

June 10, 1969

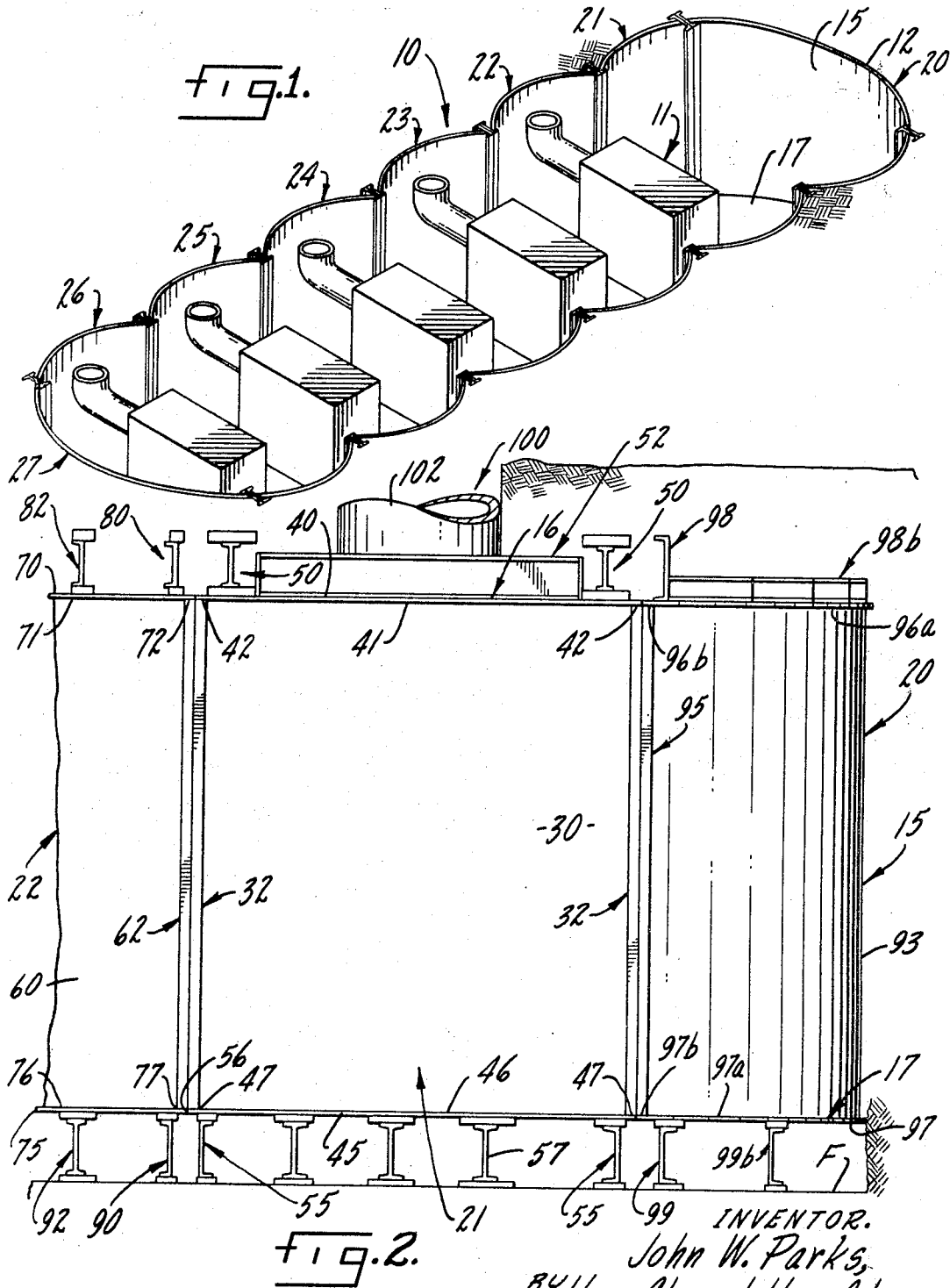
J. W. PARKS

3,448,885

CELLULAR PUMP STATION STRUCTURE

Filed Sept. 15, 1967

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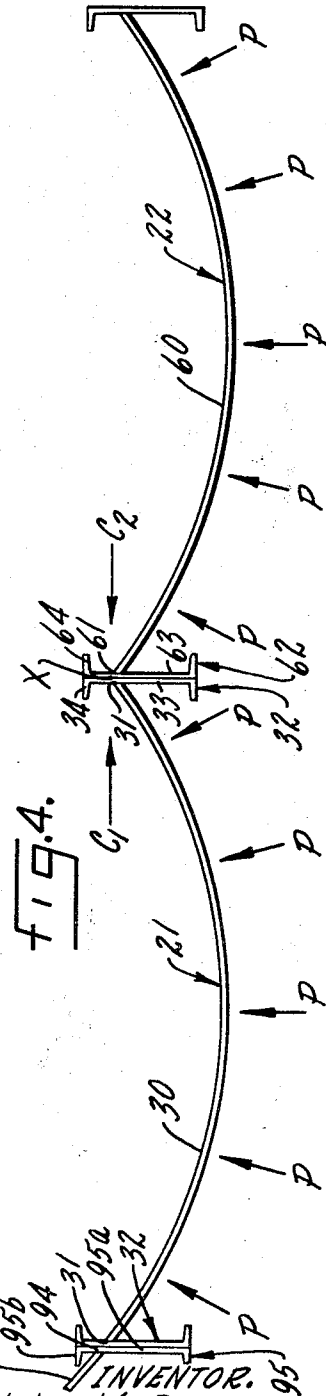
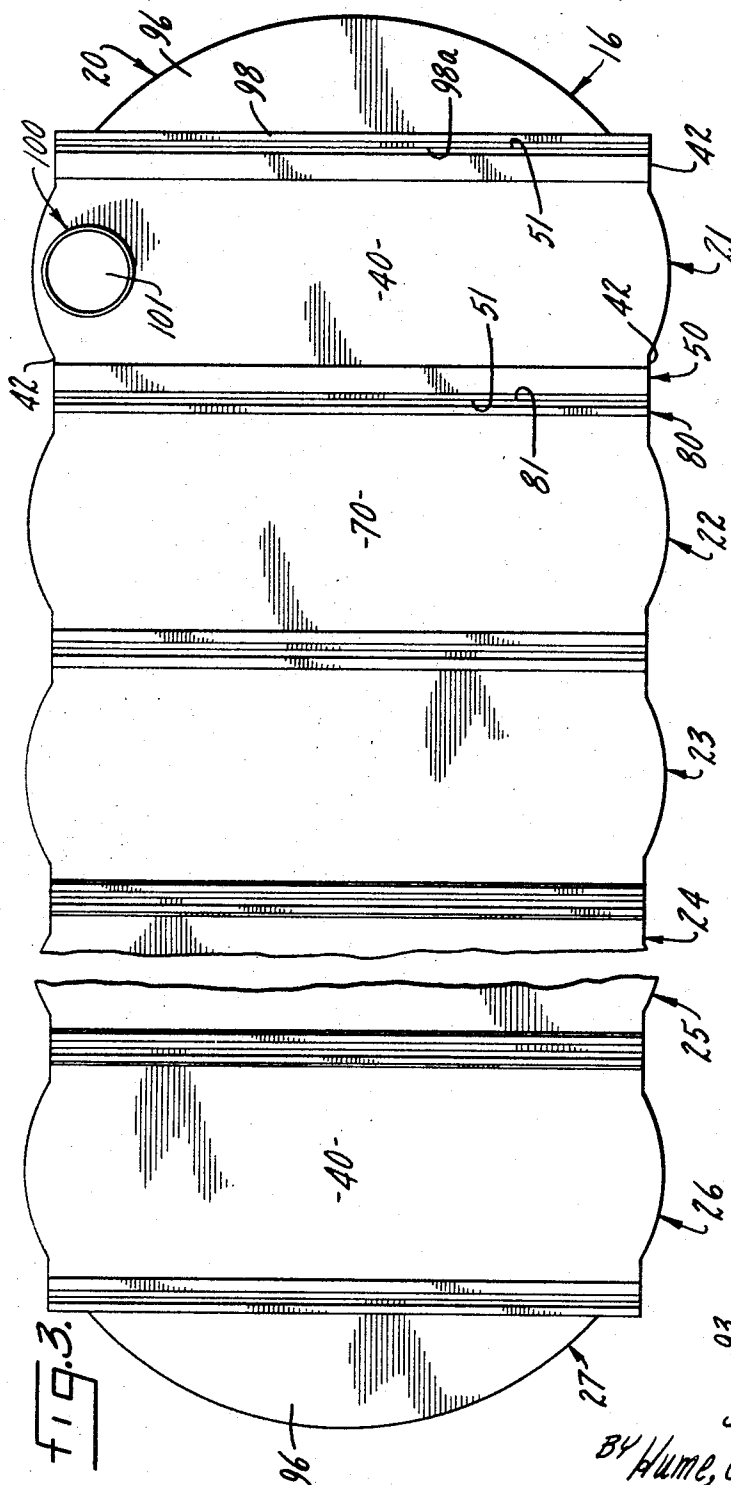
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Sheet 2 of 2



INVENTOR.
John W. Parks,
BY Hume, Clement, Hume & Lee
Attorneys.

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CELLULAR PUMP STATION STRUCTURE

John W. Parks, Shawnee Mission, Kans., assignor to Union Tank Car Company, Chicago, Ill., a corporation of New Jersey

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13 Claims

ABSTRACT OF THE DISCLOSURE

A longitudinally elongated container for an underground equipment installation. The container is fabricated in separate sections having truncated cylinder wall segments and transported to a site where sections are joined. Wall segment arch strength counteracts lateral load.

This invention relates in general to large containers. It deals particularly with large containers especially adapted for use in an underground environment.

In a self-contained sewage treatment system, for example, it is conventional to house the pumping equipment for the system in an underground container. Normally this equipment includes a plurality of pumps arranged side-by-side, in an elongated series. The protective container must necessarily have a generally horizontal, elongated configuration to house the equipment, as will readily be understood.

The simplest form of a horizontally elongated container can take is, of course, a rectangular box-like structure having a flat side, end, top and bottom walls. Where the container is buried underground, however, the external pressure caused by the weight of the earth and effective on the flat walls necessitates substantially reinforcing the walls to prevent their collapse under stress. This is particularly true in a hollow container containing no liquid sewage or the like to counteract external pressures. The heavy reinforcement required in such a container necessarily increases the cost of the container substantially.

The object of the present invention is to provide a container structure for housing pumping equipment or the like underground wherein the container side walls are able to withstand relatively high compressive loads from the surrounding earth without extensive reinforcing structure. The foregoing and other objects of the invention are realized in a container which is horizontally elongated, yet has side walls with arcuate cross-sectional configurations. More precisely, a plurality of generally elliptical cylindrical sections fabricated of steel plate are truncated parallel to their major axes so that their truncated edges match each other in vertical planes. The truncated edges are welded together to form a continuous side wall for a container.

When the sections are fabricated, channel members are welded to their vertical straight edges in one form of the invention. In assembling the container on location, the backs of opposing channel members are welded then together to form what are, effectively, I-beams. These I-beams are tied to the opposite ends of horizontal brace members through the top and bottom walls of the container to provide reinforcement of the side walls at those points where external pressure is not effectively counteracted by compressive strength of the arcuate side wall sections; that is, at the vertical weld joints. The resultant rectangular reinforcing structures formed by the I-beams and the cross members provide the only reinforcement required by the side walls in the container constructed according to the present invention.

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According to the method of the invention, the container structure is actually fabricated in a series of generally cylindrical sections truncated on one or both sides and provided with a top wall member and a bottom wall member. Each of the sections is constructed so that its external dimensions fall within the maximums permitted by shipping limitations. The equipment to be enclosed by the finally assembled container is mounted within the sections in a suitable manner at the system manufacturer's plant. The sections are then transported to the system site in this form and assembled in a suitably formed excavation.

The invention described generally above, including further objects and advantages thereof, is illustrated more or less diagrammatically in the drawing, in which:

FIGURE 1 is a top perspective view of a container constructed according to the invention seated in its underground location, with the earth above the container and the container top removed;

FIGURE 2 is an enlarged side elevational view of the container illustrated in FIGURE 1, in position underground, with parts removed;

FIGURE 3 is a top plan view of the container with parts removed; and

FIGURE 4 is a plan view of a portion of the container side wall showing the forces effective on the cylindrical segments of the container side walls and at the weld joints between the segments.

Referring now to the drawings, and particularly to FIGURE 1, an underground pumping station for sewage or the like is seen generally at 10. The pumping station 10, which is buried several feet under the soil, includes a plurality of pumps 11 arranged in a longitudinally elongated series within a container 12 constructed according to the present invention.

The container 12 is constructed in such a manner that it readily withstands the lateral load imposed on it by the surrounding soil; the lateral load being that part of the weight of the soil which is converted to lateral pressure and is dependent on the shear characteristics of the soil. Nevertheless, the side wall 15 of the container 12 requires almost no reinforcements, notwithstanding the fact that in operation the container holds no liquid such as sewage or the like to provide an effective counter-force to this lateral load.

Referring now to all of the figures, the container 12 includes a top wall 16, and bottom wall 17, in addition to the side wall 15, all fabricated of steel sheet. The top wall 16 and bottom wall 17 have conventionally flat configurations. The side wall 15 configuration is characterized, according to the invention, as a series of truncated generally elliptical cylinders.

The container 12 is fabricated in separate sections 20-27 at the manufacturing plant and transported to the sewage system site in this form. In this light, six sections 20-27 are illustrated. Each of the intermediate sections 21-26 is approximately 10 feet in width, and the end sections are approximately 5 feet wide if an overall container length of 70 feet is desired. Each section thus falls within generally accepted shipping width limitations dictated by enroute obstacles, road widths, etc. A greater or fewer number of these sections might be employed, according to the length of the container 12 required as determined by the number of pumps 11, for example.

Each of the end sections 20 and 27 is substantially identical to the other in the present illustration. Accordingly, only one end section 20 is described in detail. The intermediate sections 21-26 are also identical to each other in the present illustration, although their size and configurations might vary as will hereinafter be explained. Two adjacent intermediate sections are described in detail.

Referring first to the intermediate sections 21 and 22, the section 21 comprises a pair of identical, oppositely disposed side wall members 30 in the shape of truncated cylinders. The truncated cylindrical members 30 are arranged so that corresponding vertically extending edges 31 on opposed members 30 define vertical juncture planes between the sections 20-27.

In the illustrated form of the invention, a channel element 32 is welded to each vertical edge 31. As will be recognized, the web 33 of each channel element 32 is welded to a corresponding side wall edge 31 so that its web 33 lies in the juncture plane of the container section 21 and its flanges 34 extend perpendicularly away from this plane. The welds are usually made nearer the inner flange 34 of the channel elements 32 to assure maximum space utilization within the finished container 12.

The intermediate section 21 further includes an elongated flat top wall member 40 with the shape of its opposite ends corresponding substantially to the cross-sectional configuration of each side wall member 30. The top wall member 40 is welded at these ends to the upper edge of the side wall member 30, as at 41. The top wall member 40 also extends out over and is welded to the webs 33 and flanges 34 at the upper end of each channel element 32, as at 42.

A bottom wall member 45 is substantially identical in configuration to the top wall member 40. It is also welded, at its opposite ends, to the lower edges of the side wall members 30, as at 46, and to the corresponding portion of the lower end of each channel element 32, as at 47.

The intermediate container section 21 also includes a roof beam assembly 50 on the upper surface of the top wall member 40 immediately adjacent each straight edge 51 of the top wall member. Additional roof beam structure 52 extends longitudinally of the container 12 in the manner illustrated. Since roof beam construction and arrangement forms no specific part of the present invention, however, it is not described in detail.

The bottom wall member 45 also is provided with floor beam assemblies 55 adjacent corresponding straight edges 56 of the bottom wall member. Additional floor beam structure 57 is provided intermediate the beam assemblies 55. Once again, a detailed description is not in order since no specific part of the invention is involved.

Turning now to the intermediate container section 22, it comprises a pair of identical, oppositely disposed side wall members 60. In the present illustration the radius of curvature of each side wall member 60 is identical to the radius of the curve defined at each end of the aforescribed side wall members 30. In the form of the invention illustrated, a channel element 62 identical to the channel elements 32 hereinbefore described is welded to the vertically extending edges 61 of each side wall member 60.

A channel element 62 is welded to each corresponding edge 61 of each side wall member 60 at the web 63 of the channel element 62 with the web lying in the corresponding juncture plane defined by the edges 61 of the side wall members 60 in the intermediate container section 21. The flanges 64 of each channel element 62 extend perpendicularly inward of the corresponding plane.

The intermediate section 22 of the container further includes an elongated flat top wall member 70, having arcuate ends corresponding to the cross-sectional configuration of the side wall members 60. The top wall member 70 is welded along its arcuate edges to the upper edges of corresponding side wall members 60, as at 71. The top wall member 70 also extends over and is welded to the entire upper end of each channel element 62, as at 72.

The bottom wall member 75 is identical in shape to the top wall member 70 in the intermediate section 21. The bottom wall member 75 is welded along its arcuate edges to the corresponding lower edges of corresponding

side wall members 60, as at 76, and to the lower end of each channel element 62, as at 77.

The intermediate container section 22 also includes a roof beam assembly 80 on the upper surface of the top wall member 70 immediately adjacent each straight edge 81 of the top wall member. Additional roof beam structure 82 extends parallel to the beam assemblies 80 between them (only one seen in FIGURE 2). The bottom wall member 76 is provided with corresponding floor beam structure 90 and 92. Since the roof and floor beam structure form no specific part of the present invention, they are not described in detail.

The end sections 20 and 27 are substantially identical in construction, as has been pointed out. Referring then to the section 20 as exemplary of both, it comprises a single end wall member 93 having the shape of a truncated right circular cylinder. The radius of curvature of the wall member 93 is substantially greater than that of each adjoining side wall member 30 in the adjacent intermediate section 21, however.

Welded to each vertical edge 94 of the end wall member 93 is a channel element 95 having its web 95a disposed in the plane of juncture of the end section 20 and intermediate section 21 and its flanges 95b extending perpendicularly away from the plane. The corresponding end wall member edges 94 and channel elements 95 are illustrated in welded relationship in FIGURE 4.

The end container section 20 further includes a segmented circular top wall member 96 welded to the upper edge of the end wall member 93, as at 96a. The top wall member 96 also extends over and is welded to the upper end of each channel element 95, as at 96b.

A bottom wall member 97 identical in configuration to the top wall member 96 is welded to the lower edge of the side wall member 93, as at 97a. The bottom wall member 97 also extends under and is welded to the lower end of each channel element 95, as at 97b.

A roof beam 98 is welded to the top wall member 96 adjacent to and generally coextensive with its straight edge 98a. Additional roof beam structure 98b is also welded on the wall member 96 in the orientation illustrated in FIGURE 2, for example. A floor beam assembly 99 and additional beam structure 99b are welded to the bottom wall member 97 in the orientation illustrated. Since they form no specific part of the invention, these beam structures are not described in detail.

In addition to the aforescribed construction, the container 12 also has one or more access means for personnel and equipment. Referring to FIGURE 2, a personnel access arrangement 100 is illustrated on the intermediate container section 21. The access arrangement 100 includes a suitably sized and shaped port 101 in the top wall member 40 of the section 21. An elongated sheet steel cylinder 102 is welded over the port 101 so that it extends from the top wall member 40 to a point which will ultimately be above ground.

With each of the container sections 20-27 fabricated in the aforescribed manner, including the appropriate mounting of pumps 11 therewithin, the sections are transported separately to the system site. As has been pointed out, their segmented size facilitates shipping with ease within shipping size limitations. In an excavation especially formed for receipt of the system 10, the sections 20-27 are arranged in end-to-end relationship on the floor F of the excavation (see FIGURE 2). In this relationship, the sections rest on the floor beam assemblies and structure 55, 57, 99 and 99b.

Arranged in end-to-end relationship, the end container sections 20 and 27 and the intermediate container sections 21-26 abut each other along their sides at the webs 95a, 33 and 63 of corresponding channel members 95, 32 and 62, respectively, and along the truncated edges 51, 98a and 51, 81, for example, of top and bottom wall members. The webs 95a, 33 and 63 of these vertical channel elements are welded together, as are the horizontal

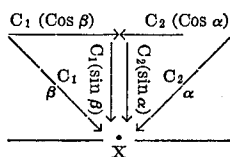
straight edges of the wall members. The container 12 is thus assembled according to the invention.

After assembly in the excavation in the aforescribed manner, the container 12 is covered with soil. The depth to which the container is buried determines the effective force which bears upon the top wall 16 and side wall 15 of the container. A part of the weight of the soil is converted to lateral pressure on the side wall 15, dependent upon the shear characteristics of the soil. The bottom wall 17 is under pressure exerted by ground water.

The side wall 15 is subjected to a lateral load P at any specific depth. According to the invention, these lateral loads P are resisted by the arch strength of the cylindrical side wall members 30, 60 and 93. Circumferential compressive stress C is developed in these members. This circumferential compressive stress C is effectively counter-balanced by arch strength to the point where no reinforcement of the side wall members 30, 60 and 93 is required in their arcuate expanses in order to prevent wall failure under the loads P .

As to the junctures between these side wall members, attention is directed to FIGURE 4 where the adjacent intermediate sections 21 and 22 of the container 12 are illustrated. The compressive stress in the cylindrical side wall member 30 of the section 21 is C_1 , while the corresponding stress in the identical side wall member 60 of the intermediate section 22 is C_2 . These stresses are a function of lateral soil load P , as has been pointed out. The stresses C_1 and C_2 exert a load on the juncture of the two wall members 30 and 60, at point X.

The load effective at a selected side wall seam, at any point X on the seam, is illustrated by the following vector diagram:



From this vector diagram, it will be seen that effective longitudinal load on the wall seam at point X equals $C_1 (\cos \beta) - C_2 (\cos \alpha)$. The effective lateral load on the wall seam at point X on the other hand, equals $C_1 (\sin \beta) + C_2 (\sin \alpha)$. Where the radii of curvature of adjacent side wall members 30 and 60 are identical, and thus the angles β and α are equal, the only uncounteracted load to which point X is subjected is a lateral load of $2C_1 (\sin \beta)$.

It is this lateral uncounteracted load which the vertical beams formed by the welded channel elements 32 and 62 at the wall seams counteract according to the invention. These vertical beams are tied at their upper and lower ends by the top and bottom wall members 40, 45 and 70, 75, respectively, and the roof and floor beam structure. As a result, a rectangular reinforcing "framework" at the juncture planes between each pair of adjoining container sections 21, 22, et seq., is constructed sufficiently sturdy to resist the calculated resultant lateral load equal to $2C_1 (\sin \beta)$.

At the juncture plane between the end section 20 and the intermediate section 21, the generally continuous curve of the wall results in the forces counteracting each other, as will be recognized. The only unbalance is a result of the difference in length between the intermediate section side wall members 30 and that of the end sections end wall member 93. This unbalance of resultant forces (both laterally and longitudinally of the container 12) which are not counteracted by the arch strength of the cylindrical wall members are in the illustrated form of the invention, easily resisted without wall 15 deformation by the vertical beams formed of channel elements 32

and 95 welded together and tied at their upper and lower ends.

The container 12 has been described in terms of eight separate sections 20-27, with all the intermediate sections 21-26 identical and the end sections 20 and 27 similarly identical. As will be recognized, the sections 20 and 27 form, with adjacent intermediate sections 21 and 26, what are referred to as "four point" ellipses. The side wall members 30 and 60 of the intermediate sections are segmented right circular cylinders. In practice, however, different wall members 30 and 60 of the container 12 might have cylindrical or even true elliptical forms varying from adjacent sections so that laterally extended or shortened sections are formed. This is to accommodate larger or smaller equipment within each section of the container 12, for example. It is only necessary that the mating rectangular openings at the planes of truncation be of identical dimensions. Where adjacent intermediate sections 21 and 22, for example, have different side wall member arcuate configurations, variations in resultant forces at the juncture planes are also effected. Longitudinal resultant forces as well as lateral forces are effected. The vertical beam structure counteracts longitudinal as well as lateral loads. The vertical beam structure serves the additional function as a column support for roof and floor loads, of course.

The container 12 has been described as inclusive of eight container sections 20-27. As previously pointed out, however, where more or less equipment is required within the container 12, a greater or fewer number of sections might be employed in constructing the container. Regardless of the number of sections, stress control is identical to that hereinbefore described.

While the embodiment described herein is at present considered to be preferred, it is understood that various modifications and improvements may be made therein.

What is desired to be claimed and secured by Letters Patent of the United States is:

1. A horizontally elongated container for an underground equipment installation, comprising:

- (a) A plurality of container sections,
- (b) each of said sections including side wall segment means unreinforced by horizontal support members and defining a truncated cylinder,
- (c) said sections being fabricated separately and joined together in seams at vertical juncture planes to form a continuous container, and
- (d) vertical beam means disposed in the seams between adjacent vertical edges of said side wall segment means and welded to said edges,
- (e) each of said sections including a top wall member overlying and welded to the arcuate horizontal upper edge of corresponding side wall segment means and a bottom wall member underlying and welded to the arcuate horizontal lower edge of said corresponding side wall segment means.

2. The container of claim 1 further characterized in that:

- (a) said top wall members extend over the upper ends of corresponding vertical beam means and said beam means upper ends are welded to the underside of said top wall members, said bottom wall members extend under the lower ends of corresponding vertical beam means and said beam means lower ends are welded to the upperside of said bottom wall members, whereby said vertical beam means are directly tied together transversely of said container at corresponding seams solely by said wall members.

3. The container of claim 2 further characterized by and including:

- (a) transversely extending horizontal beam means welded to the outside of each of said top wall members and said bottom wall member.

4. The container of claim 1 further characterized in that each of said vertical beam means is fabricated with

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cross-sectional dimensions to provide sufficient lateral strength at a corresponding seam to counteract a force effective at the seam of $2C_1 (\sin \beta)$ where C_1 equals the compressive load in each side wall segment means bracketing the beam, and β equals the effective angle from the longitudinal container axis of the load at the seam effected by compression in the bracketing side wall segment means.

5. The container of claim 2 further characterized in that:

- (a) each of said vertical beam means includes substantially identical beam elements welded to the adjacent vertical edges of each of said sections,
- (b) said beam elements being joined together to connect said sections and form the container.

6. The container of claim 5 further characterized in that:

- (a) said beam elements are channel elements with their bases welded to corresponding edges and their flanges extending toward corresponding side wall segment means,
- (b) said bases of adjacent channel elements being welded together when the container is assembled.

7. A container section for joining with similar container sections to form a horizontally elongated container for an underground equipment installation, comprising:

- (a) side wall segment means unreinforced by horizontal support members and defining a truncated cylinder,
- (b) said side wall segment means having vertical edges,
- (c) a vertical beam element welded to each vertical edge of said side wall segment means,
- (d) said section including a top wall member overlying and welded to the arcuate horizontal upper edge of said side wall segment means and a bottom wall member means underlying and welded to the arcuate horizontal lower edge of said side wall segment means,
- (e) said top wall member extending over the upper end of each vertical beam element and said beam element upper ends being welded to the underside of said top wall member, said bottom wall member extending under the lower end of each vertical beam element and said beam element lower ends being welded to the upperside of said bottom wall member, whereby said vertical means are directly tied together transversely of said container at said edges solely by said wall members.

8. The container section of claim 7 further characterized in that:

- (a) said beam elements comprise channel elements with their bases welded to corresponding edges and their flanges extending toward said side wall segment means.

9. The container section of claim 7 further characterized by and including:

- (a) transversely extending horizontal beam means welded to the outside of each of said top wall member and said bottom wall member.

10. A horizontally elongated container for an underground sewage disposal equipment installation, comprising:

- (a) a plurality of container sections including at least two intermediate sections and two opposite end sections,
- (b) each of said sections including side wall segment means fabricated of steel plates unreinforced by horizontal support members and defining a truncated cylinder, said intermediate sections being greater than a semi-cylinder and said end sections being less than a semi-cylinder,
- (c) said sections being fabricated separately and joined together at seams at vertical juncture planes to form a continuous container,

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(d) vertical beam means disposed in the seams between adjacent vertical edges of said side wall segment means and welded to said edges,

(e) each of said vertical beam means including substantially identical beam elements welded to the adjacent vertical edges of each of said sections,

(f) said beam elements being channel elements with their bases welded to corresponding edges and their flanges extending toward corresponding side wall segment means,

(g) said bases of adjacent channel elements being welded together to join said sections into said container,

(h) each of said sections including a top wall member overlying and welded to the arcuate horizontal upper edges of corresponding side wall segment means and a bottom wall member underlying and welded to the arcuate horizontal lower edges of said corresponding side wall segment means,

(i) said top wall members extending over the upper ends of corresponding vertical beam elements and said beam element upper ends being welded to the underside of said top wall members, said bottom wall members extending under the lower ends of corresponding vertical beam elements and said beam element lower ends being welded to the upperside of said bottom wall members, whereby said vertical beam elements are directly tied together transversely of said container at corresponding seams solely by said wall members,

(j) transversely extending horizontal beam means welded to the outside of each of said top wall member and said bottom wall member,

(k) and an access fitting extending upwardly from the upper surface of at least one of said top wall members, said access fitting overlying an access port in said one top wall member to facilitate entry to the container.

11. A horizontally elongated container for an underground equipment installation comprising:

- (a) plurality of container sections including at least two intermediate sections and two oppositely disposed end sections,
- (b) each of said sections including side wall segment means unreinforced by horizontal support members and defining a truncated cylinder,
- (c) said sections being fabricated separately and joined together in seams at vertical juncture planes to form a continuous container,
- (d) each of said intermediate sections being truncated on both ends so as to have two side wall segments and four vertical edges while each of said end container sections is truncated only on its inner end so as to provide a single side wall segment and two vertical edges,
- (e) vertical beam means disposed in the seams between adjacent vertical edges of corresponding side wall segments and welded to said edges,
- (f) each of said sections including a flat top wall member overlying and welded to the arcuate horizontal edge of corresponding side wall segment means and a flat bottom wall member underlying and welded to the arcuate horizontal lower edge of said corresponding side wall segment means,
- (g) transversely extending horizontal beam means welded to the outside of each of said top wall member and said bottom wall member,
- (h) each of said end container sections and an intermediate container section immediately adjacent the corresponding end container section forming a major portion of a cylinder truncated only on one side,
- (i) whereby the construction of said container is longitudinally reinforced against column buckling without the provision of longitudinal bracing members.

12. The container of claim 11 further characterized in that:

- (a) said top and bottom wall members extend over and under the corresponding upper and lower ends of corresponding vertical beam means and are welded to said ends whereby said vertical beam means are directly tied together transversely of said container at said corresponding seams solely by said wall members.

13. The container of claim 11 further characterized in that:

- (a) said beam means include channel elements with their bases welded to corresponding vertical side wall segment edges and their flanges extending toward the corresponding side wall segments,
(b) said bases of adjacent channel elements being welded together when the container is assembled.

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GEORGE E. LOWRANCE, *Primary Examiner.*

U.S. Cl. X.R.

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