Feb. 7, 1950 J. O. JACKSON 2,496,626

SPHERICAL TANK SHELL

Filed July 13, 1946 2 Sheets-Sheet 1

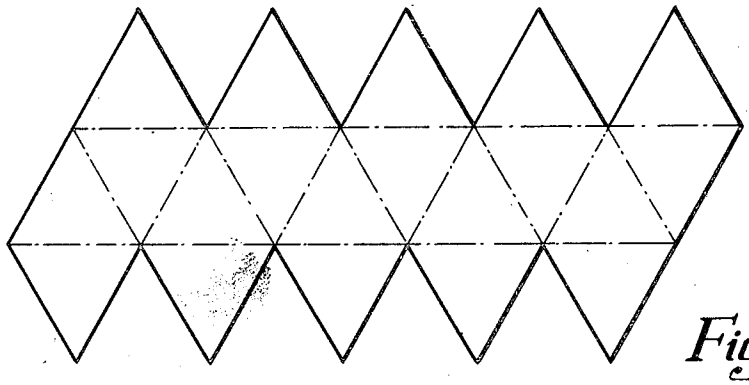


Fig. 1

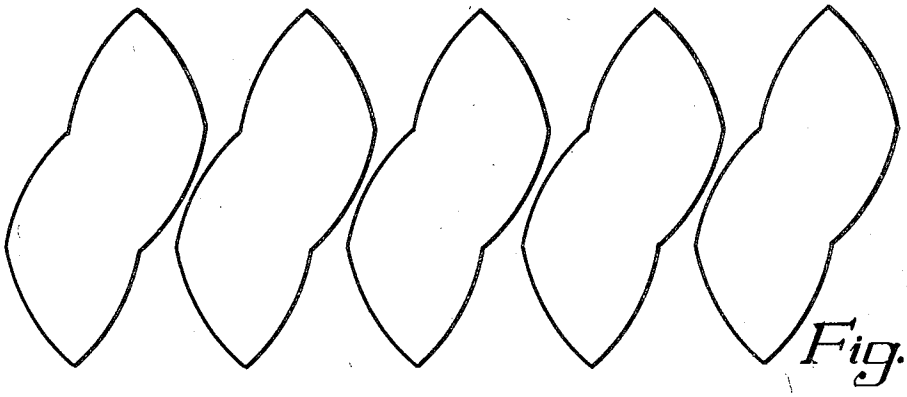


Fig. 2

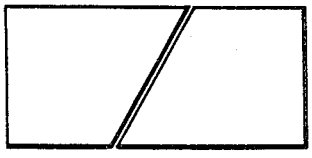


Fig. 3

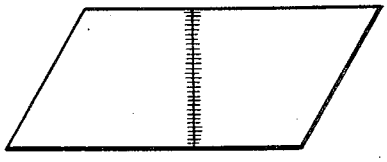


Fig. 4

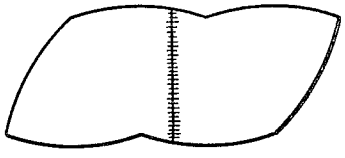


Fig. 5

INVENTOR
James O. Jackson
BY
Green, McCallister & Miller
HIS ATTORNEYS

Feb. 7, 1950 J. O. JACKSON 2,496,626

SPHERICAL TANK SHELL

Filed July 13, 1946 2 Sheets-Sheet 2

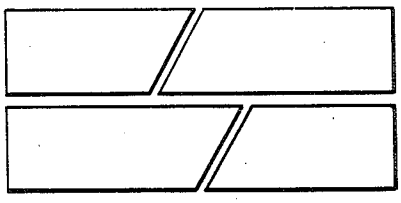


Fig.6

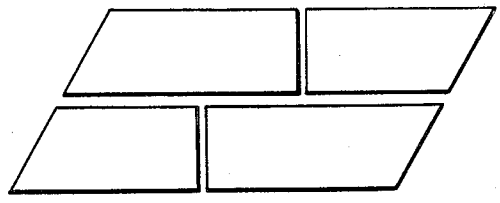


Fig.7

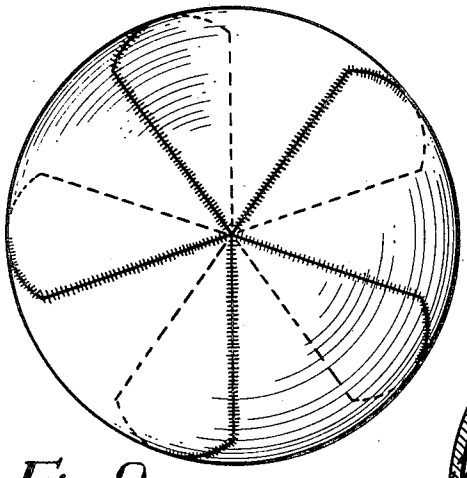


Fig.9

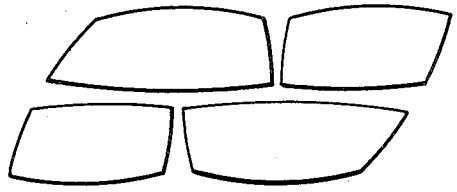


Fig.8

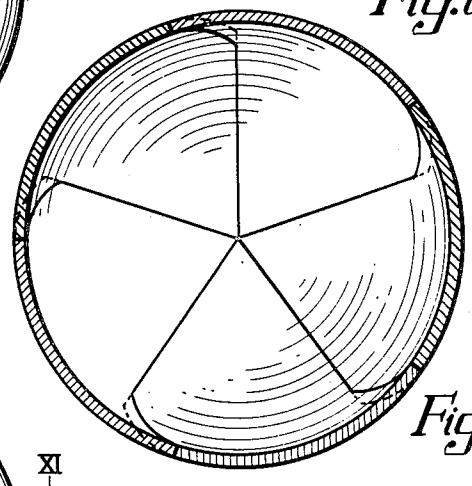


Fig.11

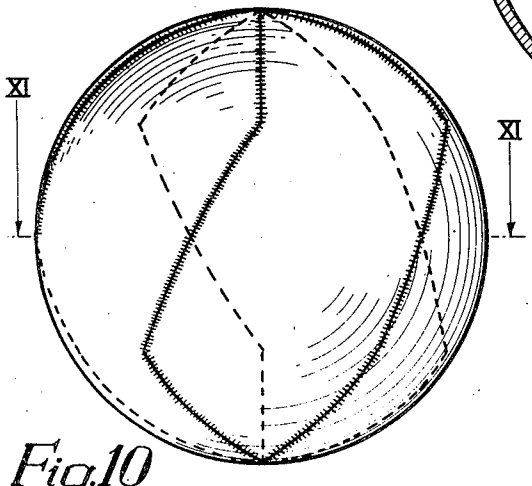


Fig.10

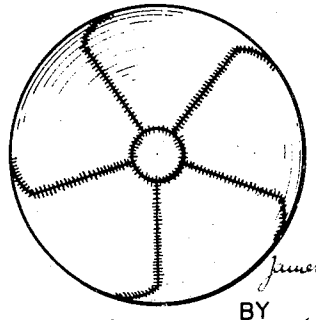


Fig.12

INVENTOR
James O. Jackson
BY
Green, McCallister & Miller
HIS ATTORNEYS

Patented Feb. 7, 1950 2,496,626

UNITED STATES PATENT OFFICE

2,496,626

SPHERICAL TANK SHELL

James O. Jackson, Crafton, Pa., assignor to Pittsburgh-Des Moines Company, a corporation of Pennsylvania

Application July 13, 1946, Serial No. 683,362

13 Claims. (Cl. 220—1)

1

This invention relates to spherical tank shells, particularly to welded spherical metallic tank shells used for the storage of gases or liquids under pressure, and to methods of making such spherical shells.

Spherical tank shells in the past have been constructed from metal plate material which has been cut into various shapes in the shop, then dished to the curvature desired to form spherical sections. These sections have then been welded or riveted together to form the spherical tank shells.

Some tank shells have been formed of plate sections such as disclosed in United States Patent 2,337,049. These sections are sometimes referred to as "orange peel" sections, the curved edges of which extend in the direction of circles of longitude on the earth's surface.

Where the shell to be produced was large, circular plates, referred to as saucers, were generally used at the two poles of the shell, and when such saucers were used the body of the shell between such saucers comprised several rows or courses of truncated "orange peel" sections as shown in said patent.

Since the material from which such tank shells are made is generally sold in the form of rectangular plates, the "orange peel" method and particularly the modification thereof in which circular plates are used at the poles of the shell, occasion an excessive amount of scrap or waste plate material. In order to reduce this amount of scrap or waste plate material, a method known as the "cube" method was devised for making riveted spherical tank shells. This method consists in arranging spherically dished plates on the six sides of an imaginary cube circumscribed by such spherical shell as disclosed in United States Patent 1,953,949.

The "cube method has the advantage that the flat plates from which the six spherical sections are formed are more nearly rectangular than the "orange peel" plate sections and therefore involve less trimming loss than is inherent in the "orange peel" method. The "cube" method was used in making riveted spherical tank shells, but with the developments in electric arc welding, and the trend toward welded tanks, the "cube" method lost favor because of the unavoidable shrinkage stresses and distortions encountered in making a welded spherical shell by such method. These shrinkage and distortion stresses are due to the arrangement of the plate sections, which prevents welding in sequence such as will permit free shrinkage.

2

When employing the "orange peel" method, in making a spherical shell, the plate sections may be sequentially welded together around the circumference of the shell, thus permitting each shell part to shrink to a smaller size without restraint.

An object of this invention is to produce an improved welded spherical tank shell.

Another object is to provide an improved method of making welded spherical tank shells.

Another object is to provide a method of making welded spherical tank shells which avoids much of the waste and scrap loss inherent in the "orange peel" method, and avoids objectionable shrinkage stresses and distortions inherent in welded shells made by the "cube" method.

A still further object is to provide a method of producing spherical tank shells from rectangular plate-like material with but a minimum amount of scrap or waste material.

These and other objects which will be apparent to those skilled in the art of making spherical tank shells, I attain by the structure and method described in the specification in connection with the diagrammatic views of the drawings in which:

Figure 1 is a development of an icosahedral shell comprising five connected parallelogrammic units, capable of forming, by suitable bending on the dot and dash lines, the twenty equilateral triangular faces of a shell having the form of a regular convex icosahedron;

Fig. 2 is an outline view of five units that are parallelogrammic in the main and are patterned after the units of Fig. 1. The units are separated, have their sides curved and are of a form which can be used in carrying out the method of this invention in forming a spherical tank shell;

Figs. 3 and 4 illustrate one way of cutting a rectangular plate, then transposing and welding together the cut parts to form a straight-sided parallelogrammic unit;

Fig. 5 illustrates a parallelogrammic unit such as disclosed in Fig. 2, formed from flat plate material in accordance with the disclosures of Figs. 3 and 4;

Figs. 6 and 7 disclose one way of forming parallelogrammic units for large tank shells. Each of these units comprises two rectangular plates which are diagonally cut and transposed;

Fig. 8 is a view similar to Fig. 7 after the four parts of the parallelogrammic unit of Fig. 7 have been trimmed, ready to be dished to the contour of the shell;

Fig. 9 is a top plan view of a spherical shell constructed from five parallelogrammic units in accordance with this invention;

Fig. 10 is a view in side elevation of the tank shell in Fig. 9;

Fig. 11 is a sectional view of such tank shell taken on line XI—XI of Fig. 10; and

Fig. 12 is a view similar to Fig. 9 but includes a relatively small circular plate section at at least one pole of the shell.

It has long been known that a hollow shell having the form of a regular convex icosahedron can be constructed from five similar pieces of sheet material, each having the form of a parallelogram, whose long sides are each equal in length to two sides of one of the twenty regular triangular faces of such icosahedron and whose short sides are each equal in length to one such side. The area of each such parallelogrammic piece, therefore, equals the combined areas of four of the twenty regular faces of the icosahedron.

Since such icosahedron can be circumscribed by a sphere that touches all of the vertices of all of its twenty triangular faces, it is possible to divide the entire surface of such sphere into twenty abutting equilateral spherical triangles.

It therefore follows that a spherical tank shell can be constructed from twenty similar equilateral triangular sections of plate-like material that are dished to the contour of the shell to be produced and which after dishing, have their edges trimmed so that they will interfit to form the complete spherical shell. The dishing and trimming operations convert the equilateral triangular sections into equilateral spherical triangular shell sections. Instead of dishing and then trimming, the flat plate-like material can be divided into twenty pieces each having the outline of a development of one of the twenty similar equilateral triangular spherical shell sections.

Welded spherical tank shells can be fabricated from such spherical triangular sections, but it would involve an excessive amount of welding, and, unless the spherical triangular sections were welded together in a manner which permits free shrinkage of each such section, the completed shells would contain excessive weld shrinkage stresses and distortions.

I have found that the welding can be materially reduced, weld shrinkage stresses and distortions reduced to a negligible quantity and rectangular plate-like material can be used with but a minimum of waste or scrap loss, if the twenty equilateral spherical triangular shell sections into which a spherical shell surface is capable of being divided are grouped into five similar units, each of which in the main has the form of a parallelogram, but has curved sides or edges as disclosed in Figs. 2, 5 and 8.

In what I now consider the preferred manner of carrying out the method of this invention, I divide the spherical shell to be produced into twenty similar equilateral spherical triangles, or spherical triangular shell sections. I arrange these triangular sections in five similar groups each of which forms a unit which embraces four of the twenty triangles making up the complete spherical shell. The four triangles of each such group or unit are arranged side by side in abutting but alternately reversed relation, to form, when such triangles are developed, a figure having an outline which in the main is that of a parallelogram, except that each of the long sides of each such figure comprises two curved sides of two of the four spherical triangles when developed, while the short sides each comprise one such curved side, as disclosed in Figs. 2 and 5.

The five parallelogrammic units are then dished to form spherical shell sections having the contour of the spherical shell to be produced. These spherical sections are secured together in side by side relation, preferably by welding, to produce the complete spherical tank shell with the extreme ends of the five spherical sections meeting at opposite poles of the spherical shell as disclosed in Figs. 9 to 11 inclusive.

In some spherical tanks, it may be desirable to place a relatively small circular plate section at one or both poles of the shell as shown in Fig. 12 for the purpose of accommodating manholes or other tank elements. When this is done, the five spherical shell units which normally extend from pole to pole and meet at such poles will either have to have one or both ends, as the case may be, trimmed to accommodate such circular plate section or sections, or may have one or both ends purposely formed to accommodate such circular section or sections to which they are united as by welding. When a circular plate section is used at a pole of the spherical shell, the end triangle of the four into which each spherical shell unit is divisible, will be more or less truncated or minus its extreme outer vertex. In such case, the spherical shell units will not extend exactly, but substantially from pole to pole.

If the tank shell to be produced is relatively small, the five spherical sections can be assembled in position and temporarily connected together, as by tack welding after which the shell sections are permanently welded together in a fluid-tight manner. In this welding procedure, two adjacent sections are first welded together throughout the full extent of their abutting edges. Welding of the other shell sections to these may then proceed in either direction around the circumference of the shell, and as long as each weld seam between adjacent shell sections is completed throughout its full length before welding of the next adjacent seam has started, the shell sections can shrink without restraint.

If the tank shell is relatively small, all five units may be cut from one long flat plate, or each of the five units can be formed from a single small flat plate by diagonal cutting, transposing and welding, as disclosed in Figs. 3, 4 and 5. As shown in Figs. 2 and 5, each of these units is given an outline which in the main is that of a parallelogram, but has the exterior edges or sides of the four triangles embraced in each such unit, slightly curved as they appear when the spherical triangles are developed. They then appear substantially as shown in Figs. 2 and 5. The curved edges or sides allow for the dishing operation which transforms them into spherical sections.

The dimensions of each of the five parallelogrammic units will depend upon the size of the spherical tank shell to be produced.

When the tank shell is to be relatively large, each of the parallelogrammic units may be a multi-part unit made from any desired number of pieces of rectangular plate material without producing excessive scrap or waste material. Fig. 8 discloses such a multi-part unit having four parts and such unit may be made from two rectangular plates by following the procedure depicted in Figs. 6 and 7. In this procedure, each of the two rectangular plates is cut diagonally as shown in Fig. 6 to form one long and one short plate. These four plates are then transposed and arranged as disclosed in Fig. 7 to form such multi-part parallelogrammic unit. Each of the parts making up such unit may then be trimmed as

shown in Fig. 8 or they may be dished and then trimmed. I prefer to trim them before dishing, since the procedure is simpler. Some scrap loss will be produced by following either procedure, but the amount will be less than produced when using the "orange peel" method in constructing a spherical shell.

By way of example, in constructing a spherical tank shell 28'9½'' inside diameter, utilizing the "orange peel" method, it is necessary to purchase 3670 square feet of steel plate material. Such a tank shell requires 590 lineal feet of seam welding. In constructing, by the method of this invention, a spherical tank shell of the same diameter, I need to purchase but 2900 square feet of steel plate material and the seam welding amounts to but 476.5 lineal feet. The saving in steel plate material for the spherical shell utilizing the method of this invention as against the "orange peel" method, therefore, amounts to 19%, while the saving in the welding procedure amounts to 21%.

In constructing large spherical tank shells from multi-part units, the several parts of each such unit will be trimmed and dished in the shop, shipped to the point of erection and assembled and welded in the field. It is, therefore, advisable to so mark each part of the different multi-part units that its proper position within the unit of which it forms a part can be readily ascertained and maintained.

In making welded spherical tank shells, the individual spherical shell units making up such shells may overlap as in riveted spherical tank shells. In order to make these lap joints, either welded or riveted, the individual spherical shell units will be made oversize and the center lines of the overlaps, whether the tank shell is lap welded or riveted, will define five similar spherical triangular shell units. Each of the five units thus defined will be divisible into four equilateral triangular shell sections arranged side by side in alternately reversed abutting relation.

When lap joints are used, one or both units of any adjacent pair of units may be oversize in order to provide for the lap. Whether such lap is all provided in one of a pair of adjacent units or in both such adjacent units, the center line of the lap—when both units are oversize or the outline of the normal unit when only one unit is oversize—will be considered the outline of each unit of the adjacent pair and such outline will be divisible into four equilateral spherical triangular shell units of the same size arranged side by side in alternately reversed abutting relation.

In addition to complete spherical tank shells, the method of my invention is valuable and of advantage in the making of partial spherical tank shells, such for example as half, or hemispherical tank shells or tank bottom portions.

A hemispherical tank shell embodying this invention may be made in several ways. One way is to in effect prepare the spherical shell units as though a complete spherical shell were to be made, then cut each shell unit transversely into halves and construct two hemispherical tank shells from such half units.

Another way is to utilize two spherical shell units, each having an overall length equal to substantially half the circumference of the shell to be produced and being divisible into four equilateral spherical triangular shell sections of the same size arranged in reversed abutting relation, and then in filling each of the gaps on opposite sides of the adjacent pair of shell units with a

spherical shell section made in the form of a spherical isosceles triangle having two sides each equal in length to one of the sides of the four equilateral triangles of the adjacent units and each having its third side equal in length to half the circumference of the shell minus the length of one side of such equilateral triangles.

Still another way is to lay out two regular spherical shell units, each divisible into four equilateral spherical triangular shell sections of the same size arranged in reversed abutting relation. Then lay out the two shell sections made in the form of spherical isosceles triangles above referred to, one for each side of the double unit. Then place these in position in the layout. This will form two spherical units, each having a spherical surface equalling the spherical surface of one half of the hemispherical shell, or five of the regular twenty equilateral triangular sections into which the complete spherical shell is divisible.

What I claim is:

1. A hollow spherical tank shell comprising five similar spherical shell units connected together in a fluid-tight manner and each being divisible into four equilateral spherical triangular sections of the same size, arranged side by side in alternately reversed abutting relation and which take in the entire area of such unit.

2. A hollow spherical shell comprising five spherical shell units connected together in a fluid-tight manner and in side by side relation, each such unit extending substantially from one pole to the opposite pole of such shell and each being divisible into four substantially complete equilateral spherical triangular shell sections of the same size arranged side by side, in alternately reversed abutting relation and which take in the entire area of such spherical shell unit.

3. A spherical shell section for use as a unit in making a spherical or hemispherical tank shell, such unit having an overall length substantially equalling one half the circumference of the tank shell or part to be produced and being divisible into four equilateral spherical triangular shell sections of the same size arranged side by side in alternately reversed abutting relation and which take in the entire area of such shell unit.

4. A hollow welded spherical metallic tank shell comprising five multi-part spherical shell units arranged in side by side relation, each such unit extending substantially from one pole of such shell to the opposite pole thereof, each such unit being divisible into four substantially complete equilateral spherical triangular sections arranged side by side, in alternately reversed abutting relation and which take in the entire area of such unit, such multi-part units and the parts thereof being welded together in a fluid-tight manner.

5. A hemispherical tank shell comprising two units each having an overall length substantially equalling one half the circumference of the tank shell and being divisible into four equilateral spherical triangular shell sections of the same size arranged side by side in alternately reversed abutting relation, and two spherical isosceles triangular shell sections each having two of its sides equal in length to one side of such equilateral triangular sections and its third side equal in length to one half the circumference of the shell minus the length of one side of such equilateral triangular sections; such shell sections into which each unit is divisible embracing the entire area of such unit.

6. A multi-part parallelogrammic unit for use in making a spherical or hemispherical tank shell, such unit having an overall length substantially equalling one-half the circumference of the tank shell or part to be produced, comprising a number of spherical shell sections connected together in a fluid-tight manner, being divisible into four equilateral spherical triangular shell sections of the same size arranged side by side in alternately reversed abutting relation and taking in the entire area of such unit.

7. A multi-part parallelogrammic unit for use in making a spherical or hemispherical tank shell, such unit having an overall length substantially equalling one-half the circumference of the tank shell or part to be produced, comprising a number of spherical shell sections welded together in a fluid-tight manner, being divisible into four equilateral spherical triangular shell sections of the same size arranged side by side in alternately reversed abutting relation and taking in the entire area of such unit.

8. A multi-part parallelogrammic unit for use in making a spherical or hemispherical tank shell, such unit having an overall length substantially equalling one-half the circumference of the tank shell or part to be produced, comprising a number of spherical shell sections arranged in overlapping relation, riveted together in a fluid-tight manner, being divisible into four equilateral spherical triangular shell sections of the same size arranged side by side in alternately reversed abutting relation and taking in the entire area of such unit.

9. A multi-part parallelogrammic unit for use in making a spherical or hemispherical tank shell, such unit having an overall length substantially equalling one-half the circumference of the tank shell or part to be produced, comprising a number of spherical shell sections arranged in overlapping relation, connected together in a fluid-tight manner, being divisible into four equilateral spherical triangular shell sections of the same size arranged side by side in alternately reversed abutting relation and taking in the entire area of such unit.

10. A hollow spherical shell comprising five spherical shell units connected together in a fluid-tight manner and in side by side relation, each such unit extending substantially from one pole to the opposite pole of such shell and each being divisible into four substantially complete equilateral spherical triangular shell sections of the same size arranged side by side, in alternately reversed abutting relation and which take in the entire area of such spherical shell unit, such shell having a circular plate section located at at least one of its poles and having substantially one-fifth of its peripheral edge connected in a fluid-tight manner to each of such spherical shell units.

11. A hollow spherical shell comprising five spherical shell units connected together in a fluid-tight manner and in side by side relation, each such unit extending substantially from one pole to the opposite pole of such shell and each being divisible into four substantially complete equilateral spherical triangular shell sections of the same size arranged side by side, in alternately reversed abutting relation and which take in the entire area of such spherical shell unit, such shell having a circular plate section located at each of its poles, each such circular plate section having substantially one-fifth of its peripheral edge connected in a fluid-tight manner to each of such spherical shell units.

12. A hollow spherical tank shell comprising five similar overlapping spherical shell units connected together in a fluid-tight manner and in which the center lines of the overlaps around each such unit define a figure which is divisible into four equilateral spherical triangular sections of the same size arranged side by side in alternately reversed abutting relation and which take in the entire area of such figure.

13. A hollow spherical shell comprising five spherical shell units connected together in a fluid-tight manner and in overlapping relation, each such unit extending substantially from one pole to the opposite pole of such shell and in which the center lines of the overlaps define five figures each of which is divisible into four substantially complete equilateral spherical triangular shell sections of the same size arranged side by side, in alternately reversed abutting relation and which take in the entire area of such spherical shell unit.

JAMES O. JACKSON.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
425,099	Gothberg	Apr. 8, 1890
1,916,051	Jagschitz	June 27, 1933
2,117,314	Goodrich	May 17, 1938
2,118,388	Zerbe	May 24, 1938
2,287,198	Sandberg	June 23, 1942