slots for receiving connectors 56a, 56b of other supports 10f. Similar to the other first supports 10a-10d, the first support 10f includes a length L extending between the top surface 36 and bottom surface 38. The thickness t is selected for each of the portions 12, 14, 16, 18 so as to electrically and thermally isolate the intended batteries from one another, when they releasably contact the cylindrical surfaces 20, 22, 24, 26 taking into the materials, connectors 56a, 56b, and slots 58a, 58b. First support 10f may include any number of connectors 56 and slots 58, and such may be customized appropriately for supporting any number of batteries.

Figures 12 and 13 illustrate yet another embodiment of a custom shaped component 100a for assembling cylindrical batteries of the present invention. In this embodiment, the component

100a includes a series of supports formed together. The component 100a includes a plurality of first cylindrical surfaces 120a-120e. The component 100a includes a plurality of second cylindrical surfaces 122a-122e, opposite the plurality of first cylindrical surfaces 120a-120e. Extending between adjacent first cylindrical surfaces 120a-120e is first end surfaces 128b-128e, respectively. The component 100a also includes a first major side surface 144 and a second major side surface 146 opposite the first major side surface 144. A first end surface 128a is extending between the first major side surface 144 and the first cylindrical surface 120a. A first end surface 128f is extending between the second major side surface 146 and the first cylindrical surface 102e. Similarly, the component 100a includes second end surfaces 130b-130e extending between adjacent second cylindrical surfaces 122a-122e, respectively. And, a second end surface 130a is extending between the first major side surface 144 and the second cylindrical surface 122a. A second end surface 130f is extending between the second major side surface 146 and the second cylindrical surface 122e. The component 100a includes a top surface 136 and a bottom surface 138 opposite the top surface 136.

The cylindrical surfaces 120a-120e, 122a-122e are tacky to the touch to properly hold batteries in position, as shown in Figure 17. To provide tacky surfaces component 100a may be manufactured using adhesive, more specifically cured adhesive, and in one particular embodiment using UV-curable acrylate adhesive. Alternatively, the cylindrical surfaces 120, 122 may be coated with a pressure sensitive adhesive.

The component 100a includes a plurality of first portions 112a-112f, which include at least one cylindrical surface 120 and a first end surface 128. The component 100a also includes a plurality of second portions 114a-114f, which include at least one cylindrical surface 122 and a second end surface 130. The end surfaces 128, 130, are shown as all the same thickness t, but this is not absolutely necessary. However, the thickness t of each of the portions 112, 114, may be chosen so as to electrically and thermally isolate the intended batteries from one another, when they releasably contact the cylindrical surfaces 120, 122. For instance, the thickness t may range from 0.1 mm to 1.5 cm or more particularly may range from 1mm to 5 mm for components comprised of UV-curable adhesives. The thickness of the portions 112, 114 may be also tapered from example at its widest thickness of 2.6 mm and at its narrowest thickness 1.2 mm, for example. The component 100a includes a length L customized for the batteries intended to be held within the component 100a. The length L may be equal to or less than the overall length of the intended batteries. Alternatively, the length L may exceed the length of the intended batteries.

Figure 14 illustrates an alternative component 100b, which is just like component 100a illustrated in Figures 12 and 13 except that component 100b includes a plurality of cylindrical surfaces 120a-120e and opposite such cylindrical surfaces 120a-120e is a major back surface 148. Component 100b may be used in combination with component 100a to store a plurality of batteries 150, as illustrated in Figure 17.

Figure 15 illustrates another embodiment of first support 10g which includes the includes a reservoir 42 for receiving a fire extinguishing liquid. First support 10g may include any number of reservoirs 42. Figure 15 illustrates a first reservoir 42a and a second reservoir 42b. One example of a suitable fire extinguishing liquid for assisting with putting out sparks or fires generated from the batteries is commercially available from 3M Company based in St. Paul, Minnesota as Novec™ 1230 Fire Protection Fluid.

First support 10g includes a first portion 12, a second portion 14, and a third portion 16, which provides a first cylindrical surface 20, a second cylindrical surface 22, 24, respectively therebetween. The surfaces 20, 22, and adjacent portions 12, 14, 16 are shown as all the same length L, but this is not absolutely necessary. In one embodiment, the first support 10g has a first portion 12 having a first length L that is equal to or is less than the height of a first intended cylindrical battery. In another embodiment, the first support 10g has a first portion 12 having a first length that exceeds the height of a first intended cylindrical battery. Likewise, in either embodiment, preferably the first portion 12 and second portion 14 have the same length L. The surfaces 20, 22 are preferably concave to align with the cylindrical surfaces of any intended batteries which are convex. The first support 10g includes a top surface 36 and a bottom surface 38 which is opposite the top surface 36.

The support 10g includes a first end surface 28 extending between the first cylindrical surface 20 and the second cylindrical surface 22. The first support 10a also includes a second end surface 30 extending between the second cylindrical surface 22 and a back surface 48. The first support 10a also includes a third end surface 32 extending between the first cylindrical surface 20 and the back surface 48. The end surfaces 28, 30, and 32 are shown as two different thicknesses t_1 and t_2, but this is not absolutely necessary. The thickness t of each of the portions 12, 14, 16 may be chosen so as to electrically and thermally isolate the intended batteries from one another, when they releasably contact the cylindrical surfaces 20, 22, 24. The cylindrical surfaces 20, 22 are tacky to the touch. To provide tacky surfaces the first support 10g may be manufactured using adhesive, more specifically cured adhesive, and in one particular embodiment using UV-curable acrylate adhesive. Alternatively, the cylindrical surfaces 20, 22 may be coated with a pressure sensitive adhesive.

Figure 16 illustrates an assembly of plurality of batteries with the custom shaped components of Figure 3. Figure 17 illustrates an assembly of plurality of batteries with the custom shaped components of Figure 1, 14 and 15. However, any combination of the supports 10a-10g may be used to form custom shaped components for storing, packaging, and shipping any number of batteries 150. Figure 16 illustrates the use of eight supports 10b to hold nine batteries 150 securely in place. The convex surfaces 20, 22, 24, 26 of each support 10b releasably attach to concave surfaces of different batteries 150. Figure 17 illustrated the use of two supports 10b, one component 100a and one component 100b to hold nine batteries 150.

The customized components which provide certain supports for releasably storing cylindrical batteries described herein including supports 10 may be made by 3D printing techniques, using commercially available 3D printers incorporating certain additive manufacturing process. For a material extrusion additive manufacturing process, of which one example is fused deposition molding, certain materials suitable for use include thermoplastic polymers, such as polyolefins, polyamides, polystyrenes. For a material/binder jetting additive manufacturing process, certain materials suitable for use include nylon, thermoplastic polyamide (TPA), thermoplastic polyurethane (TPU), polypropylene (PP), and photocurable compositions based on (meth)acrylates, epoxies, and/or polyurethanes. For a powder bed fusion additive manufacturing process, of which two examples include multi jet fusion (MJF) and selective laser sintering (SLS), certain materials suitable for use include nylon, polypropylene (PP), thermoplastic elastomer (TPE), polyaryletherketone, (PAEK), and polyetherketone (PEEK), TPU. For vat photopolymerization additive manufacturing process, of which three examples include stereolithography (SLA), digital light processing (DLP), and continuous digital light processing (CDLP), certain material suitable for us include photocurable compositions based on (meth)acrylates, epoxies, and/or polyurethanes. Alternatively, the customized components including supports 10 described herein may be made by standard extrusion manufacturing methods. Suitable materials for use with this method include thermoplastic polymers, such as polyolefins, polyamides, polystyrenes. Polymers can be modified with fillers, such as glass fibers and thermal conductive fillers, to adjust properties. Fillers could also include materials such as aluminum nitride, silicon carbide, aluminum, graphite, boron nitride, aluminum oxide, and metals, in general. Materials could also include acrylonitrile butadiene styrene (ABS), ethylene vinyl acetate (EVA), flexible and rigid polyvinyl chloride (PVC), high density polyethylene (HDPE), low density polyethylene (LDPE), polycarbonate (PC), polypropylene (PP), polyurethane (PUR or PU), thermoplastic elastomers (TPE), thermal plastic vulcanite (TPV), thermal plastic olefin (TPO), polyamide thermoplastic elastomer (TPA), and polyetherketone (PEEK).

As yet another alternative, the customized components including supports 10 described herein may be made by standard injection molding manufacturing methods. Suitable materials for use with this method include polypropylene (PP), polyethylene (PE), high density polyethylene (HDPE), low density polyethylene (LDPE), polystyrene (PS), medium impact polystyrene (MIPS), high impact polystyrene (HIPS), polycarbonate (PC), polyamide (PA) (Nylon), acrylic (PMMA), acrylonitrile butadiene styrene (ABS), polyethylene terephthalate (PET), polyethylene terephthalate glycol (PETG), polybutylene terephthalate (PBT), polyoxymethylene (POM), polyvinyl chloride (PVC), perfluoroalkoxy (PFA), polyvinylidene fluoride (PVDF), polyphenylene sulfide (PPS), polytetrafluoroethylene (PTFE), polyurethane (PUR or PU), polyphenylsulfone (PPSU), polyetherimide (PEI), styrene acrylonitrile (SAN), polysulfone (PSU), polyamide-imide (PAI),

polybenzimidazole (PBI), polyimide (PI), and PEEK (polyetherketone). Thermoset materials for injection molding could include epoxy resin and phenol formaldehyde resin.

Examples

This disclosure is not limited to the above-described embodiments but is to be controlled by the limitations set forth in the following claims and any equivalents thereof. This disclosure may be suitably practiced in the absence of any element not specifically disclosed herein.

Unless otherwise noted, all parts, percentages, ratios, etc. in the Examples and the rest of the specification are by weight. Unless otherwise indicated, all other reagents were obtained, or are available from fine chemical vendors such as Sigma-Aldrich Company, St. Louis, Missouri, or may be synthesized by known methods. The following abbreviations are used in this section: min = minutes, s = second, g = gram, centimeter = cm, mm = millimeter, nm = nanometer, m = meter, °C = degrees Celsius, mW/cm^2 = milliWatt per centimeter square, mJ/cm^2 = milli Joule per centimeter square, and mL = milliliters.

Table 1: Materials

Abbreviation	Description
VHB 4910	Foam tape, obtained under the trade designation "VHB 4910", from 3M Company, St. Paul, MN
3M™ SP 7555	Adhesive, obtained under the trade designation "3M SCREEN PRINTABLE UV-CURING ADHESIVE 7555", from 3M Company, St. Paul, MN
2-isopropanol	Solvent, technical grade, obtained from VWR Chemicals, Radnor, PA
Ultracur3D™ EL 150	Urethane photopolymer (Shore 77 A), obtained under the trade designation "ULTRACUR3D EL 150", from BASF, Ludwigshafen am Rhein, Germany
Cylindrical battery cell models	AA alkaline battery, obtained under the trade designation "DURACELL PLUS", from Bethel, CT

Additive Manufacturing

Ultracur3D™ EL 150 from BASF was added to the vat of a Asiga-Pro4K printer (Sydney, Australia). The printer was operated at 30°C. The printer platform of the printer moved down into the vat to leave a gap of 0.075 mm. The printer radiated the material with 384 nm UV LEDs with an intensity of 5.77 mW/cm^2 at selective locations in the x-y direction. After 5.6 seconds radiation (for the first lacer, subsequent layers were only radiated for 2.8 seconds) and 2 seconds waiting time (0.1 seconds for the subsequent layers), the platform was lifted 15 mm with a speed of 2.475 mm/s. The cured material moved up with the platform, while uncured material flowed underneath the platform. Subsequently, the platform moved down again with 4.3 mm/s leaving a gap of 0.075 mm for the next layer. The procedure was repeated until all layers were completed. The printed part was

allowed to drain for 30 minutes and was subsequently removed from the platform. The parts were rinsed with 2 mL of 2-isopropanol.

Table 2: Printing parameters for above part production:

Parameter	Unit	Burn-in (First Layer)	Layers
Layer Thickeness	mm	0.075	0.075
Heater Temperature		30°C	30°C
Light intensity	mW/cm^2	5.77	5.77
Exposure time	s	5.634	2.791
Fill exposure	%	100	100
Z compensation	mm	0.15	0.15
Support Exposure (not applicable here as printed without supports)	%	100	100
Fill Noise	%	0	0
Seperation Velocity	mm/s	2.475	2.475
Seperation Acceleration	mm/s^2	0.1	0
Seperation Deceleration	mm/s^2	0	0
Seperation Distance	mm	15	15
Seperation Detect Window	g	100	100
Seperation Detect Window Time	s	0.5	0.5
Seperation Detect Hard stop		1	1
Seperation Pressure Limit	g/cm^2	100	100
Approach Velocity	mm/s	4.3	4.3
Approach Accelertion	mm/s^2	0	0
Approach Deceleration	mm/s^2	0	0
Approach Pressure limit	g/cm^2	100	100
Tare interval	mm	0.001	0.001
Pressure hysteresis	%	5	5
Layer Tolerance	%	30	30
Viscosity range	mm	1	1
Motor timeout	s	300	300
Traverse Timeout range	mm	0.1	0.1
Wait time after exposure	s	2	0.1
Wait time after seperation	s	5	0
Wait time after approach	s	0	0

Preparation of Examples 1-4 (EX1 – EX4)

Example 1 (EX1)

The printed part was post-cured at 100% power setting of RS Cure (Rapidshape, Heimsheim, Germany) for 10 minutes. UV-curing under nitrogen removed tackiness of the samples. The surfaces of the finished part were wiped with 2-isopropanol and subsequently allowed to dry at 20°C for 30 min. The printed part of Example 1 resembled the embodiment illustrated in Figures 3

and 4. The longitudinal surfaces (20) were covered with a 4.5 x 5 cm piece of double-sided tape (VHB 4910). After removal of the tape liner, the part was adhered to cylindrical battery cell models.

Example 2 (EX2)

The printed part was post-cured at 100% power setting of RS Cure (Rapidshape, Heimsheim, Germany) for 10 minutes. The surfaces of the finished part were wiped with 2-isopropanol and subsequently allowed to dry at 20°C for 30 min. The printed part of Example 2 resembled the embodiment illustrated in Figures 3 and 4. The bottom surface of the part (38) was dipped into 3M SP 7555. The parts were placed with the coated bottom was irritated from the with UV Quickstart QST 3000 (Kühnast Strahlungstechnik, Wächtersbach, Germany) with 70 mJ/cm^2 (75% radiation with 4.8 m/min). After curing, the parts were tacky at the bottom, which allowed to adherence of the parts next to each other on a plate.

Example 3 (EX3)

The printed part was post-cured at 100% power setting of RS Cure (Rapidshape, Heimsheim, Germany) for 10 minutes. The surfaces of the finished part were wiped with 2-isopropanol and subsequently allowed to dry at 20°C for 30 min. The printed part of Example 3 resembled the embodiment illustrated in Figures 3 and 4. The longitudinal surfaces (20) were covered with 3M SP 7555. The coated surfaces were cured with UV Quickstart QST 3000 (Kühnast Strahlungstechnik, Wächtersbach, Germany) with 70 mJ/cm^2 (75% radiation with 4.8 m/min). After curing, the part was adhered to cylindrical battery cell models.

Example 4 (EX4)

The Ultracur3D® EL 150 3D printed part was not finally cured to remain a strong tacky surface. The printed part of Example 4 resembled the embodiment illustrated in Figures 3 and 4. The non-finally cured parts were placed together with a cylindrical battery cell model and for 10 min post-UV cured in the assembled construct. After UV exposure, the battery model and the printed part bonded together. The bond strength was increased by adding a drop of fresh, uncured material to the bond line prior to UV exposure.

Select Embodiments of the Present Disclosure

Embodiment 1 is a custom-shaped component for assembling cylindrical batteries, comprising: a first support that has been 3-D printed, wherein the first support has a first portion having a first length that is sized relative to the length of a first intended cylindrical battery, wherein the first support has a first cylindrical surface that aligns closely with the cylindrical surface of the first intended cylindrical battery, wherein the first support has a second cylindrical surface that aligns closely with the cylindrical surface of a second intended cylindrical battery, wherein the first

portion includes a thickness between the first and second cylindrical surfaces to electrically and thermally isolate the intended batteries from one another, and wherein the first and second cylindrical surfaces are tacky.

Embodiment 2 is the custom-shaped component of embodiment 1, wherein the first support comprises adhesive.

Embodiment 3 is the custom-shaped component of embodiment 2, wherein the first support comprises cured adhesive.

Embodiment 4 is the custom-shaped component of embodiment 3, wherein the first support comprises UV-curable acrylate adhesive that is UV-cured.

Embodiment 5 is the custom-shaped component of embodiment 1, wherein the first support comprises a layer of pressure-sensitive adhesive on the first and second cylindrical surfaces.

Embodiment 6 is the custom-shaped component of embodiment 1, wherein an intended first battery may releasably attached and detached from the first support.

Embodiment 7 is the custom-shaped component of embodiment 1, wherein the first support comprises a core of polymer coated with pressure-sensitive adhesive.

Embodiment 8 is the custom-shaped component of embodiment 1, wherein the first support comprises a core of non-woven structure coated with pressure-sensitive adhesive.

Embodiment 9 is the custom-shaped component of embodiment 1, wherein the first support comprises auxetic structure.

Embodiment 10 is the custom-shaped component of embodiment 1, wherein the first support has a first portion having a first length that is equal to or is less than the length of a first intended cylindrical battery.

Embodiment 11 is the custom-shaped component of embodiment 1, wherein the first support has a first portion having a first length that exceeds the length of a first intended cylindrical battery

Embodiment 12 is the custom-shaped component of embodiment 1, wherein the first support has a second portion having a second length that is equal to or is less than the length of the second intended battery, and wherein the first and second cylindrical surfaces are at a 90-degree angle relative to each other

Embodiment 13 is the custom-shaped component of embodiment 1, wherein the first cylindrical and second cylindrical surface of the first support are concave, and the cylindrical surface of the intended battery is convex.

Embodiment 14 is the custom-shaped component of embodiment 1, wherein the first support includes a third cylindrical surface that aligns closely with the cylindrical surface of a third intended cylindrical battery, and wherein the first portion includes a thickness between the first and second and third cylindrical surfaces to electrically and thermally isolate the intended batteries from one another.

Embodiment 15 is the custom-shaped component of embodiment 14, wherein the first support includes a fourth cylindrical surface that aligns closely with the cylindrical surface of a fourth intended cylindrical battery.

Embodiment 16 is the custom-shaped component of embodiment 15, wherein the third cylindrical and fourth cylindrical surface of the first support are concave, and the cylindrical surface of the intended battery is convex.

Embodiment 17 is the custom-shaped component of embodiment 1, wherein the first support is hollow throughout the length of the first support.

Embodiment 18 is the custom-shaped component of embodiment 1, wherein the first support includes a reservoir for receiving a fire extinguishing liquid.

Embodiment 19 is the custom-shaped component of embodiment 1, wherein the first support is solid throughout the length of the support.

Embodiment 20 is the custom-shaped component of embodiment 1, wherein the first support comprises a lattice structure of interconnected filaments.

Embodiment 21 is the custom-shaped component of embodiment 20, wherein interconnected filaments comprises cured adhesive.

Embodiment 22 is the custom-shaped component of embodiment 1, wherein the first support comprises a lattice structure of interconnected filaments and solid cylindrical surfaces.

Embodiment 23 is the custom-shaped component of embodiment 1, wherein the first support further comprises end surfaces adjacent the cylindrical surfaces, and where in the end surfaces include a plurality of channels.

Embodiment 24 is the custom-shaped component of embodiment 1, wherein the first support further comprises a first end surface adjacent the cylindrical surfaces, wherein the first end surface includes a connector extending therefrom.

Embodiment 25 is the custom-shaped component of embodiment 24, wherein the first support comprises a second end surface adjacent the cylindrical surfaces, wherein the second end surface includes a slot for receiving another connector.

Embodiment 26 is the custom-shaped component of embodiment 24, wherein the connector comprises UV-curable acrylate adhesive that is UV-cured.

Embodiment 27 is the custom-shaped component of embodiment 1, wherein the first support further comprises a top surface and a bottom surface opposite the top surface.

Embodiment 28 is the custom-shaped component of embodiment 27, wherein the top surface and bottom surface comprise a lattice structure of interconnected filaments.

Embodiment 29 is the custom-shaped component of embodiment 1 in combination with at least a first cylindrical battery releasably attached to the first cylindrical surface of the first support; and a second cylindrical battery releasably attached to the second cylindrical surface of the first support.

Embodiment 30. A custom-shaped component for assembling cylindrical batteries, comprising: a first support that has been injected molded, wherein the first support has a first portion having a first length that is sized relative to the length of a first intended cylindrical battery, wherein the first support has a first cylindrical surface that aligns closely with the cylindrical surface of the first intended cylindrical battery, wherein the first support has a second cylindrical surface that aligns closely with the cylindrical surface of a second intended cylindrical battery, wherein the first portion includes a thickness between the first and second cylindrical surfaces to electrically and thermally isolate the intended batteries from one another, and wherein the first and second cylindrical surfaces are tacky.

Embodiment 31. A custom-shaped component for assembling cylindrical batteries, comprising: a first support that has been extruded, wherein the first support has a first portion having a first length that is sized relative to the length of a first intended cylindrical battery, wherein the first support has a first cylindrical surface that aligns closely with the cylindrical surface of the first intended cylindrical battery, wherein the first support has a second cylindrical surface that aligns closely with the cylindrical surface of a second intended cylindrical battery, wherein the first portion includes a thickness between the first and second cylindrical surfaces to electrically and thermally isolate the intended batteries from one another, and wherein the first and second cylindrical surfaces are tacky.

Embodiment 32 is the custom-shaped component of embodiment 30 or 31, wherein the first support comprises a layer of pressure-sensitive adhesive on the first and second cylindrical surfaces.

Embodiment 33 is the custom-shaped component of embodiment 30 or 31, wherein an intended first battery may releasably attached and detached from the first support.

Embodiment 34 is the custom-shaped component of embodiment 30 or 31, wherein the first support comprises a core of polymer coated with pressure-sensitive adhesive.

Embodiment 35 is the custom-shaped component of embodiment 30 or 31, wherein the first support comprises a core of non-woven structure coated with pressure-sensitive adhesive.

Embodiment 36 is the custom-shaped component of embodiment 30 or 31, wherein the first support comprises a core of polymer coated with pressure-sensitive adhesive.

Embodiment 37 is the custom-shaped component of embodiment 30 or 31, wherein the first support has a first portion having a first length that is equal to or is less than the length of a first intended cylindrical battery.

Embodiment 38 is the custom-shaped component of embodiment 30 or 31, wherein the first support has a first portion having a first length that exceeds the length of a first intended cylindrical battery

Embodiment 39 is the custom-shaped component of embodiment 30 or 31, wherein the first support has a second portion having a second length that is equal to or is less than the length of the

second intended battery, and wherein the first and second cylindrical surfaces are at a 90-degree angle relative to each other

Embodiment 40 is the custom-shaped component of embodiment 30 or 31, wherein the first cylindrical and second cylindrical surface of the first support are concave, and the cylindrical surface of the intended battery is convex.

Embodiment 41 is the custom-shaped component of embodiment 30 or 31, wherein the first support includes a third cylindrical surface that aligns closely with the cylindrical surface of a third intended cylindrical battery, and wherein the first portion includes a thickness between the first and second and third cylindrical surfaces to electrically and thermally isolate the intended batteries from one another.

Embodiment 42 is the custom-shaped component of embodiment 41, wherein the first support includes a fourth cylindrical surface that aligns closely with the cylindrical surface of a fourth intended cylindrical battery.

Embodiment 43 is the custom-shaped component of embodiment 42, wherein the third cylindrical and fourth cylindrical surface of the first support are concave, and the cylindrical surface of the intended battery is convex.

Embodiment 44 is the custom-shaped component of embodiment 30 or 31, wherein the first support is hollow throughout the length of the first support.

Embodiment 45 is the custom-shaped component of embodiment 44, wherein the first support includes a reservoir for receiving a fire extinguishing liquid.

Embodiment 46 is the custom-shaped component of embodiment 30 or 31, wherein the first support is solid throughout the length of the support.

Embodiment 47 is the custom-shaped component of embodiment 30 or 31, wherein the first support comprises a lattice structure of interconnected filaments.

Embodiment 48 is the custom-shaped component of embodiment 47, wherein interconnected filaments comprises cured adhesive.

Embodiment 49 is the custom-shaped component of embodiment 30 or 31, wherein the first support comprises a lattice structure of interconnected filaments and solid cylindrical surfaces.

Embodiment 50 is the custom-shaped component of embodiment 30 or 31, wherein the first support further comprises end surfaces adjacent the cylindrical surfaces, and where in the end surfaces include a plurality of channels.

Embodiment 51 is the custom-shaped component of embodiment 30 or 31, wherein the first support further comprises a first end surface adjacent the cylindrical surfaces, wherein the first end surface includes a connector extending therefrom.

Embodiment 52 is the custom-shaped component of embodiment 51, wherein the first support comprises a second end surface adjacent the cylindrical surfaces, wherein the second end surface includes a slot for receiving another connector.

Embodiment 53 is the custom-shaped component of embodiment 51, wherein the connector comprises UV-curable acrylate adhesive that is UV-cured.

Embodiment 54 is the custom-shaped component of embodiment 30 or 31, wherein the first support further comprises a top surface and a bottom surface opposite the top surface.

Embodiment 55 is the custom-shaped component of embodiment 54, wherein the top surface and bottom surface comprise a lattice structure of interconnected filaments.

Embodiment 56 is the custom-shaped component of embodiment 30 or 31, wherein the first support comprises auxetic material.

Embodiment 57 is the custom-shaped component of embodiment 30 or 31 in combination with at least a first cylindrical battery releasably attached to the first cylindrical surface of the first support; and a second cylindrical battery releasably attached to the second cylindrical surface of the first support.

Embodiment 58. An assembly of a plurality of batteries and a custom-shaped components for assembling cylindrical batteries, comprising: a plurality of batteries including at least a first cylindrical battery and a second cylindrical battery;

a first support that has been 3-D printed, wherein the first support has a first portion having a first length that is sized relative to the length of a first cylindrical battery, wherein the first support has a first cylindrical surface that aligns closely with the cylindrical surface of the first cylindrical battery, wherein the first support has a second cylindrical surface that aligns closely with the cylindrical surface of a second cylindrical battery, wherein the first portion includes a thickness between the first and second cylindrical surfaces to electrically and thermally isolate the first and second batteries from one another, and wherein the first and second cylindrical surfaces are tacky; wherein the first cylindrical battery is releasably attached to the first support by contacting the cylindrical surface of the first cylindrical battery with the first cylindrical surface of the first support and wherein the second cylindrical battery is releasably attached to the first support by contacting the cylindrical surface of the second cylindrical battery with the second cylindrical surface of the first support.

Embodiment 59 is the custom-shaped component of embodiment 58, wherein the first support comprises adhesive.

Embodiment 60 is the custom-shaped component of embodiment 59, wherein the first support comprises cured adhesive.

Embodiment 61 is the custom-shaped component of embodiment 60, wherein the first support comprises UV-curable acrylate adhesive that is UV-cured.

Embodiment 62 is the custom-shaped component of embodiment 58, wherein the first support comprises pressure-sensitive adhesive on the first and second cylindrical surfaces.

Embodiment 63 is the custom-shaped component of embodiment 58, wherein a first battery and second battery both may releasably attached and detached from the first support.

Embodiment 64 is the custom-shaped component of embodiment 58, wherein the first support comprises a core of polymer coated with pressure-sensitive adhesive.

Embodiment 65 is the custom-shaped component of embodiment 58, wherein the first support comprises a core of non-woven structure coated with pressure-sensitive adhesive.

Embodiment 66 is the custom-shaped component of embodiment 58, wherein the first support includes an auxetic structure.

Embodiment 67 is the custom-shaped component of embodiment 58, wherein the first support has a first portion having a first length that is equal to or is less than the length of a first cylindrical battery.

Embodiment 68 is the custom-shaped component of embodiment 58, wherein the first support has a first portion having a first length that exceeds the length of a first cylindrical battery

Embodiment 69 is the custom-shaped component of embodiment 58, wherein the first support has a second portion having a second length that is equal to or is less than the length of the second battery, and wherein the first and second cylindrical surfaces are at a 90-degree angle relative to each other

Embodiment 70 is the custom-shaped component of embodiment 58, wherein the first cylindrical and second cylindrical surface of the first support are concave, and the cylindrical surface of the intended battery is convex.

Embodiment 71 is the custom-shaped component of embodiment 58, wherein the first support includes a third cylindrical surface that aligns closely with the cylindrical surface of a third intended cylindrical battery, and wherein the first portion includes a thickness between the first and second and third cylindrical surfaces to electrically and thermally isolate the intended batteries from one another.

Embodiment 72 is the custom-shaped component of embodiment 71, wherein the first support includes a fourth cylindrical surface that aligns closely with the cylindrical surface of a fourth intended cylindrical battery.

Embodiment 73 is the custom-shaped component of embodiment 72, wherein the third and fourth cylindrical surfaces are tacky; wherein the third cylindrical battery is held in the first support by contacting the cylindrical surface of the third cylindrical battery with the third cylindrical surface of the first support; and wherein the fourth cylindrical battery is held in the support by contacting the cylindrical surface of the fourth cylindrical battery with the fourth cylindrical surface of the first support.

Embodiment 74 is the custom-shaped component of embodiment 58, wherein the first support is hollow throughout the length of the first support.

Embodiment 75 is the custom-shaped component of embodiment 58, wherein the first support includes a reservoir for receiving a fire extinguishing liquid.

Embodiment 76 is the custom-shaped component of embodiment 58, wherein the first support is solid throughout the length of the support.

Embodiment 77 is the custom-shaped component of embodiment 58, wherein the first support comprises a lattice structure of interconnected filaments.

Embodiment 78 is the custom-shaped component of embodiment 77, wherein interconnected filaments comprises cured adhesive.

Embodiment 79 is the custom-shaped component of embodiment 58, wherein the first support comprises a lattice structure of interconnected filaments and solid cylindrical surfaces.

Embodiment 80 is the custom-shaped component of embodiment 58, wherein the first support further comprises end surfaces adjacent the cylindrical surfaces, and where in the end surfaces include a plurality of channels.

Embodiment 81 is the custom-shaped component of embodiment 58, wherein the first support further comprises a first end surface adjacent the cylindrical surfaces, wherein the first end surface includes a connector extending therefrom.

Embodiment 82 is the custom-shaped component of embodiment 81, wherein the first support comprises a second end surface adjacent the cylindrical surfaces, wherein the second end surface includes a slot for receiving another connector.

Embodiment 83 is the custom-shaped component of embodiment 81, wherein the connector comprises UV-curable acrylate adhesive that is UV-cured.

Embodiment 84 is the custom-shaped component of embodiment 58, wherein the first support further comprises a top surface and a bottom surface opposite the top surface.

Embodiment 85 is the custom-shaped component of embodiment 84, wherein the top surface and bottom surface comprise a lattice structure of interconnected filaments.

Embodiment 86 is a method of manufacturing a custom-shaped component for assembling cylindrical batteries, comprising: providing UV-curable acrylate adhesive; providing a 3D printer; 3D printing a first support from the UV-curable acylate adhesive using the 3D printer, wherein the first support has a first portion having a first length that is sized relative to the length of a first intended cylindrical battery, wherein the first support has a first cylindrical surface that aligns closely with the cylindrical surface of the first intended cylindrical battery, wherein the first support has a second cylindrical surface that aligns closely with the cylindrical surface of a second intended cylindrical battery, wherein the first portion includes a thickness between the first and second cylindrical surfaces to electrically and thermally isolate the intended batteries from one another, and curing the support, wherein the first and second cylindrical surfaces are tacky.

Embodiment 87 is the method of embodiment 86, further including attaching a first battery may to the first support.

What is claimed is:

1. A custom-shaped component for assembling cylindrical batteries, comprising:

a first support that has been 3-D printed,

wherein the first support has a first portion having a first length that is sized relative to the length of a first intended cylindrical battery,

wherein the first support has a first cylindrical surface that aligns closely with the cylindrical surface of the first intended cylindrical battery,

wherein the first support has a second cylindrical surface that aligns closely with the cylindrical surface of a second intended cylindrical battery,

wherein the first portion includes a thickness between the first and second cylindrical surfaces to electrically and thermally isolate the intended batteries from one another, and

wherein the first and second cylindrical surfaces are tacky.

2. The custom-shaped component of claim 1, wherein the first support comprises adhesive.

3. The custom-shaped component of claim 2, wherein the first support comprises cured adhesive.

4. The custom-shaped component of claim 3, wherein the first support comprises UV-curable acrylate adhesive that is UV-cured.

5. The custom-shaped component of claim 1, wherein the first support comprises a layer of pressure-sensitive adhesive on the first and second cylindrical surfaces.

6. The custom-shaped component of claim 1, wherein an intended first battery may releasably attached and detached from the first support.

7. The custom-shaped component of claim 1, wherein the first support comprises a core of polymer coated with pressure-sensitive adhesive.

8. The custom-shaped component of claim 1, wherein the first support comprises a core of non-woven structure coated with pressure-sensitive adhesive.

9. The custom-shaped component of claim 1, wherein the first support comprises auxetic structure.

10. The custom-shaped component of claim 1, wherein the first support has a first portion having a first length that is equal to or is less than the length of a first intended cylindrical battery.

11. The custom-shaped component of claim 1, wherein the first support has a first portion having a first length that exceeds the length of a first intended cylindrical battery.

12. The custom-shaped component of claim 1, wherein the first support has a second portion having a second length that is equal to or is less than the length of the second intended battery, and wherein the first and second cylindrical surfaces are at a 90-degree angle relative to each other.

13. The custom-shaped component of claim 1, wherein the first cylindrical and second cylindrical surface of the first support are concave, and the cylindrical surface of the intended battery is convex.

14. The custom-shaped component of claim 1, wherein the first support includes a third cylindrical surface that aligns closely with the cylindrical surface of a third intended cylindrical battery, and

wherein the first portion includes a thickness between the first and second and third cylindrical surfaces to electrically and thermally isolate the intended batteries from one another.

15. The custom-shaped component of claim 14, wherein the first support includes a fourth cylindrical surface that aligns closely with the cylindrical surface of a fourth intended cylindrical battery.

16. The custom-shaped component of claim 15, wherein the third cylindrical and fourth cylindrical surface of the first support are concave, and the cylindrical surface of the intended battery is convex.

17. The custom-shaped component of claim 1, wherein the first support is hollow throughout the length of the first support.

18. The custom-shaped component of claim 1, wherein the first support includes a reservoir for receiving a fire extinguishing liquid.

19. The custom-shaped component of claim 1, wherein the first support is solid throughout the length of the support.

20. The custom-shaped component of claim 1, wherein the first support comprises a lattice structure of interconnected filaments.

21. The custom-shaped component of claim 20, wherein interconnected filaments comprises cured adhesive.

22. The custom-shaped component of claim 1, wherein the first support comprises a lattice structure of interconnected filaments and solid cylindrical surfaces.

23. The custom-shaped component of claim 1, wherein the first support further comprises end surfaces adjacent the cylindrical surfaces, and where in the end surfaces include a plurality of channels.

24. The custom-shaped component of claim 1, wherein the first support further comprises a first end surface adjacent the cylindrical surfaces, wherein the first end surface includes a connector extending therefrom.

25. The custom-shaped component of claim 24, wherein the first support comprises a second end surface adjacent the cylindrical surfaces, wherein the second end surface includes a slot for receiving another connector.

26. The custom-shaped component of claim 24, wherein the connector comprises UV-curable acrylate adhesive that is UV-cured.

27. The custom-shaped component of claim 1, wherein the first support further comprises a top surface and a bottom surface opposite the top surface.

28. The custom-shaped component of claim 27, wherein the top surface and bottom surface comprise a lattice structure of interconnected filaments.

29. The custom-shaped component of claim 1 in combination with at least a first cylindrical battery releasably attached to the first cylindrical surface of the first support; and a second cylindrical battery releasably attached to the second cylindrical surface of the first support.

30. A custom-shaped component for assembling cylindrical batteries, comprising:

a first support that has been injected molded,

wherein the first support has a first portion having a first length that is sized relative to the length of a first intended cylindrical battery,

wherein the first support has a first cylindrical surface that aligns closely with the cylindrical surface of the first intended cylindrical battery,

wherein the first support has a second cylindrical surface that aligns closely with the cylindrical surface of a second intended cylindrical battery,

wherein the first portion includes a thickness between the first and second cylindrical surfaces to electrically and thermally isolate the intended batteries from one another, and

wherein the first and second cylindrical surfaces are tacky.

31. A custom-shaped component for assembling cylindrical batteries, comprising:

a first support that has been extruded,

wherein the first support has a first portion having a first length that is sized relative to the length of a first intended cylindrical battery,

wherein the first support has a first cylindrical surface that aligns closely with the cylindrical surface of the first intended cylindrical battery,

wherein the first support has a second cylindrical surface that aligns closely with the cylindrical surface of a second intended cylindrical battery,

wherein the first portion includes a thickness between the first and second cylindrical surfaces to electrically and thermally isolate the intended batteries from one another, and

wherein the first and second cylindrical surfaces are tacky.

32. The custom-shaped component of claim 30 or 31, wherein the first support comprises a layer of pressure-sensitive adhesive on the first and second cylindrical surfaces.

33. The custom-shaped component of claim 30 or 31, wherein an intended first battery may releasably attached and detached from the first support.

34. The custom-shaped component of claim 30 or 31, wherein the first support comprises a core of polymer coated with pressure-sensitive adhesive.

35. The custom-shaped component of claim 30 or 31, wherein the first support comprises a core of non-woven structure coated with pressure-sensitive adhesive.

36. The custom-shaped component of claim 30 or 31, wherein the first support comprises a core of polymer coated with pressure-sensitive adhesive.

37. The custom-shaped component of claim 30 or 31, wherein the first support has a first portion having a first length that is equal to or is less than the length of a first intended cylindrical battery.

38. The custom-shaped component of claim 30 or 31, wherein the first support has a first portion having a first length that exceeds the length of a first intended cylindrical battery

39. The custom-shaped component of claim 30 or 31, wherein the first support has a second portion having a second length that is equal to or is less than the length of the second intended battery, and wherein the first and second cylindrical surfaces are at a 90-degree angle relative to each other

40. The custom-shaped component of claim 30 or 31, wherein the first cylindrical and second cylindrical surface of the first support are concave, and the cylindrical surface of the intended battery is convex.

41. The custom-shaped component of claim 30 or 31, wherein the first support includes a third cylindrical surface that aligns closely with the cylindrical surface of a third intended cylindrical battery, and wherein the first portion includes a thickness between the first and second and third cylindrical surfaces to electrically and thermally isolate the intended batteries from one another.

42. The custom-shaped component of claim 41, wherein the first support includes a fourth cylindrical surface that aligns closely with the cylindrical surface of a fourth intended cylindrical battery.

43. The custom-shaped component of claim 42, wherein the third cylindrical and fourth cylindrical surface of the first support are concave, and the cylindrical surface of the intended battery is convex.

44. The custom-shaped component of claim 30 or 31, wherein the first support is hollow throughout the length of the first support.

45. The custom-shaped component of claim 44, wherein the first support includes a reservoir for receiving a fire extinguishing liquid.

46. The custom-shaped component of claim 30 or 31, wherein the first support is solid throughout the length of the support.

47. The custom-shaped component of claim 30 or 31, wherein the first support comprises a lattice structure of interconnected filaments.

48. The custom-shaped component of claim 47, wherein interconnected filaments comprises cured adhesive.

49. The custom-shaped component of claim 30 or 31, wherein the first support comprises a lattice structure of interconnected filaments and solid cylindrical surfaces.

50. The custom-shaped component of claim 30 or 31, wherein the first support further comprises end surfaces adjacent the cylindrical surfaces, and where in the end surfaces include a plurality of channels.

51. The custom-shaped component of claim 30 or 31, wherein the first support further comprises a first end surface adjacent the cylindrical surfaces, wherein the first end surface includes a connector extending therefrom.

52. The custom-shaped component of claim 51, wherein the first support comprises a second end surface adjacent the cylindrical surfaces, wherein the second end surface includes a slot for receiving another connector.

53. The custom-shaped component of claim 51, wherein the connector comprises UV-curable acrylate adhesive that is UV-cured.

54. The custom-shaped component of claim 30 or 31, wherein the first support further comprises a top surface and a bottom surface opposite the top surface.

55. The custom-shaped component of claim 54, wherein the top surface and bottom surface comprise a lattice structure of interconnected filaments.

56. The custom-shaped component of claim 30 or 31, wherein the first support comprises auxetic material.

57. The custom-shaped component of claim 30 or 31 in combination with at least a first cylindrical battery releasably attached to the first cylindrical surface of the first support; and a second cylindrical battery releasably attached to the second cylindrical surface of the first support.

58. An assembly of a plurality of batteries and a custom-shaped components for assembling cylindrical batteries, comprising:

a plurality of batteries including at least a first cylindrical battery and a second cylindrical battery;

a first support that has been 3-D printed,

wherein the first support has a first portion having a first length that is sized relative to the length of a first cylindrical battery,

wherein the first support has a first cylindrical surface that aligns closely with the cylindrical surface of the first cylindrical battery,

wherein the first support has a second cylindrical surface that aligns closely with the cylindrical surface of a second cylindrical battery,

wherein the first portion includes a thickness between the first and second cylindrical surfaces to electrically and thermally isolate the first and second batteries from one another, and

wherein the first and second cylindrical surfaces are tacky;

wherein the first cylindrical battery is releasably attached to the first support by contacting the cylindrical surface of the first cylindrical battery with the first cylindrical surface of the first support and

wherein the second cylindrical battery is releasably attached to the first support by contacting the cylindrical surface of the second cylindrical battery with the second cylindrical surface of the first support.

59. The custom-shaped component of claim 58, wherein the first support comprises adhesive.

60. The custom-shaped component of claim 59, wherein the first support comprises cured adhesive.

61. The custom-shaped component of claim 60, wherein the first support comprises UV-curable acrylate adhesive that is UV-cured.

62. The custom-shaped component of claim 58, wherein the first support comprises pressure-sensitive adhesive on the first and second cylindrical surfaces.

63. The custom-shaped component of claim 58, wherein a first battery and second battery both may releasably attached and detached from the first support.

64. The custom-shaped component of claim 58, wherein the first support comprises a core of polymer coated with pressure-sensitive adhesive.

65. The custom-shaped component of claim 58, wherein the first support comprises a core of non-woven structure coated with pressure-sensitive adhesive.

66. The custom-shaped component of claim 58, wherein the first support includes an auxetic structure.

67. The custom-shaped component of claim 58, wherein the first support has a first portion having a first length that is equal to or is less than the length of a first cylindrical battery.

68. The custom-shaped component of claim 58, wherein the first support has a first portion having a first length that exceeds the length of a first cylindrical battery

69. The custom-shaped component of claim 58, wherein the first support has a second portion having a second length that is equal to or is less than the length of the second battery, and wherein the first and second cylindrical surfaces are at a 90-degree angle relative to each other

70. The custom-shaped component of claim 58, wherein the first cylindrical and second cylindrical surface of the first support are concave, and the cylindrical surface of the intended battery is convex.

71. The custom-shaped component of claim 58, wherein the first support includes a third cylindrical surface that aligns closely with the cylindrical surface of a third intended cylindrical battery, and wherein the first portion includes a thickness between the first and second and third cylindrical surfaces to electrically and thermally isolate the intended batteries from one another.

72. The custom-shaped component of claim 71, wherein the first support includes a fourth cylindrical surface that aligns closely with the cylindrical surface of a fourth intended cylindrical battery.

73. The custom-shaped component of claim 72, wherein the third and fourth cylindrical surfaces are tacky;

wherein the third cylindrical battery is held in the first support by contacting the cylindrical surface of the third cylindrical battery with the third cylindrical surface of the first support; and

wherein the fourth cylindrical battery is held in the support by contacting the cylindrical surface of the fourth cylindrical battery with the fourth cylindrical surface of the first support.

74. The custom-shaped component of claim 58, wherein the first support is hollow throughout the length of the first support.

75. The custom-shaped component of claim 58, wherein the first support includes a reservoir for receiving a fire extinguishing liquid.

76. The custom-shaped component of claim 58, wherein the first support is solid throughout the length of the support.

77. The custom-shaped component of claim 58, wherein the first support comprises a lattice structure of interconnected filaments.

78. The custom-shaped component of claim 77, wherein interconnected filaments comprises cured adhesive.

79. The custom-shaped component of claim 58, wherein the first support comprises a lattice structure of interconnected filaments and solid cylindrical surfaces.

80. The custom-shaped component of claim 58, wherein the first support further comprises end surfaces adjacent the cylindrical surfaces, and where in the end surfaces include a plurality of channels.

81. The custom-shaped component of claim 58, wherein the first support further comprises a first end surface adjacent the cylindrical surfaces, wherein the first end surface includes a connector extending therefrom.

82. The custom-shaped component of claim 81, wherein the first support comprises a second end surface adjacent the cylindrical surfaces, wherein the second end surface includes a slot for receiving another connector.

83. The custom-shaped component of claim 81, wherein the connector comprises UV-curable acrylate adhesive that is UV-cured.

84. The custom-shaped component of claim 58, wherein the first support further comprises a top surface and a bottom surface opposite the top surface.

85. The custom-shaped component of claim 84, wherein the top surface and bottom surface comprise a lattice structure of interconnected filaments.

86. A method of manufacturing a custom-shaped component for assembling cylindrical batteries, comprising:

providing UV-curable acrylate adhesive;

providing a 3D printer;

3D printing a first support from the UV-curable acylate adhesive using the 3D printer,

wherein the first support has a first portion having a first length that is sized relative to the length of a first intended cylindrical battery,

wherein the first support has a first cylindrical surface that aligns closely with the cylindrical surface of the first intended cylindrical battery,

wherein the first support has a second cylindrical surface that aligns closely with the cylindrical surface of a second intended cylindrical battery,

wherein the first portion includes a thickness between the first and second cylindrical surfaces to electrically and thermally isolate the intended batteries from one another, and

curing the support, wherein the first and second cylindrical surfaces are tacky.

87. The method of claim 86, further including attaching a first battery may to the first support.

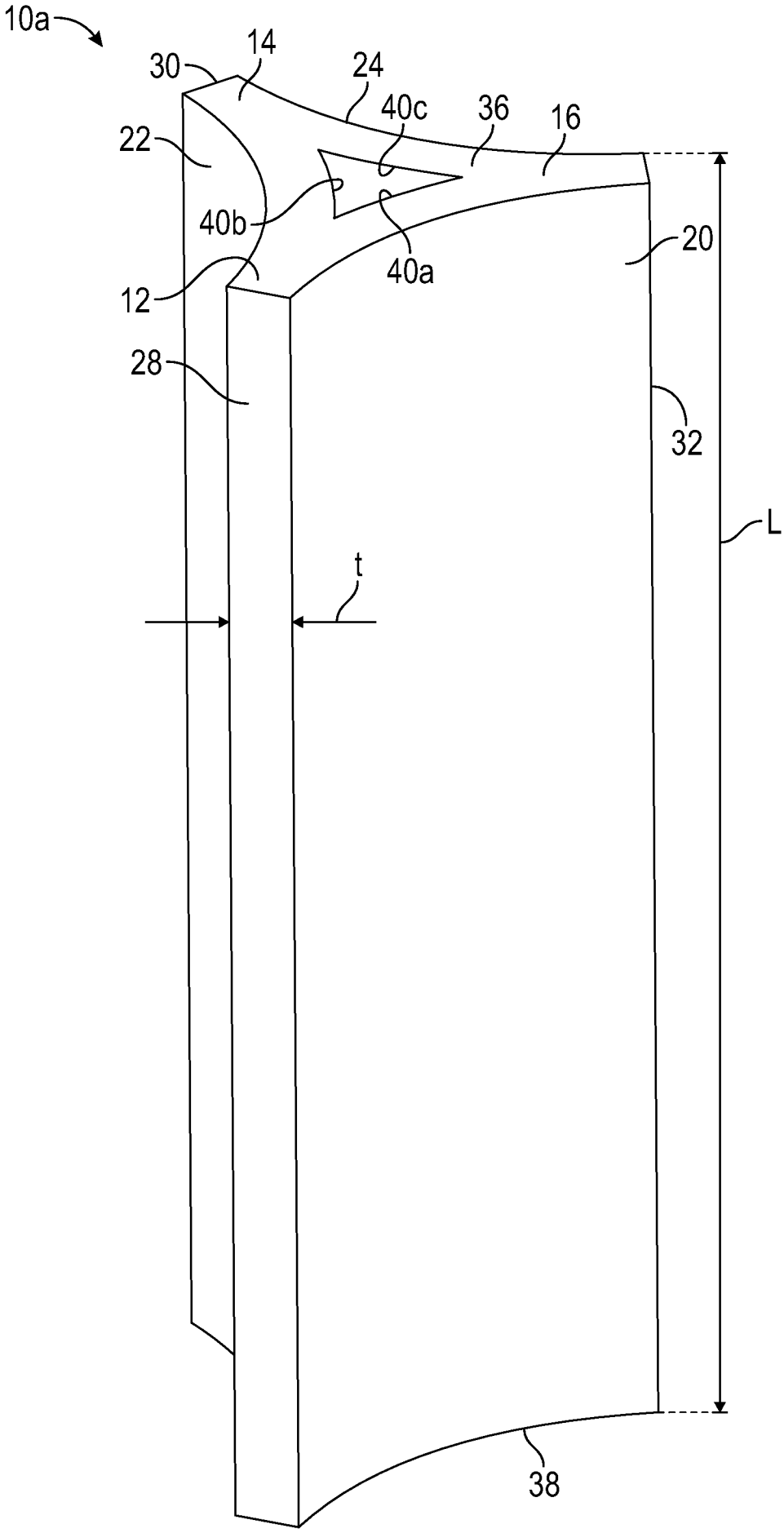


FIG. 1

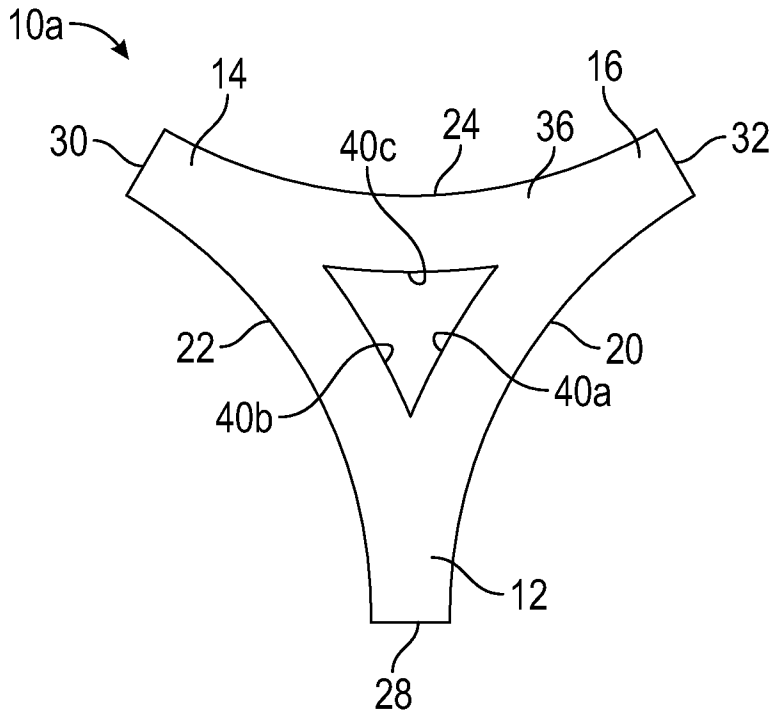


FIG. 2

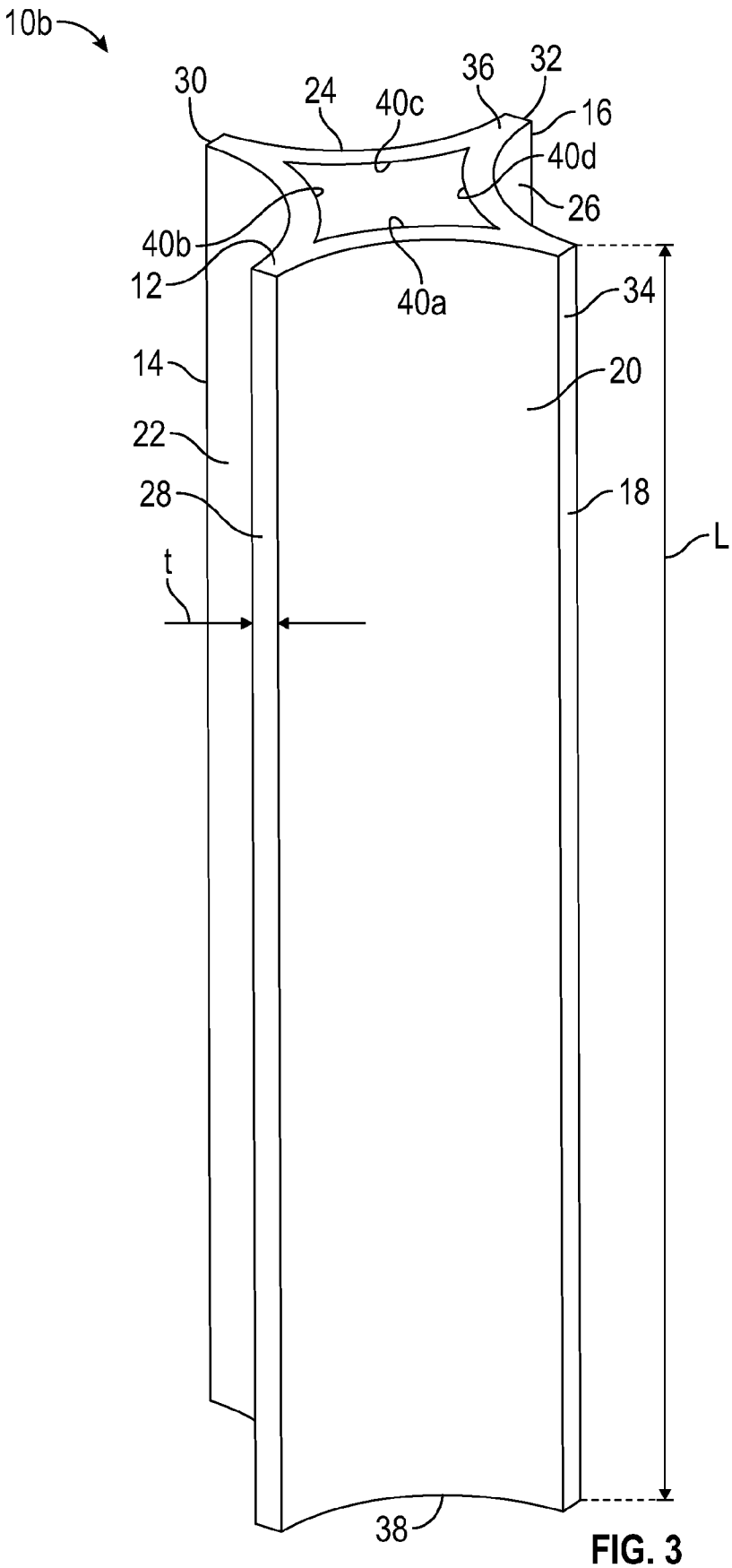


FIG. 3

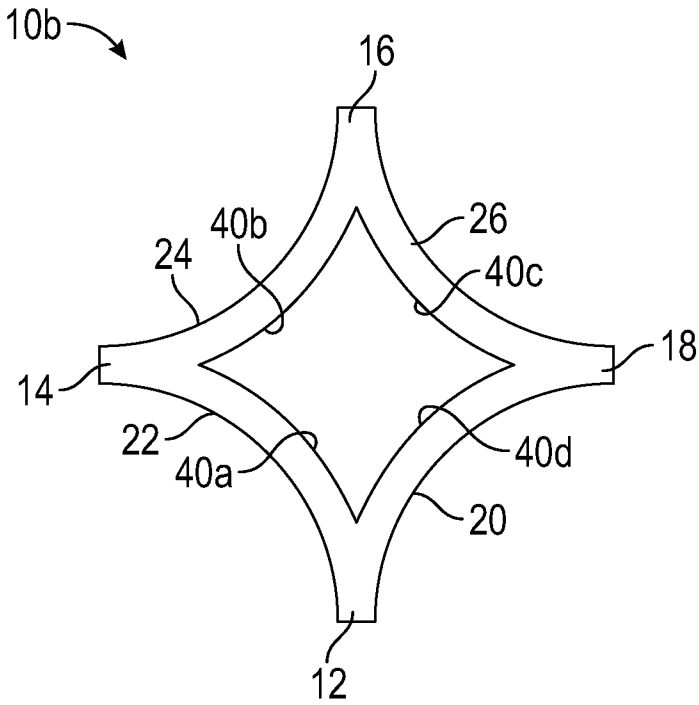


FIG. 4

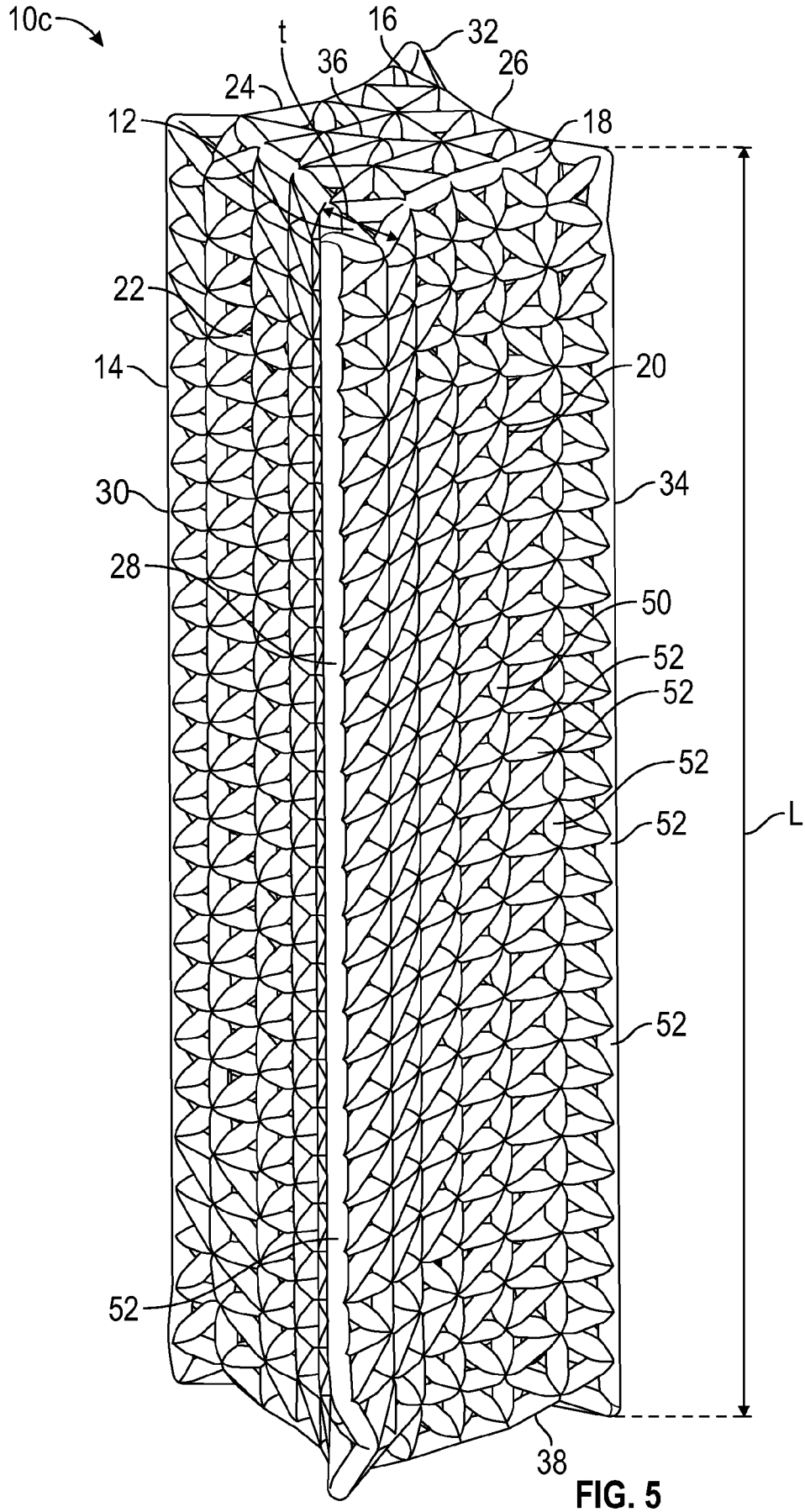


FIG. 5

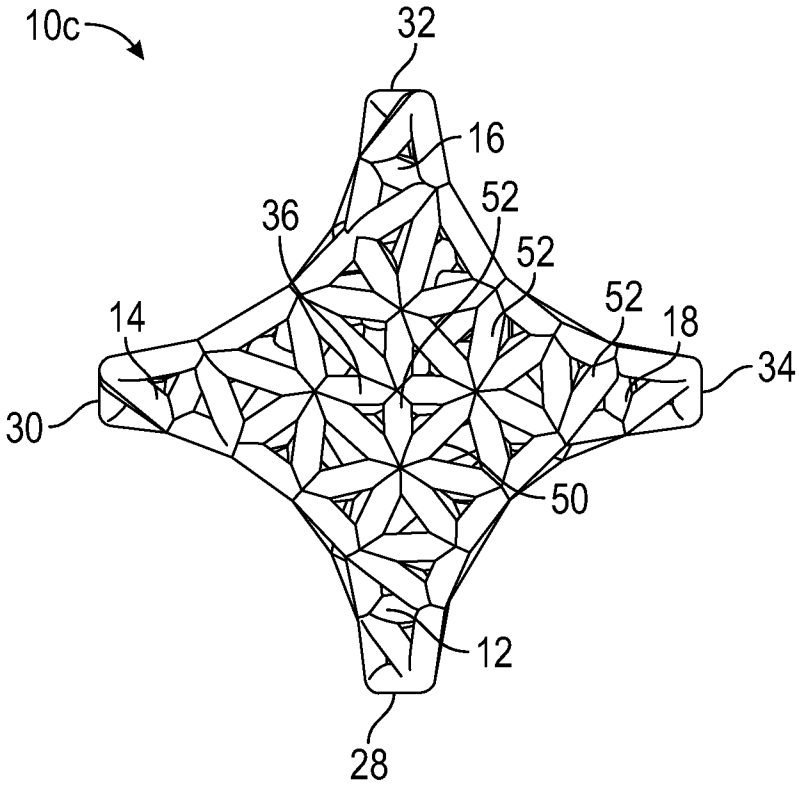
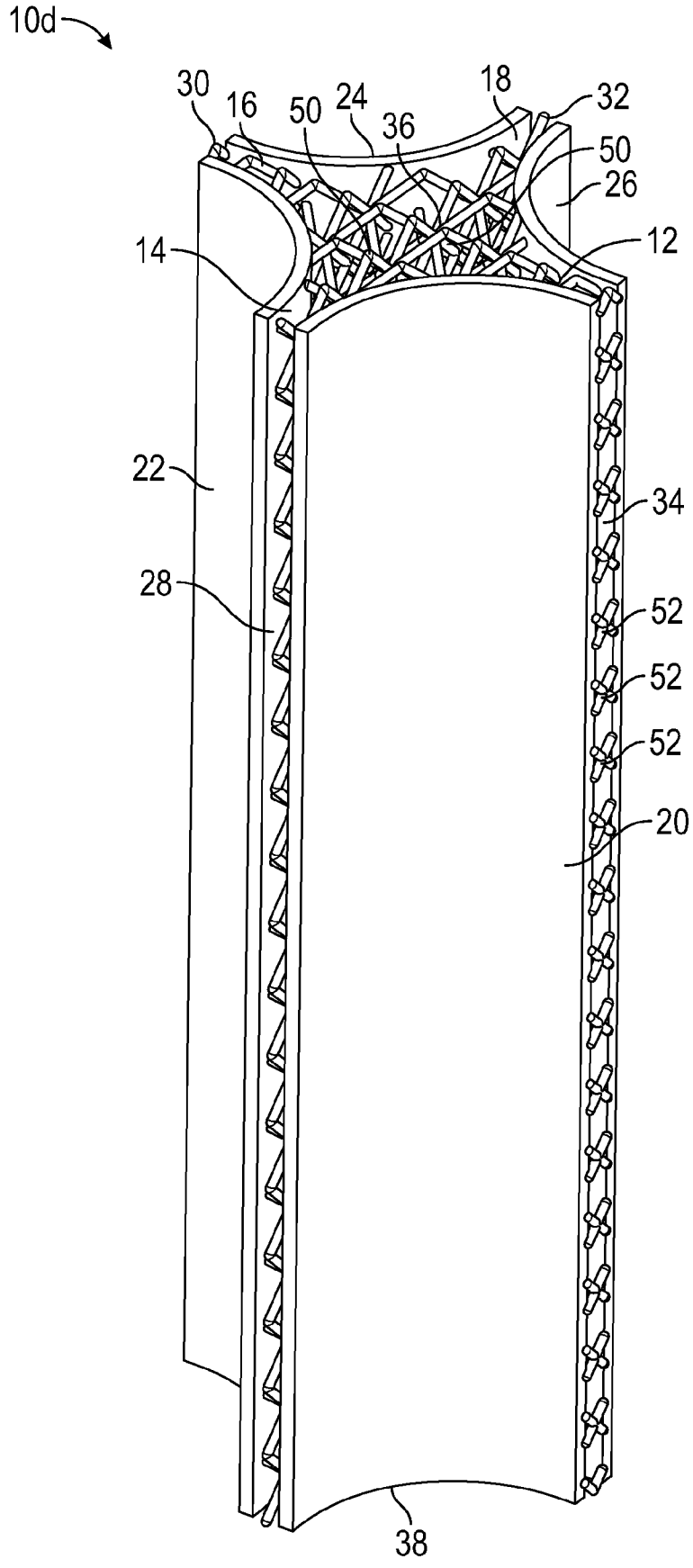


FIG. 6



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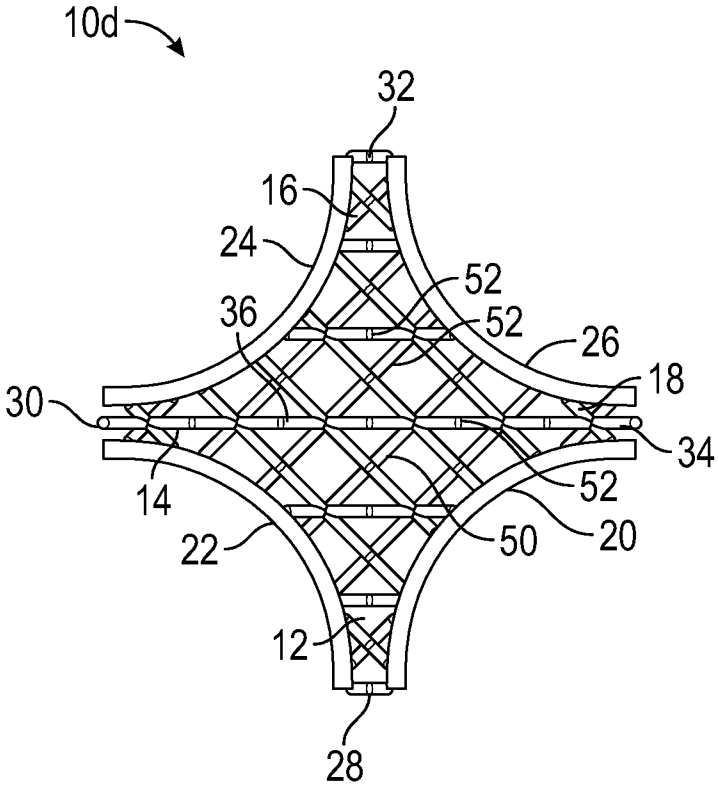

FIG. 8

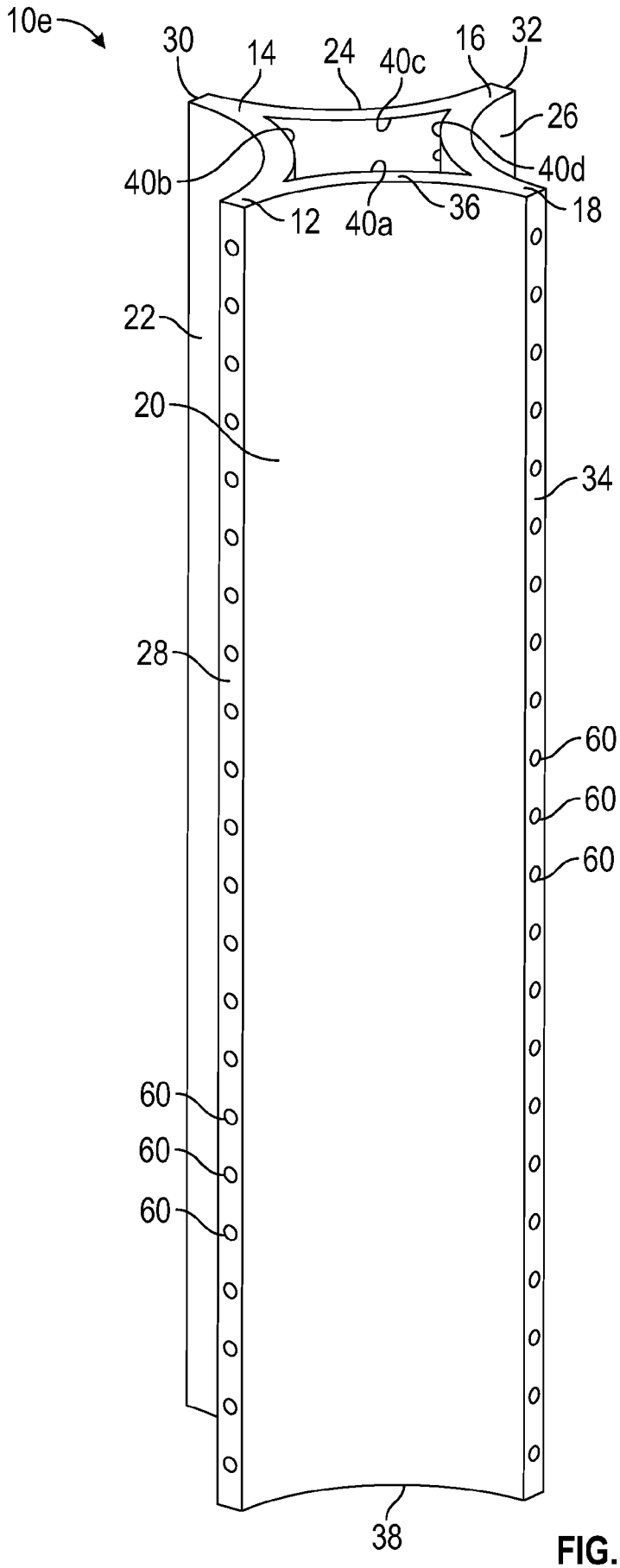
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FIG. 9

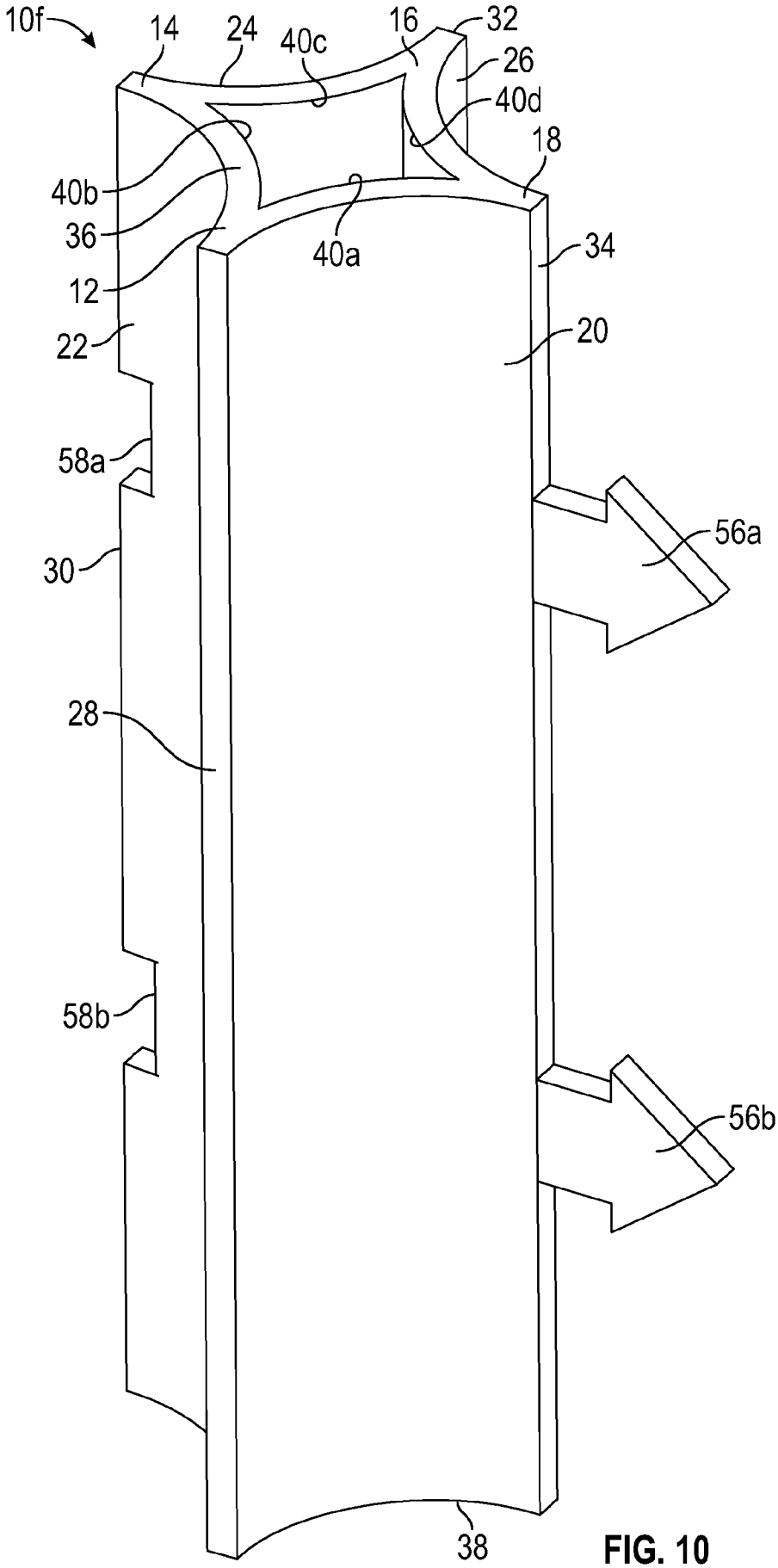
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FIG. 10

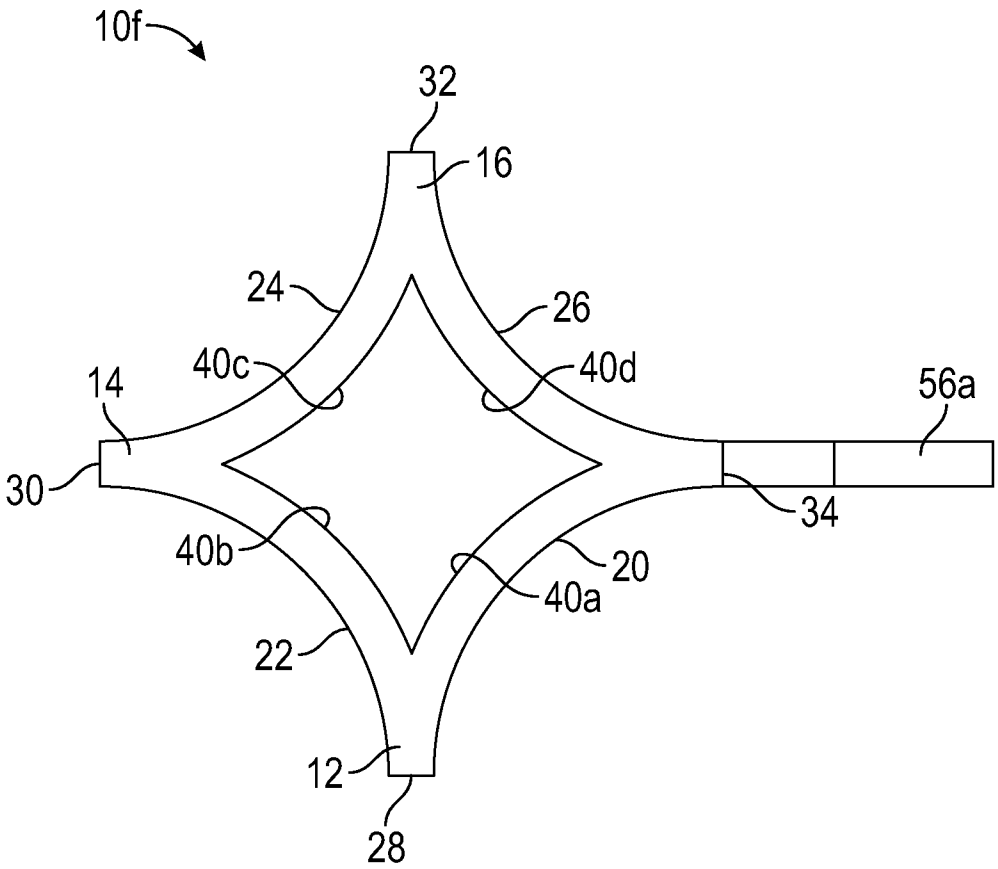

FIG. 11

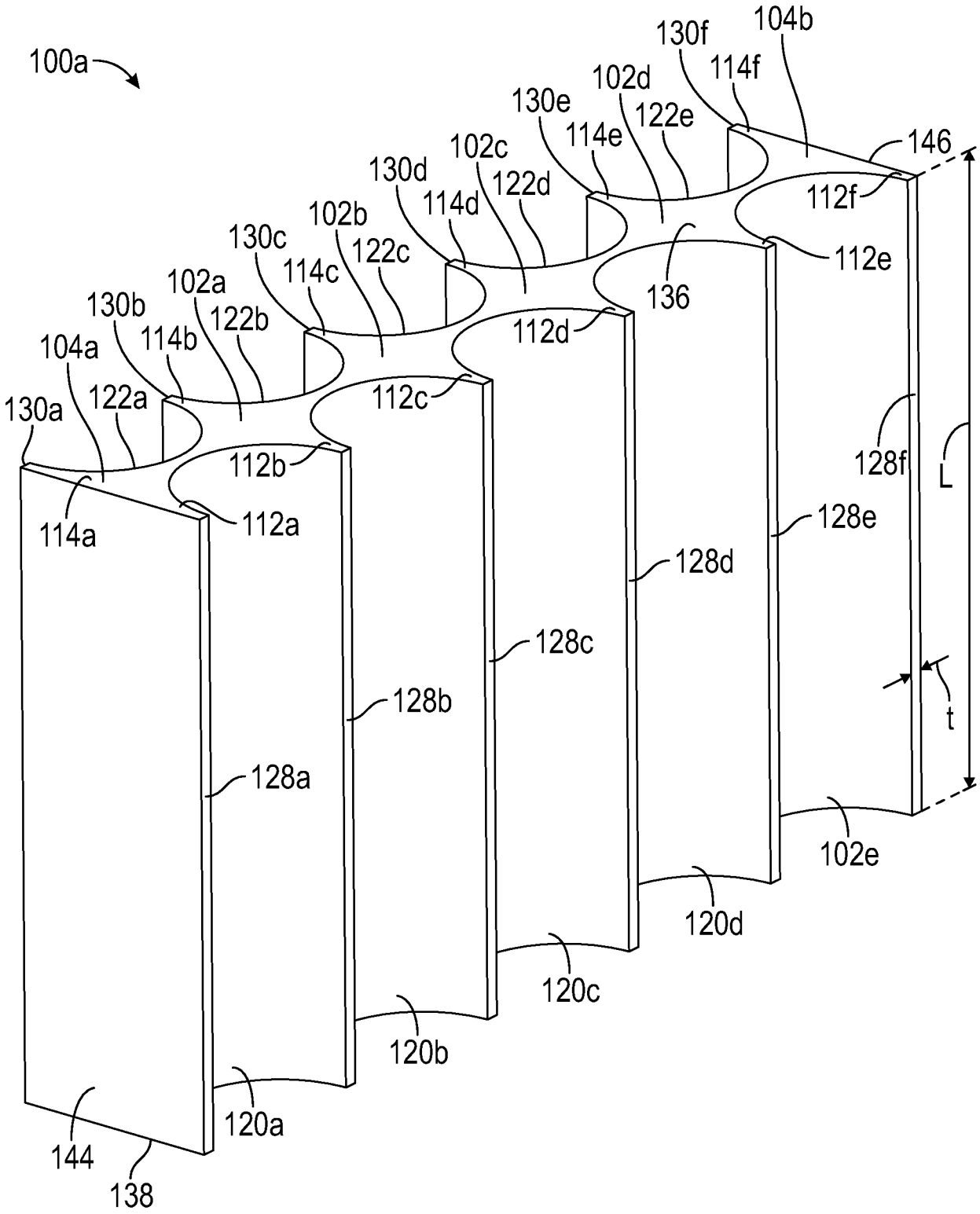
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FIG. 12

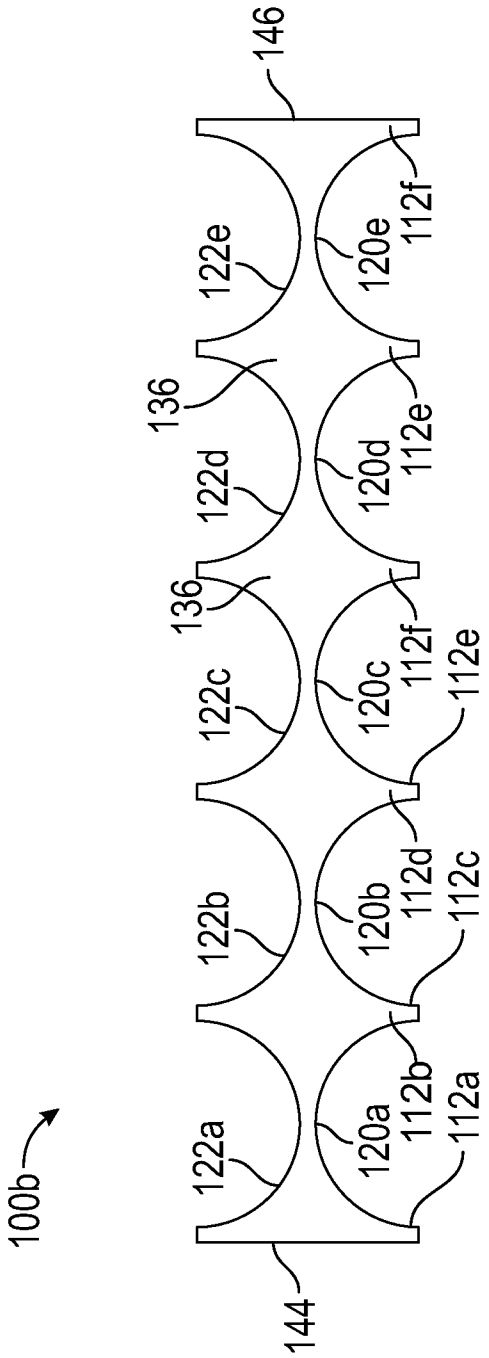
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FIG. 13

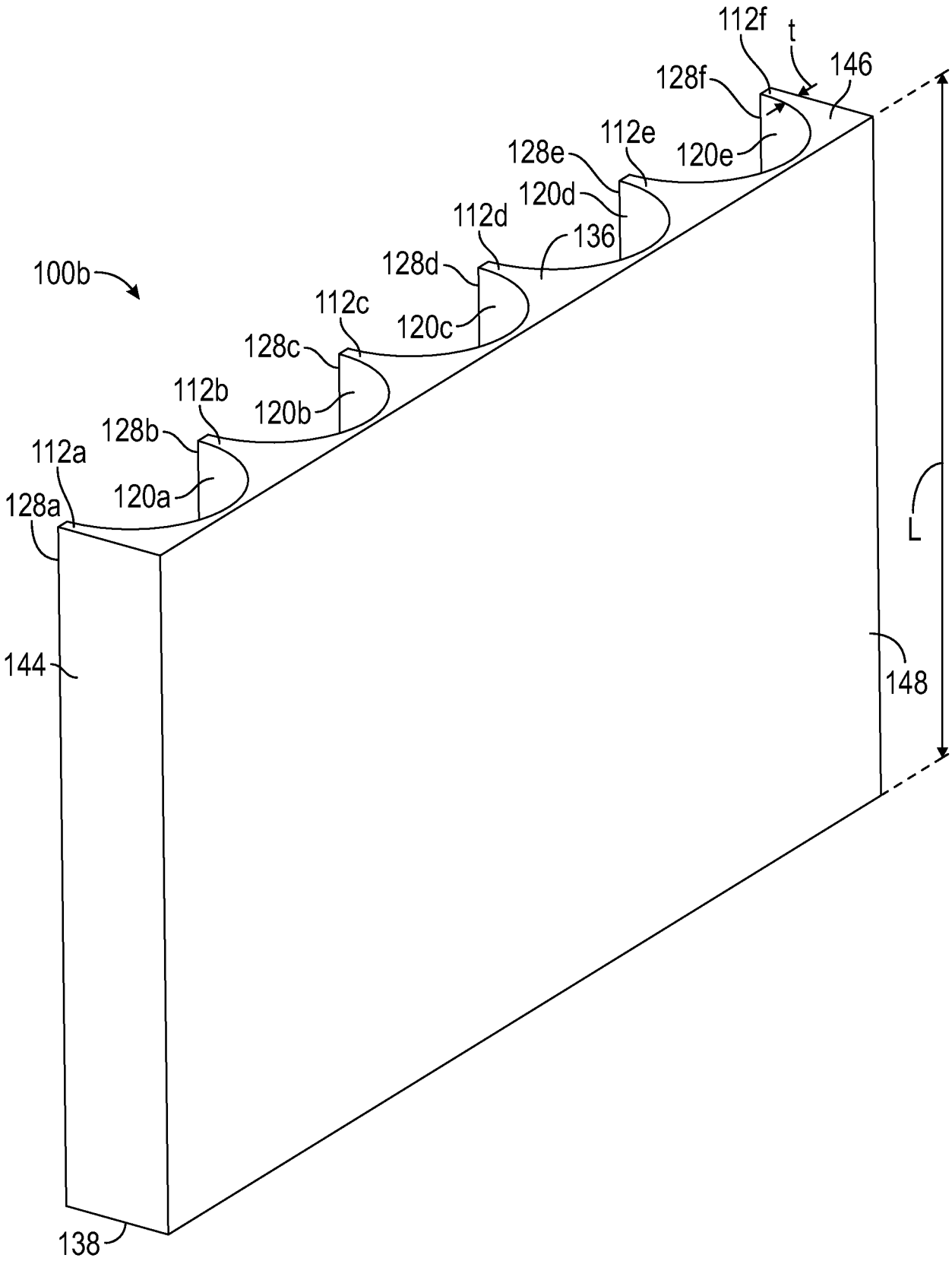
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FIG. 14

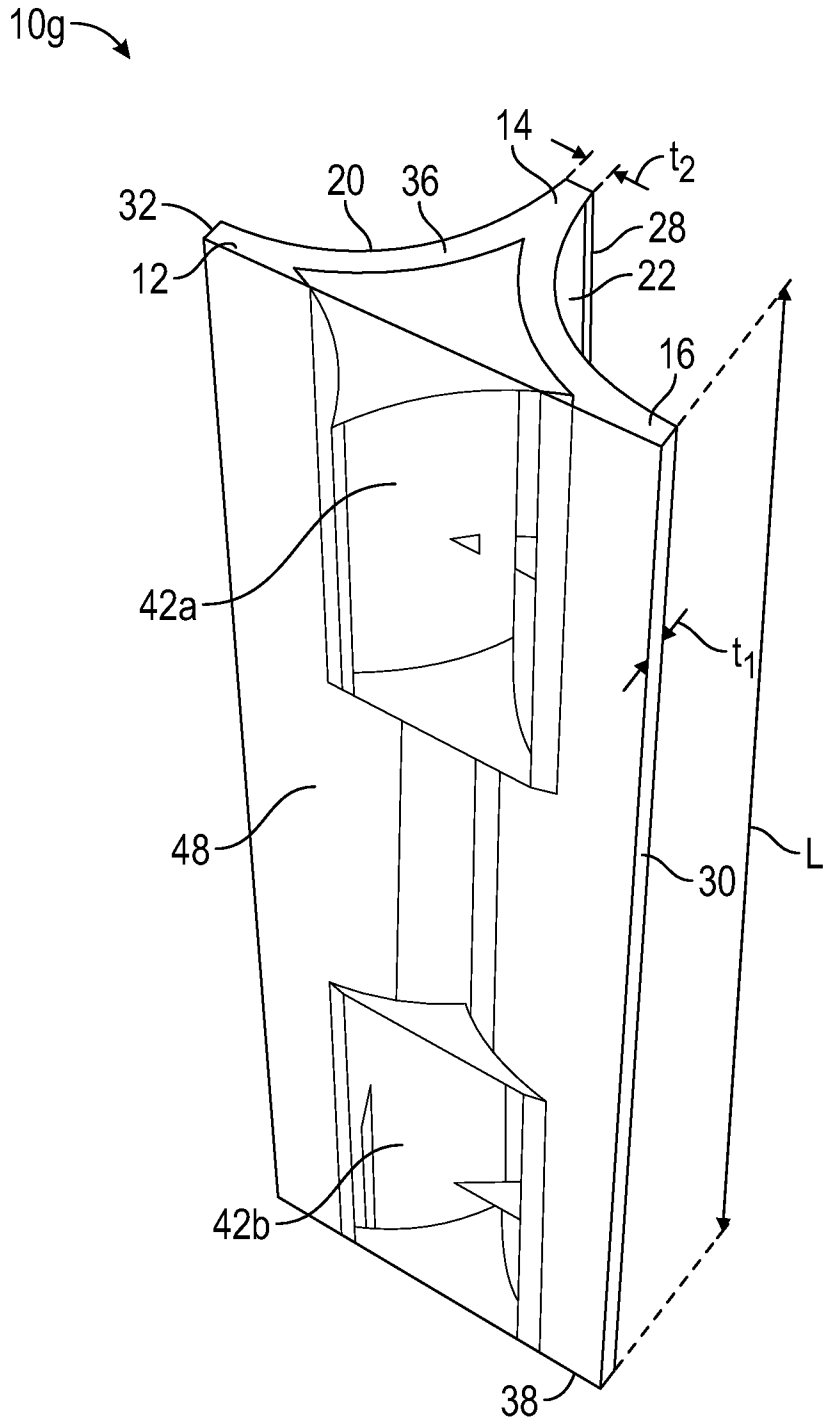

FIG. 15

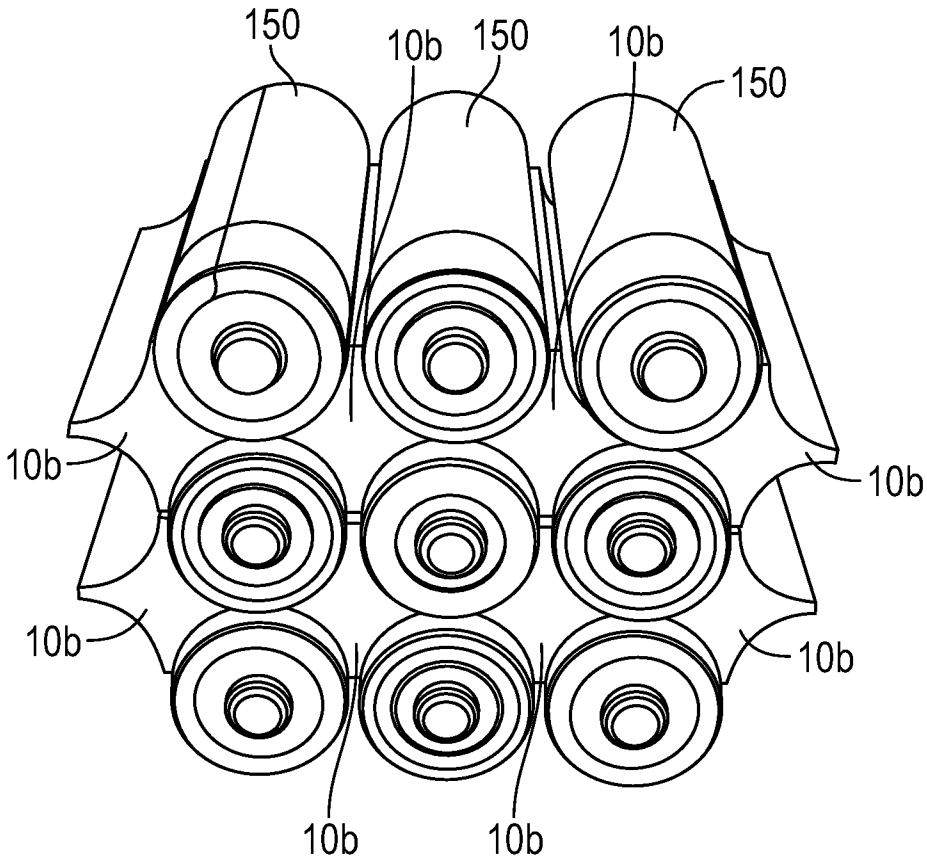

FIG. 16

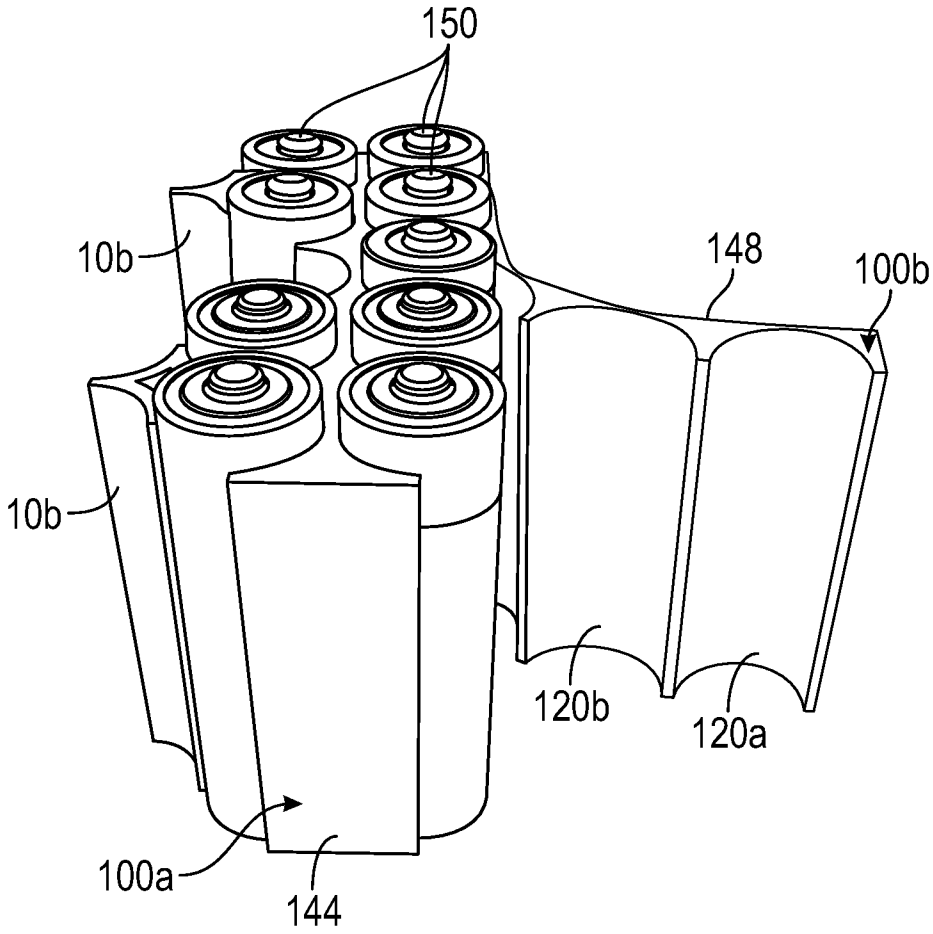

FIG. 17

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2023/061551

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01M50/213 H01M50/227 H01M50/231 H01M50/233 H01M50/238 H01M50/242
ADD.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2022/302520 A1 (AL-HALLAJ SAID [US] ET AL) 22 September 2022 (2022-09-22)	1-8, 10-55, 57-65, 67-87
A	paragraph [0007] - paragraph [0009]; figures 2,4,6,8 paragraph [0030] - paragraph [0034] paragraph [0040] paragraph [0044]	9,56,66
Y	US 2019/372173 A1 (JUZKOW MARC W [US] ET AL) 5 December 2019 (2019-12-05)	1-8, 10-55, 57-65, 67-87
	paragraph [0057] - paragraph [0064] paragraph [0071] paragraph [0080] - paragraph [0081]	

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[x] Further documents are listed in the continuation of Box C.
[x] See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
6 February 2024	14/02/2024

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Möller, Claudia

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International application No
PCT/IB2023/061551

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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