Sept. 24, 1946. H. A. STARRET 2,408,105

STORAGE TANK

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Fig. 1

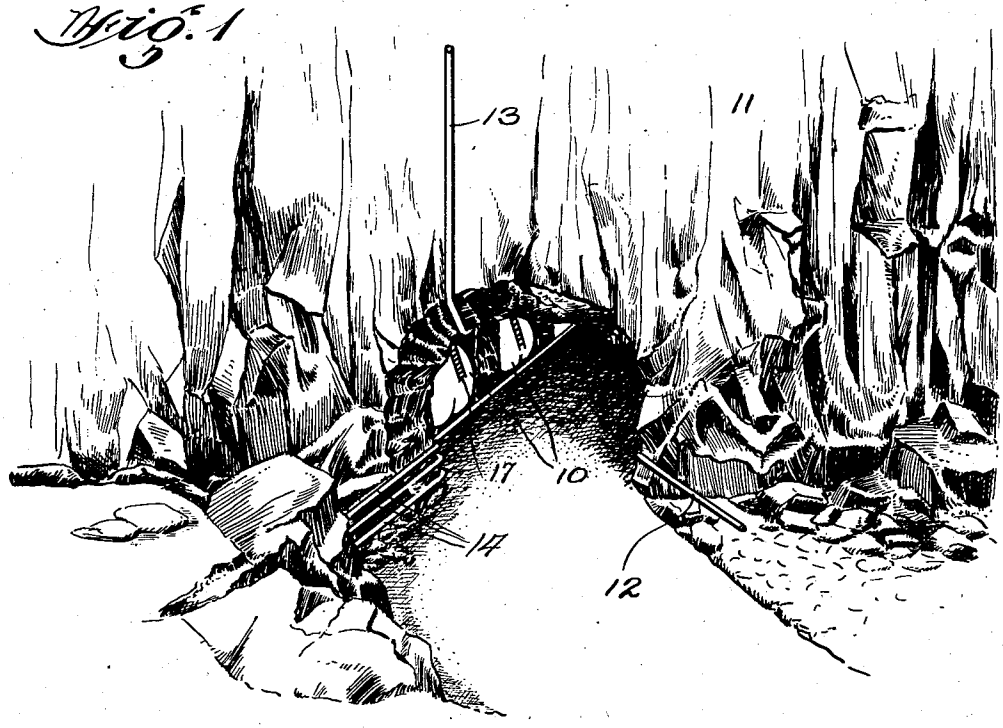
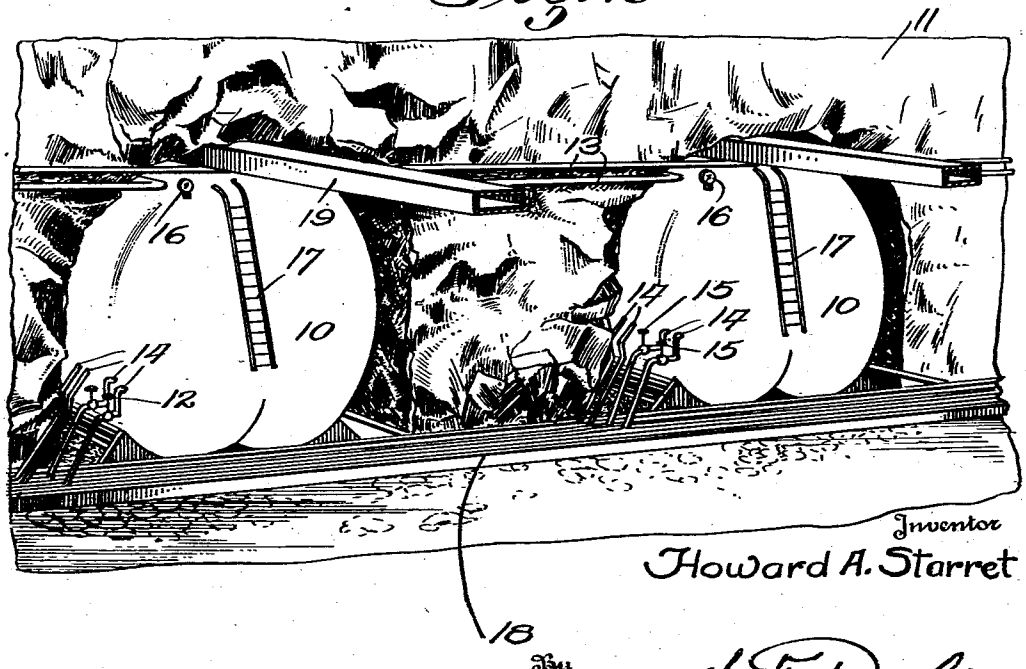


Fig. 2



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Fig. 3

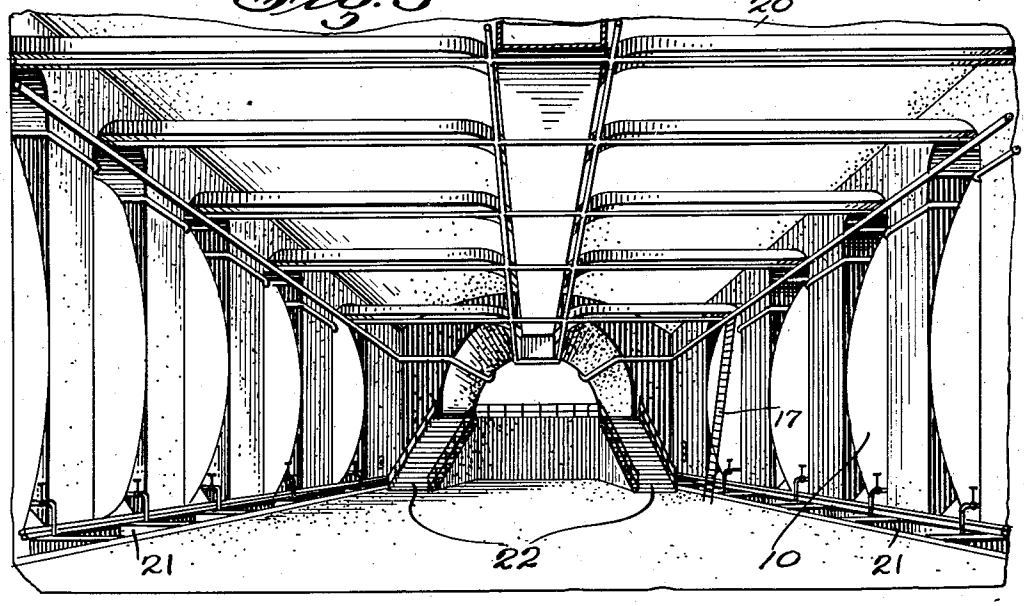
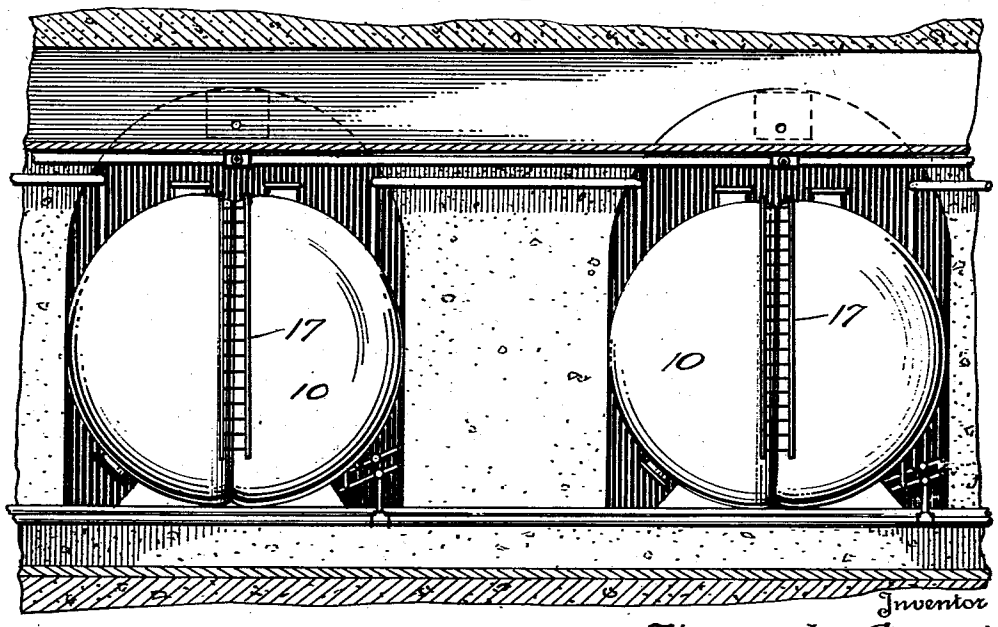


Fig. 4.



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Fig. 5

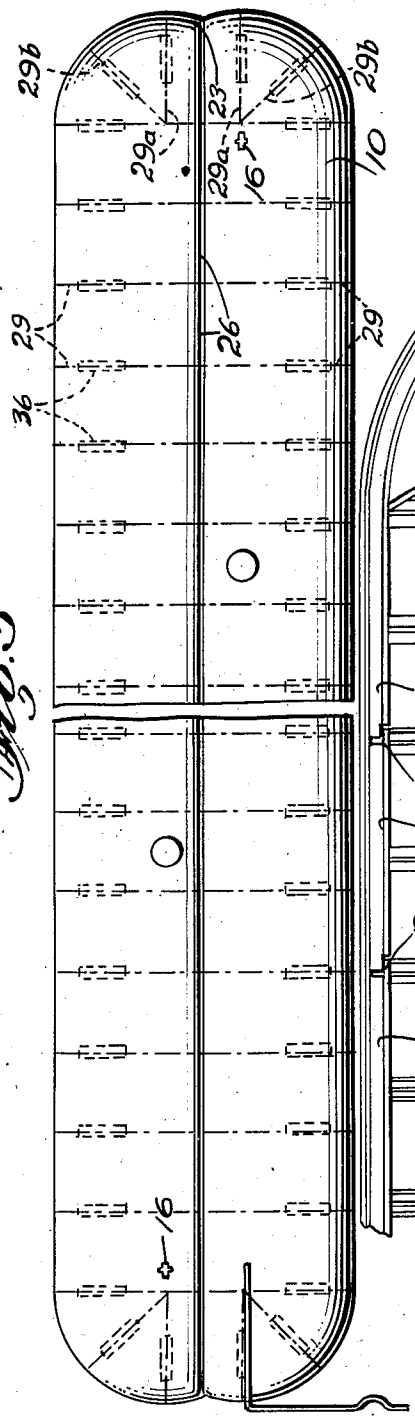
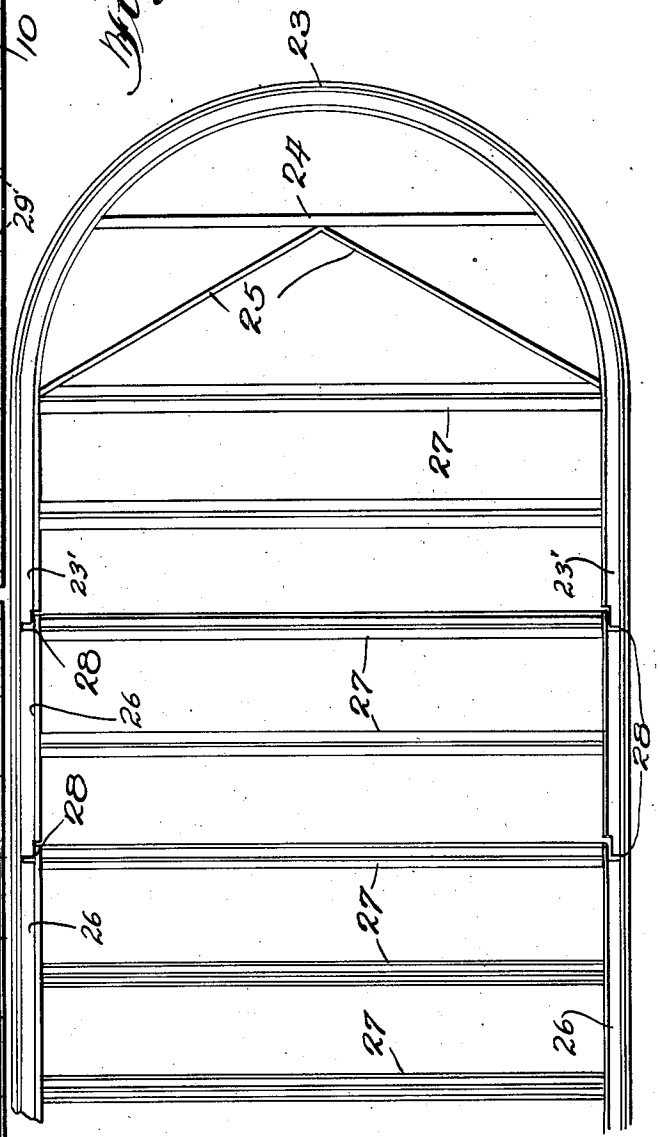


Fig. 6



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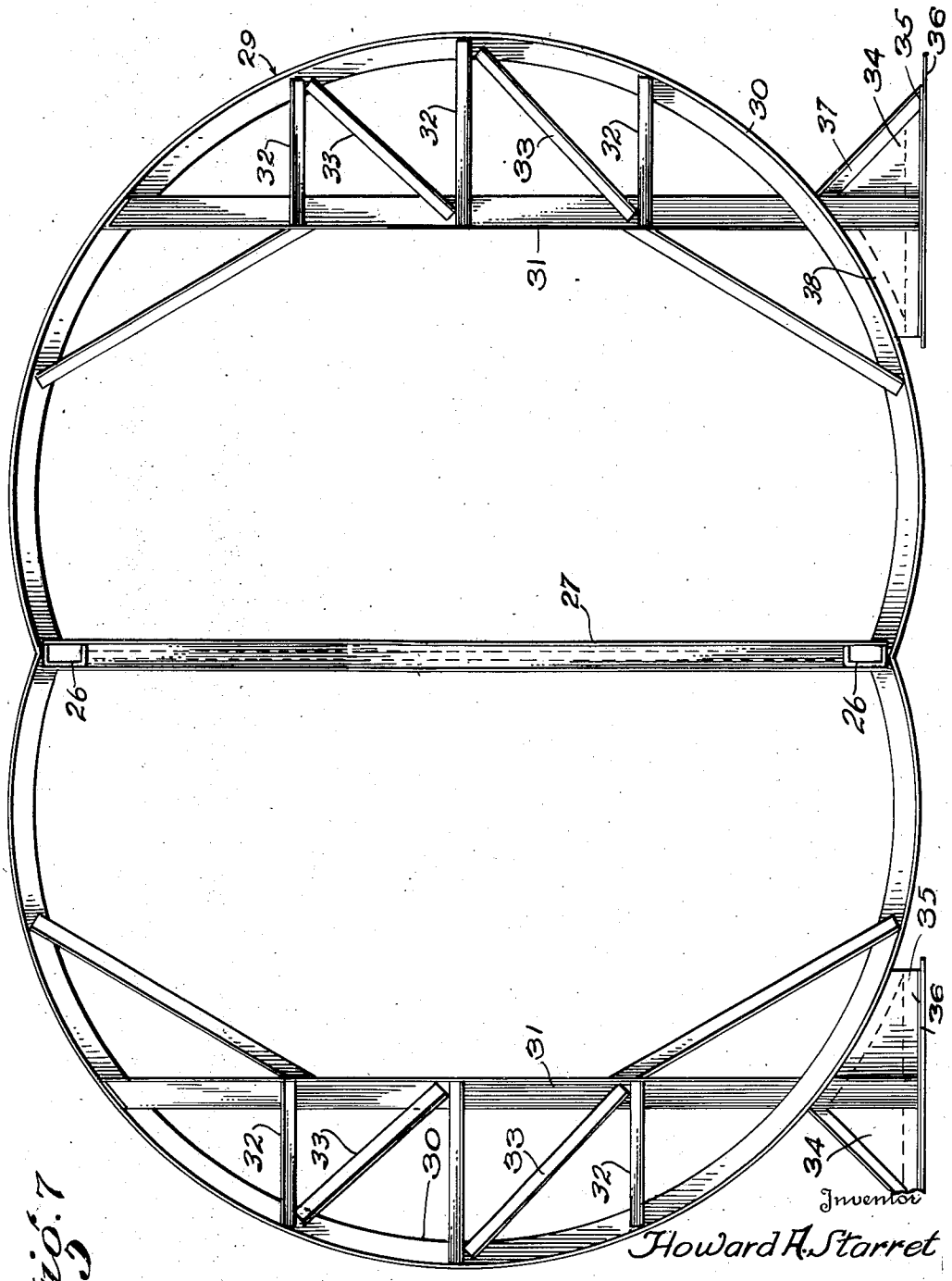


Fig. 7

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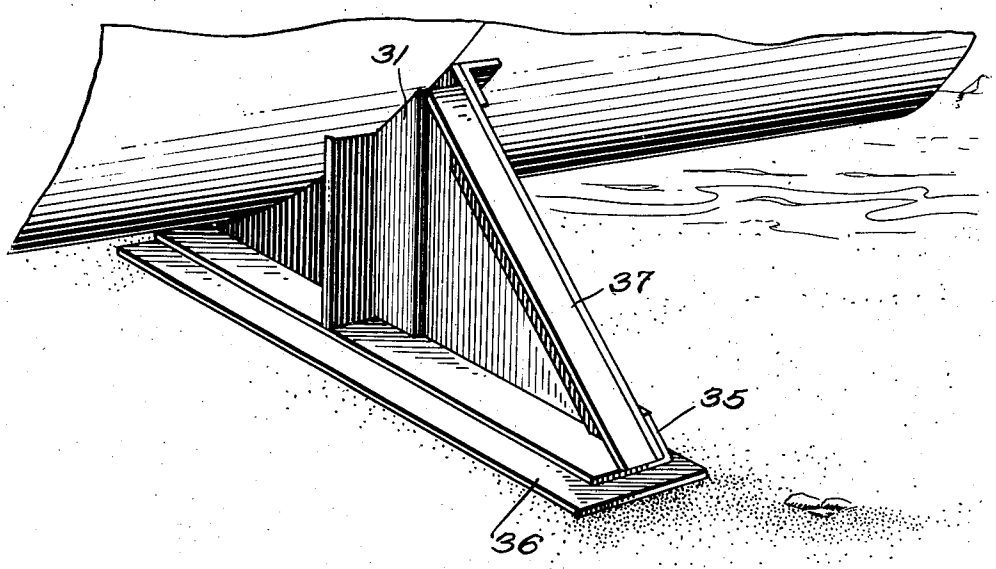


Fig. 8.

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Patented Sept. 24, 1946 2,408,105

UNITED STATES PATENT OFFICE

2,408,105

STORAGE TANK

Howard A. Starret, United States Army

Application October 16, 1941, Serial No. 415,229

3 Claims. (Cl. 220—18)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

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The invention described herein, if patented, may be manufactured and used by or for the Government for governmental purposes without the payment of any royalty thereon.

This invention relates to improvements in tanks especially adapted for the storage of gasoline in bulk.

In time of war and during periods when a country is constantly subjected to bombing attacks and the like, it is essential that means be provided for the safe storage of gasoline and other highly inflammable substances.

Therefore, it is an object of this invention to provide a storage tank of novel construction which can be quickly and easily assembled and installed at various locations for the storage of gasoline in bulk.

Another object of the invention is to build the tank in sections so that it can be assembled at any place it is desired to locate the tank.

Therefore, by constructing the tank in sections, it is possible to build tanks of any desired length or width by removing or adding sections, the same design being applicable to either large or small tanks. The size of the plates forming these sections can also be varied to facilitate construction and reduce possible delay in the procurement of material.

Another object of the invention is to freely support the tanks on a bed plate so that the tanks can withstand horizontal earth vibrations.

A further object of this invention is the provision of a storage tank so designed and constructed that it can be adequately inspected with a minimum amount of danger to life and property, minimize the problem of weathering and provide for the maintenance of the tank by a greatly reduced staff.

These and other objects are attained by the novel construction hereinafter described in the following specification and pointed out in the accompanying drawings forming a part hereof, and in which:

Fig. 1 is a perspective view of a quarry showing the tanks within.

Fig. 2 is a perspective view of a portion of the tanks in the interior of the quarry.

Fig. 3 is a perspective view of the interior of a specially constructed building to house the tanks.

Fig. 4 is a perspective view of a portion of the tanks in the interior of the building shown in Fig. 3.

Fig. 5 is a top plan view of a tank embodying the invention.

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Fig. 6 is a sectional elevational view taken longitudinally of the tank along the intersection of the intermediate cylindrical portions and along the intersection of the end hemispheres.

Fig. 7 is a sectional view taken transversely of the tank at one of the transverse frame members.

Figure 8 is a fragmentary view of the invention, showing the external leg of the compression member of one truss member 29, and its foot piece.

Referring to the drawings, and more particularly to Figs. 1 and 2, there are shown the tanks 10 located in an existing quarry or cave 11. The storage tanks 10 will be seen to have the general shape of two intersecting cylinders, with the ends assuming the shape of two intersecting hemispheres. The end sections are identical in construction and the cylindrical portions of the tank are formed from a plurality of sections of identical construction, which enable the formation of tanks of any desired size by adding intermediate cylindrical sections.

The quarry is equipped with a water line 12 for fire protection and a vapor vent pipe 13 is used to vent all vapors from the tanks. The storage tanks are equipped with the usual pipe lines 14 which are controlled by conventional valves 15 and conventional pressure gauges 16 are placed in an accessible position on the tank. Ladders 17 are provided to gain access to the gauges 16, and a drainage system 18 is provided for the tanks. A blower ventilating system 19 is provided to exhaust all fumes and thoroughly ventilate the interior of the quarry.

Figs. 3 and 4 are identical with Figs. 1 and 2 except that a specially constructed building 20 has been erected to hold the storage tanks 10. Drains 21 have been provided to clean the tanks when necessary and these tanks as shown possess all the elements previously referred to and in addition there are also shown stairs 22 by which access is gained to the outside, since, as shown, the building is built underground.

In Figure 6 there is shown the intersection of the two hemispheres forming one end section of the tank, and the intersection at the intermediate cylindrical portions of the tank. At the intersection of the end hemispheres there is an end frame comprising an arcuate beam 23, braced by a vertical post 24 and angular plates 25. The beam 23 terminates in straight horizontal inwardly extending horizontal portions 23' at top and bottom, which are parallel to one another and coincident with the line of intersection of the two cylindrical portions of the tank. The

ends of the portions 23' of the end frame abut, as at 28, short beams or rails 26 at top and bottom of the tank. The rails as shown in Figure 6 have two vertical strut members 27 extending therebetween and secured thereto, one of the struts being at the right hand extremities of the two rails 26, while the other of the two struts is located and secured midway of the horizontal extent of the rails 26. The members 26 may abut similar rails 26 next adjacent longitudinally, as seen in Figure 6.

In Figure 7 there are shown truss members or frames 29, each of which comprises an arcuate beam 30, extending over an arc of approximately 220 degrees subtending a vertical chord, a vertical post or compression member 31, spaced oppositely from the center of the arc from the chord mentioned, connected at its upper extremity to the beam 30 and connected at a lower part of the beam 30 so as to subtend an arc of approximately 105 degrees in this particular instance, also a lattice of horizontal bars 32 and diagonal braces 33 connected between the arcuate beam and the post 31. It will be noted that the arrangement of these bars and braces is such as to transmit any weight load on the beam 30 to the post 31. The inner ends of the beam 30 extend some distance to their extremities without bracing or support other than their inherent resistance to bending. The truss members 29 of Figure 7 are disposed in mutual opposed relation in a common plane which is normal to the axes of the two cylindrical portions of the tank, as indicated throughout the length of the tank in Figure 5. They thus abut the interposed parts 23' or 26, according to the location of the members 29 longitudinally in the whole frame of the tank, and together each two opposed and abutting members 29 constitute virtually a unitary cross frame. In addition to their use as transverse members, similar truss members 29*a* and 29*b* are also used in the end hemispheres, differing from the first in that their arcuate beams extend over an arc of only 180 degrees, but with their post members 31 subtending the same arc on the curved beam as in Figure 7, this also being indicated in Figure 5.

Each hemisphere has two such frame members of limited arc, one designated 29*a*, Figure 5, parallel to and near the arcuate beam 23 which joins the two hemispheres; the other, designated 29*b* is disposed between, and at an angle of forty-five degrees to, the member 29*a* and a next adjacent transverse truss member 29 which is included in the hemisphere. The members 29*a* and 29*b* have the extremities of their arcuate beams 30 in abutment with the side of the transverse member 29, at a vertical chord which intersects the axis of the respective cylindrical part which is alined therewith. In this way the hemispherical part built over these end frames and extending to the curved beam 23 forms a symmetrical continuation of the wall of the cylindrical part as in Figure 5, and the two hemispheres intersect with a horizontal section the external contour of which corresponds to the contour of the upper and lower parts in vertical section as seen in Figure 7. Thus there is no break or variation of the direction or unit of stress on the metal sheath or skin of welded sheets forming the exterior of the tank.

It may be noted from Figures 5 and 7 that a boundary defining the superficial area beneath the tank, and drawn across the outer ends of the tank foot plates 36, greatly exceeds in width the vertical dimension of the tank, and from Figure 8 it may be seen that preparation for support of the tank consists in simply levelling the ground area upon which these foot plates are to be set. In consequence of the relation of the bounds of the supports and the height of the tank, it will be appreciated that it will be highly resistant to tilting by lateral forces which would tend to upset tanks of greater proportionate height, and with the simple surface bearing of the broad foot plates 36, that abrupt and rapid translative movements of the ground beneath the feet will tend to result in relative movement of the ground without movement of the foot plates equally, with a consequent minimizing of racking strains in the tank supports and framing. It is known that the shock wave of an earthquake moves at a speed of several hundred feet per second, and that earth shock waves from detonated nearby explosives have a rate several times as great, the effect of which varies according to the distance from the point of explosion and the amount and nature of the explosive.

After the shock wave, there is a following translative earth movement partaking of the nature of a wave and of greater linear movement in the direction of its progress, but of lesser speed than the first shock wave, although still so rapid for large bombs that before inertia of the tank and content can be overcome the ground will as a mass move relatively under the foot plate, thus reducing the stresses produced in the tank as compared to one fixed with a footing embedded in the ground. By way of illustration of the effects to be overcome, it may be explained that research has shown that explosion of a bomb containing 1000 pounds of TNT will produce a translative movement horizontally of two or more inches at a distance of fifty feet from the point of detonation, this movement having a particle rate of approximately sixty feet per second, at the distance named.

No special foundation is necessary as each vertical post 31 rests on a base plate 36, Fig. 7, being secured thereto by a short horizontal angle piece 35. A web plate 34 is also secured to some or all of the parts 31, 36, 35. The upper edge of vertical plate 34 is arcuate to conform to the circular shape of the arcuate beam 30 and is secured thereto by short arcuate angle piece 38. The inclined edge of web plate 34 may be reinforced by an inclined angle piece 37.

It is clear that by making the structure of the trusses for the intermediate sections and the end sections identical, interchangeability is provided and the various elements can ebe formed in shops remote from the final location of the tank. It will appear, therefore, that the assembly of the truss frame at the location of the tank would be a relatively simple procedure. The various elements of the frame are joined by welding or the like and after construction the frame can be covered by the metal sectional sheets welded to each other to provide a water-tight tank.

A number of tanks may be constructed near each other and require only a small number of attendants for maintenance. When a suitable location is found after preliminary surveys have been made, the trusses and other members of the frames can be shipped to the location for assembly. It should be appreciated that the only survey required is to ascertain that the necessary width and height of chamber space is available, and that the floor may be levelled to receive the foot plates 36 at proper intervals. The tanks may be constructed any length by adding inter-

mediate truss frames **29** and the interposed strut and bar sections **26—27** as required, the end sections being the same regardless of the length of the tank. The tank is in that way accommodated to the space available as it is erected, without detailed plans or exact instrumental surveys. In the course of the work of erection, each truss frame **29** may be set in place on its foot plate upon the levelled floor surface and as the inner end of the foot plate is inwardly of the center of gravity of the frame piece, it will remain erect while the parts **26—27**, and an opposed member **29** are brought into place. These three units may be united as they are thus positioned, or left in simple abutment until the welding of the sheet metal covering or skin. The scarf form of the ends of the rails **26** and beam parts **23'** shown at **28** in Figure 6, will cause proper support of the pieces in proper alinement until uniting of the assembled parts. The tank can be easily and economically repaired and painted because of its accessibility.

From the above description it can be seen that there has been provided a simple and effective tank structure for housing gasoline.

The foregoing description is to be regarded as descriptive only and not limitative of the invention of which obviously embodiments may be constructed without departing from the scope of the appended claims.

Having thus described the invention, what is claimed as new and desired to secure by Letters Patent is:

1. A tank for storage of pressure fluids and for mounting independently of translative movement of earth thereunder, comprising a wall skin portion having the form of two intersecting horizontal and parallel cylinders closed at the ends by wall portions each having the form of intersecting hemispheres concentric with and of the same radius as the cylinders, and a multiplicity of interior frames spaced horizontally throughout the cylindrical and spherical parts, each of said frames including identical circular truss parts abutting and conforming to the circular form of the said wall skin in a plane normal to the abutted wall skin parts, said truss parts intermediately of said ends being opposed in pairs abutting at upper and lower intersections of their circular parts at a vertical chord coincident with the intersections of said cylinders, each said truss part including a vertical compression member spaced outwardly of said chord and having supporting relation to the upper and lower parts of each said circular truss part and respective adjacent wall skin parts, each said vertical compression member having an external lower leg continuation fixed rigidly with the respective truss part and braced to prevent horizontal displacement of the leg relative to the tank, each said external leg continuation having a foot plate adapted to rest and slide on a horizontal bed and positioned to support the tank clear of subjacent earth, whereby the tank may be set up and maintained free of damage by shock waves and abrupt horizontal displacements of earth under and in relation to any of said foot plates.

2. As an improved article of manufacture a framing for a tank for storage of pressure fluids, adapted to be assembled to various capacities, comprising a multiplicity of identical vertical planiform sector-shaped truss members, all said members arranged in horizontally spaced relation to lie within and symmetrically conform at their arcs with the surfaces of two geometrically projected parallel horizontal axially spaced intersecting cylinders at a common level and with hemispherical intersecting ends concentric with and of the same radius as said cylinders, the said truss members inwardly of those in the said hemispherical ends being arranged in opposed pairs, their circular parts meeting at a vertical chordal plane coincident with the intersections of said cylinders whereby each said pair constitutes a respective transverse frame normal to the axes of said cylinders, each said truss member comprising an external curved beam defining a circular arc boundary of the member, and including a vertical compression member joined to upper and lower parts of said curved beam and spaced outwardly of the center of its said arc, a vertical strut in said chordal plane at each frame extending between the upper and lower said meeting parts of the opposed truss members, each end of said framing including an end frame having a semicircular part coincident with the intersection of said hemispherical intersecting ends and continued at top and bottom a distance as rectilinear horizontal parallel members extending across the plane of at least the next of said transverse frames, joined to at least one said vertical strut and terminating thereadjacent, upper and lower horizontal short rail members across and attached to one or more of said struts and between adjacent opposed truss members, aligned with and arranged to abut respective said horizontal continuations of the said end frames and to abut the ends of similar adjacent rail members, said truss members each having an exterior downward leg continuation of its said vertical compression member formed with a respective broad horizontal planiform ground-engaging foot plate for support of the tank, adapted to rest slidably upon a ground surface, whereby said truss members will stand erect in the assembled relation described, and whereby a continuous wall skin of sheet metal plates may be applied thereto and welded to each other and to said framing to hold said framing in assembly and to oppose pressures of fluids in the tank by inherent tensional strength of the wall skin and to define externally a form corresponding to that of said geometrically projected intersecting cylinders and hemispherical ends.

3. The structure of claim 2, in which a load transmitting truss work is included between the said curved beam and said compression member principally at the outer side of the latter, said beam being extended at each of its ends a substantial distance without trussing, each said foot plate extending inwardly beyond a vertical from the center of gravity of the truss member.

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