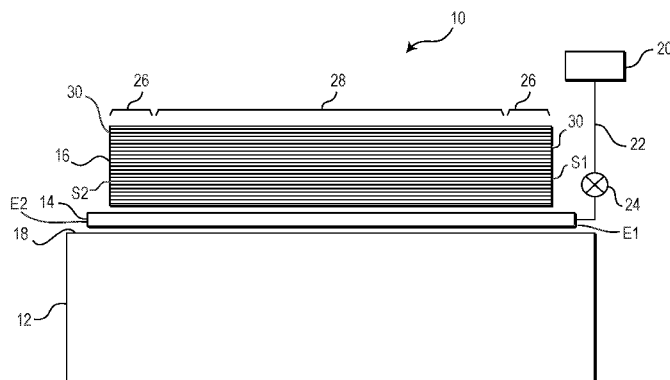




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(54) **Title:** DEMOLDING METHOD AND APPARATUS**FIG. 1**

(57) **Abstract:** A demolding apparatus includes a mold (12) for receiving a composite component (16), the composite component (16) defining a periphery, a trim zone (26) interior to the periphery and a non-trim zone (28) interior to the trim zone (26), and a first inflatable element (14) for being positioned between the mold (12) and the composite element (16), the first inflatable member (14) being disposed at least partially within the non-trim zone (28). A demolding method includes positioning a first inflatable element (14) on the mold (12), applying a plurality of layers (16) atop the first inflatable element (14) to create a layer stack, curing the layer stack to create the composite component, and inflating the first inflatable element (14) with a fluid in order to assist with demolding the composite component from the mold (12). Positioning the first inflatable element (14) on the mold (12) is contemplated to include positioning at least a portion of the first inflatable element (14) within the non-trim zone (28).



DEMOLDING METHOD AND APPARATUS

Cross-Reference to Related Application(s)

[0001] This application relies for priority on U.S. Provisional Patent Application Serial No. 62/317,869, entitled “DEMOLDING METHOD AND APPARATUS,” filed April 4, 2016, the entire content of which is hereby incorporated by reference.

Field of the Invention

[0002] The present invention concerns a demolding method and apparatus. More specifically, the present invention concerns a method and apparatus that facilitates demolding of a composite component from a mold and/or a tool used to form the composite component. Even more specifically, the present invention concerns a method and apparatus for demolding a composite component from a mold and/or a tool, with the understanding that the composite component may be used in the construction of a vehicle, such as an aircraft.

Description of the Background and Related Art

[0003] As should be apparent to those skilled in the construction of vehicles, such as aircraft, the manufacture of a composite component presents a number of challenges.

[0004] One particular challenge associated with the demolding of the composite component from a mold and/or a tool occurs after the composite component is cured.

[0005] Fiber composite components may be manufactured via any of a number of known processes.

[0006] A first process generally involves the infusion (or infiltration) of resin into a plurality of dry fiber layers that have been arranged on a mold and/or a tool. In this first process, a vacuum may be applied to the fiber layers to help the resin to wet the fiber layers. After wetting, the resin is cured by heating the wetted fiber layers.

[0007] A second process involves the application of multiple layers of fiber fabrics onto a mold and/or tool. These layers are pre-impregnated with resin, which is why the layers are often referred to as “prepregs.” After the layup is complete, the layers are subjected to heat and pressure until cured.

[0008] Regardless of the manufacturing process employed, the cured composite component needs to be removed from the mold and/or the tool before assembly into a vehicle, such as an aircraft.

[0009] In many instances, the cured composite component is not easily removed from the tool and/or the mold. The resin may cause an adhesion between the composite component and the mold and/or the tool. Still further, suction between the composite component and the mold and/or tool may inhibit demolding of the composite component therefrom.

[0010] The prior art does not provide a suitable solution to one or more of the difficulties enumerated above.

[0011] Accordingly, there has developed a need to simplify and/or to improve upon the removal of cured composite components from the molds and/or the tools on which the composite components are manufactured.

Summary of the Invention

[0012] The present invention addresses one or more of the deficiencies with respect to the prior art.

[0013] Accordingly, the present invention provides a demolding apparatus that includes a mold for receiving a composite component, the composite component defining a periphery, a trim zone interior to the periphery and a non-trim zone interior to the trim zone, and a first inflatable element for being positioned between the mold and the composite element, the first inflatable member being disposed at least partially within the non-trim zone.

[0014] In one contemplated embodiment, the first inflatable element extends from the non-trim zone into the trim zone.

[0015] In another contemplated embodiment, the first inflatable element extends from a first trim zone in proximity to a first side of the composite component, across the non-trim zone, to a second trim zone in proximity to a second side of the composite component.

[0016] In still another contemplated embodiment, the first inflatable element includes a first end that is positioned exterior to the periphery of the composite component at the first side of the composite component.

[0017] Other contemplated embodiments include an arrangement where the first inflatable element comprises a second end that is positioned exterior to the periphery of the composite component at the second side of the composite component.

[0018] It is contemplated that the inflatable element may extend across the non-trim zone between longitudinal sides of the composite component.

[0019] It is also contemplated that the inflatable element may extend across the non-trim zone between opposed lateral sides of the composite component.

[0020] Separately, the inflatable element may extend from a trim-zone at a first side of the composite component to a trim zone at a second side of the composite component across a portion of the non-trim zone having a predetermined length.

[0021] It is contemplated that the predetermined length may be a maximum linear length for the non-trim zone.

[0022] Still further, the demolding apparatus of the present invention may include a trough defined in the mold to accommodate at least a portion of the first inflatable element.

[0023] The trough may accommodate the entirety of the first inflatable element.

[0024] In another contemplated embodiment, the demolding apparatus of the present invention includes a first fluid source and a first fluid line connecting the first fluid source to a first end of the first inflatable element. Fluid from the first fluid source inflates the first inflatable member.

[0025] It is contemplated that the demolding apparatus also may include a second inflatable member for being positioned between the mold and the composite element, the second inflatable member being disposed at least partially within the non-trim zone.

[0026] The second inflatable element may extend from the non-trim zone into the trim zone.

[0027] The second inflatable element may include a first end that is positioned exterior to the periphery of the composite component, the second inflatable element extending from the first end across the non-trim zone into the trim zone.

[0028] The second inflatable element may be positioned parallel to the first inflatable element.

[0029] In still another contemplated embodiment, the demolding apparatus of the present invention includes a second fluid source and a second fluid line connecting the second fluid

source to the first end of the second inflatable element. Fluid from the second fluid source inflates the second inflatable member.

[0030] It is contemplated that the first inflatable element is made from a release material.

[0031] The present invention also provides for a method of demolding a composite component from a mold, the composite component defining a periphery, a trim zone interior to the periphery and a non-trim zone interior to the trim zone. The method is contemplated to include positioning a first inflatable element on the mold, applying a plurality of layers atop the first inflatable element to create a layer stack, curing the layer stack to create the composite component, and inflating the first inflatable element with a fluid in order to assist with demolding the composite component from the mold. Positioning the first inflatable element on the mold is contemplated to include positioning at least a portion of the first inflatable element within the non-trim zone.

[0032] With respect to the method, the positioning the first inflatable element on the mold may include positioning a first end of the inflatable element exterior to the periphery of the composite component at a first side of the composite component, such that the first inflatable element extends from exterior to the periphery of the composite component, across the trim zone, into the non-trim zone.

[0033] Further aspects of the present invention will be made apparent from the paragraphs that follow.

Brief Description of the Drawing(s)

[0034] The present invention will now be described in connection with the drawings appended hereto, in which:

[0035] Fig. 1 is a graphical, side view illustration of a first embodiment of the apparatus of the present invention, showing the apparatus in a first operating condition;

[0036] Fig. 2 is a graphical, side view of the first embodiment illustrated in Fig. 1, showing the apparatus in a second operating condition;

[0037] Fig. 3 is a graphical, top view of the first embodiment of the apparatus of the present invention illustrated in Figs. 1 and 2;

[0038] Fig. 4 is a graphical, top view of a second embodiment of the apparatus of the present invention;

[0039] Fig. 5 is a graphical, top view of a third embodiment of the apparatus of the present invention;

[0040] Fig. 6 is a graphical, top view of a fourth embodiment of the apparatus of the present invention;

[0041] Fig. 7 is a graphical, side view of a fifth embodiment of the apparatus of the present invention;

[0042] Fig. 8 is a graphical, top view of a sixth embodiment of the apparatus of the present invention; and

[0043] Fig. 9 is a flow chart illustrating a first method of manufacture of a composite component relying on the apparatus of the present invention.

Detailed Description of Embodiment(s) of the Invention

[0044] The present invention will now be described in connection with one or more embodiments thereof. The discussion of the embodiments is not intended to be limiting of the present invention. To the contrary, any discussion of embodiments is intended to exemplify the breadth and scope of the present invention. As should be apparent to those skilled in the art, variations and equivalents of the embodiment(s) described herein may be employed without departing from the scope of the present invention. Those variations and equivalents are intended to be encompassed by the scope of the present patent application.

[0045] Fig. 1 is a graphical, side view of a first embodiment of a composite demolding apparatus 10 according to the present invention. The composite demolding apparatus 10 includes a mold 12, an inflatable element 14 placed atop the mold 12, and a composite component 16 disposed atop the inflatable element 14. As should be apparent, therefore, the inflatable element 14 lies between the mold 12 and the composite component 16.

[0046] In Fig. 1, the composite demolding apparatus 10 is illustrated in a first operating condition. In particular, the composite demolding apparatus 10 is illustrated in a condition prior to demolding of the composite element 16 from the mold 12. In this first condition, the inflatable element 14 is deflated.

[0047] As should be apparent, in the deflated condition, the inflatable element 14 presents a minimal thickness by comparison with the thickness of the composite component 16. The thickness of the inflatable element 14 is considered to be on the order of 1 – 10 thousandths

of an inch (0.0254 – 0.254 mm). The present invention, however, should not be understood to be limited to any particular thickness of the inflatable element 14.

[0048] Fig. 2 is a graphical, side view of a first embodiment of a composite demolding apparatus 10 according to the present invention. The composite demolding apparatus 10 is illustrated in a second operating condition.

[0049] In the second operating condition the inflatable element 14 has been inflated. This causes the composite component 16 to be separated from the surface 18 of the mold 12. Accordingly, this second condition represents a demolded (or at least partially demolded condition) of the composite component 16.

[0050] Using Figs. 1 and 2 as a reference, the simplicity of the present invention lies in the positioning of the inflatable element 14 between the mold 12 and the composite component 16. The inflatable element 14 may be positioned between the mold 12 and the composite component 16 prior to the placement (or layering) of the composite component 16 onto the mold 12 and also prior to the curing of the composite component 16. As detailed below, the composite component 16 may be placed atop the mold 12 and the inflatable element 14 after having been assembled on a separate tool. Also, the composite component 16 may be layered atop the mold 12 and the inflatable element 14 by applying the layers, one or more at a time onto the mold 12.

[0051] After curing, the composite component 16 is essentially a rigid structure or substantially rigid structure. By inflating the inflatable element 14 after curing, the composite component 16 is forced away from the surface 18 of the mold 12. Using the inflatable element 14, the composite component 16 may be demolded easily from the mold 12 without damage to the composite component 16.

[0052] As discussed in greater detail in the paragraphs that follow, one or more inflatable elements 14 may be used in accordance with the present invention. The one or more inflatable elements 14 may be separate from one another or connected together, as will be described in more detail below.

[0053] Still further, the inflatable element 14 may be of any shape and/or size without departing from the scope of the present invention. The inflatable element 14 may be positioned at any location on the mold 12, as required or as desired, to facilitate demolding of the composite component 16 from the mold 12.

[0054] So that the inflatable element 14 may be inflated, the inflatable element 14 is connected to a fluid source 20 via a line 22. A valve 24 may be provided in the line 22 to control the inflation of the inflatable element 14 by controlling the flow of the fluid from the fluid source 20 to the inflatable element 14. As should be appreciated by those skilled in the art, the valve 24 also may control the deflation of the inflatable element 14.

[0055] With regard to control over the inflation of the inflatable element 14, it is contemplated that control may be provided over the magnitude of pressure provided to the inflatable element. For example, it is contemplated that a pressure of 5 – 10 psi (34.47 – 68.95 kPa) may be suitable for inflation of the inflatable element 14. A pressure on the order of about 8 psi (55.16 kPa) is considered to be applicable to most circumstances. However, both higher and lower pressures are contemplated to fall within the scope of the present invention. Separately, it is contemplated that the rate of inflation of the inflatable element 14 also may be controlled to facilitate separating the composite component 16 from the mold 12. A controlled application of pressure is thought to help avoid a concentration of stresses in any one part of the composite component 16 during the demolding operation.

[0056] The valve 24 may be operated manually, automatically, or a combination of manually and automatically. In a manual mode of operation, it is contemplated that a person may open the valve to inflate the inflatable member 14. If the manufacturing process is fully automated, it is contemplated that the valve 24 may be opened via any suitable remote operating device that is connected to a central processor. Still further, the process may be partially automated but also require intervention by a person to augment the automatic operation as required or desired.

[0057] With continued reference to Fig. 1, the mold 12 may be made from any suitable material. It is contemplated, for example, that the mold 12 may be made from a durable material that is capable of being reused multiple times so that many composite components 16 may be created before wearing out the mold 12. In other words, as should be apparent to those skilled in the art, the mold 12 should be durable enough to make it possible to manufacture several ones of the same part thereon and/or thereby.

[0058] For the mold 12, durable materials include, but are not limited to, metals such as iron, alloys of iron, steel, alloys of steel, aluminum, alloys of aluminum, etc. Non-metallic materials also may be used for the mold 12. For example, the mold 12 may be made from

rubber, plastic, thermoplastic, ceramic, composite materials, etc. Still further, the mold 12 may be made from a number of different materials. For example, one part of the mold 12 may be made from metal while another part of the mold 12 may be made from a material other than metal. In this example, the mold 12 may include sacrificial elements made from disposable and/or recyclable materials including, but not limited to plastics.

[0059] In addition, throughout the illustrations of the present invention, the mold 12 is shown as being a monolithic element. The present invention, however, does not require that the mold 12 have a one piece construction. The mold 12 may be made from any number of separate parts that are assembled together (or brought together) to form the surface 18 on which the composite component 16 is manufactured.

[0060] In the various figures of the drawings, the mold 12 is illustrated as having a planar surface 18. The present invention, however, is not limited to a construction where the surface is planar 18. To the contrary, the surface 18 may have any shape suitable for the formation of the composite component 16. In contemplated embodiments, the surface 18 is anticipated to present a complex, undulating shape at one or more cross-sections thereof. To this end, it is contemplated that the surface 18 of the mold 12 may have any shape without departing from the scope of the present invention.

[0061] In the illustrated embodiments, the mold 12 is shown with a single surface 18. However, it is contemplated that the mold 12 may be made with complimentary halves that may be pressed against one another to form the composite component 16. In such a construction, the mold 12 shown in the drawings may be considered as a lower mold, with an upper mold (not shown) or caul plate being complimentary thereto. Where the mold 12 includes lower and upper halves, inflatable elements 14 may be provided on one or both halves of the mold 12 for demolding of the composite component 16 therefrom.

[0062] The composite component 16, when cured, is contemplated to be a carbon fiber composite material containing a suitable resin. As a result, the composite component 16 is contemplated to include a plurality of carbon fiber layers laid on top of one another. The carbon fiber layers may be woven, non-woven, and/or a combination of the two. Alternatively, the composite component 16 may include one or more honeycomb layers.

[0063] While carbon fiber composites 16 are contemplated to be made via the method and apparatus of the present invention, the present invention is not limited to carbon fiber

composite materials. The composite component 16 may include non-carbon fibers and/or elements. For example, the composite component 16 may include aramid fibers, nylon fibers, plastic films, metal films, metal meshes, and the like. As should be apparent to those skilled in the art, composite component 16 may be made from any of a wide variety of materials. The present invention is intended to encompass any combinations of materials now known or developed in the future.

[0064] While not intended to be limiting of the present invention, the inflatable element 14 is contemplated to be a collapsible balloon, such as a tube, that may be made from a material that resists sticking to the resin used for the manufacture of the composite component 16. The inflatable element 14 is contemplated to be manufactured from a film that resists adhesion to the resin and, therefore, resists adhesion to the composite component 16 in both the cured and uncured conditions. In various contemplated embodiments, the inflatable element 14 may be constructed from a release material, may be impregnated with a release material, and/or may be coated in a release material, as required and/or as desired. In the embodiments illustrated herein, the inflatable element 14 is contemplated to be made from a release material, which may be a film, fashioned into an elongated tube.

[0065] As should be apparent to those skilled in the art, the inflatable element 14 may be made from a material that resists adhesion to the surface 18 of the mold 12. The material used for the inflatable element 14 may also resist degradation when exposed to heat and/or pressure of the magnitudes generated during curing of the composite component 16.

[0066] The fluid source 20 is contemplated to contain a fluid that may be pumped into the inflatable member 14. Alternatively, the fluid also may be injected into the inflatable member as a result of a pressure differential between the fluid source 20 and the inflatable member 14. Regardless of the mechanism by which fluid is provided to the inflatable member 14, it is contemplated that a suitable gas will be used to inflate the inflatable member 14. Suitable gases include, but are not limited to, air, nitrogen, and noble gases. In particular, gases that are understood to have a low reactivity with the materials making up the composite component 16 and/or the mold 12 are acceptable candidates.

[0067] Alternatively, it is contemplated that the fluid may be a liquid, such as water. Other liquids also may be employed, as required or as desired. As should be apparent to those

skilled in the art, liquids are able to exert higher pressures with smaller volumes than gases and, therefore, may be preferred under certain circumstances.

[0068] The fluid source 20 is contemplated to be a reservoir where the fluid contents are under pressure. In the case where the fluid is a gas, the fluid source may be a gas canister, such as a pressurized air canister. Alternatively, the fluid source 20 may include a compressor that pressurizes ambient air for introduction to the inflatable element 14. Still further, if the fluid is a liquid, the fluid source 20 may be a container with the liquid under pressure. The fluid source 20 may include a pump. As should be apparent there are a number of alternatives that may be employed in connection with the fluid source 20 without departing from the scope of the present invention.

[0069] With continued reference to Fig. 1, the composite component 16 is illustrated to highlight specific zones associated therewith. In particular, the composite component 16 has a trim zone 26 and a non-trim zone 28. The trim zone 26 represents the portion of the composite component 16 that is cut off of the composite component 16 to create the final part to be used in the construction of the vehicle. The trim zone 26, therefore, represents the material that is discarded from the composite component 16. The non-trim zone 28 designates and/or represents the final part that may be used to manufacture the vehicle. As should be apparent, the final part may require further processing (*e.g.*, trimming, sanding, shaping, coating, painting, etc.) before it may be incorporated into a vehicle.

[0070] With the depiction of a trim zone 26 and a non-trim zone 28, Fig. 1 illustrates that, in this first contemplated embodiment, the inflatable element 14 extends between the mold 12 and the composite component 16 from a first side S1 to a second side S2. More specifically, in this illustrated embodiment, the inflatable element 14 extends outside of the periphery 30 on the first side S1 of the composite component 16 and extends outside of the periphery 30 on second side S2 of the composite component 16. By extending across the composite component 16 from the first side S1 to the second side S2, it is contemplated that the placement of the inflatable element 14 will ensure separation of the composite component 16 from the mold 12.

[0071] As will be made apparent from the discussion of other contemplated embodiments of the present invention, it is contemplated that the inflatable element 14 may be disposed, at a minimum, entirely within the non-trim zone 28. In other examples, the inflatable element 14 may extend from a position within the trim zone 26 on either of first side S1 or second side S2 to

a position within the non-trim zone 28. For these embodiments, the present invention contemplates that the inflatable member 14 will straddle (or cross) the trim line 32, as shown in Figure 3. In still other embodiments, the inflatable element 14 extends from a position outside of the periphery 30 of the composite component 16 on either of first side S1 or second side S2, across the trim zone 26 to a position within the non-trim zone 28. In these embodiments, the inflatable element 14 straddles (or crosses) the trim zone 26 in its entirety.

[0072] In those embodiments where the inflatable element 14 extends from the trim zone 26 on the first side S1 of the composite component 16 to the trim zone 26 on second side S2 the composite component 16, the inflatable element crosses a predetermined length of the non-trim zone 28. It is to be understood that although the first side S1 and the second side S2 are illustrated in Fig. 1 as being generally opposite sides, it is possible for the first side S1 and the second side S2 to be adjacent each other. Alternatively, in the situation where composite component 16 does not have distinct edges, the first side S1 and the second side S2 may be portions of a periphery of the composite component 16 that are spaced apart from one another. In some non-limiting embodiments, the predetermined length of the non-trim zone 28 across which the inflatable element 14 crosses, may be a maximum length across the non-trim zone 28, meaning the longest linear length defined across the non-trim zone 28.

[0073] Regardless of the orientation and length of the inflatable element 14, to facilitate demolding of the composite component 16, the inflatable member 14 is contemplated to lie at least partially within the non-trim zone 28. By positioning at least a portion of the inflatable element 14 within the non-trim zone 28, it is contemplated that it should be possible to demold the composite component 16 while minimizing the stress(es) on the composite component 16 during demolding.

[0074] Fig. 3 is a graphical, top view of the demolding apparatus 10 of the present invention, as illustrated in Fig. 1. Fig. 3 illustrates that this first embodiment of the demolding apparatus 10 includes a single inflatable member 14. As discussed in greater detail below, the present invention may include two or more inflatable members 14.

[0075] As a matter of reference, the composite component 16 is illustrated as being rectangular. This illustration is a simplified representation of the composite component 16. As should be apparent to those skilled in the art, the composite component 16 may have a polygonal periphery 30. In the context of the present invention, polygonal is not limited to multiple,

straight edges. As should be appreciated by those skilled in the art, the composite component 16 may have straight edges, curved edges, or a combination of both straight edges and curved edges defining its periphery 30.

[0076] Fig. 3 also illustrates a trim line 32 that separates the trim zone 26 from the non-trim zone 28. Like the periphery 30, the trim line 32 is shown as being rectangular to simplify the illustration. As should be apparent to those skilled in the art, the trim line 32 is contemplated to have any suitable shape for the final composite part.

[0077] With continued reference to Fig. 3, it is noted that the periphery 30 and the trim line 32 illustrated both have rectangular shapes and that the trim zone 26 has a uniform thickness around the entire periphery 30 of the composite component 16. Again, the illustration of a uniform trim zone 26 is a simplification, and the periphery 30 and the trim line 32 may have different shapes without departing from the scope of the present invention. Moreover, the thickness of the trim zone 26 may vary around the periphery 30 of the composite component 16 without departing from the scope of the present invention.

[0078] It is noted that the composite component 16 is illustrated in Fig. 3 such that the composite component 16 has only one, central non-trim zone 28. While this is contemplated to be the most commonly employed embodiment of the present invention, it is contemplated that the composite component 16 may yield two or more finished parts. In other words, it is contemplated that the composite component 16 may encompass two or more non-trim zones 28 without departing from the scope of the present invention.

[0079] With continued reference to Fig. 3, the inflatable element 14 extends between the mold 12 and the composite component 16. A first end 141 of the inflatable element 14 is positioned outside of the periphery 30 at the first side S1 of the composite component 16 at a first end position E1. A second end 142 of the inflatable element 14 is positioned outside of the periphery of the second side S2 of the composite component 16 at a second end position E2. As should be apparent from Fig. 3, the first and second end positions E1, E2 are exterior to the sides S1, S2 of the composite component 16. In the illustrated embodiment, the sides S1, S2 define a lateral direction of the composite component 16. As is also apparent from Fig. 3, the composite component 16 includes a third side S3 and a fourth side S4 that define the longitudinal direction of the composite component 16. A longitudinal axis is defined as an axis extending from the first side S1 to the second side S2. In addition, a lateral axis is defined as an axis extending from

the third side S3 to the fourth side S4. In this embodiment, the inflatable member 14 extends parallel to the longitudinal axis between the first and second sides S1, S2.

[0080] As should be apparent to those skilled in the art, the inflatable element 14 need not be positioned in the manner illustrated in Fig. 3. One advantage of the present invention is that the inflatable element 14 may be positioned at any location or in any configuration between the mold 12 and the composite component 16. In this regard, different arrangements are discussed in connection with the remaining illustrations, which are discussed below.

[0081] With continued reference to Fig. 3, for the demolding apparatus 10, the first end 141 and the second end 142 of the inflatable element 14 extend outside of the periphery 30 at each of the first and second sides S1, S2. In this embodiment, therefore, the composite component 16 does not cover the ends 141, 142 of the composite element 14, as is contemplated for other contemplated embodiments.

[0082] In this embodiment, the first end 141 of the inflatable element 14 is disposed at the first end position E1, outside of the periphery 30, so that the line 22 may be more easily connected thereto. As will be made apparent from the discussion that follows, this construction is not required to practice the present invention.

[0083] For other contemplated embodiments, the inflatable element 14 may extend orthogonally to the orientation illustrated in Fig. 3. In other words, the inflatable element 14 may extend across the lateral dimension of the composite component 16 between the third side S3 and the fourth side S4.

[0084] In a further contemplated embodiment, the inflatable element 14 may be disposed at an angle to the longitudinal axis (extending between the sides S1, S2) or to the lateral axis (extending between the sides S3, S4) of the composite component 16 without departing from the scope of the present invention. It is noted that the terms “longitudinal” and “lateral” are merely for identification and are not intended to be limiting of the present invention.

[0085] As should be apparent, the present invention contemplates that the inflatable element 14 may be disposed at any suitable orientation between the sides S1, S2, S3, S4 of the composite component 16. For example, the inflatable element 14 may extend between side S1 and S3, such that it is positioned at an angle to both the longitudinal axis and the lateral axis.

[0086] Moreover, one or more ends 141, 142 may or may not extend outside of the periphery 30 of the composite component 16. Where one of the ends 141, 142 of the composite

element 14 does not extend outside of the periphery 30 of the composite component 16, the end 141, 142 may lie within the trim zone 26 or within the non-trim zone 28, as should be apparent from the description of other embodiments provided below.

[0087] Fig. 4 illustrates a second embodiment of the demolding apparatus 34 according to the present invention. Specifically, Fig. 4 is a graphical, top view thereof. In this second embodiment, the demolding apparatus 34 includes three inflatable elements 36, 38, 40. The three inflatable elements 36, 38, 40 each connect to lines 42, 44, 46 that, in turn, connect to the line 22 extending from the fluid source 20. As such, it is contemplated that each of the inflatable elements 36, 38, 40 will be inflated simultaneously from the same fluid source 20 and be controlled via the same valve 24.

[0088] In this embodiment, as in the embodiment of the demolding apparatus 10 illustrated in Fig. 3, each of the inflatable elements 36, 38, 40 includes ends that are external to the periphery 30 of the composite component 16. In particular, the first inflatable element 36 has a first end 361 that lies outside of the periphery 30 at the first side S1 of the composite component 16. The second end 362 of the first inflatable element 36 lies outside of the periphery 30 at the second side S2 of the composite component 16. The second inflatable element 38 has a first end 381 that lies outside of the periphery 30 at the first side S1 of the composite component 16. The second end 382 of the second inflatable element 38 lies outside of the periphery 30 at the second side S2 of the composite component 16. The third inflatable element 40 has a first end 401 that lies outside of the periphery 30 at the first side S1 of the composite component 16. The second end 402 of the third inflatable element 40 lies outside of the periphery 30 at the second side S2 of the composite component 16.

[0089] For the demolding apparatus 34, similar to the demolding apparatus 10, the inflatable elements 36, 38, 40 run parallel to the longitudinal axis of the composite component 16, which, as before, is defined as the axis extending from the first side S1 to the second side S2 of the composite component 16. As in the prior embodiment, the inflatable elements 36, 38, 40 alternatively may be oriented orthogonally to the illustrated construction. If so, the inflatable elements 36, 38, 40 would extend parallel to the lateral axis of the composite component 16 which is the axis extending from the third and fourth sides S3, S4. Still further, the inflatable elements 36, 38, 40 may be disposed at an angle to the longitudinal and/or lateral axes of the composite component 16 without departing from the scope of the present invention.

[0090] Similar to the demolding apparatus 10, the first inflatable element 36 extends from a first end position E3 to a second end position E4 on the mold 12. The second inflatable element 38 extends from a first end position E5 to a second end position E6. The third inflatable element 40 extends from a first end position E7 to a second end position E8. In this embodiment, as noted, each of the positions E3, E4, E5, E6, E7, E8 are illustrated as being external to the periphery 30 of the composite component 16. In other contemplated embodiments, one or more of the positions E3, E4, E5, E6, E7, E8 may commence within the trim zone 26 or within the non-trim zone 28, as required or as desired.

[0091] Fig. 5 is a graphical, top view of a third embodiment of a demolding apparatus 48 according to the present invention. Here, the three inflatable elements 36, 38, 40 are connected to independent fluid sources 50, 52, 54 via fluid lines 56, 58, 60. In this embodiment, each line 56, 58, 60 includes a separate valve 62, 64, 66. For this embodiment, it is contemplated that the inflatable elements 36, 38, 40 are controlled separately. Such an arrangement may be desired in instances where progressive separation of the composite component 16 from the mold 12 is needed to avoid cracking of and/or damage to the composite component 16.

[0092] In the embodiment illustrated in Fig. 5, the inflatable elements 36, 38, 40 are contemplated to have the same construction and orientation as described in connection with the demolding apparatus 34. The demolding apparatus 48 includes separate fluid sources 50, 52, 54 that may be controlled independently from one another.

[0093] With continued reference to Fig. 5, it is contemplated that the inflatable elements 36, 38, 40 may be inflated in sequence to demold the composite component 16 in a controlled manner. For example, for large composite components 16, it may be desirable to inflate the first inflatable element 36 first, the second inflatable element 38 second, and the third inflatable element 40 third. By inflating the three inflatable elements 36, 38, 40 in sequence, it may be possible to demold the composite component 16 in a manner that introduces minimal stresses into the composite component 16 during the demolding operation.

[0094] Fig. 6 is a graphical, top view of a fourth embodiment of a demolding apparatus 68. This embodiment is similar to the embodiment illustrated in Fig. 4. Here, however, the inflatable elements 36, 38, 40 have been replaced by inflatable elements 70, 72, 74. As illustrated, the inflatable elements 70, 72, 74 are of different sizes from one another and, as such, extend along different distances across the surface 18 of the mold 12.

[0095] In this embodiment, similar to the inflatable element 36, the first inflatable element 70 has a first end 701 that lies outside of the periphery 30 at the first side S1 of the composite component 16. The second end 702 of the first inflatable element 70 also lies outside of the periphery 30 of the composite component 16 on the second side S2. The second inflatable element 72 has a first end 721 that lies inside of the periphery 30 at the first side S1 of the composite component 16. In particular, the first end 721 lies within the trim zone 26. The second end 722 of the second inflatable element 72 lies inside of the periphery 30 of the composite component 16 near to the second side S2. In particular, the second side 722 lies inside of the non-trim zone 28, inside of the trim line 32. The third inflatable element 74 has a first end 741 that lies inside of the non-trim zone 28, near to the periphery 30 at the first side S1 of the composite component 16. The second end 742 of the third inflatable element 74 also lies inside of the non-trim zone 28 at a location near to the periphery 30 at the second side S2 of the composite component 16.

[0096] For the demolding apparatus 68, the inflatable elements 70, 72, 74 run parallel to the longitudinal axis of the composite component 16 as previously defined. As before, the inflatable elements 70, 72, 74 may be oriented orthogonally to the illustrated construction. If so, the inflatable elements 70, 72, 74 would extend across the lateral axis of the composite component 16, between the third and fourth sides S3, S4. Still further, the inflatable elements 70, 72, 74 may be disposed at an angle to the longitudinal and/or lateral axes of the composite component 16 without departing from the scope of the present invention.

[0097] With respect to the demolding apparatus 68, the first inflatable element 70 extends from a first position E3 to a second position E4 on the mold 12. The second inflatable element 72 extends from a first position E9 to a second position E10. The third inflatable element 74 extends from a first position E11 to a second position E12. In this embodiment, as noted, each of the positions E3, E4, E9, E10, E11, E12 are at various locations outside of the periphery 30, within the trim zone 26, and/or within the non-trim zone 28.

[0098] Fig. 7 is a graphical, side view of a fifth embodiment of a demolding apparatus 76 according to the present invention. In this embodiment, a trough 78 is provided in the surface 18 of the mold 12 to accommodate the inflatable member 14.

[0099] As should be apparent from Fig. 1, the inflatable element 14 has a thickness. While modest by comparison with the thickness of the composite component 16, the inflatable

element 14 may create a slight groove in the composite component 16 once cured. To avoid the creation of this groove, the demolding apparatus 76 illustrated in Fig. 7 includes the trough 78 so that the inflatable member 14 is flush with the surface 18 of the mold 12 when in the deflated condition.

[00100] With renewed reference to the demolding apparatus 10, any groove formed on the composite component by the inflatable element 14 may be subsequently smoothed by one or more operations known to those skilled in the art. For example, the surface of the composite component 16 may be sanded or smoothed to remove the groove created by the inflatable member 14. Still further, the groove may be filled in using a suitable epoxy and/or resin.

[00101] As should be apparent, the trough 78 is merely representative of one trough that may be employed. The present invention may include troughs 78 under all of the inflatable members or just a few of the inflatable members 14, as required or as desired. Separately, it is contemplated that the trough 78 may extend only under a portion of the inflatable element 14.

[00102] Fig. 8 illustrates a sixth embodiment of a demolding apparatus 80 according to the present invention. In this embodiment, the inflatable element 82 is plus-shaped (or cross-shaped) with a first end 84 being connected to the fluid source 20 via the line 22. The first end 84 lies outside of the periphery 30 at the first side S1 of the composite component 16. A second end 86 of the inflatable element 82 is outside of the periphery 30 of the composite component 16 on the third side S3. At least a portion of the inflatable element 82 lies within the non-trim zone 28 of the composite component 16. In the illustrated configuration, the third end 88 and the fourth end 90 of the inflatable element 82 lie within the non-trim zone 28. For reference, the first end 84 is at a position E13 on the mold 12, the second end 86 is at a position E14, the third end 88 is at a position E15, and the fourth end 90 is at a position E16.

[00103] This sixth embodiment also includes an inflatable element 92. The inflatable element 92 is L-shaped with a first end 94 extending outside of the periphery 30 of the composite component 16 on the second side S2. The second end 96 of the inflatable element lies within the trim zone 26 on the third side S3. A portion of the inflatable element 92 lies within the non-trim zone 28. The first end 94 connects to the line 22, as shown. As also illustrated, the first end 94 is at position E17 on the mold 12 external to the periphery 30. The second end 96 of the inflatable element 92 is at position E18.

[00104] Fig. 9 is a flow chart that illustrates one contemplated method 100 of operation of the demolding apparatus 10, 34, 48, 68, 76, 80 of the present invention.

[00105] The method 100 begins at 102.

[00106] At 104, at least one inflatable element 14, 36, 38, 40, 70, 72, 74, 82, 92 is positioned on the mold 12. The positioning may be longitudinal, extending between the first and second sides S1, S2 of the composite component 16. The positioning may be lateral, extending between the third and fourth sides S3, S4 of the composite component. The positioning may be at an angle to the longitudinal and/or lateral directions, as noted above. As should be apparent from the foregoing, one or more of the inflatable elements 14, 36, 38, 40, 70, 72, 74, 82, 92 may be employed.

[00107] At 106, a plurality of layers are positioned atop the at least one inflatable element 14, 36, 38, 40, 70, 72, 74, 82, 92. The plurality of layers may be deposited onto the mold 12 as a pre-formed composite component 16 or may be built on top of the mold 12, one layer at a time. Regardless of the method employed to deposit the composite component 16 onto the mold, the composite component 16 is contemplated to exist as a layer stack. The layer stack is contemplated to be an intermediate product, before the resin in the composite component 16 is cured.

[00108] At 108, resin may be optionally infused or injected into the layer stack. The type of materials used to create the later stack (*e.g.*, prepreg materials or dry (non-prepreg) materials) will determine if resin is or is not required. While other terms are known to those skilled in the art, the terms “injection” and “infusion” are intended to refer to the wetting of the layer stack with resin. The terms are not intended to limit the present invention.

[00109] At 110, the layer stack is cured to form the composite component 16. As noted, curing may involve the application of heat, pressure, and/or a combination of heat and pressure. Once cured, the composite component 16 is transformed into a rigid or semi-rigid component, depending upon its size, shape, and configuration, as should be apparent to those skilled in the art.

[00110] At 112, following curing, the inflatable element 14, 36, 38, 40, 70, 72, 74, 82, 92 is inflated. As noted, the fluid may be gas or liquid, as required or as desired.

[00111] At 114, the inflatable element or elements 14, 36, 38, 40, 70, 72, 74, 82, 92 are inflated for assisting with demolding of the composite component 16 from the mold 12.

[00112] As discussed above, the inflatable element 14, 36, 38, 40, 70, 72, 74, 82, 92 may be connected such that all of the inflatable elements 14, 36, 38, 40, 70, 72, 74, 82, 92 are inflated at the same time. Alternatively, the inflatable elements 14, 36, 38, 40, 70, 72, 74, 82, 92 may be inflated separately. Still further, the inflatable elements 14, 36, 38, 40, 70, 72, 74, 82, 92 may be inflated in sequence. As noted, the inflatable elements 14, 36, 38, 40, 70, 72, 74, 82, 92 may be inflated manually, automatically, and/or a combination of manually and automatically, as required or desired.

[00113] The method 100 ends at 116. At this point, the composite component 16 has been demolded from the mold 12.

[00114] Taking all of the foregoing into account, the present invention offers a flexible, simplified approach to the manufacture of a composite component 16.

[00115] As should be apparent, since the inflatable elements 14, 36, 38, 40, 70, 72, 74, 82, 92 may be placed at any location on the mold 12, the demolding operation is easily adapted to any type of mold 12 and/or for any type of composite component 16.

[00116] As also should be apparent, the inflatable elements 14, 36, 40, 70, 72, 74, 82, 92 are contemplated to be positioned at least within the non-trim zone 28. In some cases, the inflatable elements 14, 36, 40, 70, 72, 74, 82, 92 may be located entirely within the non-trim zone 28. In other cases, the inflatable elements 14, 36, 40, 70, 72, 74, 82, 92 extend from the non-trim zone 28 into the trim zone 26. In these embodiments, the inflatable elements 14, 36, 40, 70, 72, 74, 82, 92 extend outside of the trim line 32 but not outside of the periphery 30. In still further embodiments, the inflatable elements 14, 36, 40, 70, 72, 74, 82, 92 extend from outside of the periphery 30 of the composite component 16, across the trim zone 26 to positions component 16 within the non-trim zone 28.

[00117] It is noted that, with the exception of the demolding apparatus 76 illustrated in Fig. 7, the present invention offers the advantage of being applicable to existing molds 12 that are used for the manufacture of composite components 16, without modification of those molds 12.

[00118] As should be apparent, the method 100 is applicable to existing molds 12, also without modification of those molds.

[00119] Without limitation of the present invention, one or more of the inflatable elements 14, 36, 40, 70, 72, 74, 82, 92 may be positioned atop the mold 12 in a configuration where the

inflatable elements 14, 36, 40, 70, 72, 74, 82, 92 overlap one another, at least in part. This is considered to be a further embodiment of the present invention. Where the inflatable elements 14, 36, 40, 70, 72, 74, 82, 92 overlap, troughs 78 may be provided for the lower ones of the inflatable elements 14, 36, 40, 70, 72, 74, 82, 92, as required or as desired.

[00120] As noted above, the embodiment(s) described herein are intended to be exemplary of the wide breadth of the present invention. Variations and equivalents of the described embodiment(s) are intended to be encompassed by the present invention, as if described herein.

What is claimed is:

1. A demolding apparatus, comprising:
a mold for receiving a composite component, the composite component defining a periphery, a trim zone interior to the periphery and a non-trim zone interior to the trim zone; and
a first inflatable element for being positioned between the mold and the composite element, the first inflatable member being disposed at least partially within the non-trim zone.
2. The demolding apparatus of claim 1, wherein the first inflatable element extends from the non-trim zone into the trim zone.
3. The demolding apparatus of claim 2, wherein the first inflatable element extends from a first trim zone in proximity to a first side of the composite component, across the non-trim zone, to a second trim zone in proximity to a second side of the composite component.
4. The demolding apparatus of claim 3, wherein the first inflatable element comprises a first end that is positioned exterior to the periphery of the composite component at the first side of the composite component.
5. The demolding apparatus of claim 4, wherein the first inflatable element comprises a second end that is positioned exterior to the periphery of the composite component at the second side of the composite component.
6. The demolding apparatus of claim 1, wherein the inflatable element extends across the non-trim zone between longitudinal sides of the composite component.
7. The demolding apparatus of claim 1, wherein the inflatable element extends across the non-trim zone between opposed lateral sides of the composite component.

8. The demolding apparatus of claim 1, wherein the inflatable element extends from a trim-zone at a first side of the composite component to a trim zone at a second side of the composite component across a portion of the non-trim zone having a predetermined length.
9. The demolding apparatus of claim 8, wherein the predetermined length is a maximum linear length for the non-trim zone.
10. The demolding apparatus of claim 1, further comprising a trough defined in the mold to accommodate at least a portion of the first inflatable element.
11. The demolding apparatus of claim 10, wherein the trough accommodates the entirety of the first inflatable element.
12. The demolding apparatus of claim 1, further comprising:
 - a first fluid source; and
 - a first fluid line connecting the first fluid source to a first end of the first inflatable element,wherein fluid from the first fluid source inflates the first inflatable member.
13. The demolding apparatus of claim 1, further comprising:
 - a second inflatable member for being positioned between the mold and the composite element, the second inflatable member being disposed at least partially within the non-trim zone.
14. The demolding apparatus of claim 13, wherein the second inflatable element extends from the non-trim zone into the trim zone.
15. The demolding apparatus of claim 14, wherein the second inflatable element comprises a first end that is positioned exterior to the periphery of the composite component, the second inflatable element extending from the first end across the non-trim zone into the trim zone.

16. The demolding apparatus of claim 13, wherein the second inflatable element is positioned parallel to the first inflatable element.
17. The demolding apparatus of claim 13, further comprising:
a second fluid source; and
a second fluid line connecting the second fluid source to the first end of the second inflatable element,
wherein fluid from the second fluid source inflates the second inflatable member.
18. The demolding apparatus of claim 1, wherein the first inflatable element comprises a release material.
19. A method of demolding a composite component from a mold, the composite component defining a periphery, a trim zone interior to the periphery and a non-trim zone interior to the trim zone, the method comprising:
positioning a first inflatable element on the mold;
applying a plurality of layers atop the first inflatable element to create a layer stack;
curing the layer stack to create the composite component; and
inflating the first inflatable element with a fluid in order to assist with demolding the composite component from the mold;
wherein positioning the first inflatable element on the mold comprises positioning at least a portion of the first inflatable element within the non-trim zone.
20. The method of claim 19, wherein the positioning the first inflatable element on the mold comprises positioning a first end of the inflatable element exterior to the periphery of the composite component at a first side of the composite component, such that the first inflatable element extends from exterior to the periphery of the composite component, across the trim zone, into the non-trim zone.

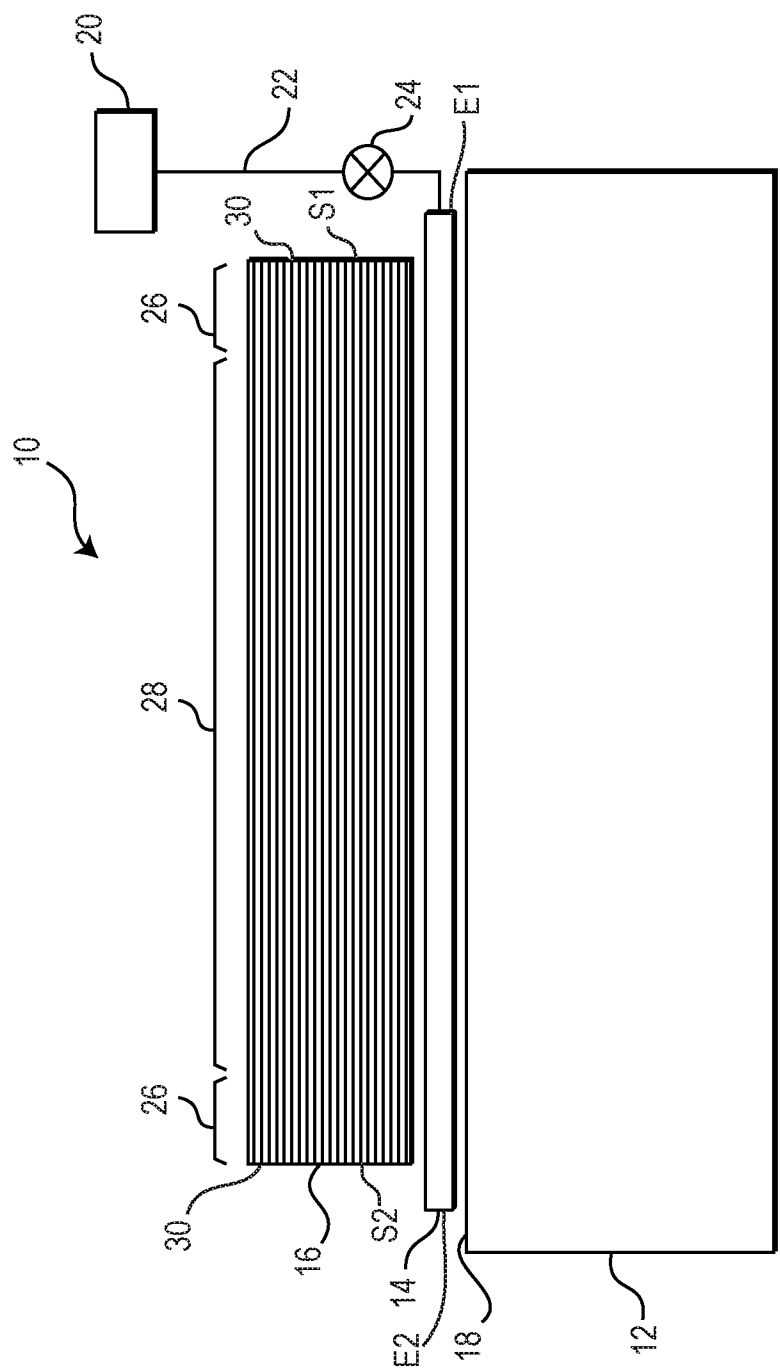


FIG. 1

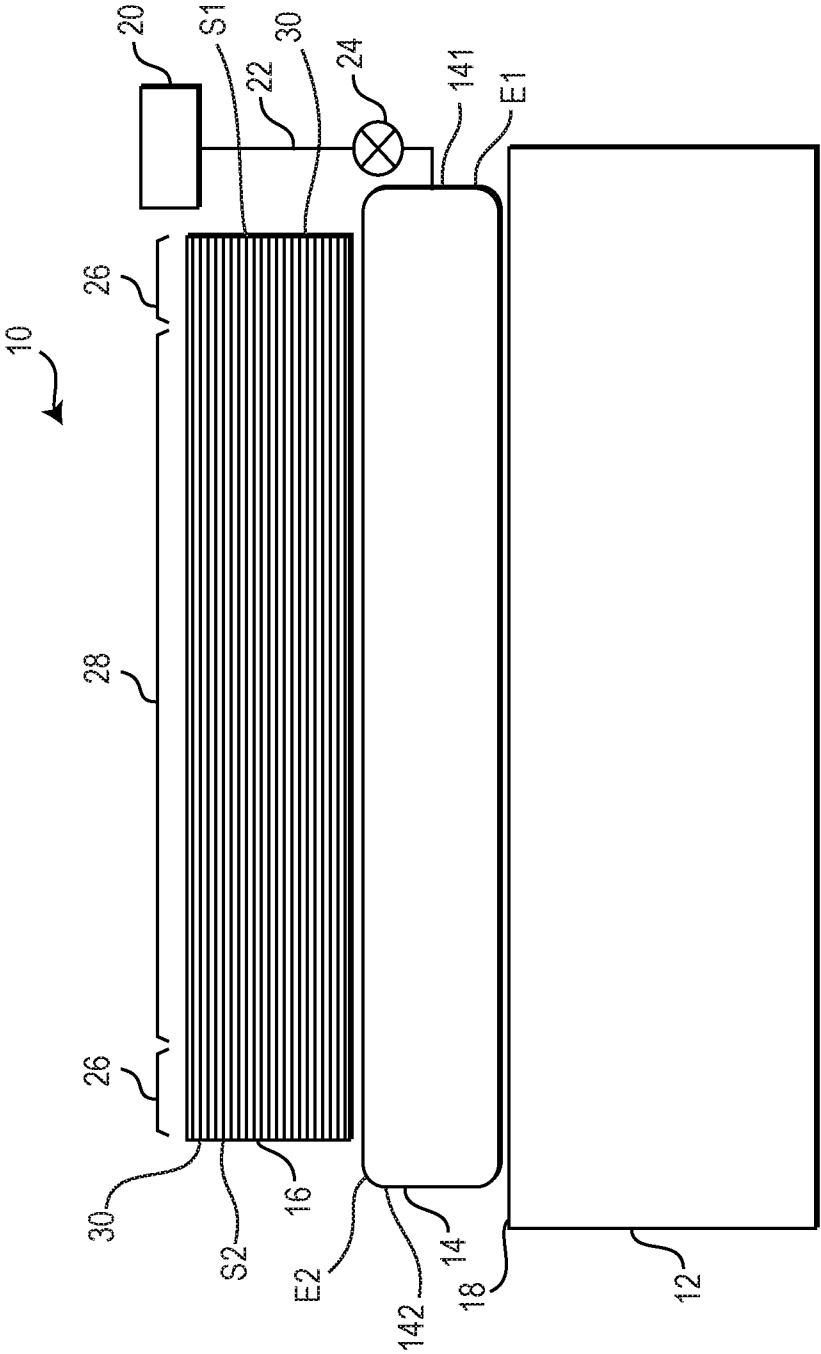


FIG. 2

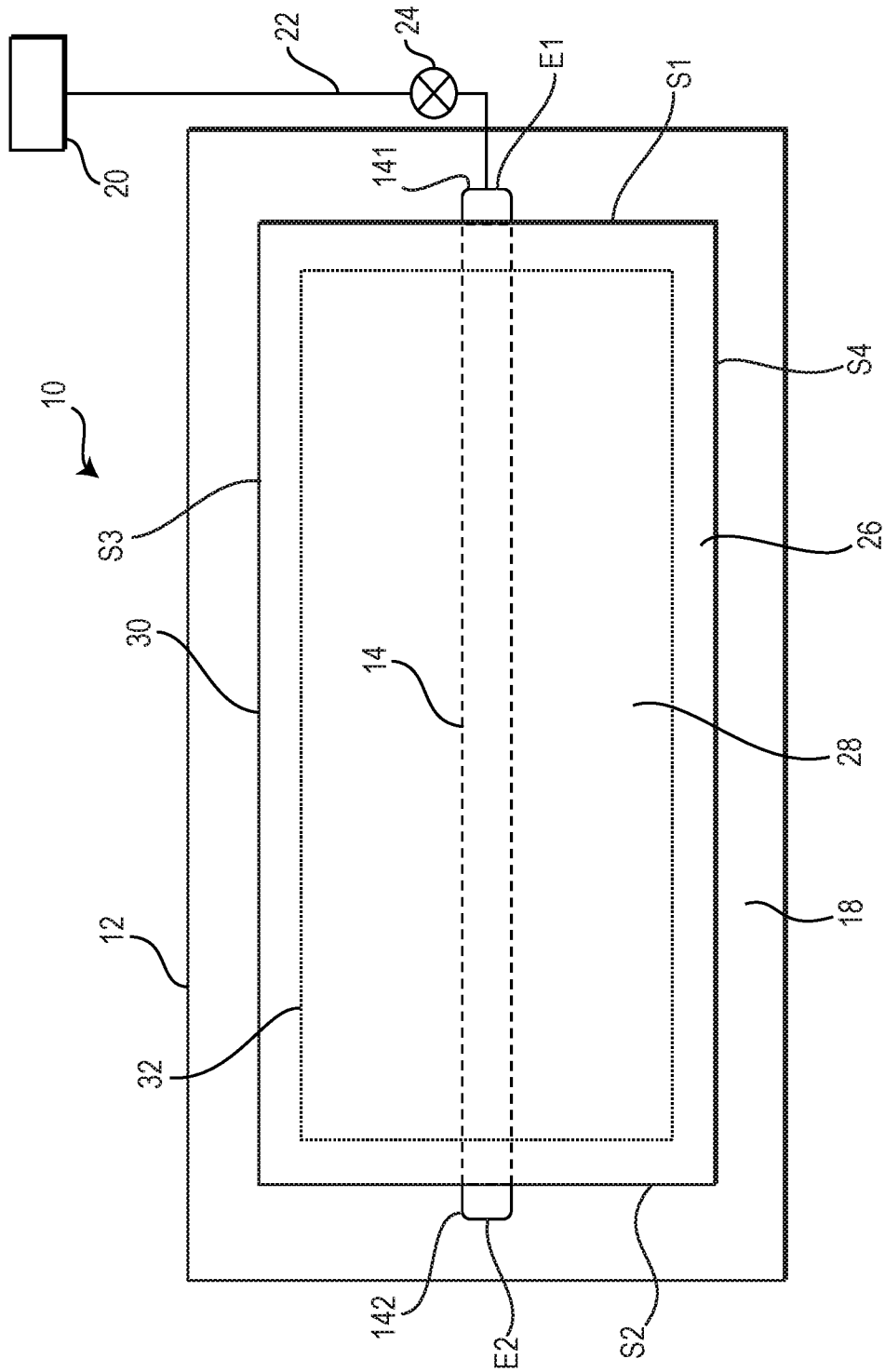
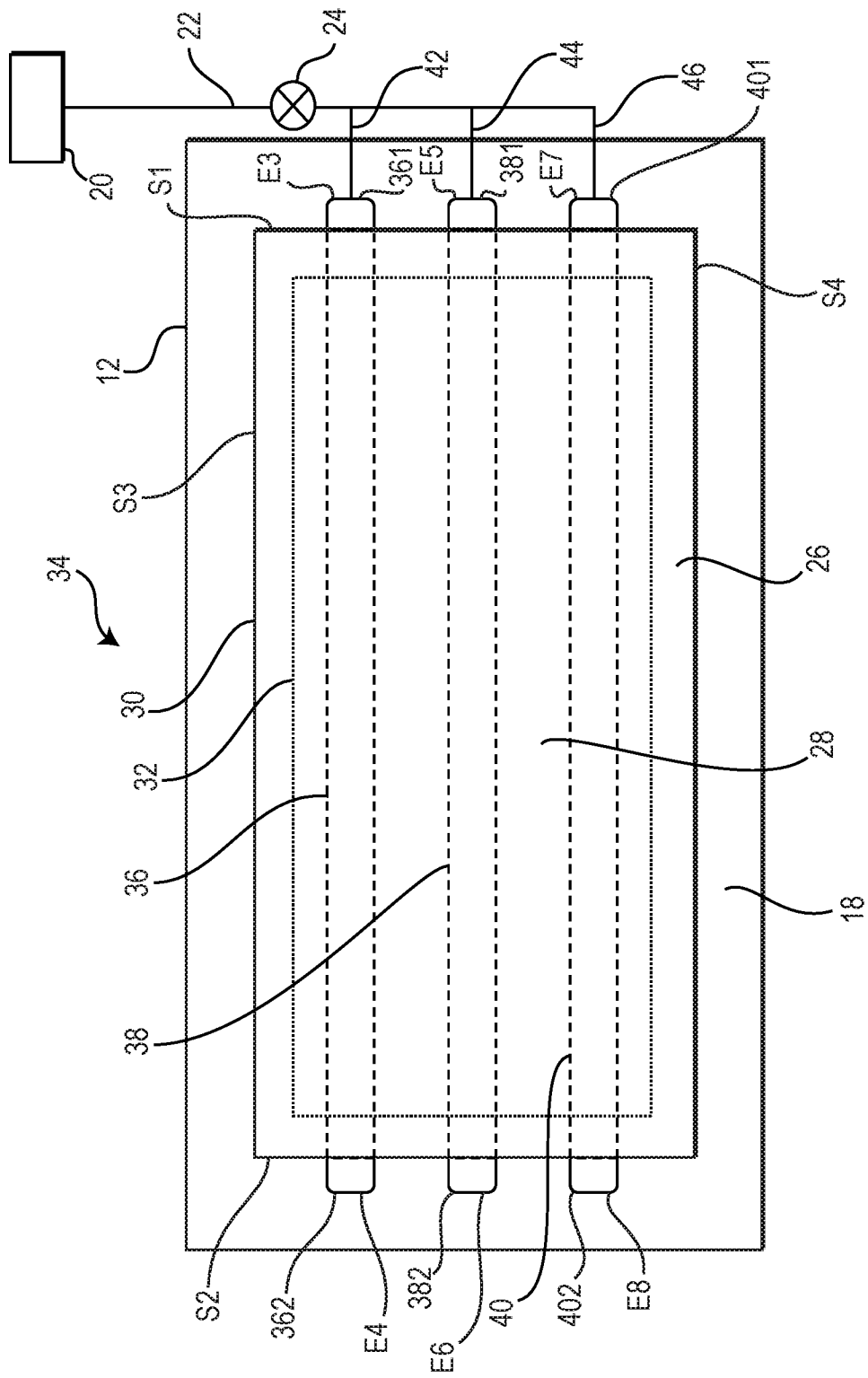


FIG. 3

**FIG. 4**

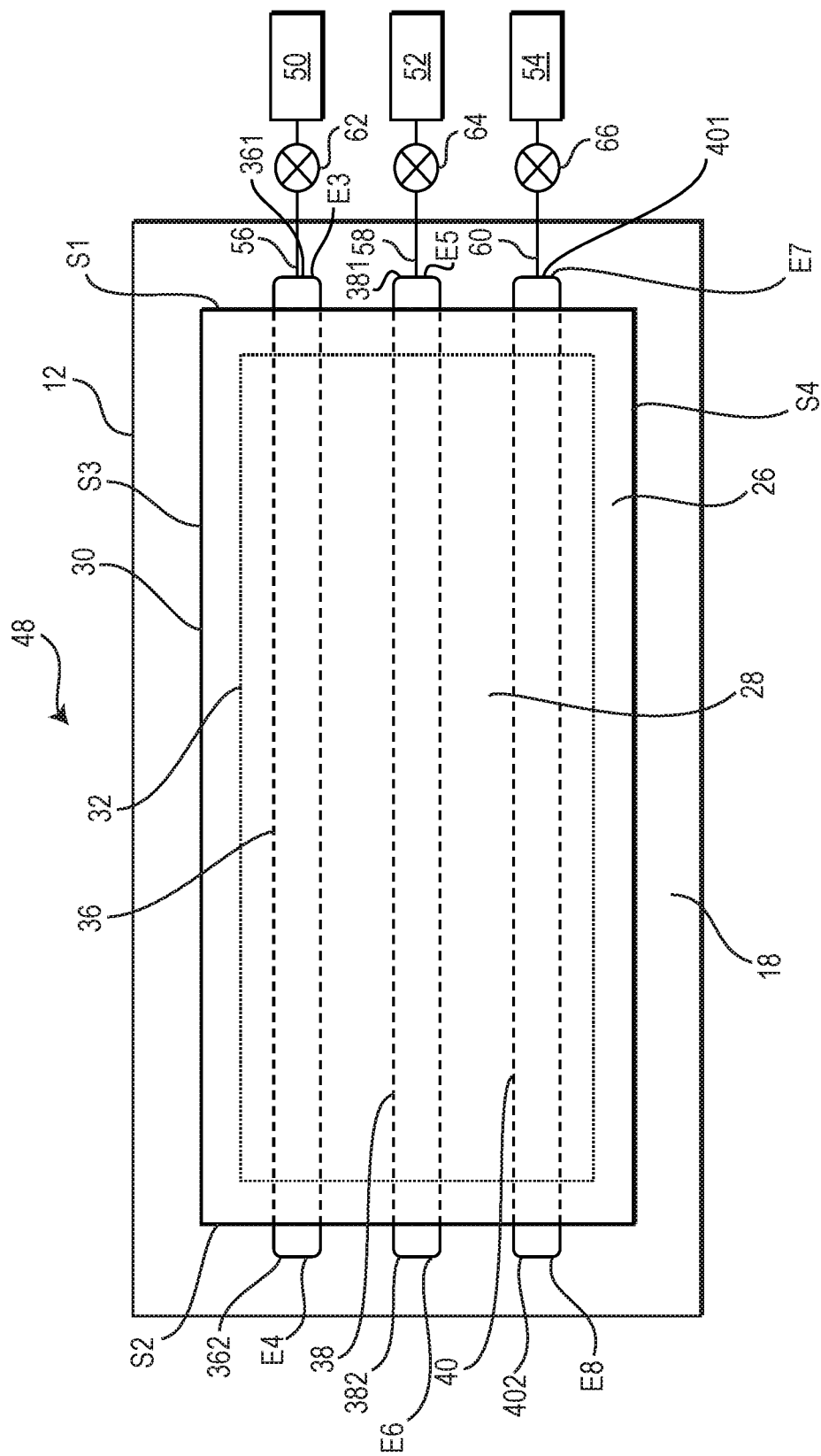
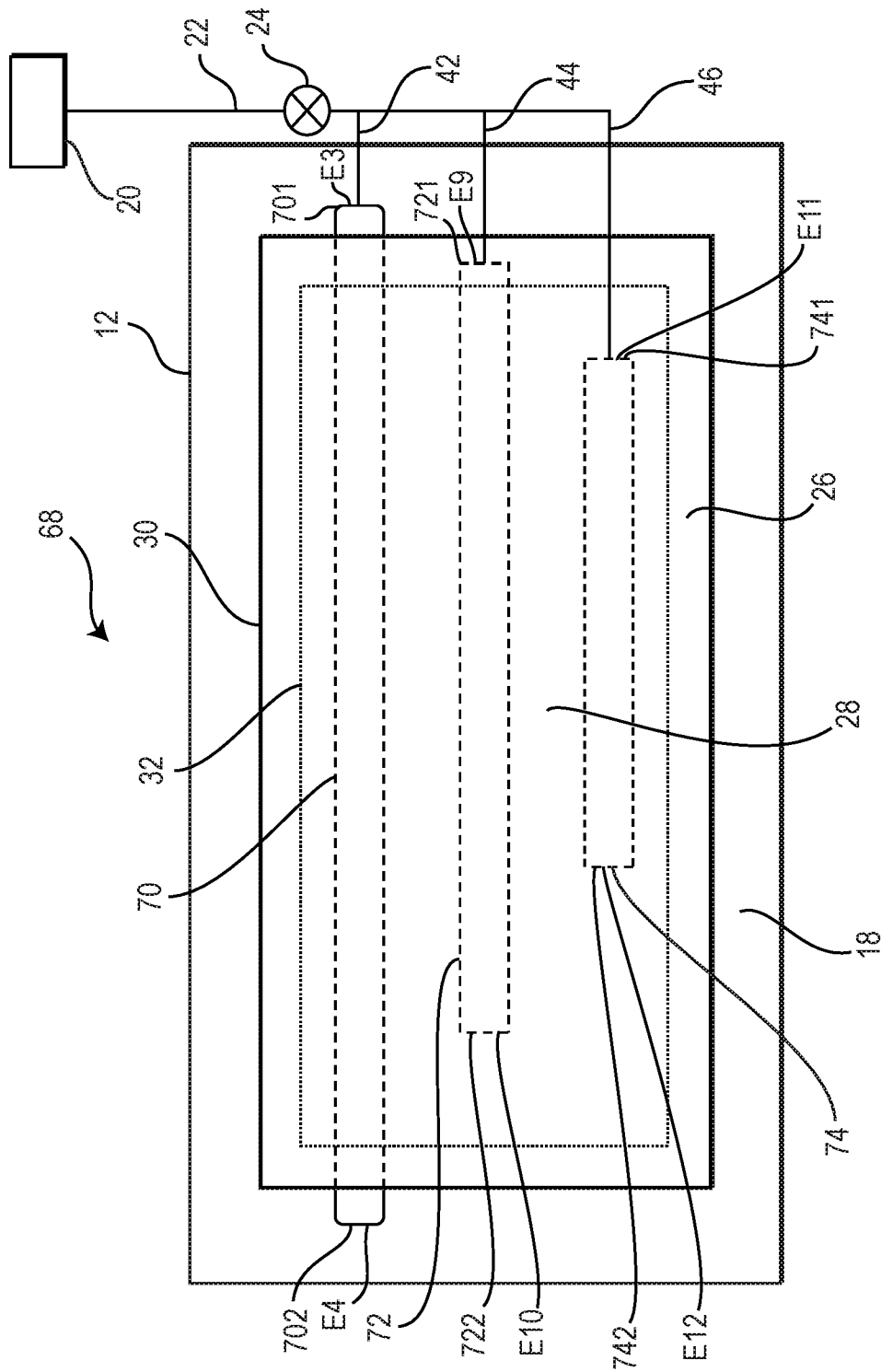


FIG. 5

**FIG. 6**

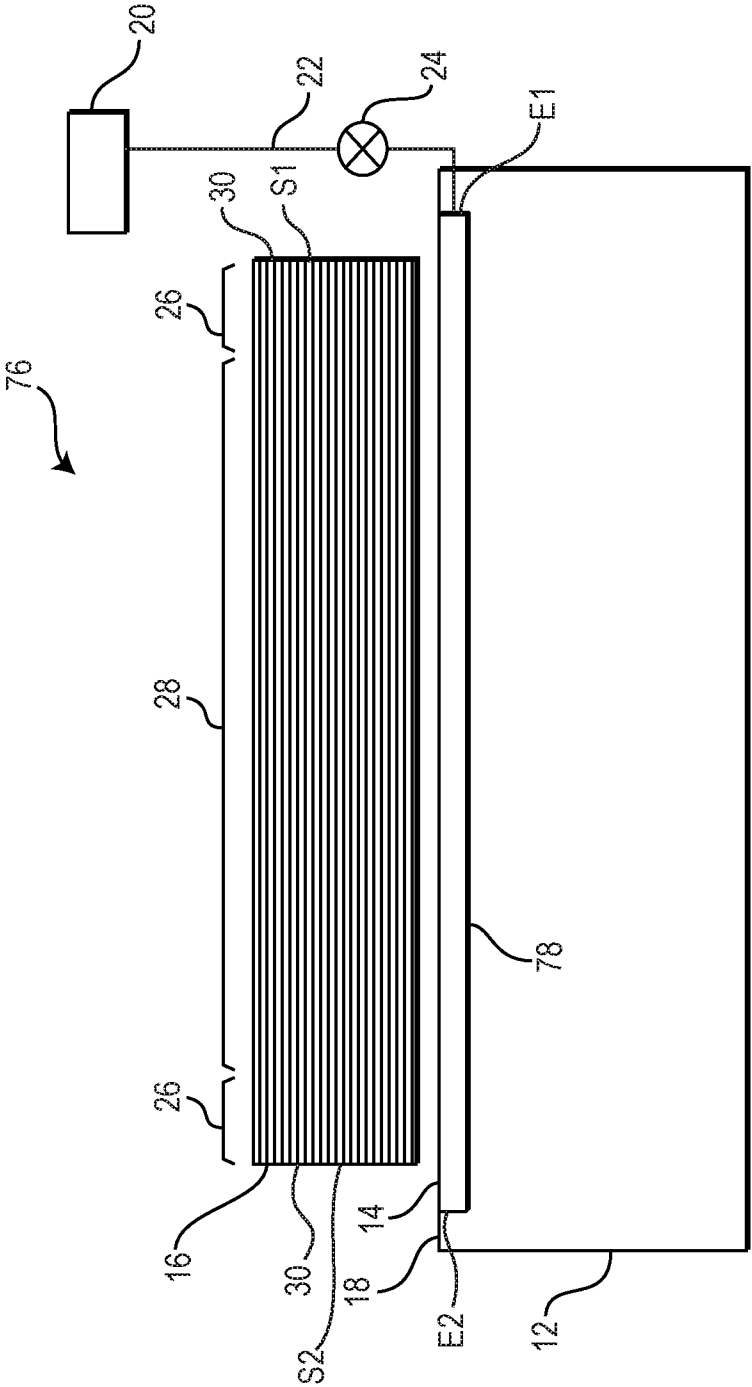


FIG. 7

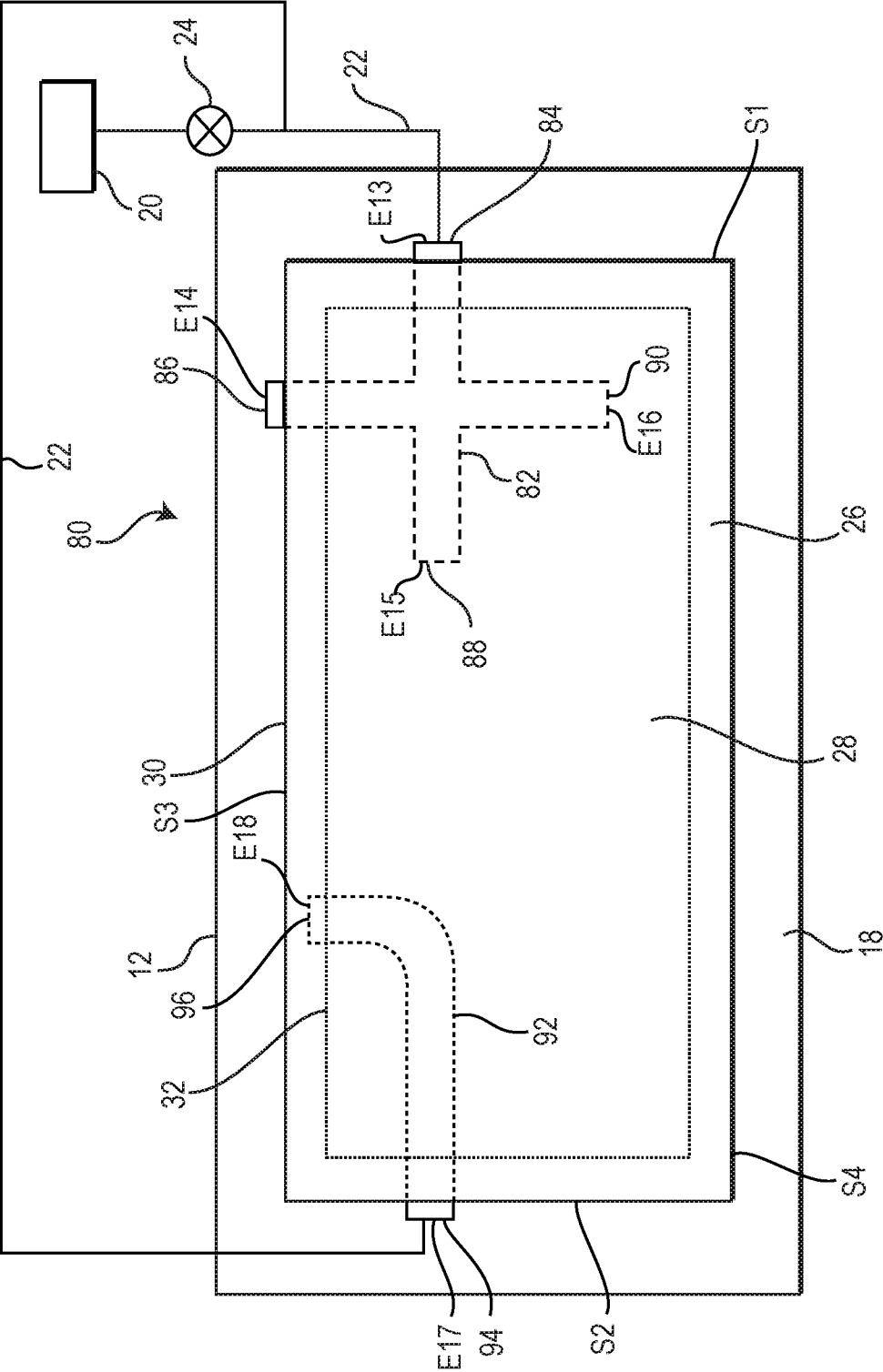


FIG. 8

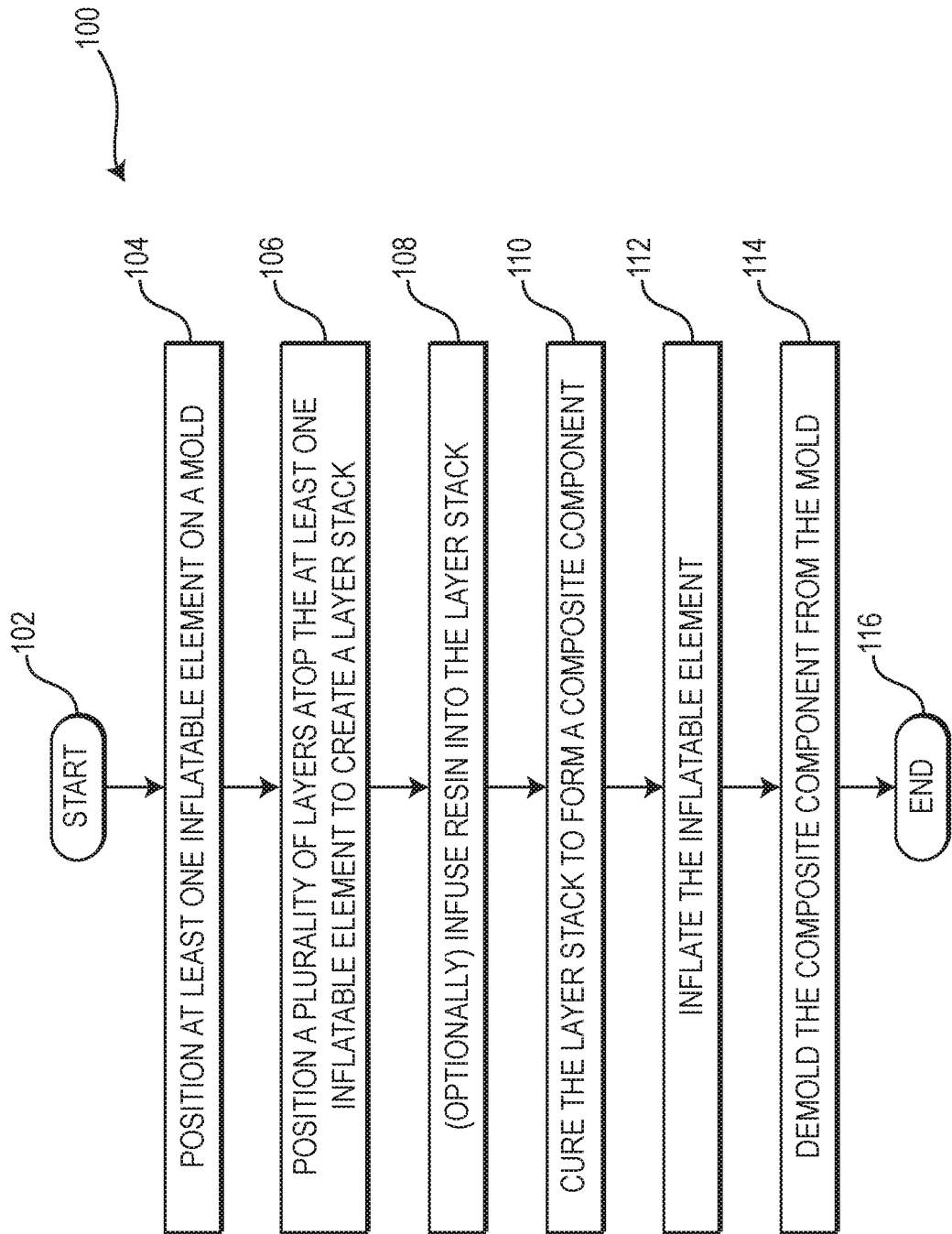


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/025344

A. CLASSIFICATION OF SUBJECT MATTER
INV. B29C70/54 B29C33/46
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)
B29C

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, WPI Data

C. 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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X	US 2007/216064 A1 (LOGAN BENJAMIN [US]) 20 September 2007 (2007-09-20) claims 1,6,14,15,17,18; figure 11 -----	1-20
A	GB 449 301 A (KURT BRATRING) 24 June 1936 (1936-06-24) figures 1-4 -----	1
X	US 5 728 333 A (TABATA KEIICHIRO [JP] ET AL) 17 March 1998 (1998-03-17) figures 1A-1C -----	1



Further documents are listed in the continuation of Box C.



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Date of the actual completion of the international search

4 July 2017

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18/07/2017

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2017/025344

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