

Jan. 21, 1958

L. P. ZICK ET AL

2,820,568

WALL STRUCTURE

Original Filed July 18, 1951

4 Sheets-Sheet 1

Fig. 1.

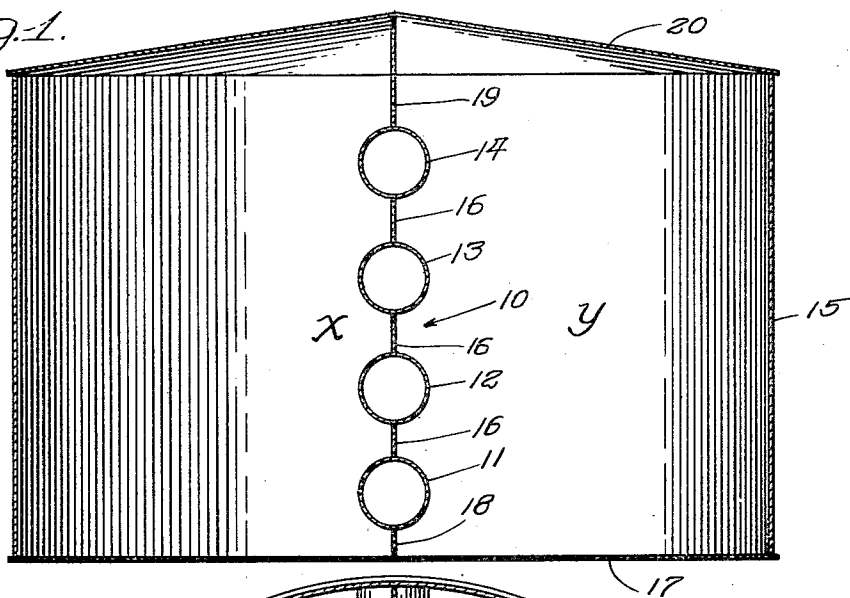
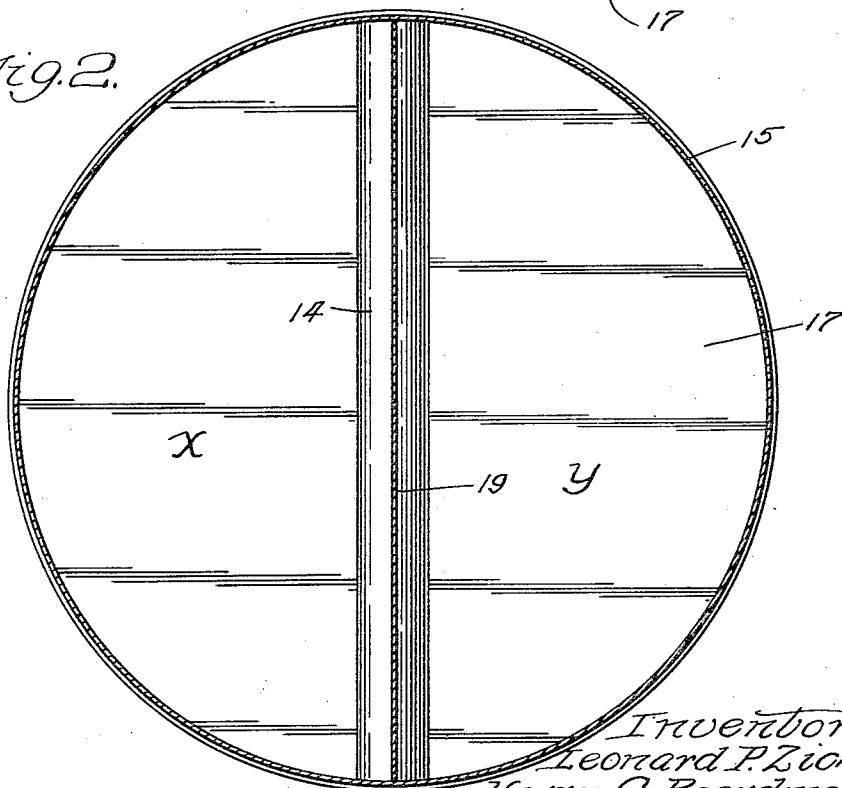


Fig. 2.



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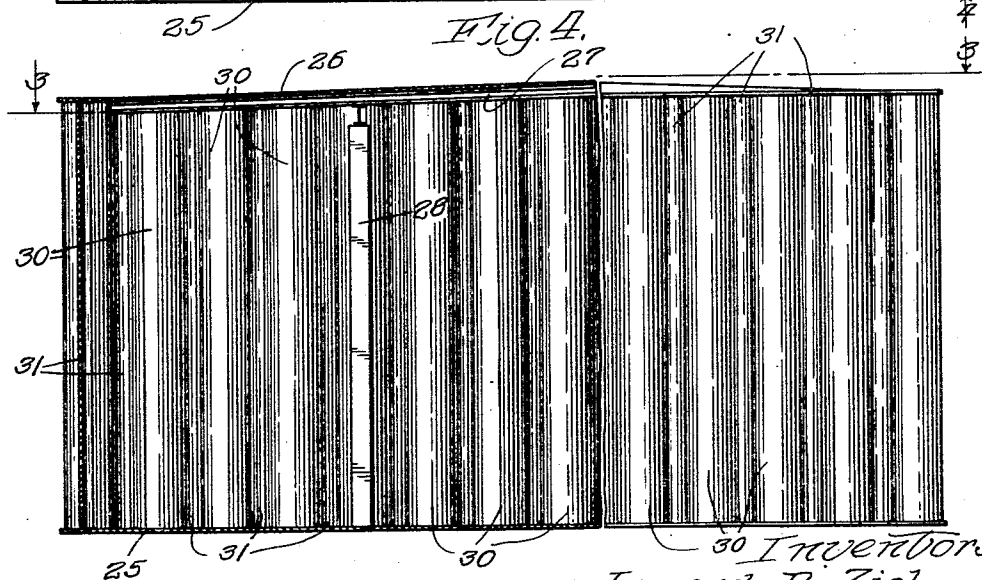
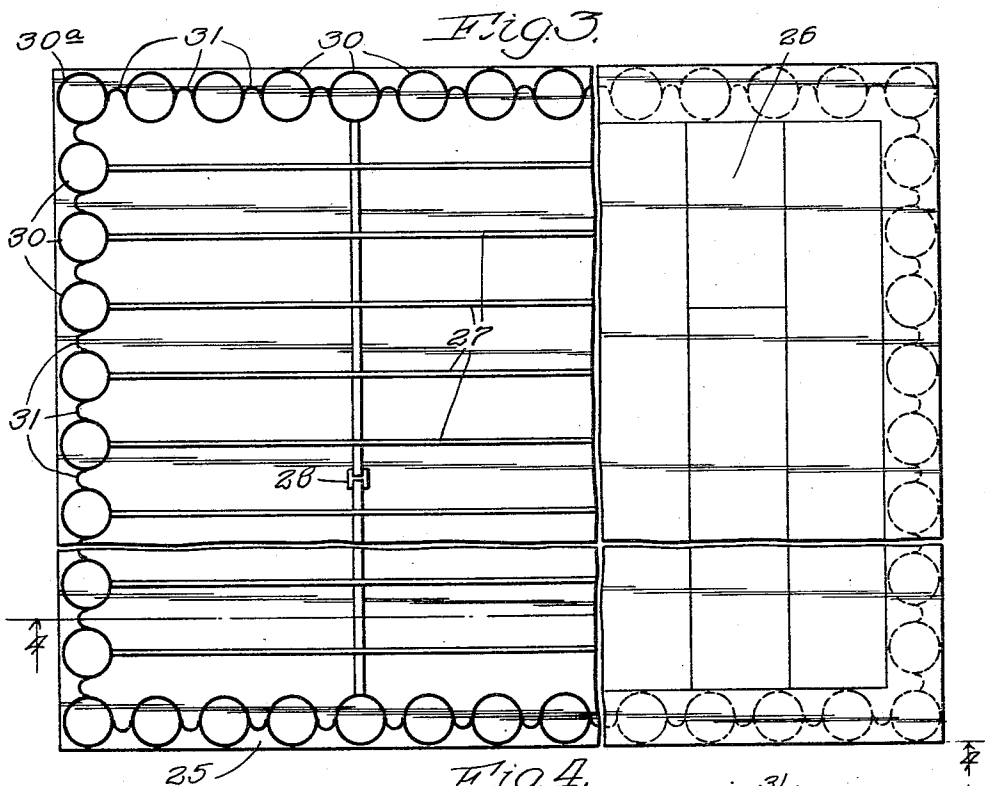
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Fig. 5.

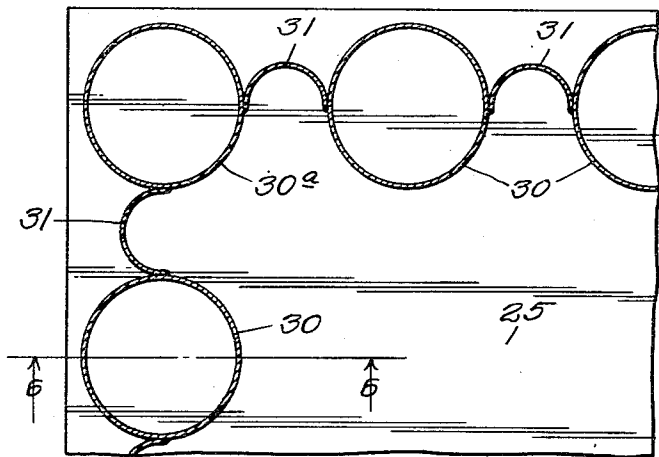


Fig. 8.

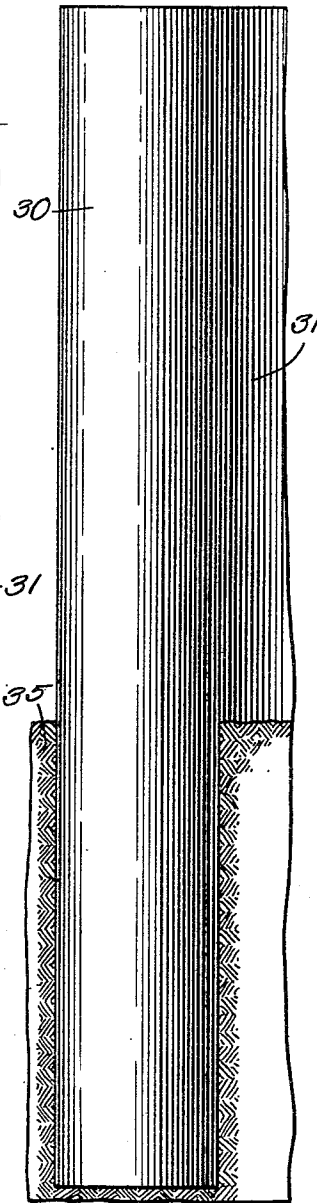
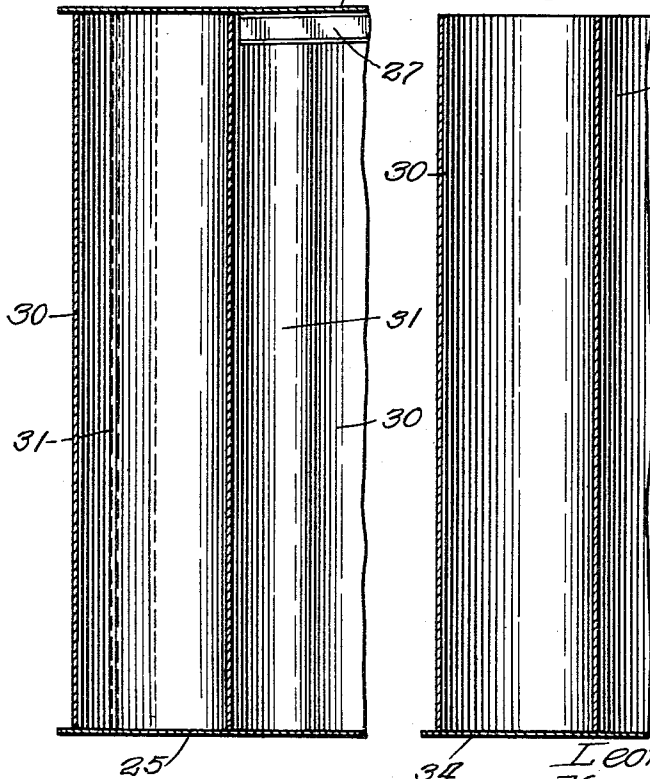


Fig. 6. 86 Fig. 7.



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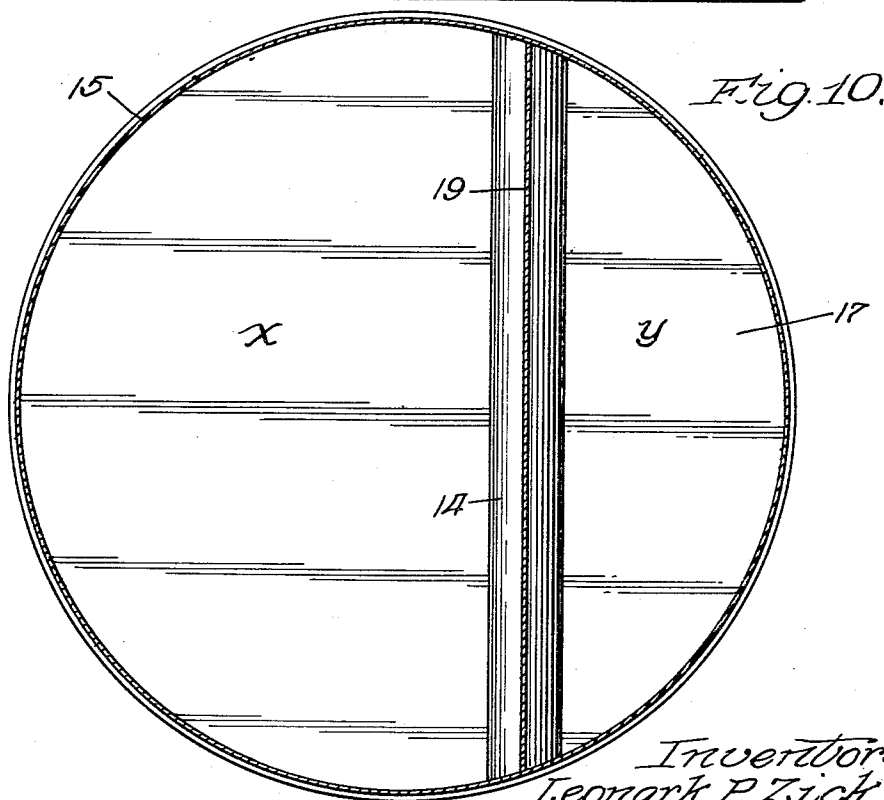
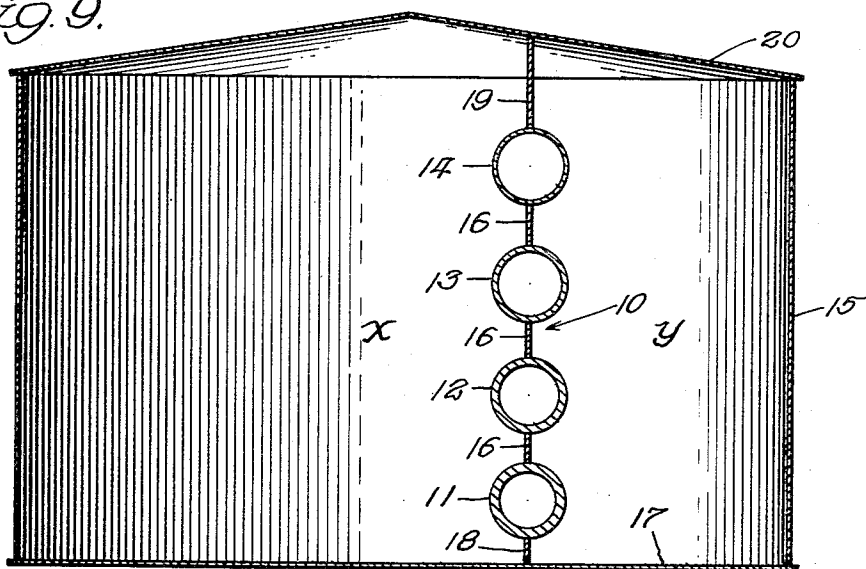
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Fig. 9.



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WALL STRUCTURE

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Continuation of application Serial No. 237,396, July 18, 1951. This application October 14, 1954, Serial No. 462,165

2 Claims. (Cl. 220--22)

This invention relates to a wall structure and more particularly to walls subjected to liquid and/or earth loads such as may be found in liquid storage tanks, breakwaters, cofferdams and the like, and is a continuation of applicants' copending application Serial No. 237,396, filed July 18, 1951.

The problem of providing a wall structure capable of withstanding great loads without additional bracing has been present especially in the field to which this invention applies. The loads referred to are those which may be applied to one or either side of such a wall.

Liquid storage tanks which have walls made of plates welded or riveted together in a circular plan, obtain their ability to withstand internally applied pressures by ring tension in the shell plates. At the greater depths of liquid, the plates must be thicker to withstand greater pressures and hence greater ring tension. It is recognized that there is an economical limit to the size of such tanks. Ring tension alone cannot be used in tanks having a plan other than circular, so trusses and braces must be provided to strengthen the side walls. Some walls are required to withstand pressure from either side. Tank partitions made of plates are in this class and must be tied to opposite side walls and sometimes to the bottom and roof of the tank so as to withstand pressures on either side. Also in this class of walls are the side walls of underground storage tanks, which must be able to withstand both internal liquid pressure and external earth pressures. Such side walls, when made of plates, must be reinforced with a great deal of bracing structure.

The wall structure of this invention is adapted to withstand all of the pressures applied to it without the addition of trusses, bracing or other reinforcing structure. In general, the wall structure of this invention employs a series of hollow cylinders which are arranged with their axes parallel and with some space between cylinders. Each cylinder acts as a beam to resist pressures applied either axially of the cylinder or laterally from any direction. Relatively thin webs join the cylinders and bridge the spaces between them. Any pressures applied directly to the webs are carried or transferred to the cylinders. A wall constructed in accordance with this invention may have a single support wherein the cylinders would act somewhat like cantilevers or may be provided with a support at each end of the cylinders.

Specific embodiments of the invention are illustrated in the accompanying drawings, in which:

Fig. 1 is a vertical section through approximately the middle of a cylindrical storage tank showing the wall of this invention as a partition in the tank;

Fig. 2 is a plan view of the tank of Fig. 1 with the roof removed;

Fig. 3 is a broken plan view partly in section as taken along line 3--3 in Fig. 4 of a rectangular tank incorporating the wall of this invention as a side wall;

Fig. 4 is a vertical sectional view of the tank of Fig. 3 taken substantially along line 4--4 in Fig. 3;

Fig. 5 is an enlarged fragmentary plan view of one corner of the tank shown in Fig. 3;

Fig. 6 is a vertical sectional view taken along line 6--6 in Fig. 5;

Fig. 7 is a view similar to Fig. 6 showing a modification of the wall structure;

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Fig. 8 is similar to Figs. 6 and 7 showing a further modification of the wall structure; and

Figure 9 is a view similar to Figure 1 showing a further modification in which the wall thickness of the partition tubes is varied; and Figure 10 is a view similar to Figure 2 showing a further modification in which the partition is off center.

The wall structure of this invention may be very appropriately used as a partition in a cylindrical storage tank such as is illustrated in Figs. 1 and 2. The partition wall generally indicated 10 comprises a series of horizontally arranged hollow metal cylinders 11, 12, 13, and 14 with a cylinder 11 at the bottom and 14 at the top of the wall. These hollow cylinders are arranged with their axes parallel and vertically spaced one above the other. As seen in Fig. 2, the cylinders each extends between opposite side walls of the cylindrical tank 15 and in this particular embodiment extends diametrically across the tank. Each cylinder acts as a beam to transfer by bending and shear all pressures to the side walls 15 of the storage tank. In this regard the cylinders ordinarily act independently of each other.

To complete the wall structure the spaces between the cylinders are filled or bridged by relatively thin vertical webs 16. The bottom cylinder 11 is spaced above the bottom 17 of the tank and a web 18 bridges the space between the lower cylinder 11 and the bottom. Likewise a web 19 bridges the space between the upper cylinder 14 and the top 20 of the cylindrical tank. These webs are each respectively secured along their edges to the cylinders 11 and 14 and to the top 20 and bottom 17 of the tank as well as to the side walls 15. Thus a liquid-tight partition across the tank is effected by the combination of the cylinders and the webs.

When the cylindrical tank is filled on one side of the partition only, the pressures on the webs are transferred to the cylinders which in turn have end reactions at the side walls. As is known, a cylindrical tank contains the pressure exerted against its side walls by ring tension in the plates making up its side walls. In the case of a partition extending diametrically across the cylindrical tank, this ring tension is balanced by the end reactions of the cylinders making up the partition. This condition exists when the partitioned tank contains liquid only on one side, and irrespective of on which side of the partition the liquid is present.

The wall structure is also particularly suited for partitions in cylindrical tanks adapted to divide the tank along a plane which is off-center. Thus, the partition shown in Figs. 1 and 2 could be moved to the right or left of its center position as shown in Fig. 10 and still serve to divide the tank without the addition of ties to the tank walls or other bracing structure. In the case of a nondiametrical vertical partition, for example, chamber Y might be smaller than chamber X on the other side of the partition. When the larger chamber X is filled with liquid and Y is empty, the partition is subjected to axial tensile loads in addition to the side bending loads since the ring tension in the shell plates at the ends of the cylinders induces tension in the cylinders. On the other hand, the smaller chamber Y may be filled when chamber X is empty, in which case the cylinders in the partition would be subjected to axial compressive loads as well as side bending. The cylinders which make up the partition are particularly adapted to withstand axial loads as well as bending loads.

If desired, the cylinders may be drilled with sufficient holes to open them to either side of the partition, in which case the storage capacity of the tank is not markedly decreased. Also the cylinders may, if desired, remain closed to the interior of the tank and openings through the shell at the ends of the cylinders may be

provided for access to the interior thereof. If the cylinders contain only atmospheric air, there may be some small buoyancy which can be transferred from one cylinder to the next through the webs 16; however, the cylinders may be considered as acting independently for all purposes with the webs only transferring pressures against them to the cylinders.

The wall of this invention provides a means whereby tanks may be built of greater dimensions. In cylindrical tanks there is an economical limit to their size because all parts of the side walls cooperate in withstanding the pressures exerted against them by ring tension in the shell. Of course tanks may be made much larger by the addition of considerable bracing structure to reinforce the side walls.

In Figs. 3 and 4, a rectangular tank employing the wall in this invention as its side wall is illustrated. The tank has the usual bottom 25 made of plates upon a suitable foundation and a top 26 also made up of plates and supported on rafters 27 and posts 28 extending between the rafters and the bottom 25. The side walls of the tank are constructed of a plurality of cylinders 30 similar to the cylinders shown in Figs. 1 and 2 in the partition. These cylinders are arranged with their axes vertical and parallel with a space being left between each adjacent pair of cylinders. The cylinders are arranged in plan to the configuration of the tank and, as illustrated in Fig. 3, the plan is generally rectangular or square although the plan of the tank could be curved instead of rectangular or square. As best seen in the detail of Fig. 5, the cylinders 30 are joined across the shortest distance between them by half-cylinders 31 welded along the free edges thereof to the cylinders 30. The half-cylinders 31 serve the same purpose as the flat plate webs shown in the partition of Fig. 1 in that they transfer the pressure against them to the cylinders 30. The corner cylinder 30a may have the webs joined to it along parallel lines 90° spaced apart in the case of a rectangular tank or along parallel lines lying in the planes of the adjoining sides. This structure at the corners may vary such as by using a quarter-cylinder to bridge the space between the adjoining cylinders 30 of the intersecting side walls.

In this structure the pressure on the side walls is carried by shear and bending in the cylinders 30 to the ends thereof. These end reactions are resisted by the bottom plates 25 and the top plates 26 of the tank. Since each cylinder 30 acts independently of the others, there is no limitation to the size to which such tanks may be built. The side walls can thus be extended to any dimension without varying the strength of the individual components of the side wall.

In some installations it may be desirable to build a tank utilizing a side wall of the present construction wherein the reactions at the ends of the cylinders may be resisted only at one end. Such structures are illustrated in Figs. 7 and 8. In Fig. 7 the cylinder 30 is connected at one end to the bottom plates 34 of the tank and act somewhat in the manner of a cantilever. That is, all pressure against the side wall is carried to the bottom plates by the cylinder 30.

In the form illustrated in Fig. 8, the cylinder 30 is extended beyond the foundation surface in to the ground 35 so that the end reaction may be resisted by earth and in this instance each cylinder acts as a beam having one fixed end support. If desired, ballast may be added within the cylinders 30 to help resist overturning in the forms shown in Figs. 7 and 8. This ballast may be sand, concrete or similar materials or may be the liquid in the tank. In the latter case, holes in the cylinders are provided for entry of the stored liquid into some or all of the cylinders.

Rectangular or polygonal shaped tanks are often used for underground liquid storage. Such tanks must be made to withstand both internal liquid pressure and external earth pressure. The side wall of this invention

is well adapted to withstand such loads as the cylinders have a section modulus which is the same about all axes. In underground storage the webs between cylinders may most appropriately be made of flat plates as in the partition illustrated in Figs. 1 and 2. The rounded plates 31 illustrated in Fig. 3 are most desirable in tanks which are adapted to withstand only internally applied pressure since the plates may be made much thinner and yet transfer all pressures against them to the cylinders.

In some applications of the wall structure of this invention, the webs between cylinders described above may be omitted and the cylinders arranged with their peripheries in contact. Welding may be used to join the adjacent edges of the cylinders, in which case, the entire wall is formed of joined cylinders. The webs are intended to carry liquid loads thereon to the adjacent cylinders which in turn carry the load to the support for the cylinders. For example, the cylinders used in a partition such as illustrated in Fig. 1 are spaced apart a distance varying with the distance of the cylinder from the bottom. The lower cylinder 11 is 12 inches from the bottom and the web vertical widths are 14, 16, 20 and 22 inches respectively progressing upwardly in a 30 foot diameter tank having 19 foot side walls. The cylinders are sufficiently strong to carry the loads on the webs, but in some installations it may be desirable to eliminate the webs in part or altogether. It may also be desirable in some instances to decrease the wall thickness of the cylinders with increase in distance of the cylinder from the bottom as shown in Fig. 9. Furthermore, it may be desirable to increase tube wall thickness at the center of the tubes.

The foregoing detailed description has been given for clearness of understanding only, and no unnecessary limitation should be understood therefrom, for some modifications will be obvious to those skilled in the art.

We claim:

1. A metal cylindrical fluid storage tank capable of withstanding great loads having a metallic vertical cylindrical wall, a metallic bottom joined thereto, and a vertical partition wall within the tank connected at each end to said cylindrical wall and along its lower end to said tank bottom, said tank being free from additional bracing, said partition wall comprising a plurality of horizontally arranged elongated metal cylinders arranged and spaced in parallel relation, each cylinder being resistant to both axially and laterally applied loads and being connected to its adjacent cylinder by narrow webs edge-joined, the vertical spacing between the cylinders increasing in proportion to the distance of the cylinders from the bottom of the tank.

2. A metal cylindrical fluid storage tank capable of withstanding great loads having a metallic vertical cylindrical wall, a metallic bottom joined thereto, and a vertical partition wall within the tank connected at each end to said cylindrical wall and along its lower end to said tank bottom, said tank being free from additional bracing, said partition wall comprising a plurality of horizontally arranged elongated metal cylinders arranged and spaced in parallel relation, each cylinder being resistant to both axially and laterally applied loads, and being connected to its adjacent cylinder by narrow webs edge-joined, the wall thickness of the cylinders decreasing with increase in distance of the cylinders from the bottom of the tank.

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