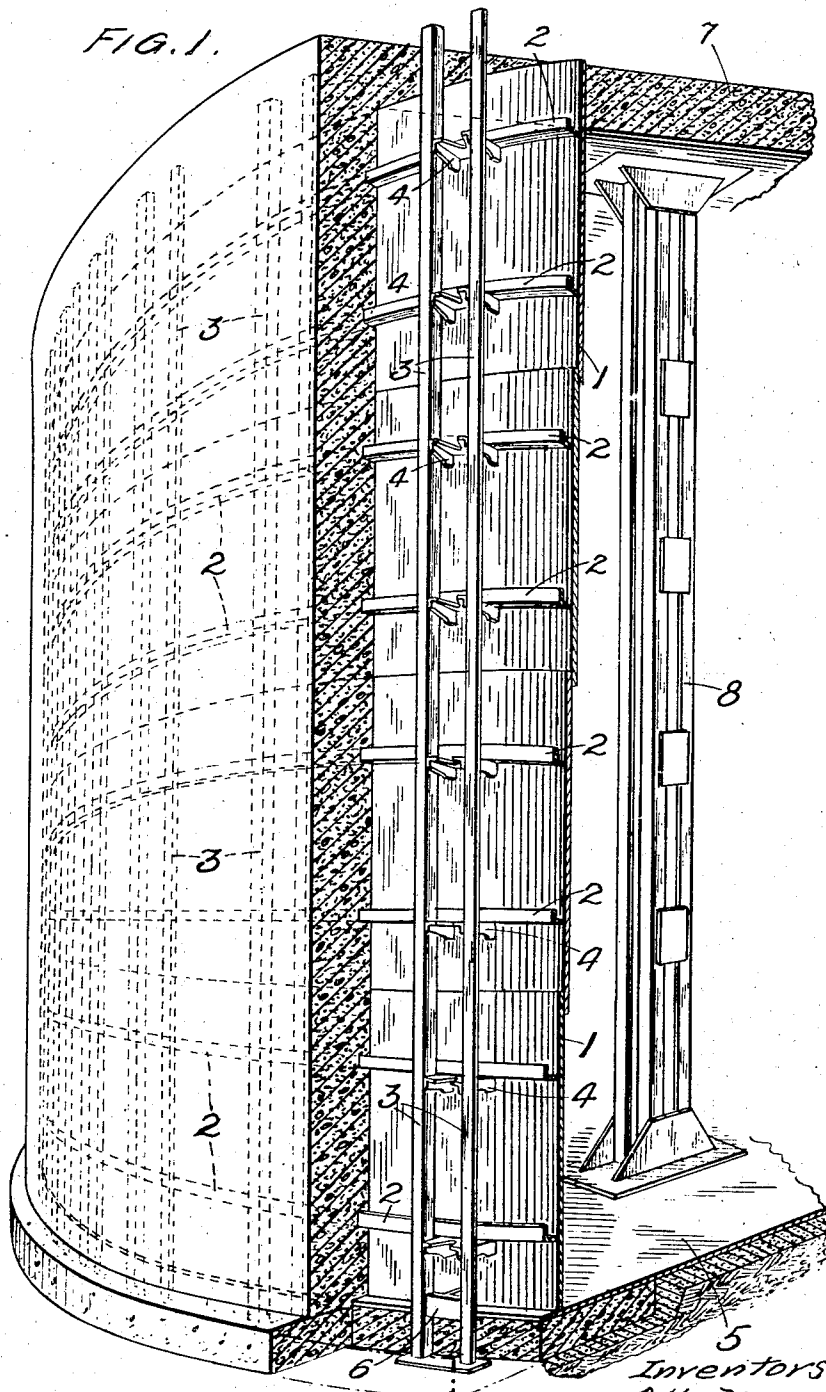
Aug. 15, 1944. O. BONDY ET AL 2,355,947

STORAGE TANKS OR CONTAINERS AND LIKE SHELL STRUCTURES

Filed Dec. 18, 1942 3 Sheets-Sheet 1

FIG. 1.




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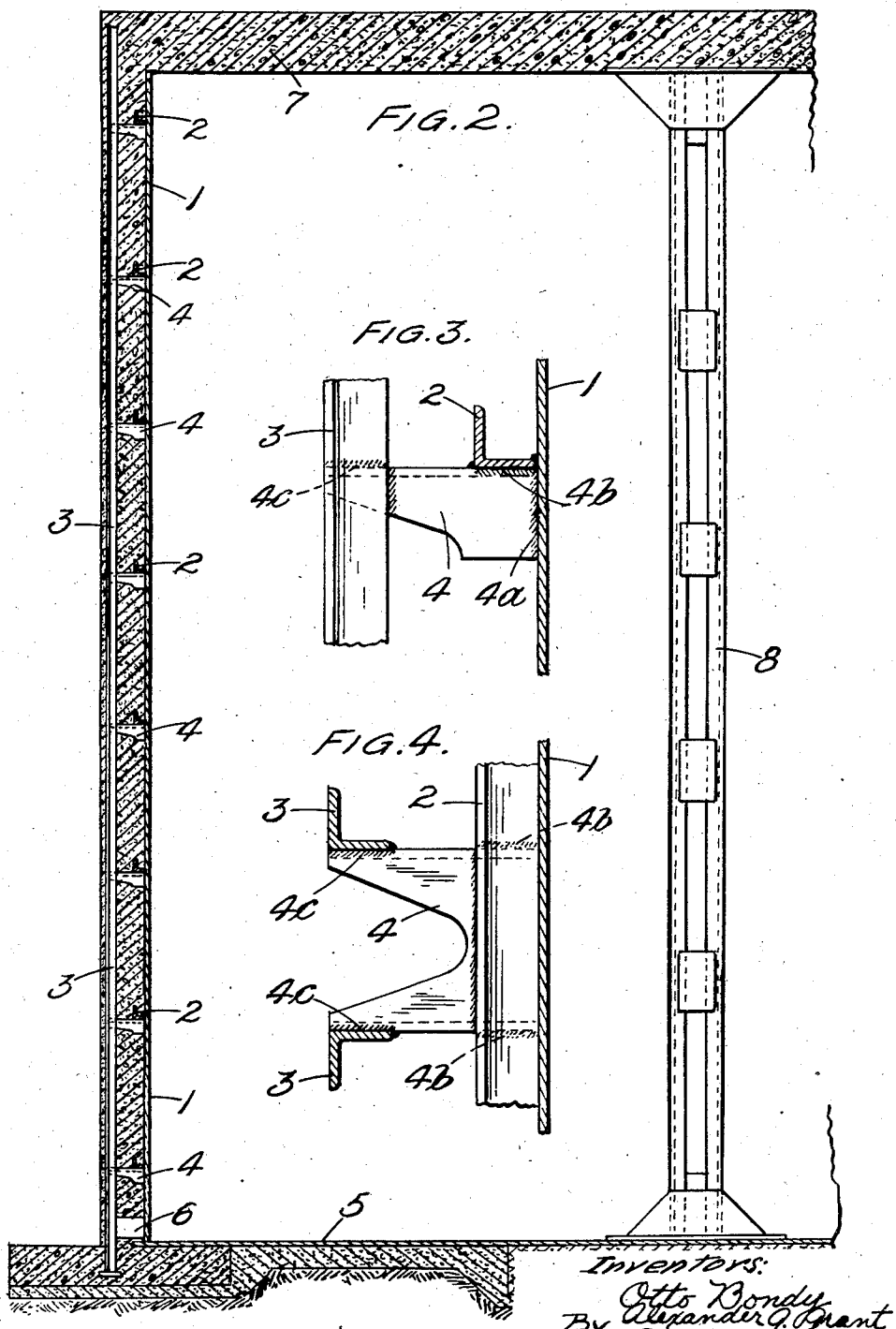



FIG. 2.

FIG. 3.




FIG. 4.




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Filed Dec. 18, 1942 3 Sheets-Sheet 3

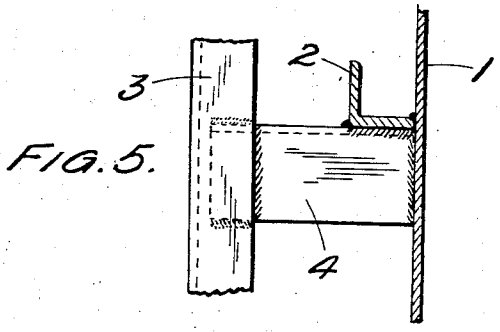



FIG. 5.

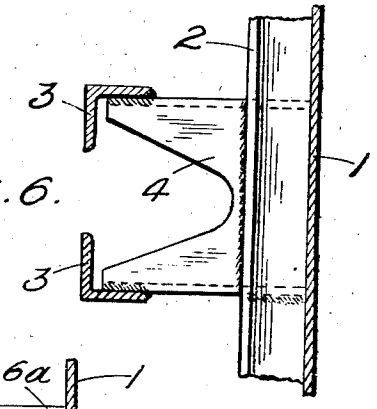



FIG. 6.

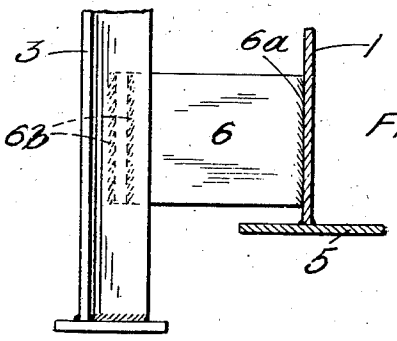



FIG. 7.

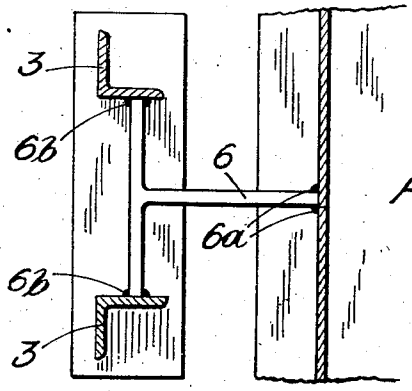



FIG. 8.

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# UNITED STATES PATENT OFFICE

2,355,947

## STORAGE TANK OR CONTAINER AND LIKE SHELL STRUCTURE

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Application December 18, 1942, Serial No. 469,428
In Great Britain October 13, 1941

8 Claims. (Cl. 72—14)

This invention relates to storage tanks or containers and like shell structures and in particular to tanks suitable for the bulk storage of motor spirit, lubricating oil and the like.

The primary object of the invention is to provide an improved construction of storage tank which is of light weight and of economical construction in comparison with tanks of usual design.

The principle underlying the invention by means of which the object aforesaid is attained is the utilisation of a tank shell of steel or other metal of reduced thickness or gauge, when compared with the shell thickness which would be required in normal tank construction for similar duty, and the supporting of this shell against both internal and external pressure by both externally applied stiffening means and preferably by axial and horizontal stiffening members acting in co-operation.

The term axial is used herein merely in its directional sense as indicating the general direction in which the axial stiffeners run.

The invention, which is applicable to tanks for use either above ground where the forces to be accommodated are outwardly acting due to the liquid contents of the tank, or to underground or other tanks where pressures due to external loading have also to be accommodated, consists broadly of a thin steel or other suitable metal shell supported or stiffened externally.

The invention also comprises the particular arrangement where the external stiffening means consist of axial and perimetral stiffening members both of which are respectively attached to the tank shell externally.

In the preferred construction the perimetral stiffening members are welded to the shell and the axial stiffening members are spaced from the shell and connected thereto and to the perimetral stiffening members by means of bracing brackets extending radially from the shell.

The virtue of the construction according to the invention when considered in relation to vertical tanks resides in the fact that when the tank is subjected to internal pressure due, for example, to the liquid contained in the tank, the pressure acting outwardly in a radial direction loads the whole structure comprising both the shell and the external perimetral or circumferential and the axial stiffening means. This pressure acting radially outwardly puts the shell into ring tension, causing an outwardly tending elastic movement of the shell the degree of movement being directly proportional to the tensile stress. The shell of the tank is, however, rigidly attached to the tank bottom thus keeping the ring tensile stress at this position down to a small figure.

At other positions than at bottom level of the tank structure the tendency to outward radial movement of the shell is resisted by the axial and perimetral supporting members or stiffeners connected to it and the tank bottom as before mentioned, the axial members acting in conjunction with the shell as supporting beams or in some cases as cantilevers.

It will thus be plain that an important function of the axial supporting members or stiffeners is to prevent outward movement of the shell, the restraint at the bottom of these members, and at the top also in the case of roofed tanks, resulting in a better distribution of the load thus permitting the use of a shell of thinner gauge metal. The perimetral stiffeners act as restraining bands in further reduction of stress and moreover also serve to promote stress uniformity around the tank perimeter and serve to transmit the stresses satisfactorily to the axial supporting members.

When a tank of the foregoing general construction is designed for use as an underground storage tank, i. e. a tank buried underground and thus subject to external pressure due to earth loading, the whole structure of the shell may be clothed with mass concrete with the vertical stiffeners or supporting members and the perimetral supporting bands embedded therein. Thus the crippling stresses liable to induce local buckling are provided for. Of course, the same conditions could arise in the case of a tank for use above ground which was required to sustain an internal vacuum and in such a case the concrete outer casing could also be applied.

It will, of course, be appreciated that this is not merely a case of enclosing a tank in a reinforced concrete outer shell. The stability of the complete structure does not depend on the bond between the concrete and the steel shell although in fact the perimetral and vertical stiffeners of the shell are firmly embedded in the concrete and as a consequence the steel shell and the concrete are forced to act together as one structure to resist stresses and bending moments. That is to say the integrated steel-concrete tank becomes a steel tank with its shell and stiffening members retrained against lateral buckling by the concrete and a concrete tank which is reinforced by the stiffening members and restrained by the tank shell.

Furthermore the integration of the steel and

concrete produces such a rigid structure that the tensile and compressive stresses normally expected in the tank shell are greatly reduced in magnitude.

It will be appreciated that the pitch or spacing of the vertical stiffening beams and also of the circumferential stiffening bands are determined in conjunction with the shell plate thickness, adequately to withstand internal pressure and/or external pressure and in the case where the tank is clothed with concrete the keying and reinforcing functions of the stiffeners may also be decisive factors in the pitching.

The form of the perimetral or circumferential and of the axial stiffeners may vary but may conveniently be made from commercial steel angle sections either plain or serrated or may be specially constructed from steel plate or derived from channel section metal divided into two parts by cutting their webs either in a straight line, where straight edges are desired, or sinuously to produce angle sections with serrated edges. Whatever be the respective forms of stiffeners the perimetral or circumferential stiffeners are connected to the shell, for example by welding, and the vertical beam stiffeners are connected to the circumferential stiffeners and to the tank shell by rigid bracings designed to act as the web posts of a Vierendeel girder, e. g. the connection may again be by welding.

The perimetral or circumferential stiffeners may consist of angle section bands welded to the shell along their edges and the vertical supporting members or stiffeners may consist of a pair of angle section pillars arranged in opposite relation with an edge facing the shell to which they may be connected by struts welded to their flanges at one end and to the shell and the perimetral or circumferential stiffeners at their outer ends.

The connection of these vertical supporting members or stiffeners to the tank bottom may be by means of a plate bridging the two angle section members to which the plate is welded at its corners, the other edge of the plate being welded to the bottom plate of the tank. An example of a cylindrical underground tank constructed in accordance with the invention is illustrated in the accompanying drawings, wherein

Figure 1 is a perspective view of a portion of a tank constructed in accordance with the invention encased in concrete.

Figure 2 is a vertical sectional elevation of a portion of the tank.

Figures 3 and 4 are elevational and plan views of elements for connecting the perimetral stiffeners to the vertical stiffeners,

Figures 5 and 6 are similar views of a modified method of effecting the connection, and

Figures 7 and 8 are sectional elevational and sectional plan views respectively illustrating the means by which the tank shell is connected to the vertical stiffeners at the bottom of the tank.

Referring to these drawings the numeral 1 designates the tank shell constructed of steel panels in the usual way except that the thickness of the mild steel plate employed is less than would normally be required in the case of known constructions. This steel shell is, according to the invention, strengthened by means of perimetral or circumferential stiffeners 2 which may conveniently be constituted by angle iron bands welded to the outside of the steel shell. The numeral 3 designates vertical stiffening members or beams which may also conveniently be of angle iron. These vertical stiffeners may be separated from the tank shell as shown and may be welded to radial bracing brackets 4 which are in turn welded to the tank shell and to the perimetral stiffeners 2. These radial bracing brackets 4 are shown in Figures 3 and 4 and consist of bracket-like structures which are welded at the inner edges 4*a* to the tank shell and at the inner upper faces 4*b* to the undersides of the perimetral stiffeners 2 while their outer bifurcated corners 4*c* are each welded to one of a pair of vertical stiffeners as shown, for example, by Figures 3 and 4 or alternatively in the manner shown in Figures 5 and 6 where the vertical angle iron stiffeners are arranged with their angular channels facing each other. The vertical stiffeners are, at their bottom ends, embedded in concrete as shown and are connected to the bottom plate 5 of the tank by means of T brackets 6 shown best in Figures 7 and 8. The inner ends of the legs of these T brackets are welded to the tank shell at 6*a* and the opposing ends of the cross member each welded to a vertical stiffener as shown at 6*b*.

The tank roof 7 may be of known construction either self-supporting or supported by suitably disposed columns 8, also in known manner, and in this example the upper ends of the axial stiffening members are shown embedded in the concrete of the roof.

By means of the invention it has been found possible to secure a saving in weight from the viewpoint of internal pressure conditions only, and further weight economy can also be obtained in tanks designed to withstand external pressure.

The invention is applicable particularly to cylindrical storage tanks erected with the axis of the tank vertical as before described but the advantages of the construction also apply when the axis is horizontal or in any other position, and may with advantage be applied to other steel storage tank constructions where large volumes are contained in relatively thin shells, e. g. rectangular or polygonal tanks, and like shell structures.

What we claim and desire to secure by Letters Patent is:

1. A storage tank comprising a cylindrical metal tank shell, a plurality of spaced circumferential bands welded to the outside of said shell for stiffening purposes, a plurality of spaced axial beams disposed about the outer periphery of said shell out of contact with said shell and said circumferential bands, and a plurality of radial bracing brackets having their inner edges welded to said tank shell and to said circumferential bands and having their outer ends welded to said axial beams.

2. A storage tank comprising a cylindrical metal tank shell, a plurality of spaced circumferential bands welded to the outside of said shell for stiffening purposes, a plurality of spaced pairs of axial beams disposed about the outer periphery of said shell out of contact with said shell and said circumferential bands, and a plurality of radial bracing brackets having their inner edges welded to said tank shell and to said circumferential bands and having their outer ends welded to the respective pairs of axial beams.

3. A storage tank comprising a concrete foundation, a horizontal metal bottom plate on said foundation, a cylindrical metal tank shell mounted on said bottom plate with its axis disposed vertically, a plurality of spaced circumferential bands welded to the outside of said shell for

stiffening purposes, a plurality of spaced pairs of vertical beams disposed about the outer periphery of said shell out of contact with said shell and said circumferential bands and having their lower ends embedded in said foundation, and a plurality of radial bracing brackets having their inner edges welded to said shell and to said circumferential bands and having their outer ends welded to the respective pairs of vertical beams.

4. A storage tank comprising a concrete foundation, a horizontal metal bottom plate on said foundation, a cylindrical metal tank shell mounted on said bottom plate with its axis disposed vertically, a plurality of spaced circumferential angle-iron bands welded to the outside of said shell for stiffening purposes, a plurality of spaced pairs of vertical angle iron beams disposed about the outer periphery of said shell out of contact with said shell and said circumferential bands and having their lower ends embedded in said foundation, and a plurality of radial bracing brackets having their inner edges welded to said shell and to said circumferential bands and having their outer ends bifurcated and welded to the respective pairs of vertical beams.

5. A storage tank comprising a concrete foundation, a horizontal metal bottom plate on said foundation, a cylindrical metal tank shell mounted on said bottom plate with its axis disposed vertically, a plurality of spaced circumferential angle-iron bands welded to the outside of said shell for stiffening purposes, a plurality of spaced pairs of vertical angle iron beams disposed about the outer periphery of said shell out of contact with said shell and said circumferential bands and having their lower ends embedded in said foundation, a plurality of radial bracing brackets having their inner edges welded to said shell and to said circumferential bands and having their outer ends bifurcated and welded to the respective pairs of vertical beams, and axial T-shaped brackets adjacent the bottom of said shell each having its single leg welded to said shell and its cross piece welded to and between a pair of said vertical beams.

6. A storage tank comprising a concrete foundation, a horizontal metal bottom plate on said foundation, a cylindrical metal tank shell mounted on said bottom plate with its axis disposed vertically, a plurality of spaced circumferential angle-iron bands welded to the outside of said shell for stiffening purposes, a plurality of spaced pairs of vertical angle iron beams disposed about the outer periphery of said shell out of contact with said shell and said circumferential bands and having their lower ends embedded in said foundation, a plurality of radial bracing brackets having their inner edges welded to said shell and to said circumferential bands and having their outer ends bifurcated and welded to the respective pairs of vertical beams, and axial T-shaped brackets adjacent the bottom of said shell each having its single leg welded to said shell and its cross piece welded to and between a pair of said vertical beams, said tank shell and said circumferential bands and vertical beams being encased in concrete whereby the concrete mass provides lateral restraint to the shell stiffening members and itself is reinforced by the shell structure and the embedded stiffening members.

7. A storage tank structure comprising a thin metal shell, a bottom for said tank rigidly secured to one end of said shell, said shell being supported by external perimetral stiffening members welded to and extending around said shell, a plurality of radially extending bracing brackets having one of their ends welded to said shell and said perimetral stiffening members, the free ends of said bracing members being welded to said axial stiffening members.

8. A storage tank or like shell structure comprising a thin steel or like metal shell rigidly secured to the tank bottom and supported by external axial stiffening members and by external perimetral stiffening members, said perimetral stiffening members comprising bands welded to and around said shell, and said axial stiffening members being secured to said perimetral stiffening members by means of bracing brackets extending radially from said shell to which bracing brackets both the perimetral stiffening members and the axial stiffening members are welded.

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