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(54) **SPHERICAL ENCLOSURE SUITABLE AS A BUILDING STRUCTURE, PRESSURE VESSEL, VACUUM VESSEL, OR FOR STORING LIQUIDS**

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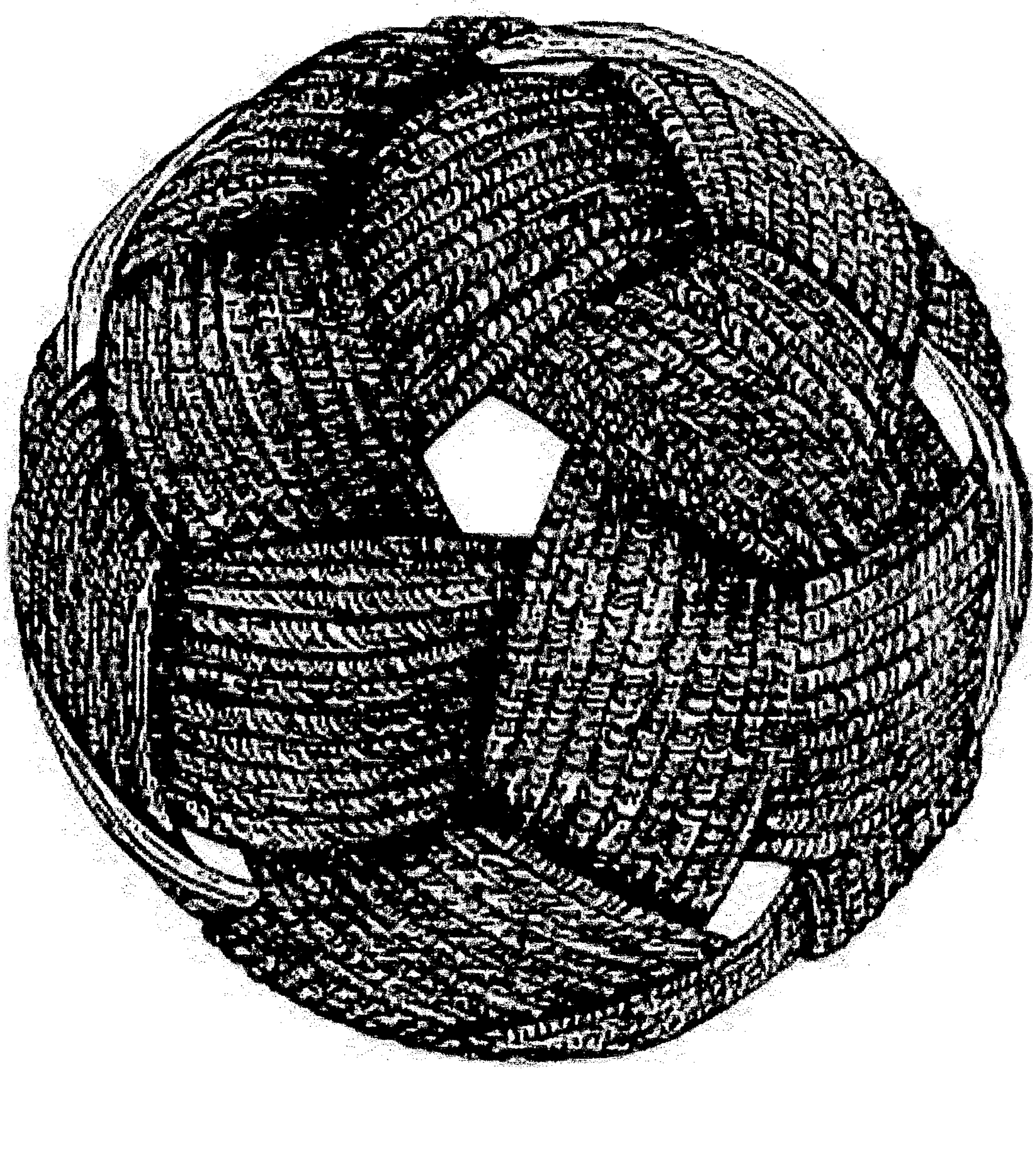
(52) **U.S. Cl.** **52/81.1**

(57) **ABSTRACT**

A spherical container having a shell formed by 6 bands, interwoven in such a way as to create 12 pentagonal openings spaced evenly around the sphere. 12 pentagonal covers, 20 disk shaped covers, and 30 struts. Building materials for the invention can be composite materials such as graphite or fiberglass fibers wherein; the parts are joined with stitching and then permanently bonded together with a suitable adhesive such as epoxy to form an airtight container. The invention can also be fashioned from sheets of weldable material, wherein all seams are welded together to form an airtight container. The 30 struts are placed inside the sphere with their end points located with reference to the vertexes of the pentagonal openings in such a way as to form a tensegrity dodecahedron. This structure may be used as a building, a pressure vessel, a vacuum vessel, or as a container.



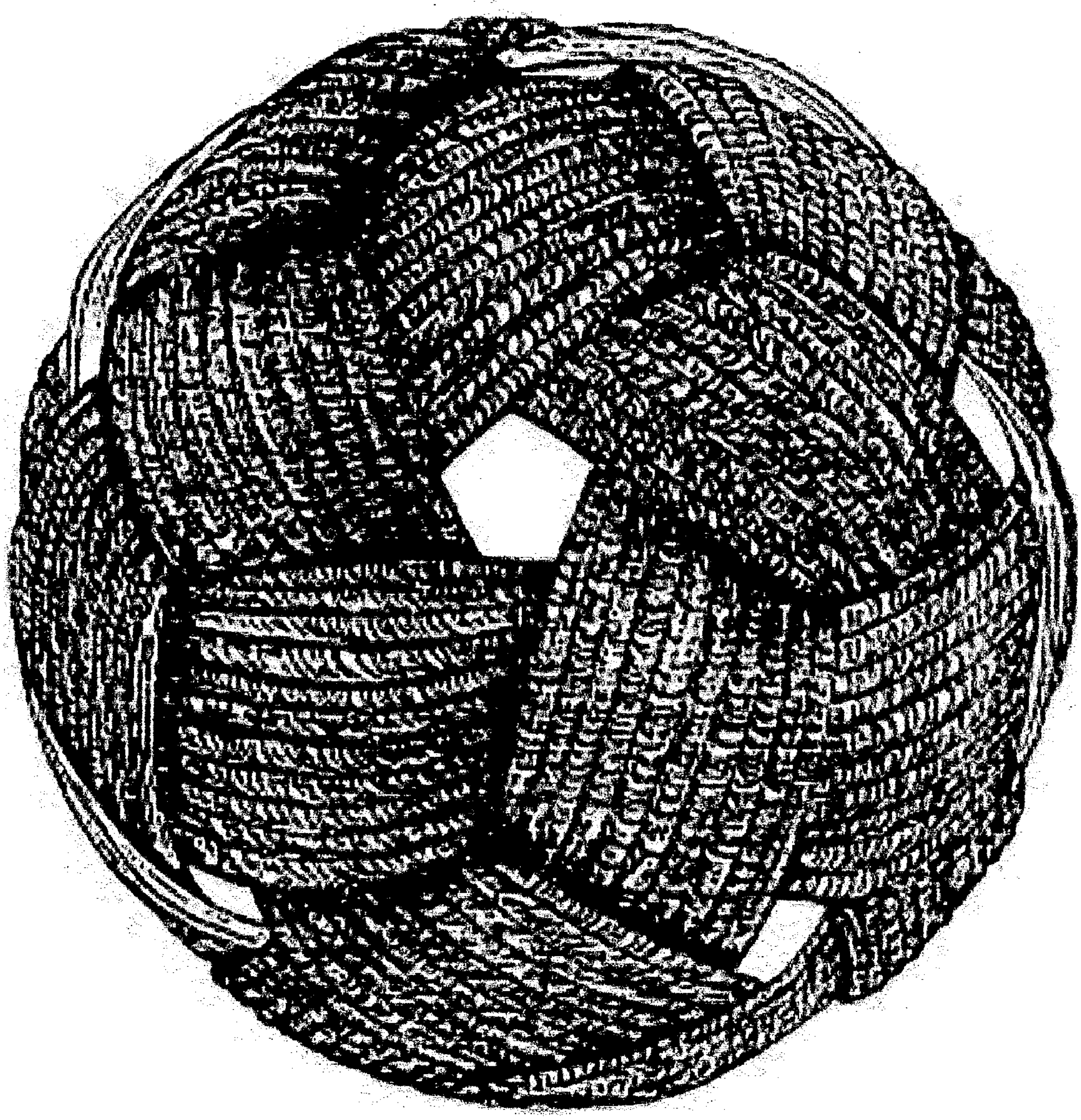


Fig. 1

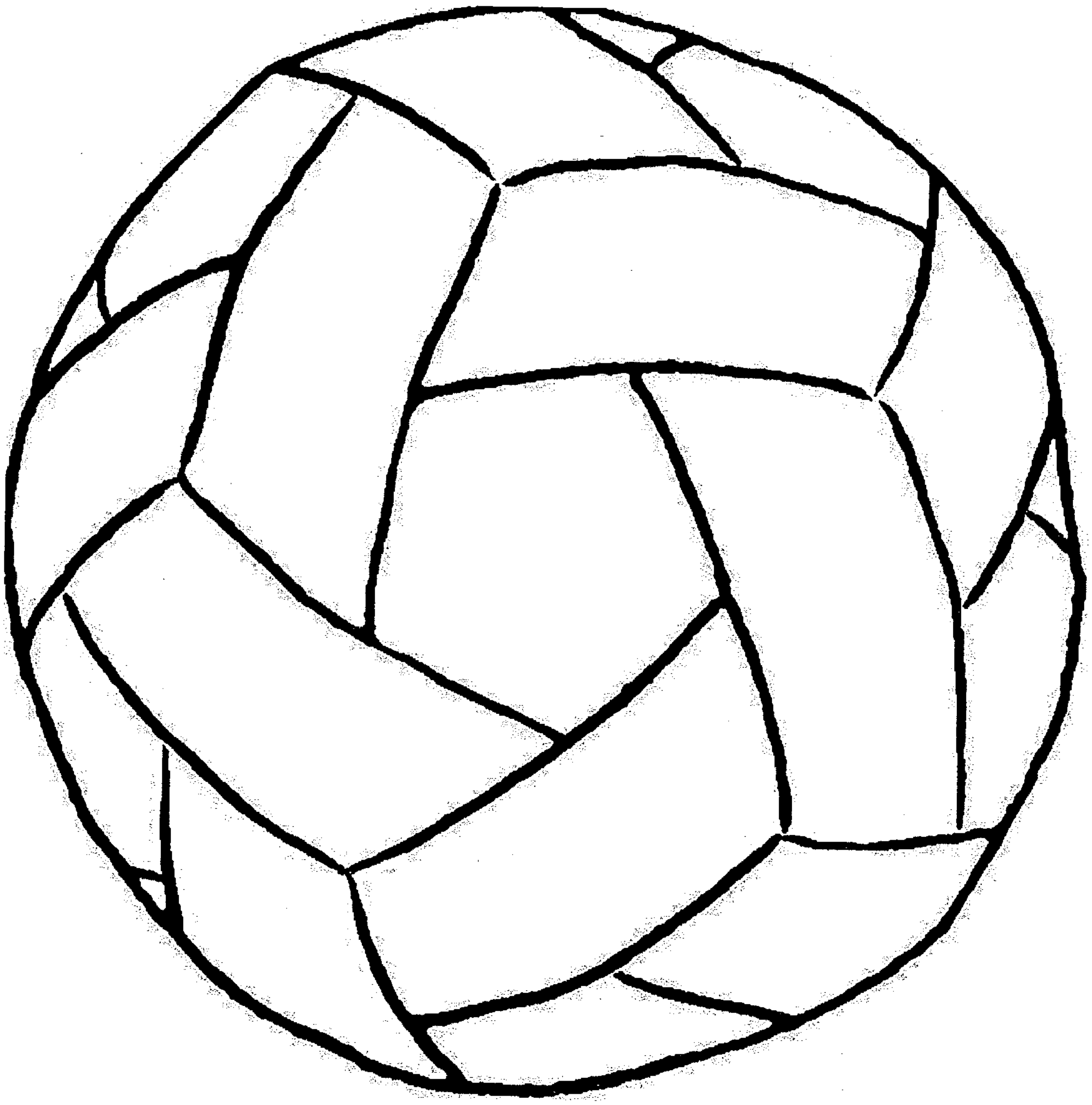


Fig. 2

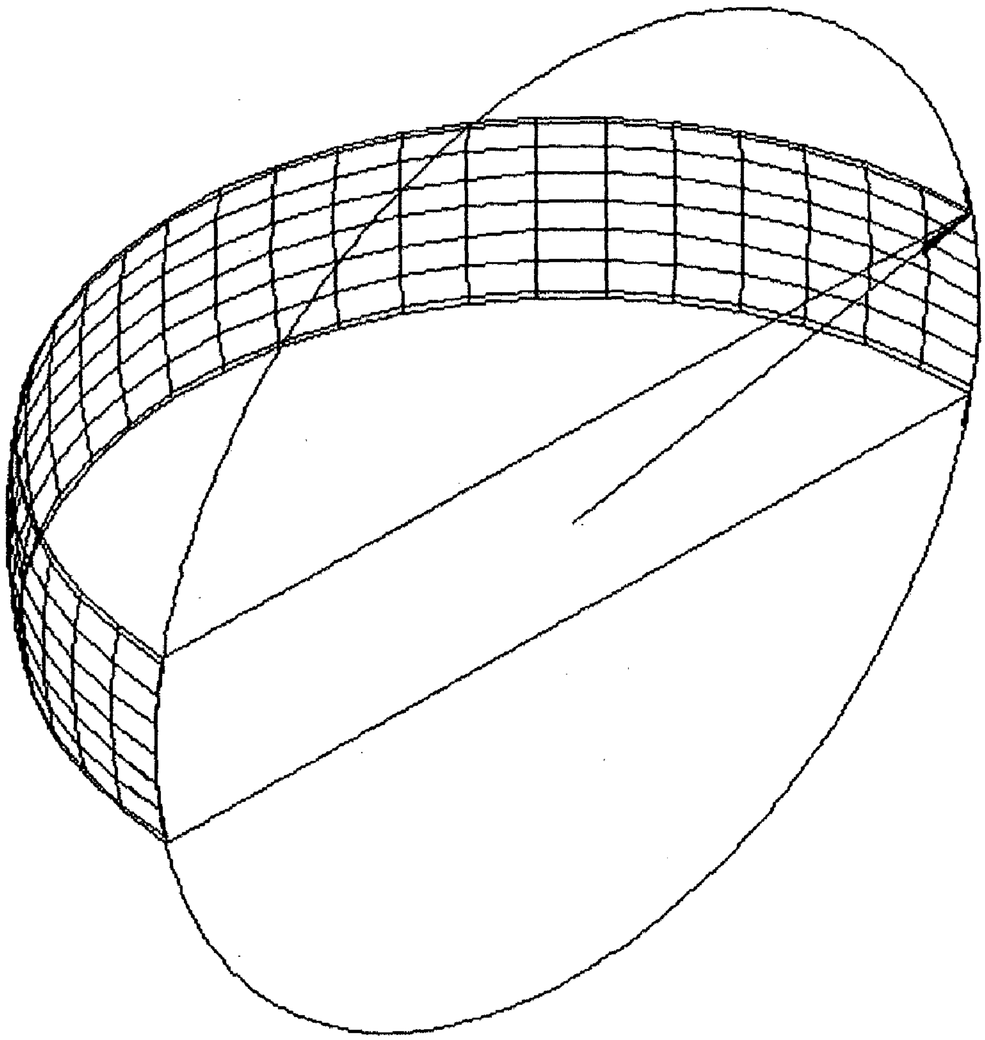
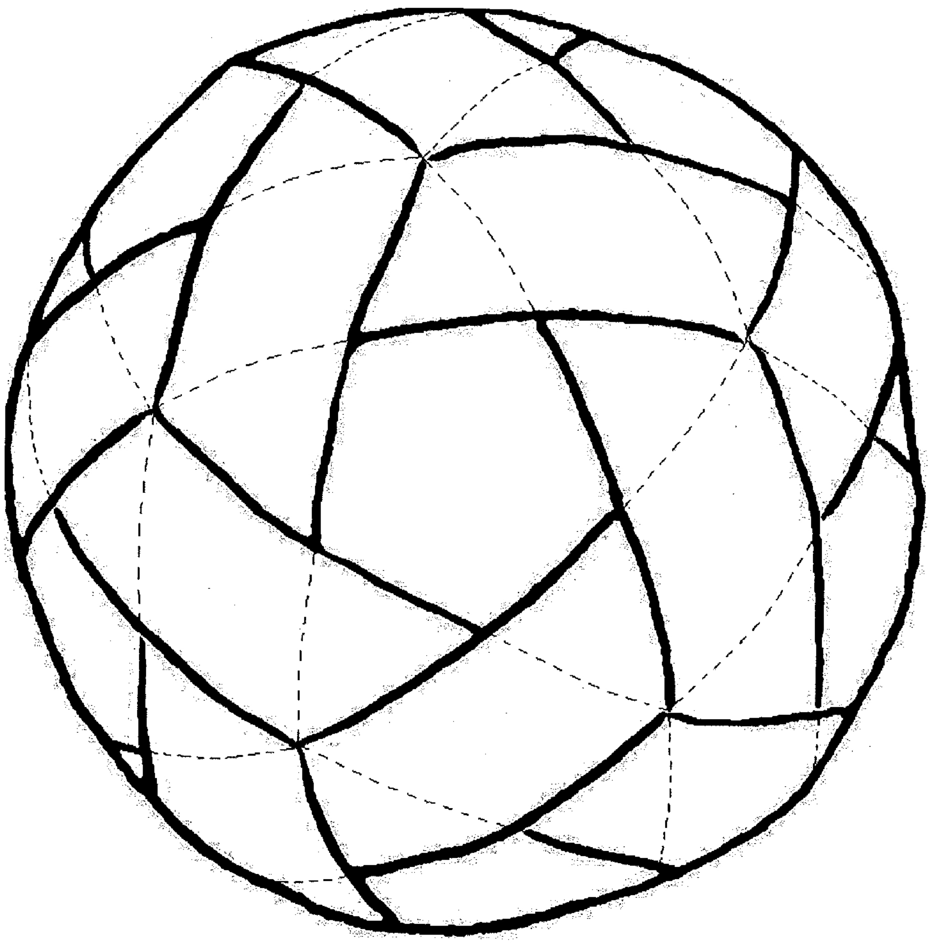


Fig. 3



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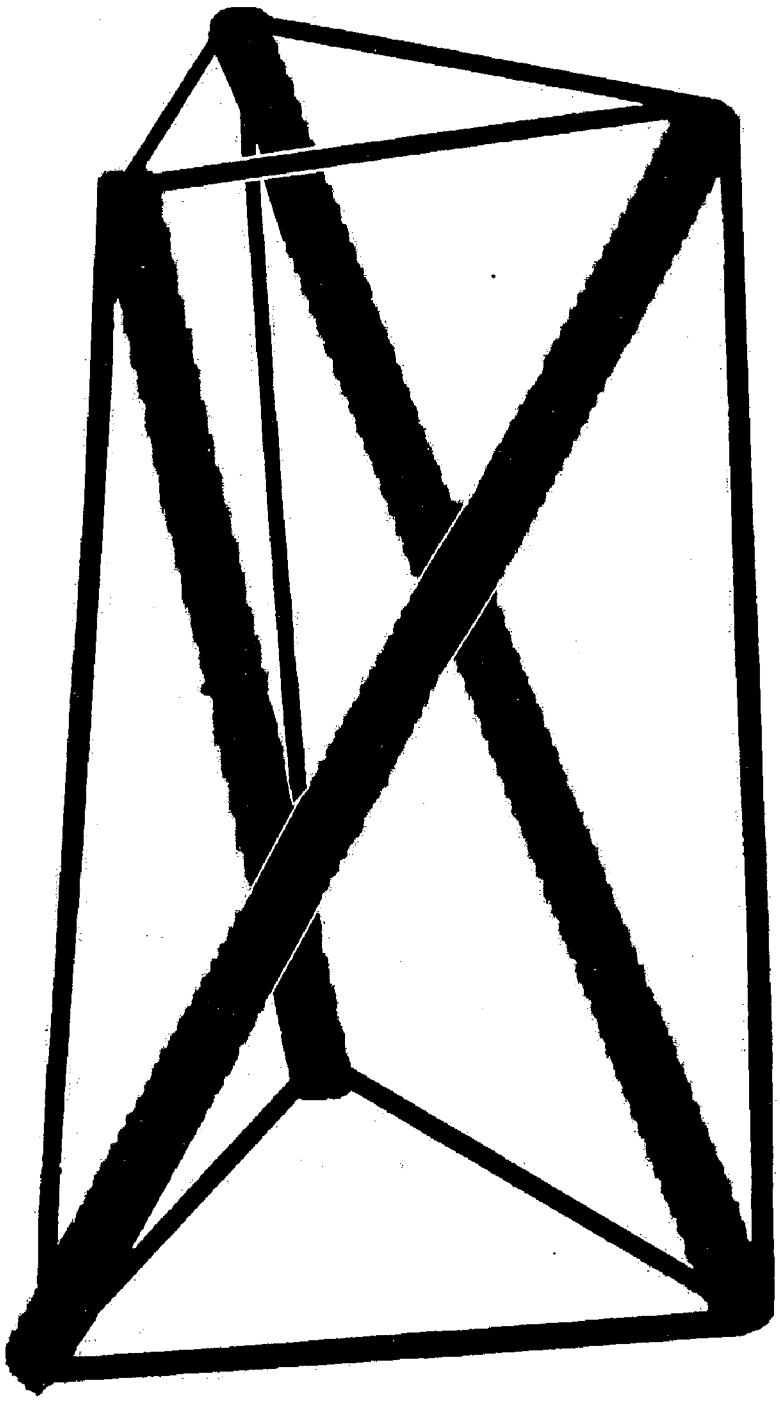


Fig. 5

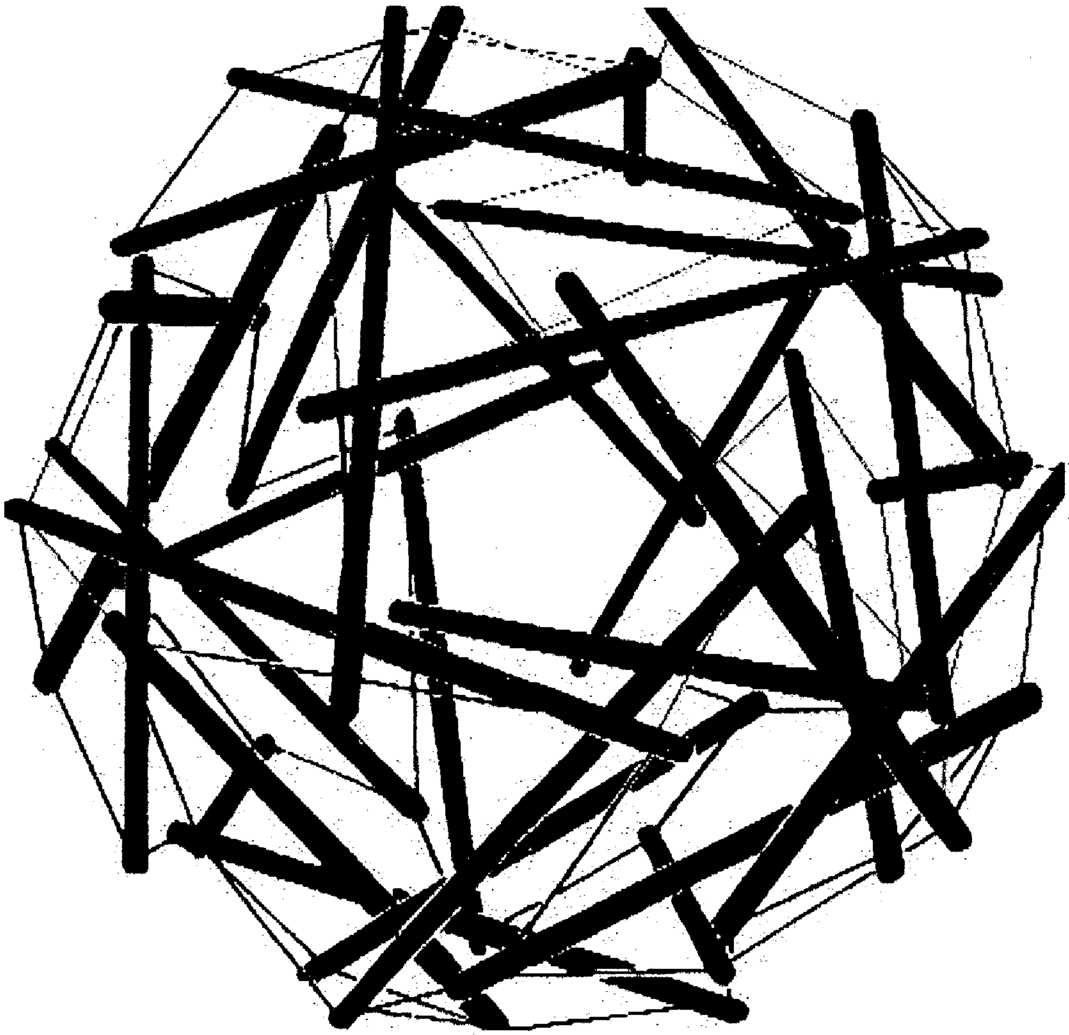
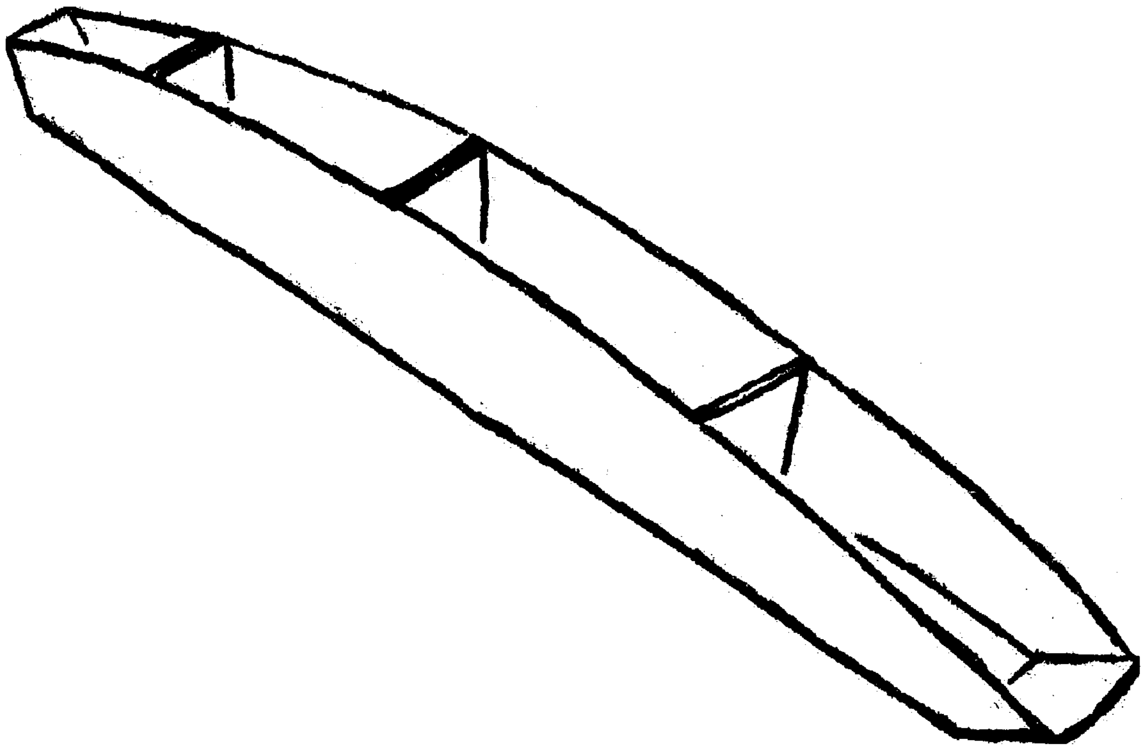


Fig. 6



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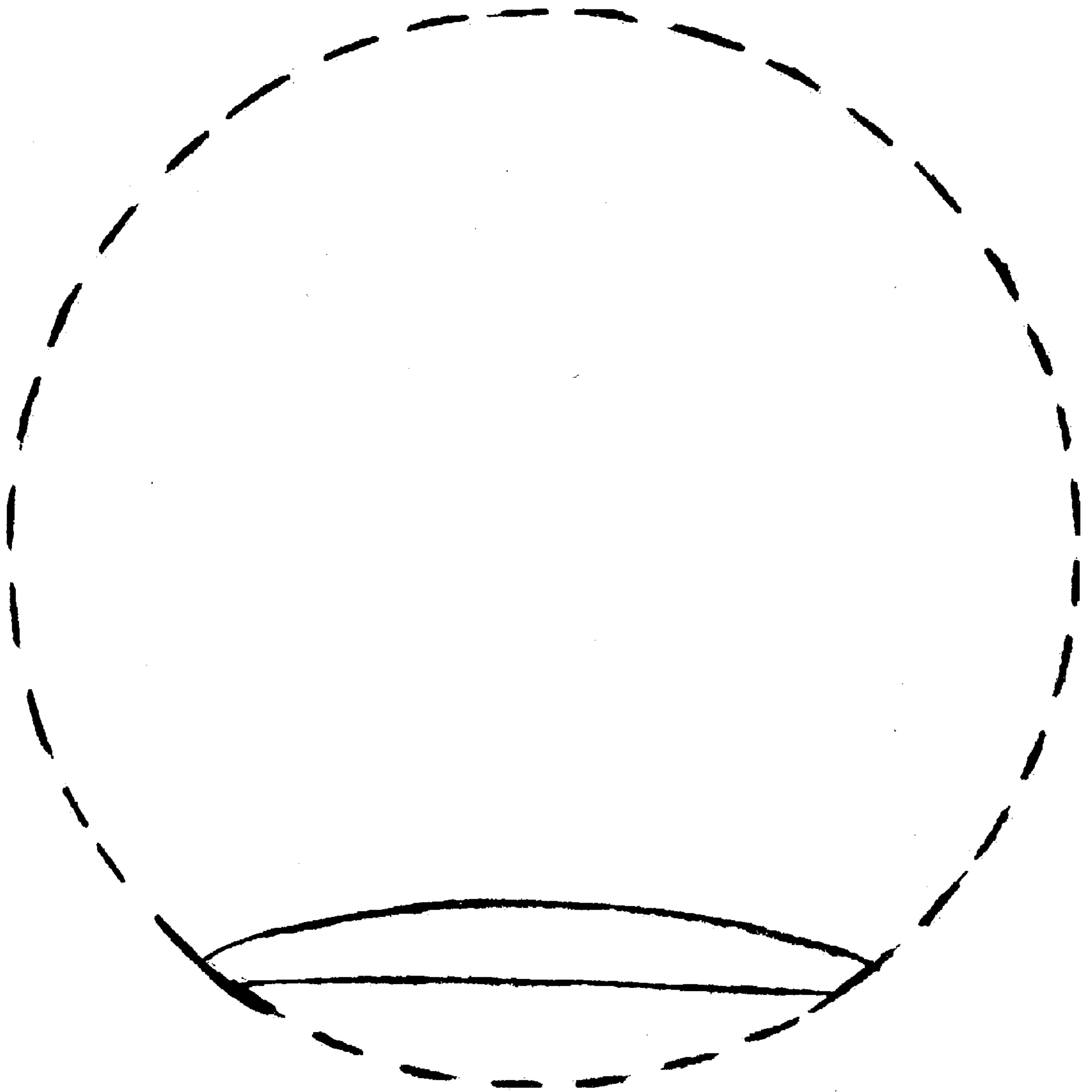

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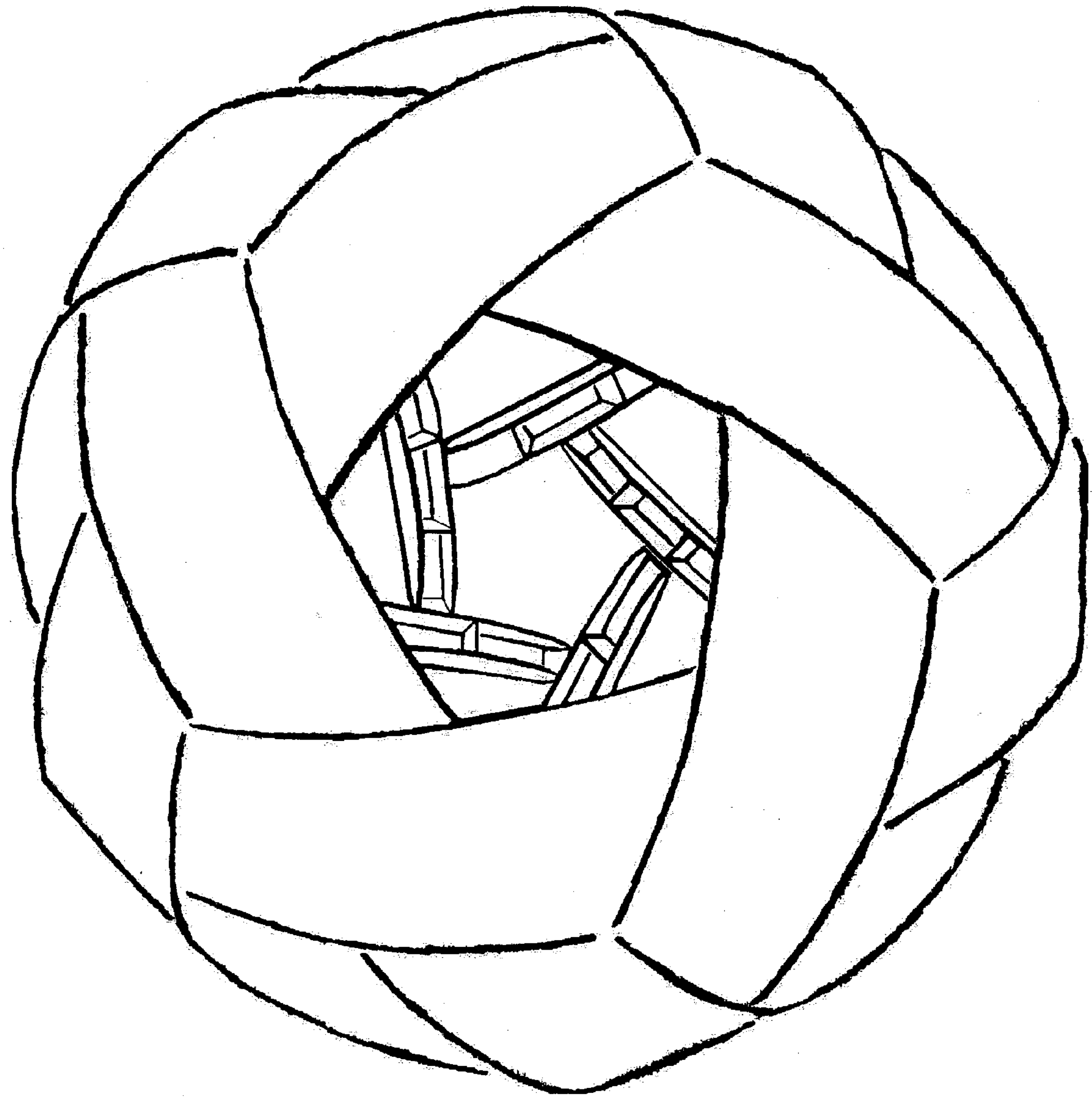


Fig. 9

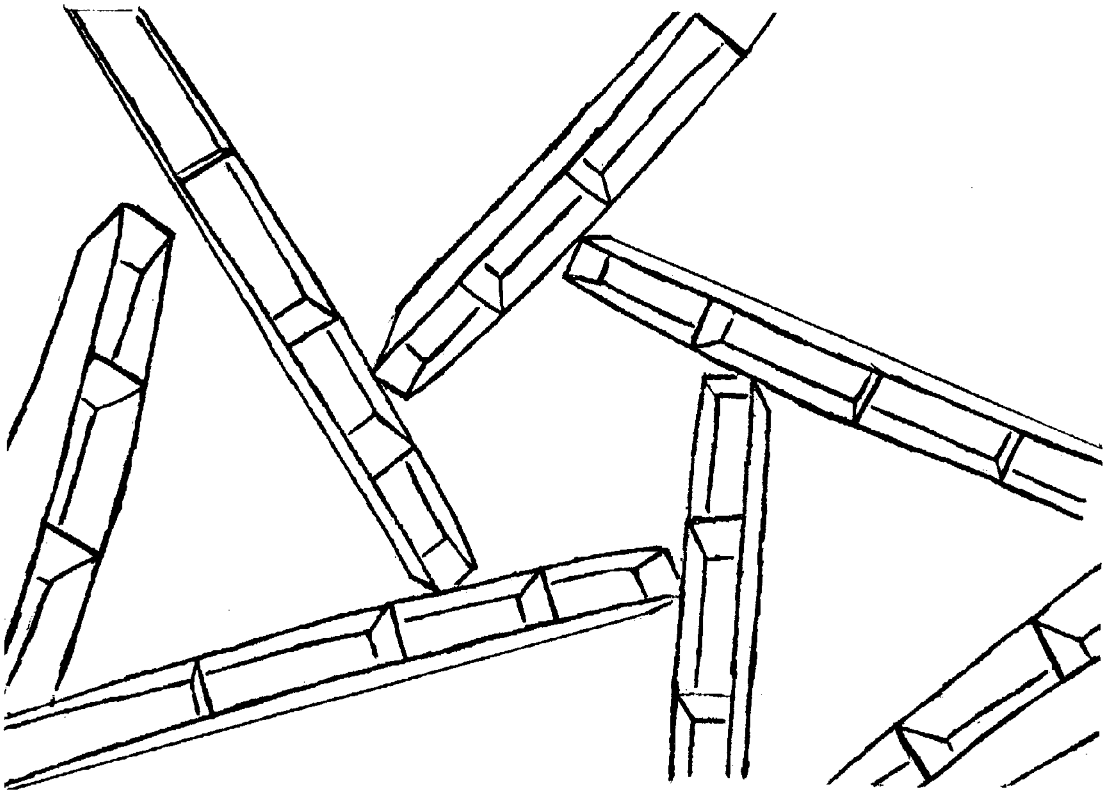
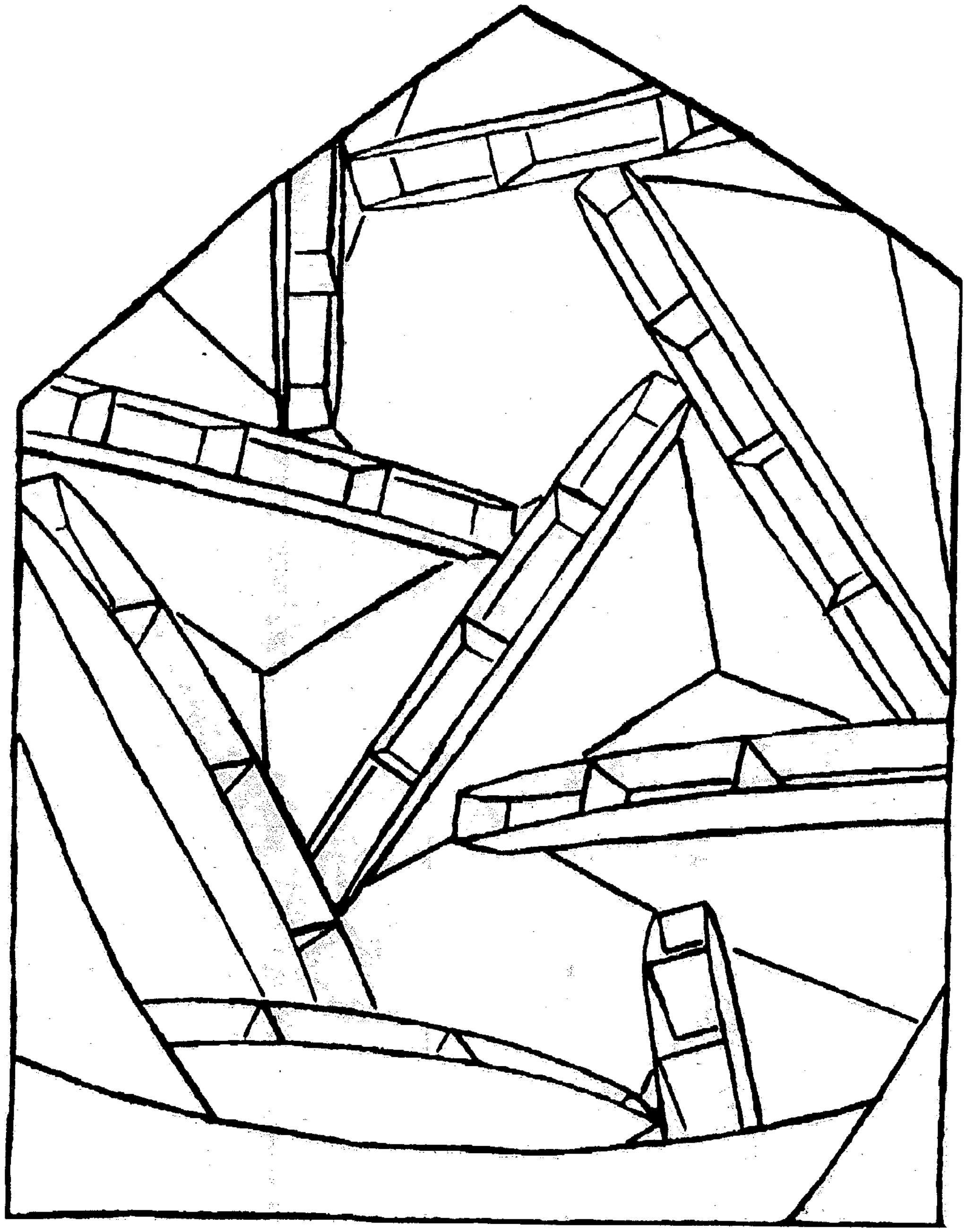


Fig. 10



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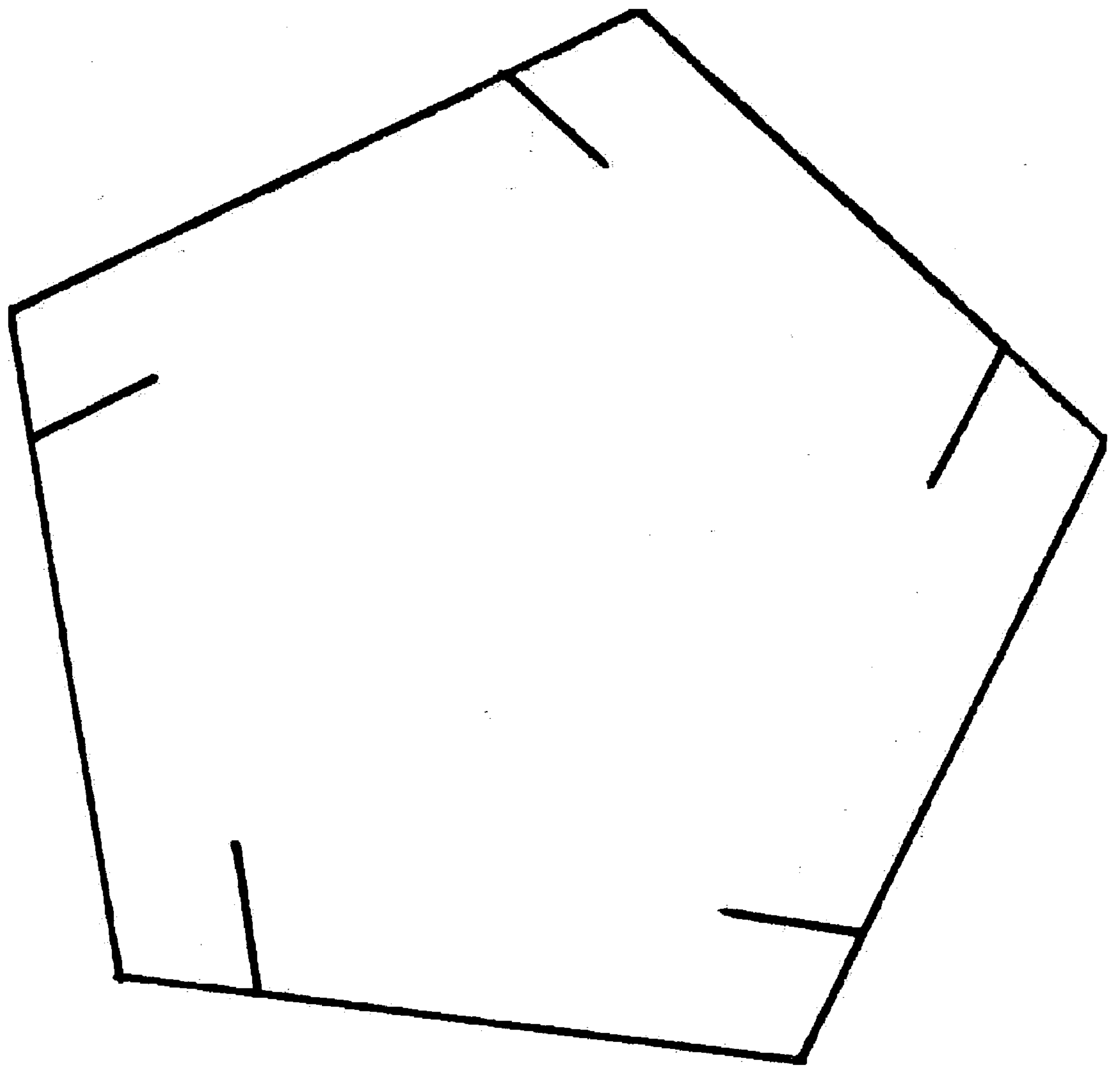

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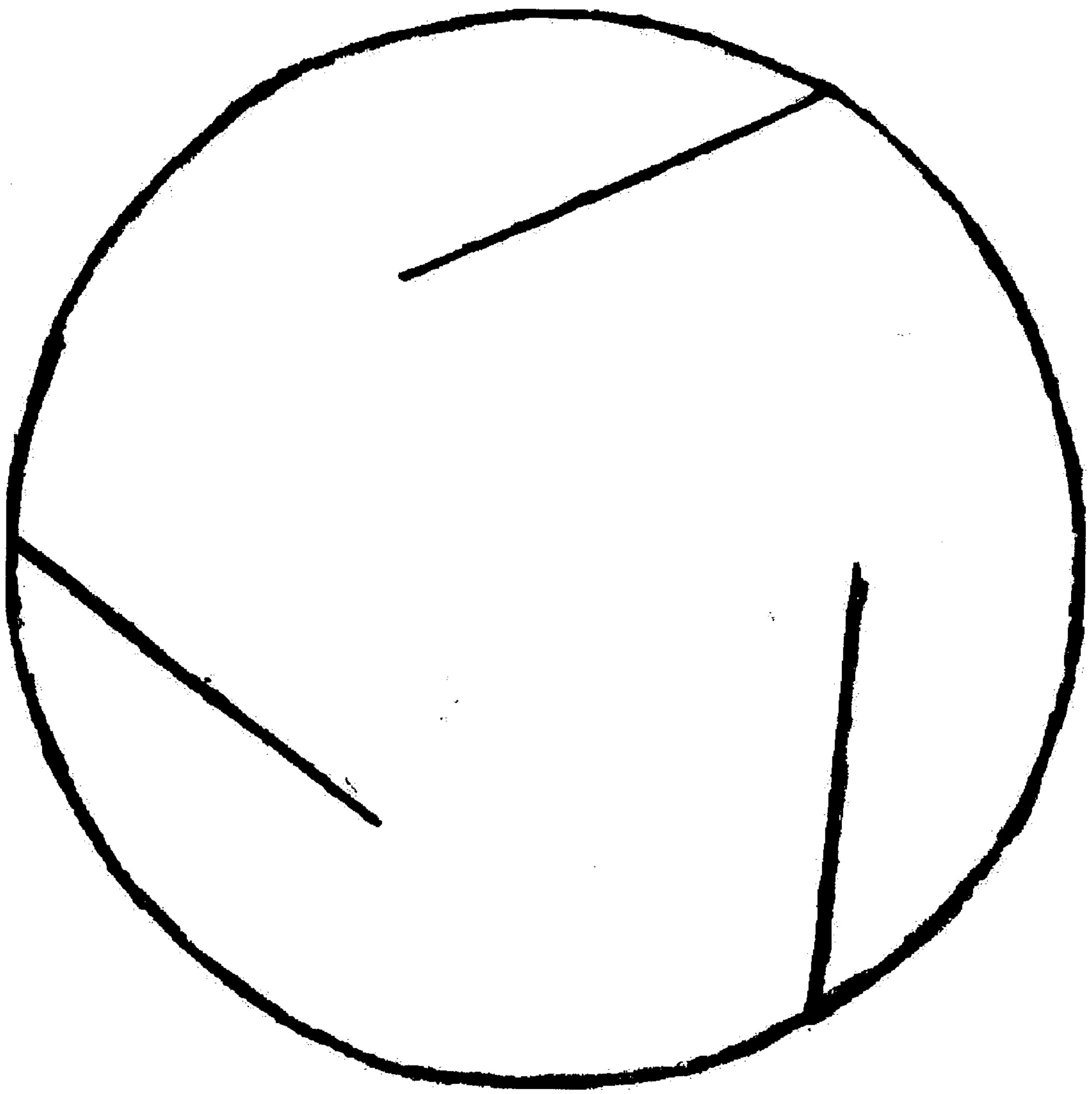

Fig. 13

Fig. 14

Fig. 15

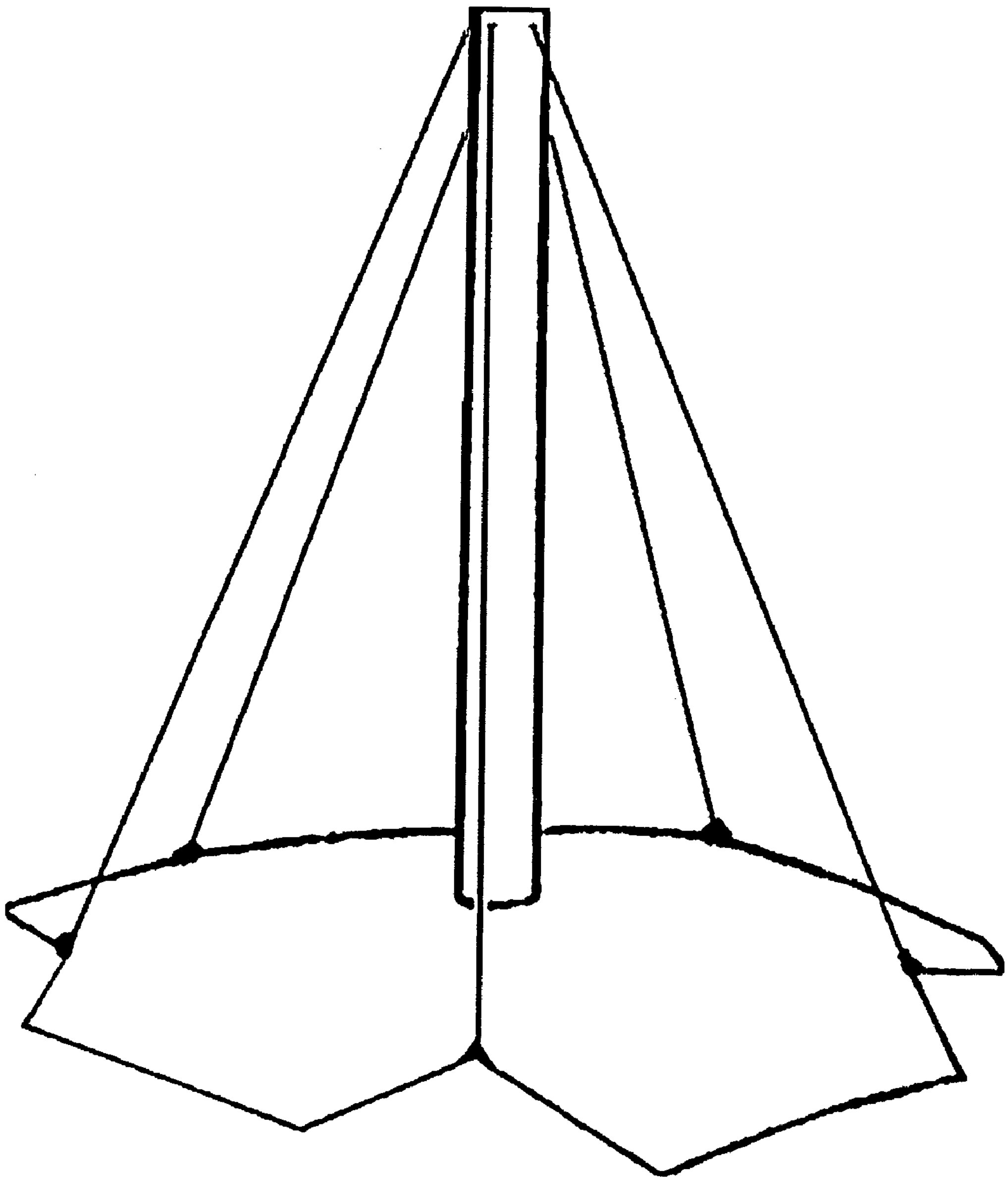

Fig. 16

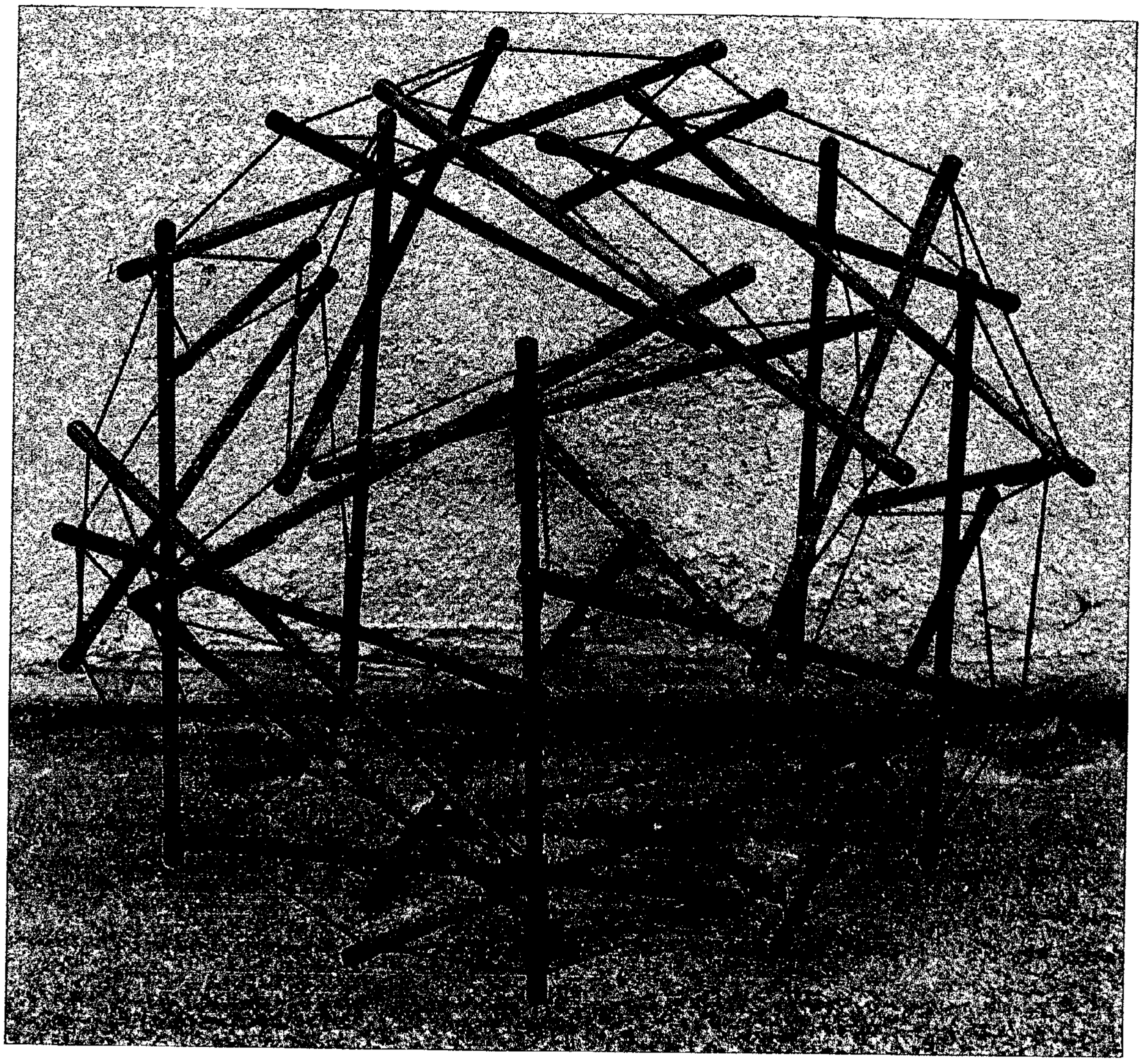

Fig. 17

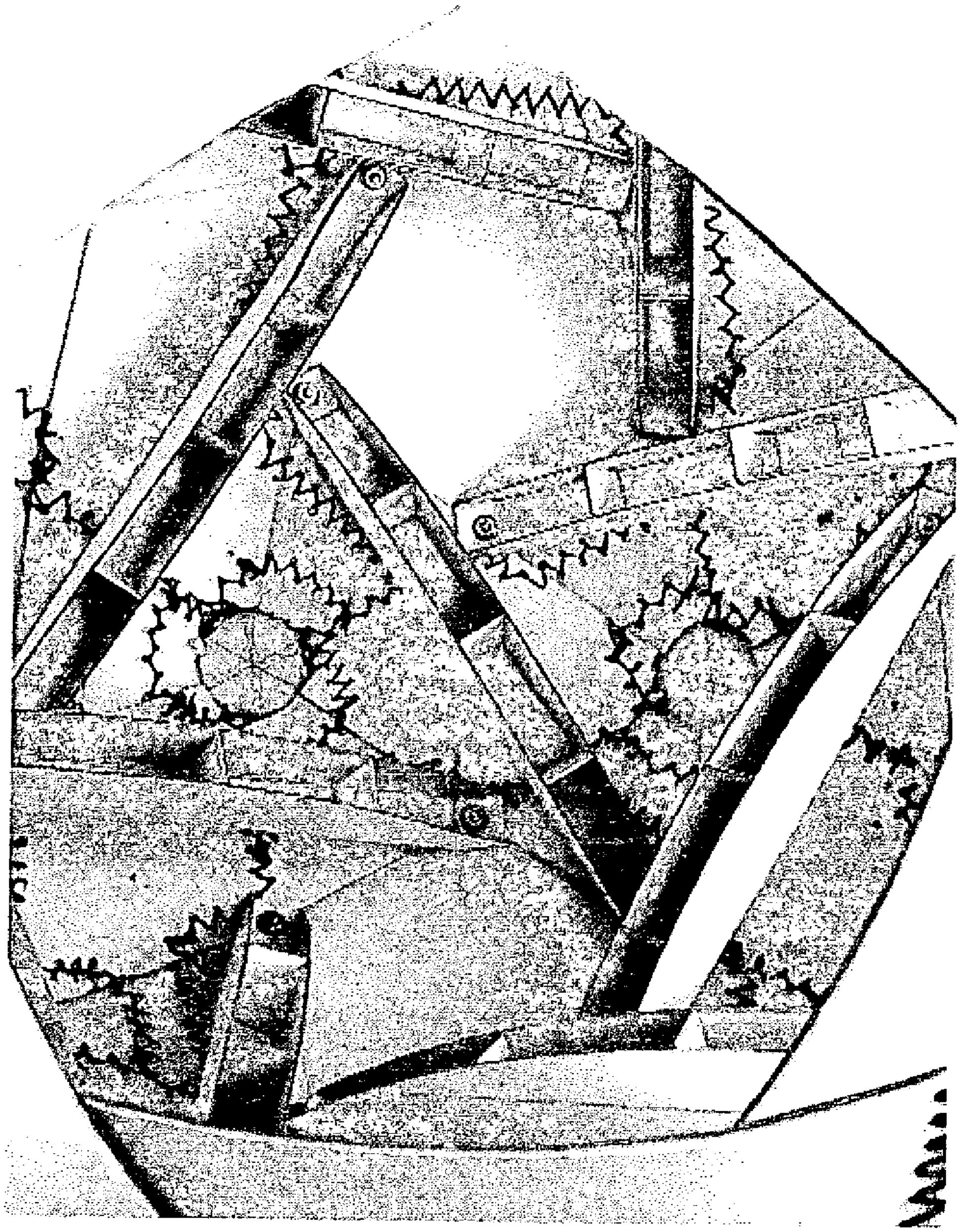

Fig. 18

Fig. 19

SPHERICAL ENCLOSURE SUITABLE AS A BUILDING STRUCTURE, PRESSURE VESSEL, VACUUM VESSEL, OR FOR STORING LIQUIDS

[0001] This application claims benefit of priority under 35 USC 120 to application "Spherical Enclosure Suitable As A Building Structure, Pressure Vessel, Vacuum Vessel, Or For Storing Liquids" filed on Jan. 15, 2003 and assigned U.S. PTO application Ser. No. 10/342,767

CROSS-REFERENCE TO RELATED APPLICATIONS

[0002] Not Applicable

STATEMENT REGUARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0003] Not Applicable

REFERENCE TO SEQUENCE LISTING, A TABLE, OR A COMPUTER PROGRAM LISTING COMPACT DISC APPENDIX

[0004] Not Applicable

BACKGROUND OF THE INVENTION

[0005] Most everyone involved with airships has wondered if it would be possible to use vacuum bottles instead of helium filled ballonets to provide lift for airships. After all, a vacuum is even lighter than helium. And by using relief valves and vacuum pumps, vertical takeoffs and landings would be possible.

[0006] When constructing our vacuum bottles, there is really only one important consideration. The bottles must be lighter than the air they displace. This is what gives the bottles positive buoyancy and allows them to float.

[0007] The perimeter of a sphere (Read as the weight of the building materials) increases with the square of the diameter. But the volume of a sphere (Read as the weight of the air that the sphere displaces) increases with the cube of the diameter. So no matter how you build your bottle, there is some diameter where the empty bottle has neutral buoyancy. And at any diameter greater than that, the bottles will float.

[0008] So far, So good . . . except for one thing . . . At sea level, the atmosphere exerts the enormous crushing force of more than 2000 pounds per square foot along the surface of the bottles.

[0009] So using conventional materials, and conventional construction techniques, there were two possible outcomes for your efforts. Either the bottles were able to stand up to atmospheric pressure; in which case, the bottles were too heavy to float. Or the bottles were light enough to float, but were crushed under the weight of the atmosphere. In either case, your airship never got off the ground.

[0010] This document defines materials and methods that will facilitate the production of vacuum bottles that are lighter than the air they displace, while being strong enough to stand up to atmospheric pressure.

DESCRIPTION OF PRIOR ART

[0011] Known in the prior art are spherical enclosures made either by using geodesic construction techniques or by joining spherically contoured sections together.

[0012] In U.S. Pat. No. 3,063,521, Richard Buckminster Fuller describes his invention "Tensile Integrity Structures" (here after referred to as tensegrity structures) which is an indispensable component of my invention. But Fuller starts his discussion regarding the building of spheres, with an example using 270 struts and refers to this structure as a geodesic sphere tensegrity. He uses this structure to help the reader understand how it is possible to combine a structure's tension members with it's compression members to form a single tension-compression unit in which the outermost surface of the unit provides the tension while the inner most surface provides the compression. It is quality that defines a geodesic structure. And it is this quality that explains why no internal columns or beams are seen inside geodesic structures. While geodesic structures are indeed tensegrity structures, they are only a small subset of the structures that can be built using tensegrity. My invention explores the use of non-geodesic tensegrity structures and their use in creating spherical or semispherical enclosures that are stronger, easier to build, and cheaper to manufacture than is currently possible using geodesic techniques.

[0013] In U.S. Pat. No. 4,113,206, David Wheeler describes a geodesic structure that is lighter than the air it displaces. The intent is to evacuate the air from inside the structure so that the structure will float in the atmosphere. But even with today's super strong and super light composite materials, a working model has never been built. The reason for this is that the atmosphere at sea level, maintains a crushing force of about 2000 PSI. And even today's composite materials cannot stand up to that force when configured as a geodesic structure. My invention explores the novel use of the spherical dodecahedron combined with non-geodesic tensegrity structures in order to create structures that are lighter than the air they displace while also being strong enough to stand up to atmospheric pressure.

[0014] U.S. Pat. No. 5,529,239 describes a method for pressure forming metal plates to have a spherical contour. U.S. Pat. No. 5,662,264 of the same inventors goes on to describe how these plates can be welded together. My invention explores the novel use of the spherical dodecahedron combined with non-geodesic tensegrity structures and their use in creating spherical or semispherical enclosures that are stronger, easier to build, and cheaper to manufacture than is currently possible using the previously mentioned techniques.

BRIEF SUMMARY OF THE INVENTION

[0015] The purpose of this invention is to:

[0016] 1. Provide a new method for creating a vacuum container that has the properties of being lighter than the air it displaces yet being strong enough to stand up to atmospheric pressure. Such a structure would float when evacuated of air. Such a structure would find enormous use in the airship industry, which is now dependent on helium filled ballonets to provide lift.

[0017] 2. Provide an easier and more cost effective way to make spherical tanks including pressure vessels, vacuum vessels, and tanks for storing liquids, than is currently available.

[0018] 3. Provide a way of making spherical vessels that are lighter and or stronger than is currently possible in the current state of the art.

[0019] 4. Provide a way of making dome and spherical shaped buildings that are stronger, easier to build, and cheaper to manufacture than is currently possible using geodesics.

[0020] This will be accomplished by combining the use of super strong, super light materials such as graphite, which exhibit most of their strength in tension with the geometry of tensegrity, which takes maximum advantage of a material's tensile strength. Also we will make novel use of what might be the worlds oldest man made sphere.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] **FIG. 1** is a South East Asian ball called a Takraw. This picture has been reproduced from U.S. Pat. No. 5,566,937.

[0022] **FIG. 2** shows a similar structure created using six bands.

[0023] **FIG. 3** shows that the cross-sectional contour of the bands are spherical

[0024] **FIG. 4** shows a method for making a container with a perfectly spherical contour and uniform wall thickness

[0025] **FIG. 5** shows the simplest possible tensegrity structure. This figure has been reproduced U.S. Pat. No. 3,169,611.

[0026] **FIG. 6** shows a spherical tensegrity structure.

[0027] **FIG. 7** shows a strut to be used as an internal support for a sphere.

[0028] **FIG. 8** shows that the end of the strut must have approximately the same contour as the inside of the sphere it supports.

[0029] **FIG. 9** shows struts positioned inside a spherical dodecahedron.

[0030] **FIG. 10** just shows a closer view of **FIG. 7**.

[0031] **FIG. 11** shows strut positions from a different angle

[0032] **FIG. 12** shows a pentagonal cover with slits cut into it.

[0033] **FIG. 13** shows a disk shaped cover with slits cut into it.

[0034] **FIG. 14** shows a pentagonal cover and a disk shaped cover twisted into place.

[0035] **FIG. 15** shows one preferred embodiment of the outside surface of a completed spherical container.

[0036] **FIG. 16** shows one way to support the spherical dodecahedron externally

[0037] **FIG. 17** is a B/W photograph of a tensegrity dodecahedron.

[0038] **FIG. 18** is a B/W photograph of the struts attached to the inside of a spherical dodecahedron to form a tensegrity dodecahedron.

[0039] **FIG. 19** is a B/W photograph of the outside of this invention in one of its preferred embodiments.

DETAILED DESCRIPTION OF THE INVENTION

[0040] **FIG. 1** is a South East Asian game ball, called a Takraw. It is made from reeds and has been used for perhaps thousands of years.

[0041] **FIG. 2** shows a similar structure created using six bands. The width of the band is approximately ⅕th of the spheres diameter. By playing with this number, you can control how tightly the bands fit together. This structure has 12 pentagonal shaped openings and 20 points along its surface where the edges of 3 bands intersect. From this point on, I shall refer to this structure as a spherical dodecahedron in honor of its 12 pentagonal openings. By giving the bands a spherical cross section defined by swinging a radius who's length is equal to the radius of the band and who's origin is at the center of the band, in a plane which is parallel with the band's axis as shown in **FIG. 3**, it is possible to achieve a perfect fit for when it comes time to assemble the bands into a spherical dodecahedron and seal the seams. This is not a necessary operation, but it does make the job of sealing the structure easier because you don't need fasteners to pull all the bands together.

[0042] **FIG. 4** shows, that by using the lower band as a guide, to cut along the dotted lines, then removing the top section, and then welding or joining the bands in some manner again along the dotted lines, it is possible to make structures with a perfectly spherical contour and of uniform wall thickness. The removed material can then be used to fabricate the pentagonal covers.

[0043] **FIG. 5** shows the simplest possible tensegrity structure. This figure has been reproduced from Kenneth Snelson's U.S. Pat. No. 3,169,611. Snelson is credited with being the cofounder of the principals of tensegrity along with Richard Buckminster Fuller. I have included this drawing so that the uninitiated reader will have a starting point for understanding what is happening in **FIG. 6**. The important thing to notice is that none of the compression members, (the struts), touch each other, but are rather held in suspension by the tension members. This type of structure is amazingly strong and resilient because any forces applied to a point on the structure will be communicated through out the system and shared by all its members.

[0044] **FIG. 6** shows a spherical tensegrity structure where the interplay between the 30 tension members (cables of some type) and 30 compression members (struts of some type) join to create a strong and resilient structure in the approximate shape of a sphere. This structure is referred to by those familiar in the art, as a tensegrity dodecahedron. This structure is in no way a geodesic structure because the tension members are distinctly separate from the compression members. Many people have created sculptures using tensegrity. But except for geodesics, (a special case of tensegrity), I have yet to see anyone use the principals of tensegrity for anything useful. But one of the most important concepts defined by this invention is the novel combination of this tensegrity dodecahedron with the spherical dodecahedron previously shown in **FIG. 2**, to form a new structure that enjoys the qualities of the previous two while gaining other qualities that exist in neither alone. This will be explained more under **FIG. 9**. **FIG. 17** shows a black and white photograph of the same structure.

[0045] **FIG. 7** shows one possible strut configuration that could meet the aims of combining the spherical dodecahedron (**FIG. 2**), with the tensegrity dodecahedron (**FIG. 6**).

[0046] **FIG. 8** shows one important quality of the strut. And that is, the ends of the struts must have approximately the same contour as the inside of the spherical dodecahedron of **FIG. 2**. The length of the strut is another consideration. Experimentation has shown the length to be about ⅙th the circumference of the spherical dodecahedron of **FIG. 2**. This is suspiciously close to the ratio of a circles radius to its circumference. So I am going guess that a strut length, equal to a bands radius is the ideal length for a strut.

[0047] **FIG. 9** shows how the struts are positioned inside the spherical dodecahedron by locating the ends with reference to the vertexes of the pentagonal openings. The other end of the struts, (shown in **FIG. 11**), are located with reference to one of the vertexes of an adjacent pentagonal opening as dictated by the form of the tensegrity dodecahedron depicted in **FIG. 6**. What we are doing in effect is placing a tensegrity dodecahedron inside of spherical dodecahedron, where the struts handle compression and the bands of the spherical dodecahedron provide the tension and the spherical shape. Also, we are taking advantage of the fact that there is a one to one correspondence between the ends of the 30 struts and the 60 pentagonal vertexes. And as such, we have an easy way to locate the correct positions for attaching the end points of the struts to the spherical dodecahedron so as to form a tensegrity dodecahedron inside.

[0048] **FIG. 10** just shows a closer view of **FIG. 9**.

[0049] **FIG. 12** shows a pentagonal cover with slits cut into it that allow the cover to be twisted into place in order to facilitate precise location of the cover with respect to the center of one of the 12 pentagonal openings.

[0050] **FIG. 13** shows a disk shaped cover with slits cut into it that allow the cover to be twisted into place in order to facilitate precise location of the cover with respect to the one of the 20 places where three bands intersect.

[0051] **FIG. 14** shows a pentagonal cover and a disk shaped cover twisted into place. By installing these covers around the structure and sealing all seams, it is possible to create an airtight enclosure.

[0052] **FIG. 15** shows one preferred embodiment of the outside surface of a completed spherical container. **FIG. 19** is a photograph of the same structure. This type of structure consisting of 6 bands enclosed by 12 pentagonal covers and 20 disk shaped covers shall from here on be referred to as a spherical dodecahedral enclosure and is intended for use as a storage container or pressure vessel. And if said container is supported by a collection of struts whose end points if connected would form a tensegrity dodecahedron (previously defined by **FIG. 6**), then the structure will from here on be defined as a spherical dodecahedral enclosure with a dodecahedral tensegrity support. And this structure would find use as a vacuum vessel. It is important to note at this point that as far as I know, this is the only vacuum vessel ever conceived in which the entire surface of the vessel is in tension. This is important because most materials exhibit maximum strength while in tension. So the strength to weight ratio is extremely high.

[0053] **FIG. 16** shows a dodecahedral enclosure supported externally by a tower in a manner similar to a suspension bridge. The tower in this preferred embodiment is located in the center of a pentagonal cover and runs entirely through the sphere and comes out the other side where it is fastened also as show in **FIG. 16**. This is repeated, in this preferred embodiment, 5 more times so that the sphere is uniformly covered with towers and suspension cables. The actual number of towers and exact position is not as important as having the towers uniformly spaced around the sphere. For instance, it is possible to use the 20 places on the dodecahedral enclosure where 3 bands intersect as the locations for the towers. And suspension cables would then be attached uniformly around the towers, as would make sense to the designer. Again, this configuration is intended for use as a vacuum vessel.

DISCUSSION

[0054] This invention defines a novel way of building and supporting a spherical container. This said container would be a suitable structure to use as a building, a pressure vessel, a vacuum vessel, or a container to store liquids or gases.

[0055] As a building, this said container offers an alternative to geodesic construction. Such a building may or may not make use of the internal struts shown in **FIG. 10**. But the use of six bands enclosed by twelve pentagonal covers and 20 disk shaped covers previously defined as a spherical dodecahedral enclosure, offers many advantages over current geodesic techniques. Including shorter construction times, lower construction costs, and a greater strength to weight ratio. By aligning one of the of the 6 bands horizontally and parallel with the ground, it is possible to create a semi-spherical dodecahedral enclosure with all the same advantages of a fully spherical dodecahedral enclosure and with the extra advantage that it can not roll away.

[0056] If a building was formed from a dodecahedral enclosure and was supported by a dodecahedral tensegrity structure, then the building would have the extra ability to standup to great external pressure. This would make the building suitable as an underwater structure. If this same structure were also made from super strong lightweight fibers such as graphite, and of sufficient diameter, then it should be possible to create a structure that is lighter than the air it displaces while still being strong enough to stand up to atmospheric pressure. In either case, the structure would be very resilient and forgiving of impact and deformation because, tensegrity structures have a remarkable ability to distribute stresses throughout their entire structure.

[0057] Although it is not depicted in any of the drawings, it is important to note that the dodecahedral tensegrity supports could also be located on the outside of the spherical dodecahedral enclosure, provided that they have enough curvature so as not to interfere with the enclosure or the end points of other struts. The important thing is that the points where the struts connect to the enclosure would be the same points used to define a tensegrity dodecahedron if the struts were internal.

[0058] As a pressure vessel or storage vessel this said container offers an alternative to forming and welding spherically contoured segments together with the following advantages.

[0059] 1. The bands, which are the majority of the outer surface, can be made from rolls or long lengths of any relatively stiff material including sheet metals, plate metals and composites.

[0060] 2. The bands are self-aligning and hold themselves in the correct positions prior to joining.

[0061] 3. The 12 pentagonal covers and 20 disk shaped covers are self-aligning and hold themselves in position prior to joining.

[0062] 4. There are fewer parts to align and join then when using other construction techniques. And because there are fewer parts to join there are fewer total inches of seams to be welded or fastened.

[0063] Also, as pressure vessel made from Kevlar or other super strong super lightweight fiber, this said container would make an excellent structure for use in outer space. This is because it would be light enough to launch into space, and once inflated, would be very resistant to impacts by virtue of the material and the tensegrity structure's remarkable ability to distribute stresses.

[0064] Although it is not depicted in any of the drawings, it is important to note that by varying the width of the some of the 6 bands as we move along their length, and by playing with the length of others, it is possible to create other bodies of revolution besides the sphere. But in my claims, I will refer to these other bodies of revolution as the spherical dodecahedron.

[0065] The remarkable ability of this spherical dodecahedral enclosure (**FIG. 15**) supported by a tensegrity dodecahedron (**FIGS. 6, 9, 10, 11** and **17**), to standup to external pressure, makes it ideal as a vacuum vessel. And with the invention of super strong, super lightweight materials such as graphite and Kevlar, we may soon be able to make vacuum vessels that are lighter than the air they displace. This would pave the way for a new airship/air-crane industry that is no longer dependent on helium for lift. Such airships and air-cranes would be less expensive to fly. Also, they would able to control their buoyancy without the need to dump expensive helium in order to sink, or dump ballast in order to rise.

I claim:

1. A spherical dodecahedral enclosure comprised of:

A). 6 bands of airtight material, woven together to form a sphere with 12 pentagonal openings and 20 places where 3 bands intersect:

B). 12 covers suitably shaped to cover the 12 pentagonal openings, and attached in such a way as to form an airtight seal.

C). The 20 intersections of said enclosure to be covered and or sealed in such a way as to form an airtight seal.

D). All other seams of said enclosure to be sealed in such a way as to make the said enclosure, airtight.

2. A spherical dodecahedral enclosure according to claim 1 wherein there are 12 pentagonal covers (each having 5 slits) that will be twisted and locked into place over each of the 12 pentagonal openings in order to center the covers over the center of the pentagonal openings in the said spherical dodecahedral enclosure.

3. A spherical dodecahedral enclosure according to claim 1 wherein there are 20 disk shaped covers with 3 slits in each, that will be twisted into place over each of the 20 places on the enclosure where 3 of the bands intersect. They will be twisted in such a way as to facilitate the location of the covers directly over the said points of intersection on the said spherical dodecahedral enclosure.

4. A spherical dodecahedral enclosure according to claim 1 wherein each of the six bands have a spherical cross section defined by swing an arc who's length is equal to the radius of the band and has it's origin at the center of the band, in a plane which is parallel with the band's axis. The purpose of said curvature is to facilitate fitting the bands together in order to create an airtight seal while also imparting a perfectly spherical contour to the structure.

5. A spherical dodecahedral enclosure according to claim 1 wherein the outer portions of the bands are cut away and removed at places where two bands overlap. The bands are then welded or joined in some manner along the same cut lines in order to impart a perfectly spherical contour and uniform wall thickness to the structure.

6. The novel combination of an internal or external dodecahedral frame work with any spherical or nearly spherical structure in such a way that the said framework is applied to the spherical structure so as to play the part of the compression elements of a tensegrity dodecahedron while allowing the surface of the sphere to play the part of the tension members, (formerly cables of some sort), of the same tensegrity dodecahedron.

7. The novel combination of the spherical dodecahedron with the tensegrity dodecahedron in which the 60 vertexes of the pentagonal openings are used to quickly and easily locate the points of attachment for the 30 required struts.

8. The novel use of towers spaced evenly around and running completely through a spherical or nearly spherical structure to support said structure at the point where a tower intersects said structure and for use as anchor points for suspension cables that will support the said spherical or nearly spherical structure to prevent collapse when evacuated.

* * * * *