



(12) **United States Patent**
Foster et al.

(10) **Patent No.:** **US 10,344,490 B1**
(45) **Date of Patent:** **Jul. 9, 2019**

(54) **CONCAVE SWIMMING POOL PANEL**

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(71) Applicant: **Trojan Leisure Products, LLC**,
Albany, NY (US)

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(72) Inventors: **Charles M. Foster**, Schenectady, NY
(US); **David A. Steele**, Gansevoort, NY
(US); **Collin J. Sirco**, Ballston Lake,
NY (US)

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(73) Assignee: **Trojan Leisure Products, LLC**,
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(21) Appl. No.: **14/629,129**

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(22) Filed: **Feb. 23, 2015**

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Related U.S. Application Data

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(63) Continuation of application No. 14/165,264, filed on
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(60) Provisional application No. 61/756,722, filed on Jan.
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(51) **Int. Cl.**
E04H 4/00 (2006.01)

Primary Examiner — William V Gilbert

(52) **U.S. Cl.**
CPC **E04H 4/0043** (2013.01); **E04H 4/005**
(2013.01)

(74) *Attorney, Agent, or Firm* — Tech Valley Patent,
LLC; John Pietrangelo

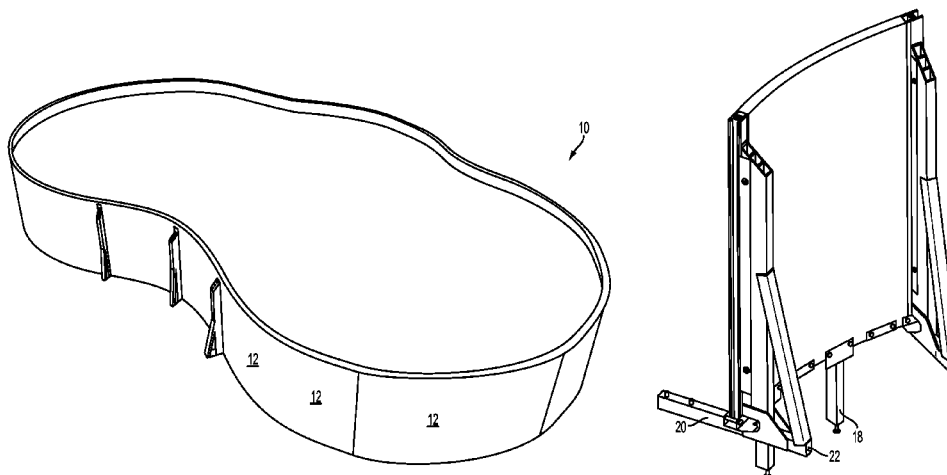
(58) **Field of Classification Search**
CPC E02D 29/0225; E02D 29/0233; E04H
4/0018; E04H 4/0031; E04H 4/0037;
E04H 4/0043; E04H 4/005; E04G 21/26;
E04G 25/00; E04G 25/02; E04G 23/04
USPC 52/127.2, 167.7, 169.8, 169.7; 4/506,
4/513

(57) **ABSTRACT**

A swimming pool consisting of a plurality of panels that
withstands water pressure in both a concave and convex
configuration to create any freeform shape or size. Each
panel consists of an adhered wall of skinning of metal or
plastic over expanded polystyrene or expanded urethane
foam. The density of the foam is adjusted as necessary to
increase the strength of the wall based on static loading of
water when swimming pool is assembled as a whole and
fully filled with water.

See application file for complete search history.

18 Claims, 15 Drawing Sheets



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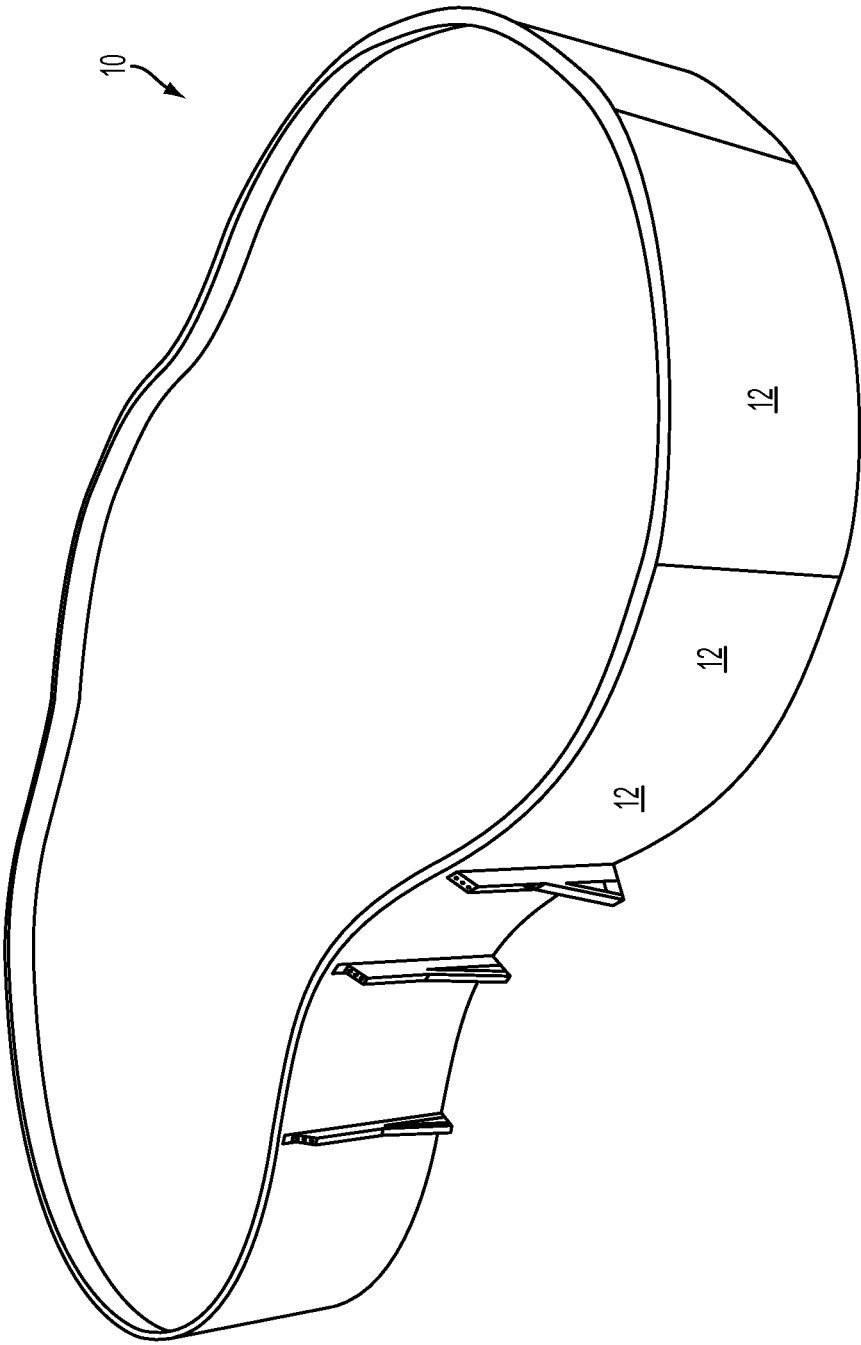


FIG. 1

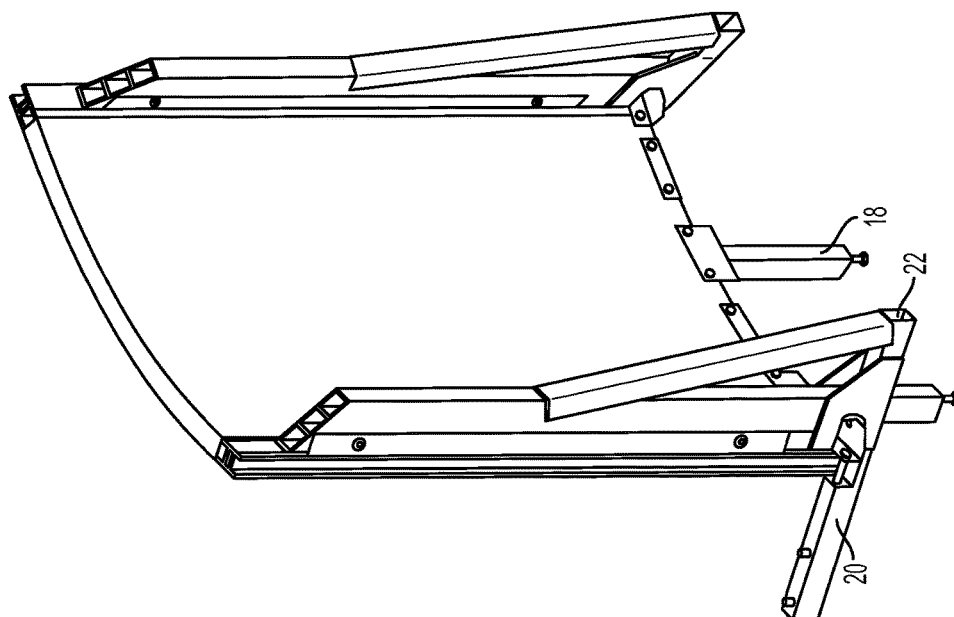


FIG. 3

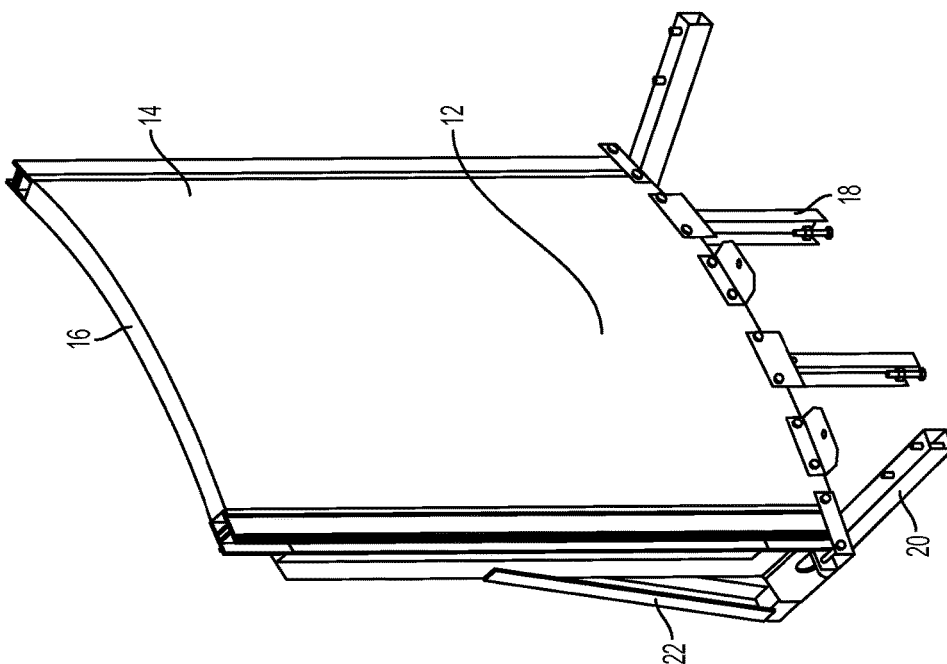


FIG. 2

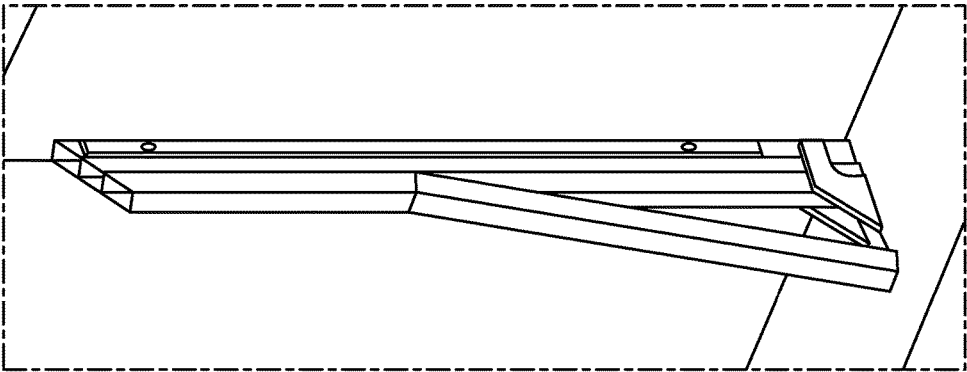


FIG. 4B

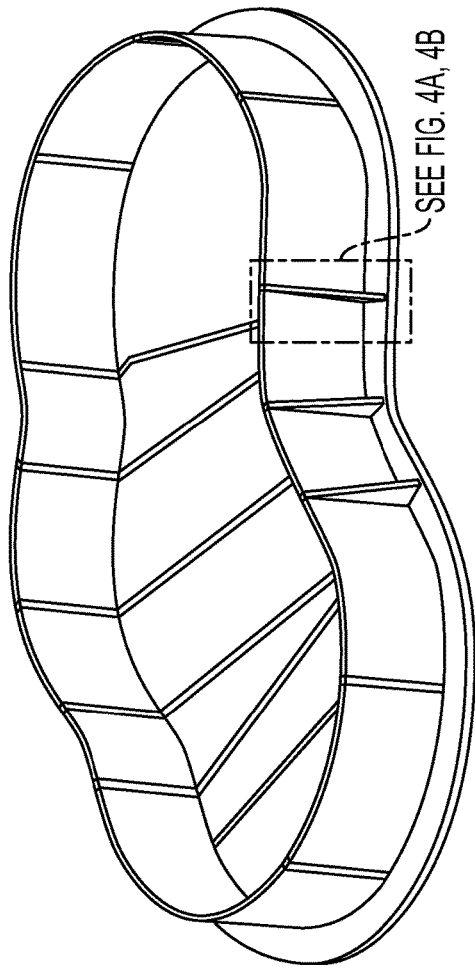


FIG. 4A

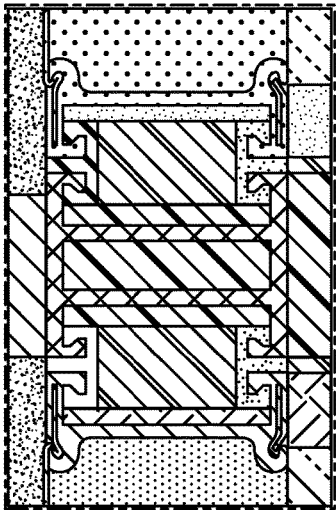


FIG. 4C

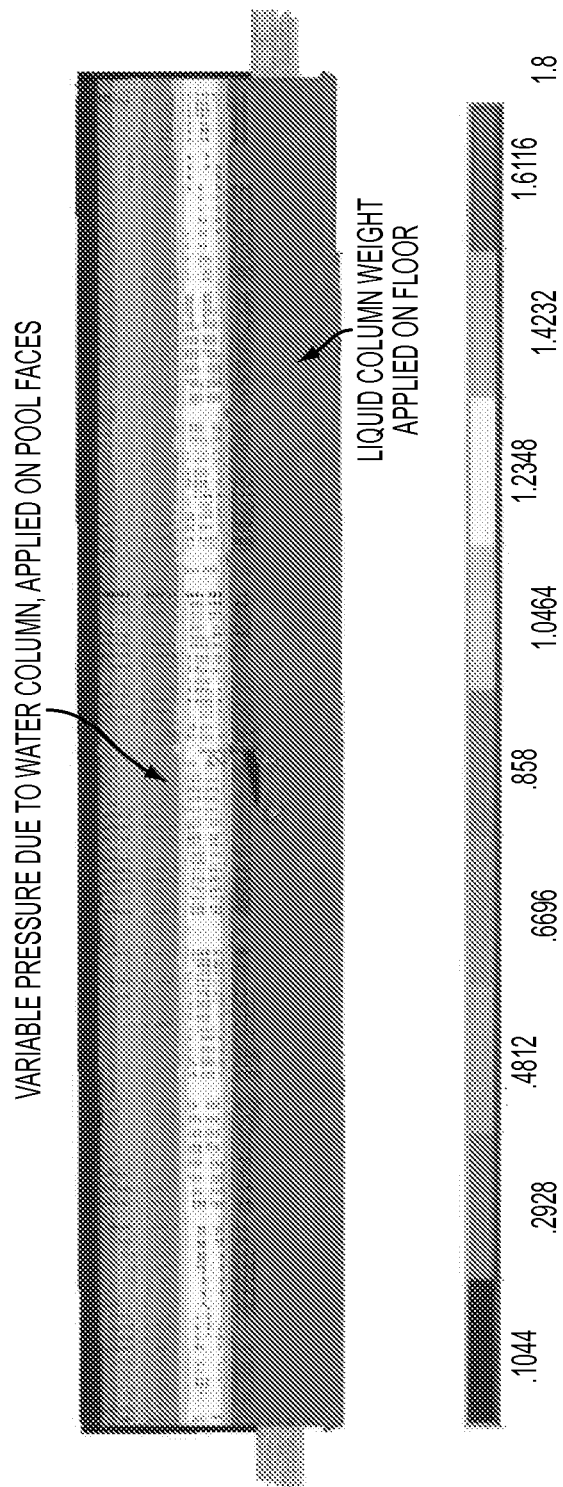


FIG. 5

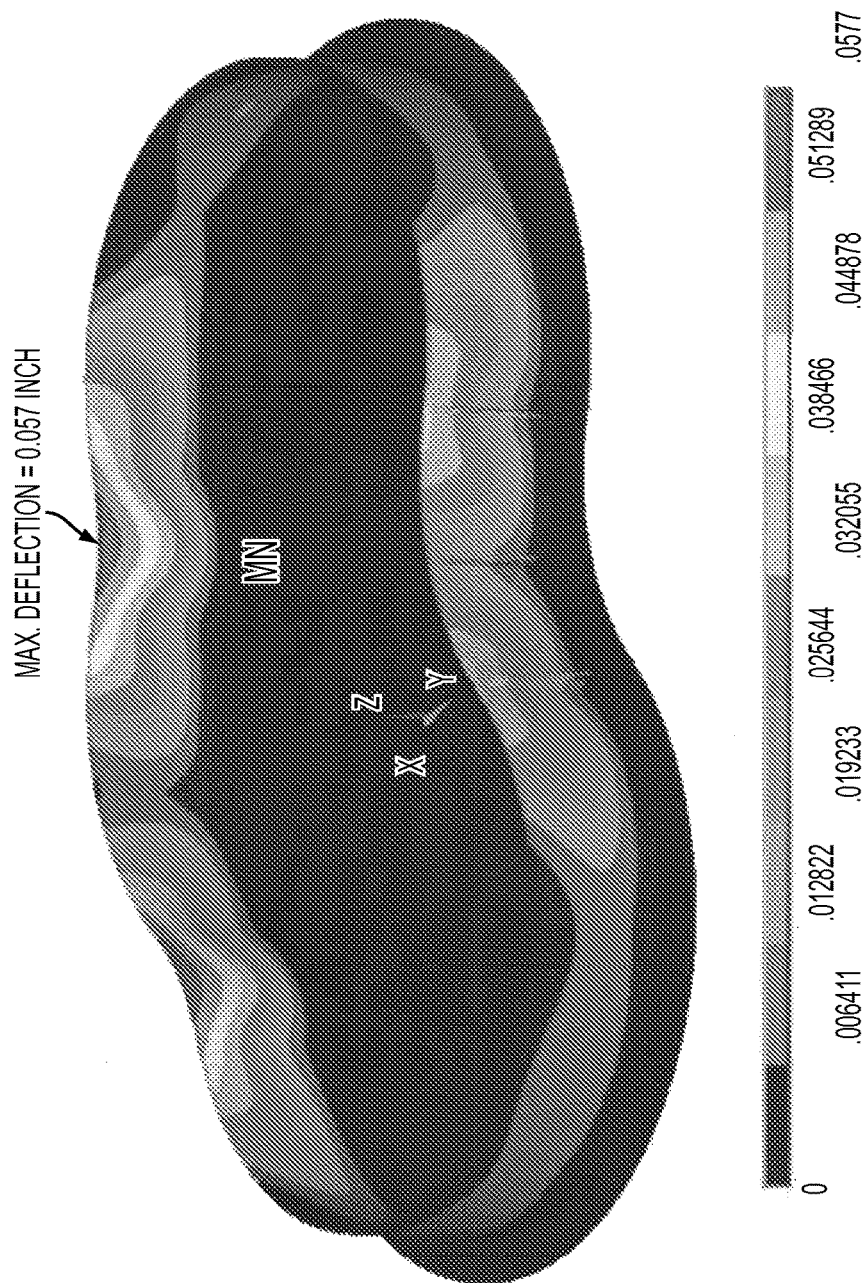


FIG. 6

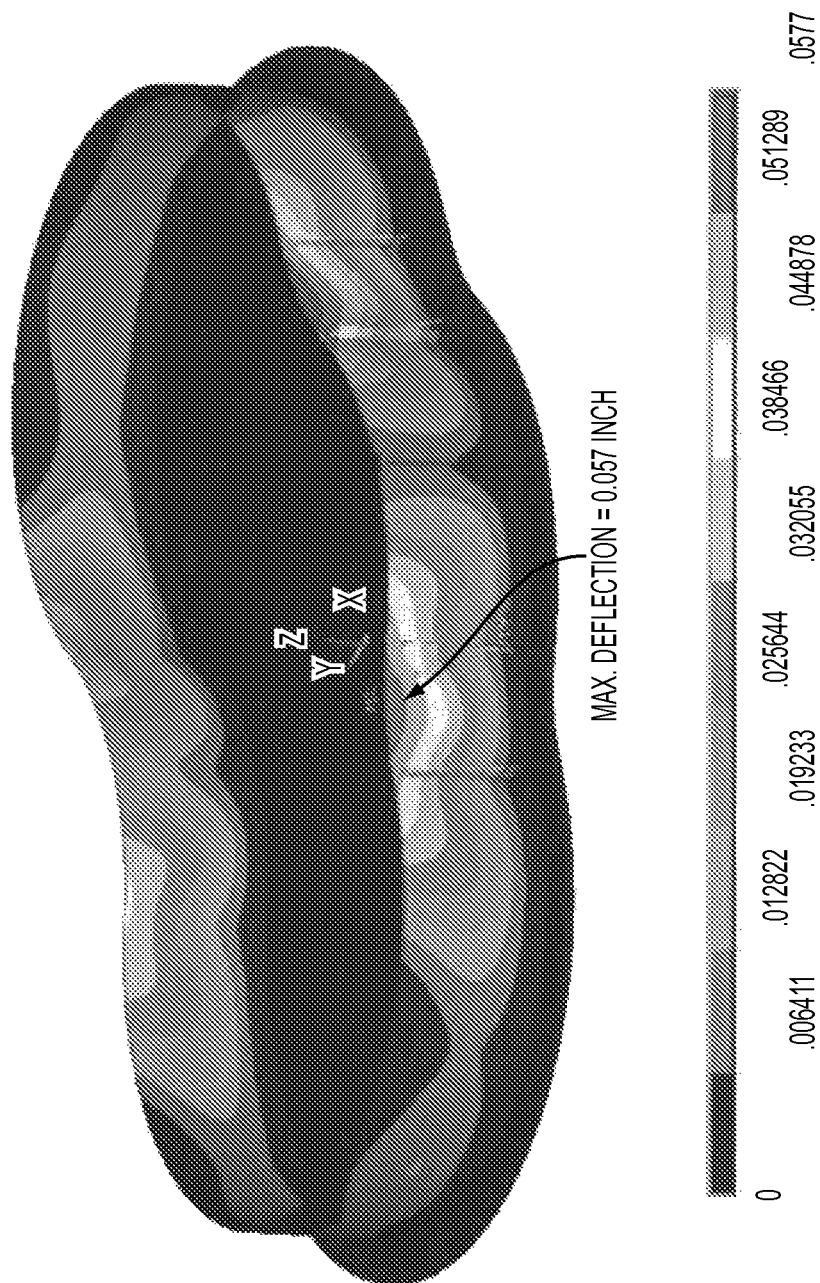


FIG. 7

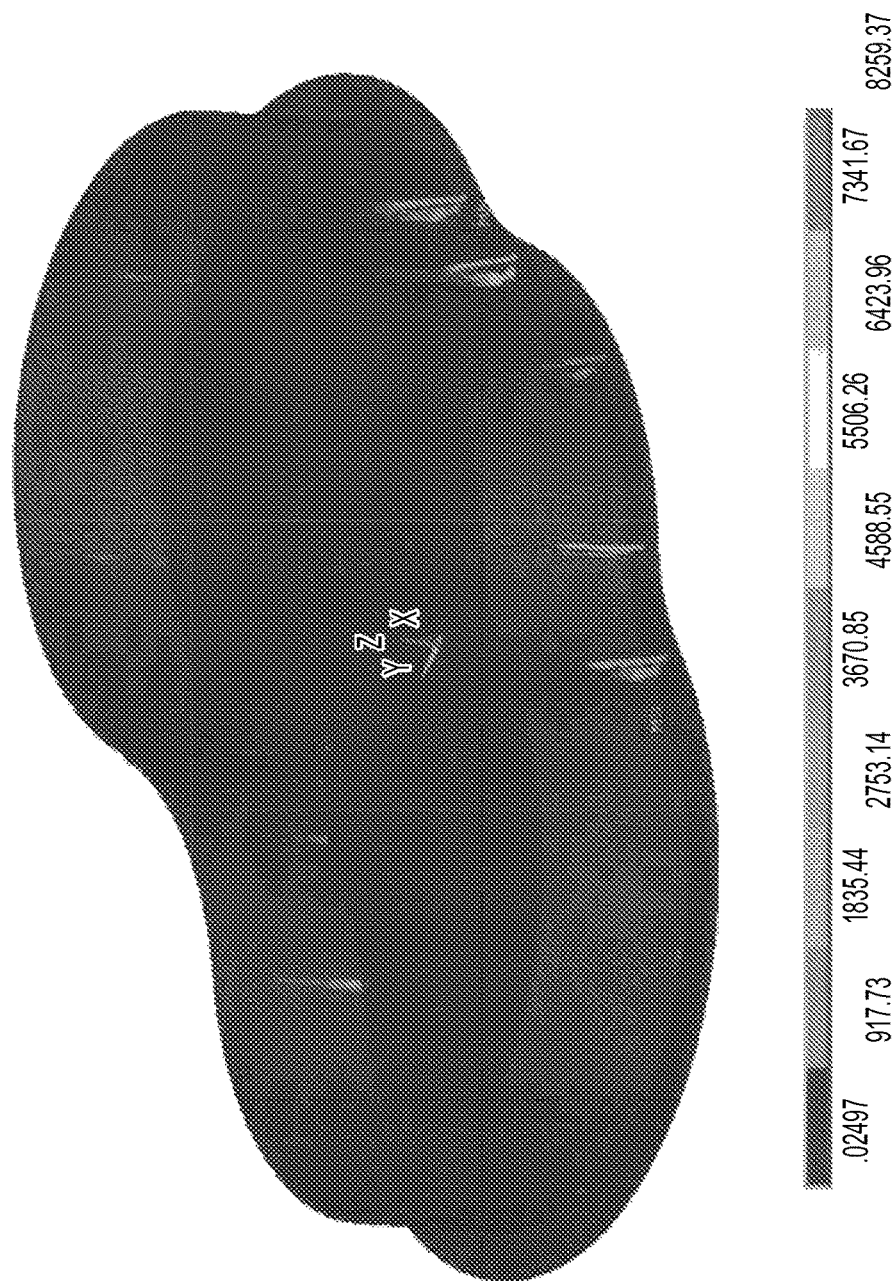


FIG. 8

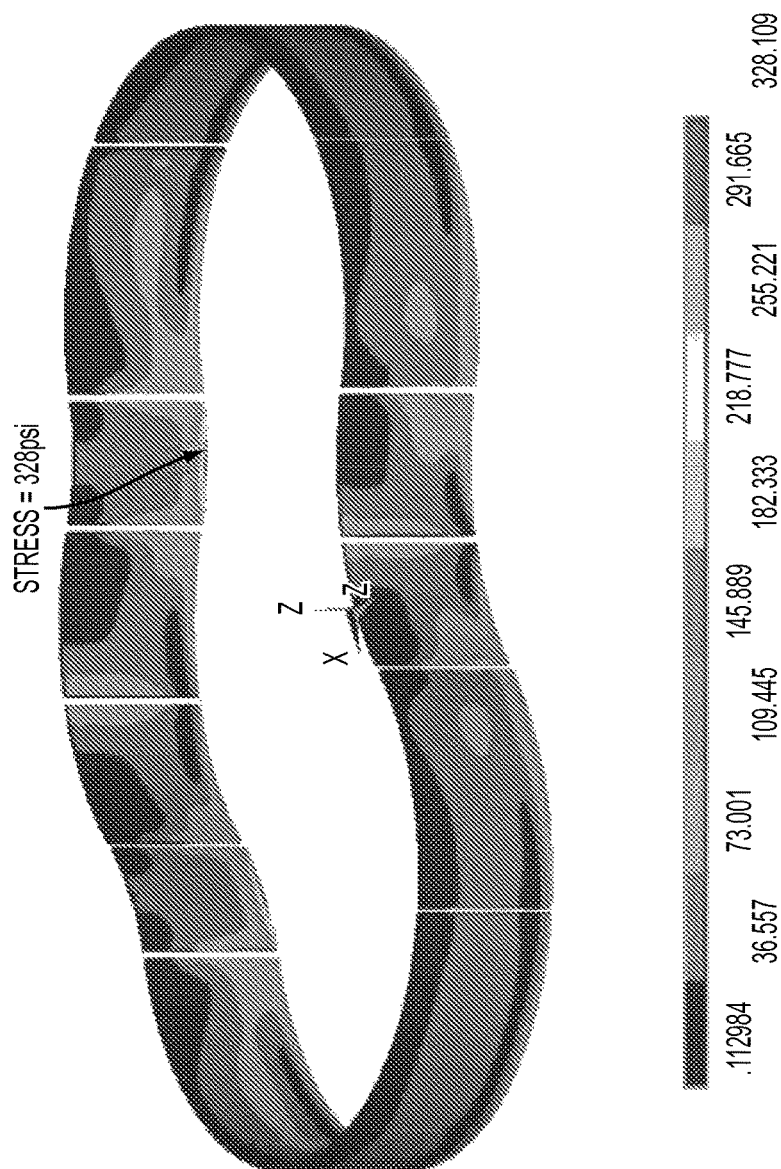


FIG. 9

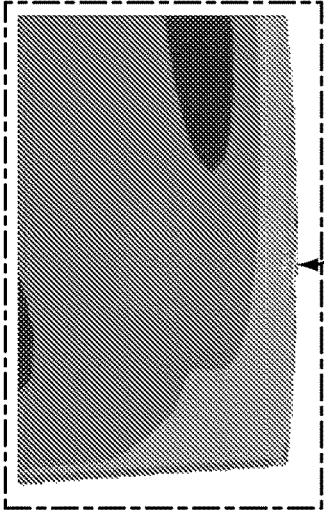
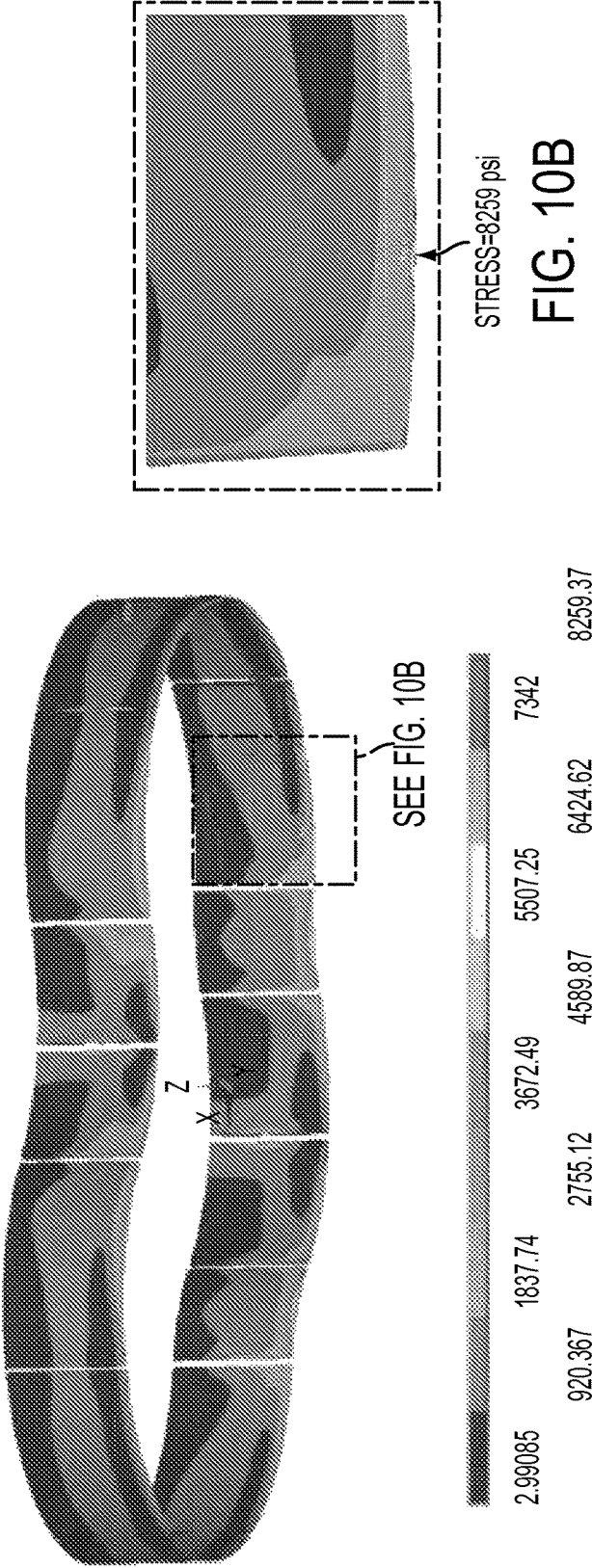


FIG. 10A

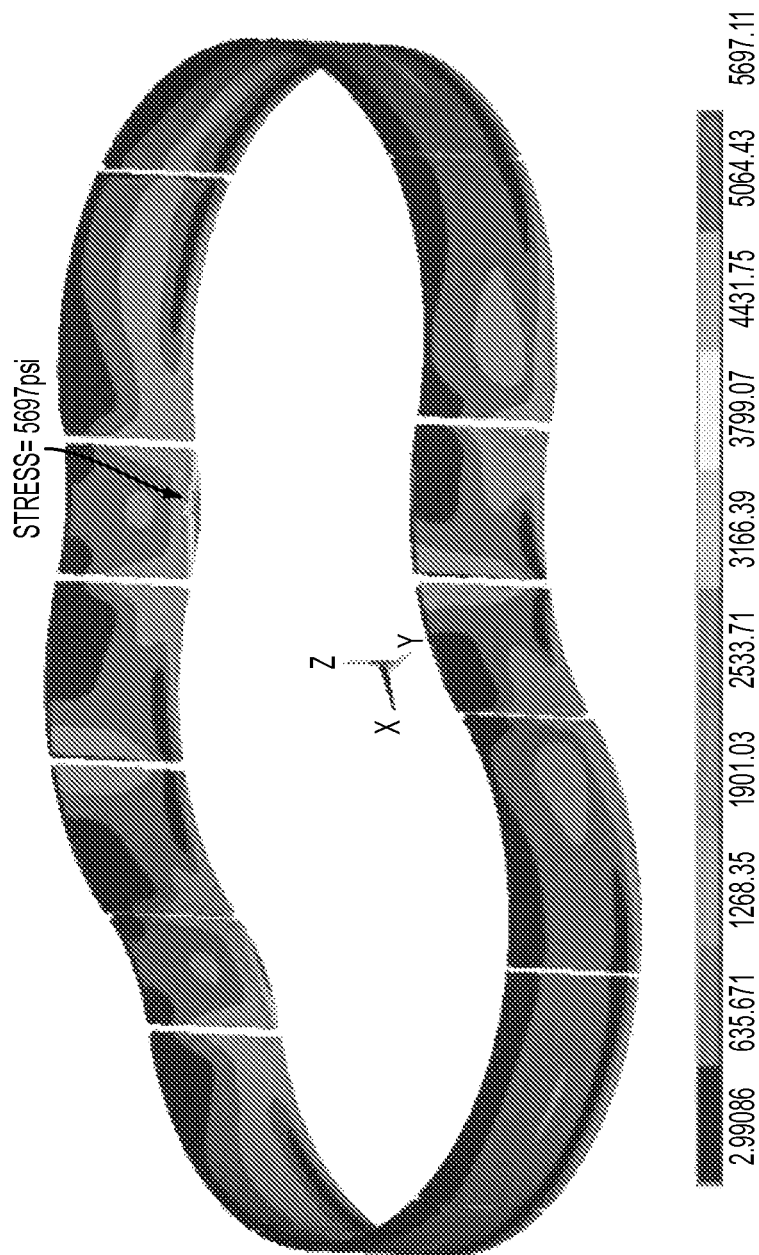


FIG. 11

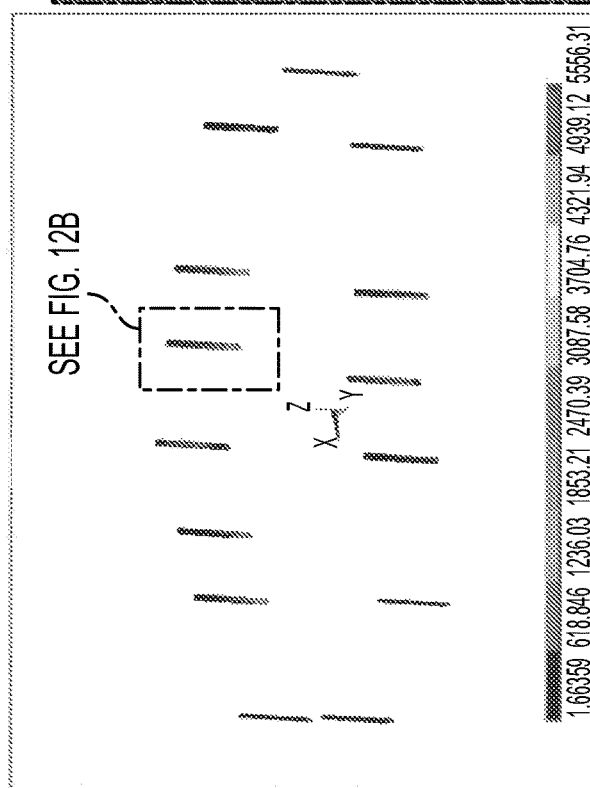


FIG. 12A

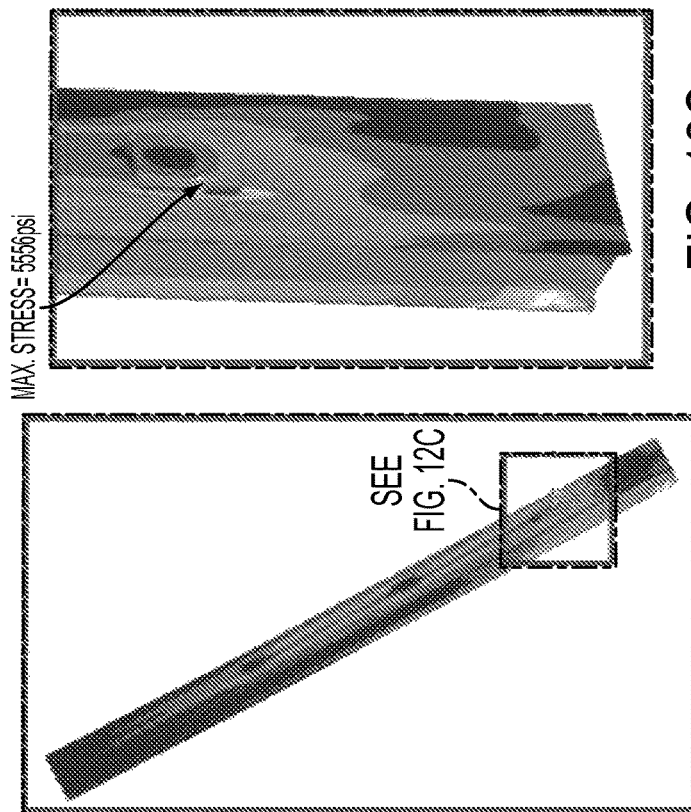


FIG. 12B

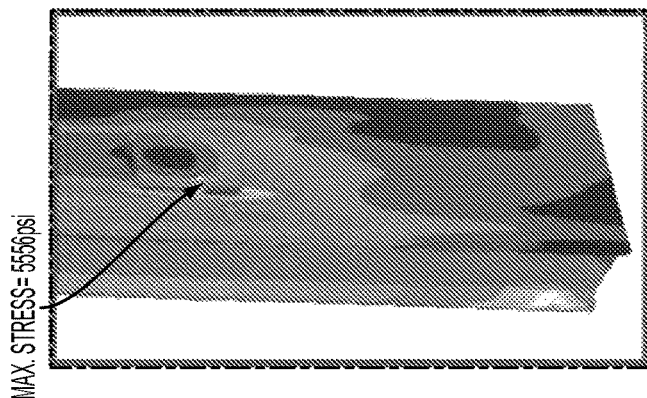
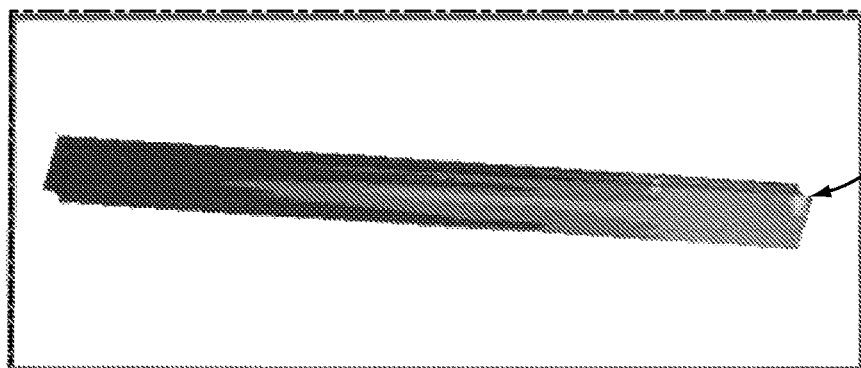


FIG. 12C



STRESS= 4509psi

FIG. 13B

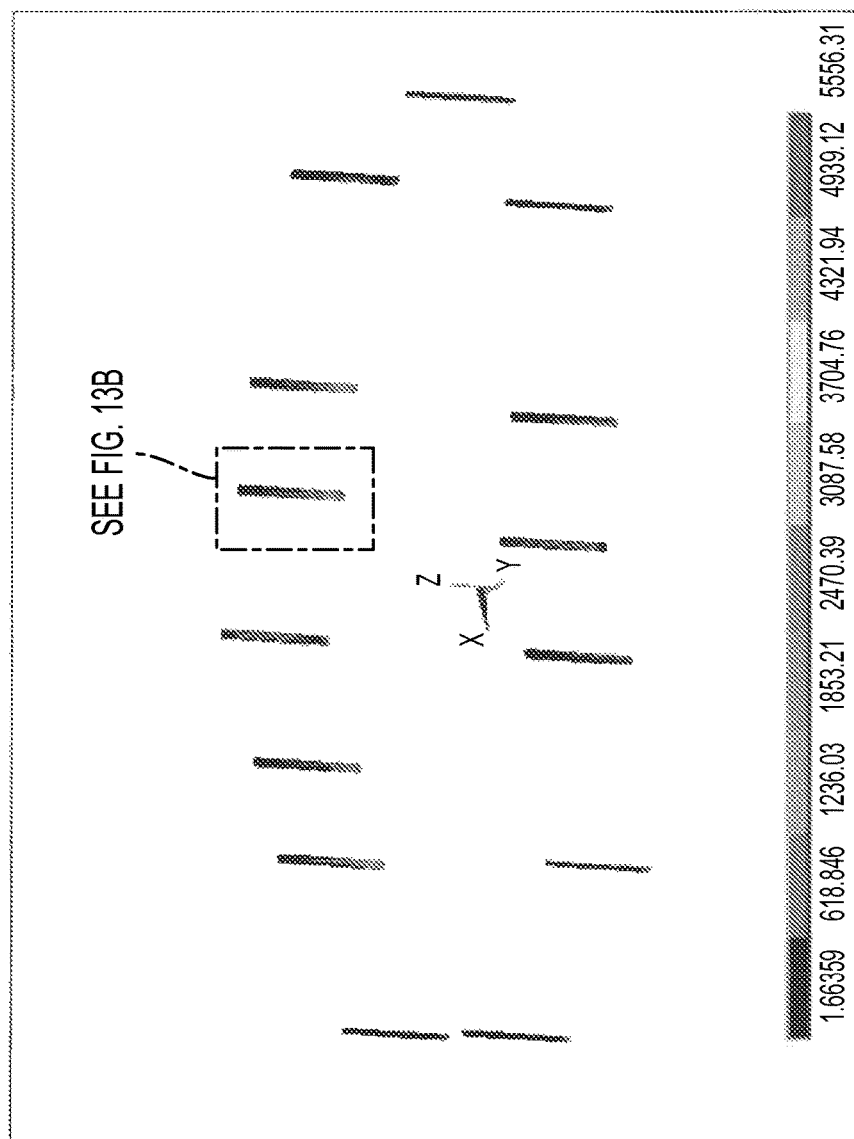


FIG. 13A

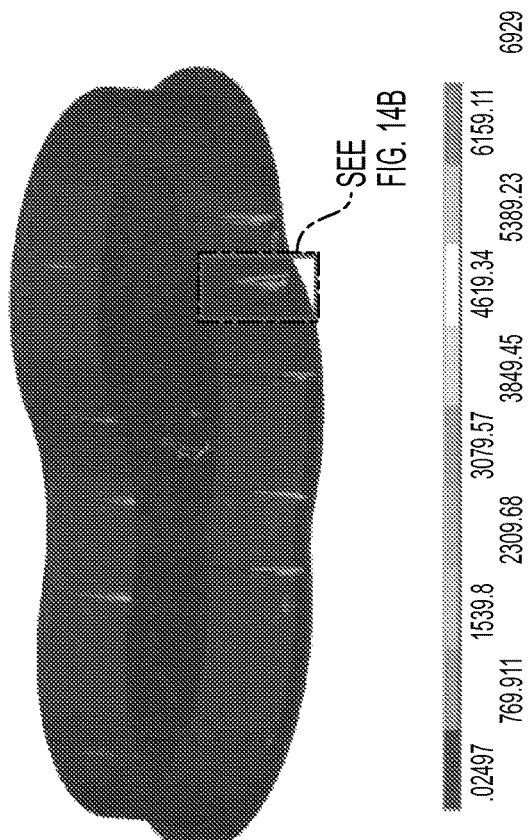


FIG. 14A

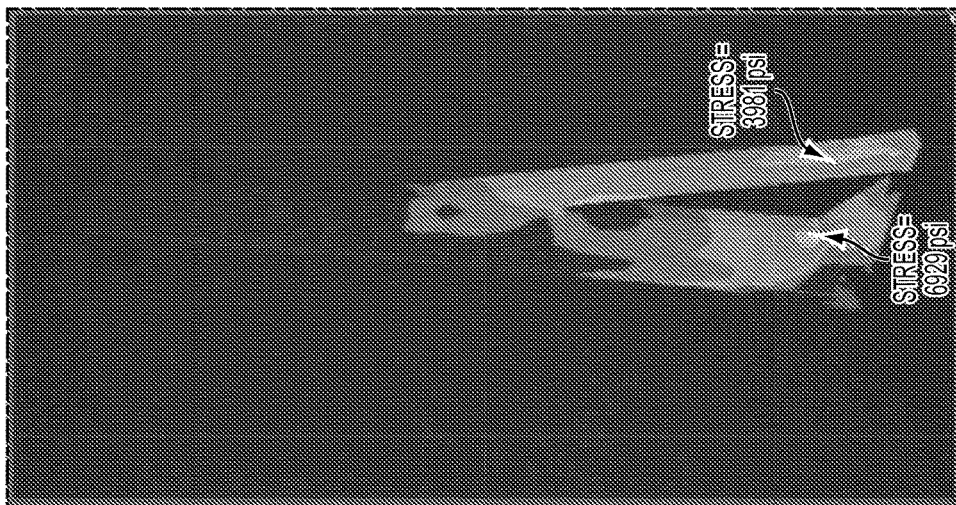


FIG. 14B

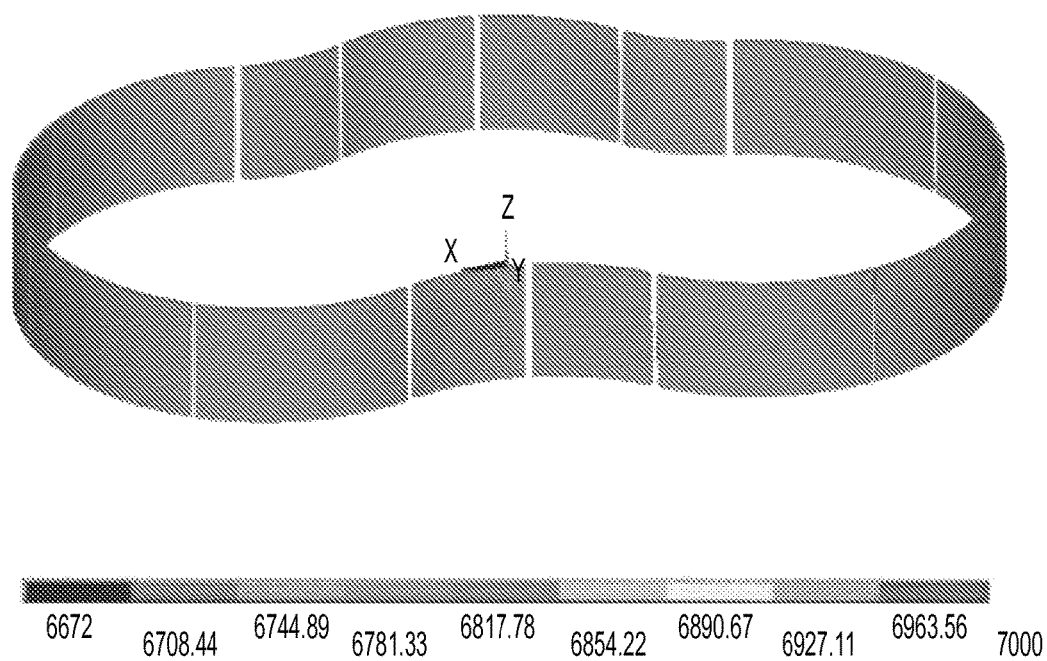


FIG. 15

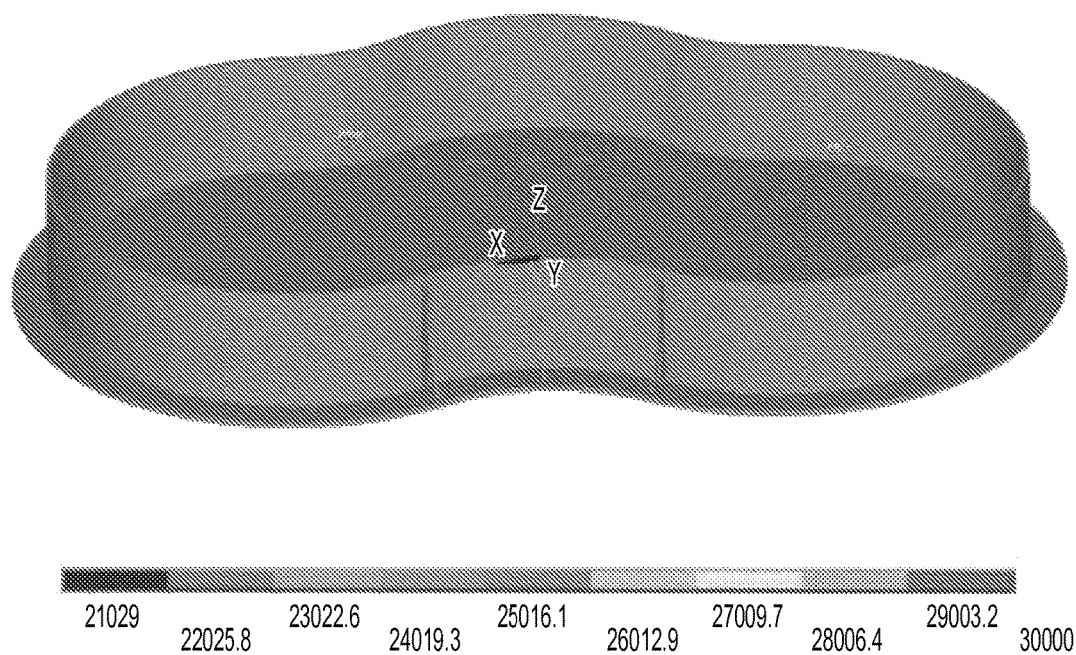


FIG. 16

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CONCAVE SWIMMING POOL PANEL**CROSS-REFERENCE TO RELATED APPLICATIONS**

The present application is a continuation application of pending U.S. application Ser. No. 14/165,264, filed on Jan. 27, 2014, which relates to and claims priority to U.S. Provisional Application Ser. No. 61/756,722, filed Jan. 25, 2013, the disclosures of which are incorporated by reference herein in their entirety.

BACKGROUND OF THE INVENTION

The present invention relates to swimming pools, and more particularly free form swimming pools.

Free form swimming pools require particular structural detail to account for the stress imparted to the curved walls when the pool is filled with water. Without appropriate bracing, convex walls will shift, buckle, and ultimately fail due to the distribution of the static loading.

SUMMARY OF THE INVENTION

A swimming pool consisting of a plurality of panels that withstands water pressure in both a concave and convex configuration to create any freeform shape or size. Each panel consists of an adhered wall of skinning of metal or plastic over expanded polystyrene or expanded urethane foam. The density of the foam is adjusted as necessary to increase the strength of the wall based on static loading of water when swimming pool is assembled as a whole and fully filled with water. Panels with water pressure in the convex direction have adjusters attached at the bottom to allow for vertical movement during installation and horizontal tabs (anchor plate) locking into a concrete foundation as the pool is assembled. The swimming pool can be installed fully above ground, semi-in-ground or fully in-ground.

According to one aspect, an embodiment of the present invention comprises a section of a swimming pool wall comprising: a panel, having a first and a second surface a top and a bottom and at least one anchor extending radially outward from at least one surface of the panel, and dimensioned to, when in use, lock the panel into a concrete foundation.

According to another aspect, a section comprising at least one adjuster extending downward from the bottom of the panel, adapted to permit vertical movement during the panel's installation.

According to another aspect a section comprising at least one a-frame support attached to the panel.

According to another aspect, the A-frame support comprises a post, having a top and a bottom, attached to and extending along the second surface of the panel; a cross-member, extending radially outward from second surface of the panel and attached to the bottom of the post, wherein the crossmember locks into the concrete foundation when in use; a leg, having a first end a second end, wherein the first end is attached to the post and the second end is attached to the crossmember.

According to another aspect, the anchor is a tab.

According to another aspect, the anchor is a plate.

According to another aspect, the panel comprises a skinning over a foam interior.

According to another aspect, the panel is bowed.

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According to another aspect, the curve of the panel is bowed outward, relative to the interior of the pool when in use.

According to another aspect, the anchor extends radially outward from the bottom of the panel.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view/photograph of a swimming pool including a plurality of panels in accordance with an embodiment of the present invention.

FIG. 2 is a rear perspective view of a pool panel of the pool assembly of FIG. 1 in accordance with an embodiment of the present invention.

FIG. 3 is a front perspective of a pool panel of the pool assembly of FIG. 1 in accordance with an embodiment of the present invention.

FIG. 4A is a diagram/perspective view of a pool assembly including a plurality of panels in accordance with an embodiment of the present invention.

FIG. 4B is a diagram/perspective view of A-frame supports of the pool assembly of FIG. 4A in accordance with an embodiment of the present invention.

FIG. 4C is a diagram/illustration of a panel joint of the pool assembly of FIG. 4A in accordance with an embodiment of the present invention.

FIG. 5 is a diagram/illustration of loads and boundary conditions of a pool assembly in accordance with an embodiment of the present invention.

FIG. 6 is a deflection plot illustration of a pool assembly from a front perspective view in accordance with an embodiment of the present invention.

FIG. 7 is a deflection plot illustration of a pool assembly from a rear perspective view in accordance with an embodiment of the present invention.

FIG. 8 is a von Mises stress plot illustration of a pool assembly in accordance with an embodiment of the present invention.

FIG. 9 is a von Mises stress plot illustration of a polystyrene foam layer of a pool assembly in accordance with an embodiment of the present invention.

FIG. 10A is a von Mises stress plot illustration aluminum panels of a pool assembly in accordance with an embodiment of the present invention.

FIG. 10B is a magnified view of a "cutout" aluminum panel portion as shown in FIG. 10A in accordance with an embodiment of the present invention.

FIG. 11 is a von Mises stress plot illustration of aluminum panels of a pool assembly in accordance with an embodiment of the present invention.

FIG. 12A is a von Mises stress plot illustration of aluminum splines of a pool assembly in accordance with an embodiment of the present invention.

FIG. 12B is a magnified view of a "cutout" aluminum spline as shown in FIG. 12A in accordance with an embodiment of the present invention.

FIG. 12C a magnified view of the aluminum spline as shown in FIG. 12B in accordance with an embodiment of the present invention.

FIG. 13A is a von Mises stress plot illustration of an aluminum spline of a pool assembly in accordance with an embodiment of the present invention.

FIG. 13B is a magnified view of a "cutout" aluminum spline as shown in FIG. 13A in accordance with an embodiment of the present invention.

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FIG. 14A is a von Mises stress plot illustration of aluminum supports of a pool assembly in accordance with an embodiment of the present invention.

FIG. 14B is a magnified view of a “cutout” aluminum support as shown in FIG. 14A in accordance with an embodiment of the present invention.

FIG. 15 is a von Mises stress plot illustration of a polystyrene foam layer of a pool assembly in accordance with an embodiment of the present invention.

FIG. 16 is a von Mises stress plot illustration of a pool assembly in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION

Referring to the drawings wherein like reference numerals refer to like parts throughout, there is seen in FIG. 1 a swimming pool 10 comprising a plurality of panels 12, most of which are either concave or convex. Each panel comprises a wall of skinning 14 of plastic or metal formed over expanded polystyrene or expanded urethane foam 16. The density of the foam is selected to increase the strength of the wall based on the static load conditions of water when the pool is fully assembled (thus, dependent on overall size volume of the pool). Those panels 12 with water pressure being asserted in the convex direction have adjusters 18 attached at their bottom to permit vertical movement during installation, horizontal tabs 20 (or an anchor plate) locking into a concrete foundation as the pool is assembled, and A-frame supports 22. Pool 10 can be a fully above ground pool, a partially above ground pool, or an entirely in-ground pool.

FIG. 4A shows a diagram of the assembled swimming pool, including pool wall panels. FIG. 4B shows a diagram of the A-frame support, and FIG. 4C shows a diagram of the panel joint when in use.

FIGS. 4-16 show a structural analysis of a free-form 18'x32' pool constructed from an embodiment of the present invention, to demonstrate the structural integrity of such a pool. To summarize the results, the maximum deflection in the assembly is 0.057", and the maximum stress is 8,259 psi, which occurs at the aluminum sheet metal. The maximum stress is still well below the tensile yield strength of the pool. The resulting factor of safety for the aluminum A-frame supports is 3.03, the aluminum spline is 3.78, and the polystyrene foam is 20. These figures demonstrate that the embodiment of the invention is safe under the fully filled water condition.

The following assumptions were made in the analysis: (1) linear material properties of aluminum and polystyrene are assumed for the purpose of the analysis; (2) 18'x32' Lagoon Swimming Pool is considered filled with water; and (3) liquid specific gravity is assumed to be equal to water density. All units are English units. Material properties were simulated with the properties shown in Table 1:

TABLE 1

Material	Young's Modulus (psi)	Poisson's Ratio	Tensile Yield Strength (psi)
Aluminum	10E+6	0.33	21029.73
Polystyrene	5.221E+5	0.34	6671.7-8702.3

FIG. 5 shows the loads and boundary conditions of the interior surface of the pool. The graph demonstrates that the liquid column applied on the floor was simulated to be 1.8

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psi, and a variable pressure was simulated on the pool faces, ranging from 0.1044 to 1.4232 psi.

FIGS. 6 and 7 are deflection plots of the pool from opposite sides. Both deflection plots demonstrate that the maximum deflection is 0.057 inches at the apex of the pool wall's convex curves.

FIGS. 8-16 show von-Mises stress plots (in psi) of various components of the structure of the pool assembly. FIG. 9 shows the stress of the polystyrene layer is 328 psi. Assuming a tensile yield strength of 6671.7 psi, results in a factor of safety of 20 for the polystyrene layer per the equation shown in Table 2 below.

TABLE 2

$$\text{SAFETY FACTOR} = \frac{\text{YIELD STRENGTH}}{\text{WORKING STRESS}} = \frac{6671.7}{328} = 20$$

FIGS. 10A-B show the stress of a concave aluminum panel is 8259 psi. Assuming the tensile yield strength is 21029.73, results in a factor of 2.55 for the concave aluminum panel per the equation shown in Table 3 below.

TABLE 3

$$\text{SAFETY FACTOR} = \frac{\text{YIELD STRENGTH}}{\text{WORKING STRESS}} = \frac{21029.73}{8259} = 2.55$$

Similarly, FIG. 11 shows the stress of a convex aluminum panel is 5697 psi, resulting in a factor of safety of 3.69. FIGS. 12A-C and 13A-B show the maximum stresses of an aluminum spline are 5556 psi and 4509 psi at the highest points, yielding a stress factor 3.78 at the spline per the equation shown in Table 4 below.

TABLE 4

$$\text{SAFETY FACTOR} = \frac{\text{YIELD STRENGTH}}{\text{WORKING STRESS}} = \frac{21029.73}{5556} = 3.78$$

FIGS. 14A-B show the stress of the aluminum A-frame supports are 6929 psi and 3981 psi at the highest points, resulting in a safety factor of 3.03 per the equation shown in Table 5 below.

TABLE 5

$$\text{SAFETY FACTOR} = \frac{\text{YIELD STRENGTH}}{\text{WORKING STRESS}} = \frac{21029.73}{6929} = 3.03$$

FIG. 15 shows a von Mises stress plot, for all stresses on the polystyrene foam layer rising above 6672 psi, demonstrating that at no point does the stress rise above 6672. Similarly, FIG. 16 shows a von Mises stress plot, for all stresses on the pool assembly rising above 21029, demonstrating that no stresses rise above 21029 psi.

What is claimed is:

1. An above ground or a semi-above ground swimming pool comprising:
 - a plurality of panels; and
 - a plurality of supports adapted to support at least some of the plurality of panels when the above ground or a semi-above ground swimming pool contains water; wherein at least one of the plurality of panels of the above ground or a semi-above ground swimming pool comprises a concave panel having an internal convex

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- surface adapted to be in contact with the water and an external exposed concave surface; and
 wherein the concave panel comprises a foam having a density adapted to withstand water pressure on the internal convex surface of the panel without failure of the swimming pool; and
 wherein the swimming pool further comprises a plurality of panel joints, each of the panel joints comprising an elongated beam adapted to connect adjacent panels, and wherein the elongated beam comprises an elongated flanged I-beam comprising a double web.
2. The swimming pool as recited in claim 1, wherein the at least one of the plurality of panels comprises at least two concave panels.
3. The swimming pool as recited in claim 1, wherein the concave panel is supported by two of the plurality of supports.
4. The swimming pool as recited in claim 1, wherein the foam comprises an expanded foam.
5. The swimming pool as recited in claim 4, wherein the expanded foam comprises one of an expanded polystyrene foam and an expanded urethane foam.
6. The swimming pool as recited in claim 1, wherein the concave panel further comprises an internal skinning and an external skinning, and wherein the foam is positioned between the internal skinning and the external skinning.
7. The swimming pool as recited in claim 1, wherein at least one of the plurality of panels of the swimming pool comprises a convex panel having an internal concave surface adapted to be in contact with the water and an external convex surface.
8. The swimming pool as recited in claim 7, wherein the convex panel is positioned adjacent to the concave panel.
9. The swimming pool as recited in claim 1, wherein the external exposed concave surface of the concave panel comprises an external concave surface of the concave panel devoid of support between the plurality of supports.
10. The swimming pool as recited in claim 9, wherein the external concave surface of the concave panel devoid of support between the plurality of supports is further devoid of backfill between the plurality of supports.

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11. An above ground or a semi-above ground swimming pool panel comprising:
 an internal convex surface adapted to be in contact with pool water and an external exposed concave above ground or a semi-above ground surface; and
 an internal foam between the internal surface and the external surface, the internal foam having a density adapted to withstand water pressure on the internal convex surface of the panel without failure of the swimming pool panel; and
 a plurality of panel joints, each of the plurality of panel joints comprising an elongated beam adapted to connect the panel to an adjacent panel, and wherein the elongated beam comprises an elongated flanged I-beam comprising a double web.
12. The swimming pool panel as recited in claim 11, wherein the panel is adapted to be supported by two supports.
13. The swimming pool panel as recited in claim 12, wherein the two supports are positioned at opposite ends of the panel.
14. The swimming pool panel as recited in claim 11, wherein the foam comprises an expanded foam.
15. The swimming pool panel as recited in claim 14, wherein the expanded foam comprises one of an expanded polystyrene foam and an expanded urethane foam.
16. The swimming pool panel as recited in claim 11, wherein the panel further comprises an internal skinning and an external skinning, and wherein the foam is positioned between the internal skinning and the external skinning.
17. The swimming pool as recited in claim 11, wherein the external exposed concave surface of the panel comprises an external concave surface of the panel devoid of support between the plurality of supports.
18. The swimming pool as recited in claim 17, wherein the external concave surface of the panel devoid of support between the plurality of supports is further devoid of backfill between the plurality of supports.

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