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"STORAGE TANKS"

The present invention relates to storage tanks.

Storage tanks are usually built in situ or constructed and transported to a required location.

- 5 In particular large storage tanks are built in situ and often employ steel reinforced concrete. Whereas, tanks for the storage of relatively small quantities of various liquids, solids or powders are often constructed and transported to a desired location for installation and use.
- 10 In general the latter form of tank may be removed and relocated for use elsewhere. However, tanks built in situ and comprising concrete are not usually intended to be relocated, nor can economically be relocated.

The present invention provides a storage tank which is built in situ
15 and may be readily dismantled and relocated.

In accordance with the present invention there is provided a storage tank comprising:

- a) an endless wall formed of a plurality of panel members each having:
- 20 i) one or more smooth portions;
- ii) a first lateral edge and a second lateral edge opposite a first lateral edge;
- iii) a plurality of upright raised ribs each located laterally of one or two smooth portions, all of the upright raised ribs
- 25 projecting in the same direction from the or each smooth portion; and

- iv) one or more integral loops formed from two substantially parallel slits made in the smooth portions and having intervening material between the slits deformed in a direction opposite to that of the upright raised ribs;
- 5 the panel members being disposed in overlapping manner; and
- b) at least one elongated endless support strap extending substantially horizontally around the endless wall and disposed through and retained by a plurality of said loops to retain and align adjacent panel members in vertical and side by side overlapped
- 10 relation and to provide support to the endless wall.

The present invention will now be described, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 is a front elevation of a panel member for use in forming a storage tank in accordance with the present invention;

- 15 Figure 2 is a side elevation of the panel member of Figure 1, shown in situ;

Figure 3 is a cross sectional view of the panel member of Figure 1 along line A-A;

Figure 4 is an enlarged view of a trough of the panel member shown in

- 20 Figure 3;

Figure 5 is an elevated view of a storage tank in accordance with the present invention; and

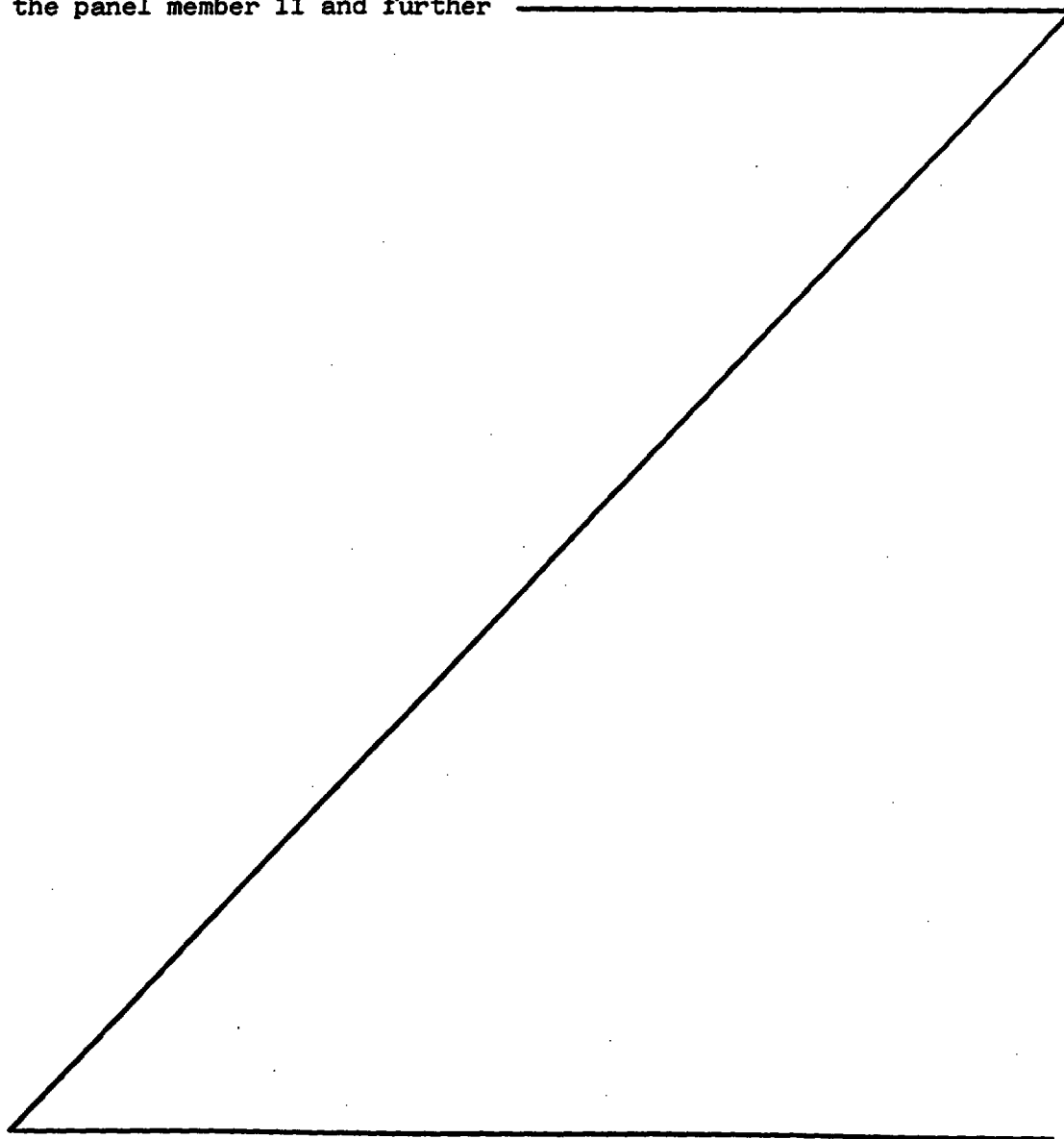
Figure 6 is an upper perspective view of a support strap of the storage tank of Figure 5.

- 25 In Figure 5 there is shown a storage tank 10 in accordance with the present invention, comprising a plurality of panel members 11.

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As can be readily seen in Figure 1, each panel member 11 comprises flat portions 12 lying in the same plane and a plurality of intermediate upright raised ribs 14 and a pair of lateral raised ribs 15 all of which project in the same direction from the plane of the
5 flat portions 12.

The raised ribs 14 and 15 are vertically disposed with a raised rib 15 at a first and a second lateral edge 15a and 15b, respectively, of the panel member 11 and further



raised ribs 14 intermediately located between the first and second lateral edges 15a and 15b. The flat portions 12 are disposed between adjacent raised ribs 14 and 15.

The raised ribs 14 and 15 are formed by deformation of the panel member 11, in known manner. The vertically disposed raised ribs 14 and 15 produce a vertical rigidity in the panel member 11 whilst allowing an amount of horizontal flexibility found to be suitable to allow erection of the storage tank 10 of the present invention.

As is best shown in Figures 1 and 3 each panel member 11 comprises a plurality of raised ribs 14 and 15, such as 6 raised ribs 14 and 15. The raised ribs 14 are equally spaced and the lateral raised ribs 15 have a lesser spacing. The panel member 11 has a width P and the distance between adjacent raised ribs 14 is designated D2, D3 and D4 respectively.

Typically the ratios $\frac{P}{D2}$, $\frac{P}{D3}$ and $\frac{P}{D4}$ of panel width to inter-rib distances is in the range from 3.2:1 to 5:1, preferably in the range from 4:1 to 4.5:1, for example about 4.3:1.

The lateral raised ribs 15 are spaced at distances of D1 and D5 from adjacent raised ribs 14. Typically the ratio $\frac{P}{D1}$ of the panel width to inter-rib distance at the first lateral edge 15a is in the range from 12.5:1 to 5:1, preferably in the range from 11.5:1 to 10:1, for example about 10.8:1.

Also, the ratio $\frac{P}{D5}$ of the panel width to inter-rib distance at the second lateral edge 15b is typically in the range from

3.5:1 to 5:1, preferably in the range from 4:1 to 5:1, for example about 4.7:1.

It is envisaged that each panel member 11 could be formed from a 1200mm wide, 2100mm long and 0.6mm thick sheet of metal.

5 In such a case the distance D1 is about 100mm; D2, D3 and D4 are about 250mm and D5 is about 230mm.

Figure 4 shows a cross section of one of the raised ribs 14 or 15 of Figure 3. The size of the raised ribs 14 or 15 suitable to form the tank 10 of the present invention is
10 dependent upon the volume and the height of the tank. For example, a larger raised rib 14 or 15 may be needed to suit a tank of greater volume and height than that considered herein. Although, it is understood that the strength of the endless wall may be increased by other means, as described hereinafter
15 Each raised rib 14 or 15 has a length L, a width W, a crest length C, a slope width S, a slope angle B, a thickness T and a curve radius R.

For the particular size panel member 11 described immediately hereinbefore the raised ribs 14 and 15 may have the following
20 characteristics; the length L is about 35mm, the width W is about 20mm, the crest length C is about 15mm, the slope width S is about 10mm, the slope angle P is about 26.6°; the thickness T is about 0.6mm and the curve radius is in the approximate range of 5 and 7mm.

25 It is envisaged that a panel member 11 of dimension other than that described hereinabove could use a different number of raised ribs 14 and 15 of different characteristics.

The raised ribs 15 of two adjacent panel members 11 are intended to overlap in use.

In particular a raised rib 15 of the first edge 15a of one panel member 11 is intended to cup, in use, into a raised rib 15 of the second edge 15b of an adjacent panel member 11.

It is envisaged that a panel member 11 having a different arrangement of raised ribs 14 and 15 could be used such that more than one raised rib 14 and 15 of adjacent panel members 11 overlap.

The panel members 11 also comprise a loop means comprising loops 16 extending from the flat portions 12 and projecting in a direction opposite to that of the raised ribs 14 and 15. The loops 16 are formed by punching two equally sized parallel slits in a flat portion 12. The material between the slits is then deformed away from the flat portion 12 in a direction opposite to the raised ribs 14 and 15 to form a loop 16 of material.

The panel members 11 each comprise a plurality of such loops 16, such as 12 loops 16, arranged toward the lateral edges 15a and 15b. The loops 16 are arranged so that half are adjacent one lateral edge 15a or 15b and half adjacent the other, with corresponding loops 16 being at the same height upon the panel member 11. Conveniently, the loops 16 are arranged in respective substantially vertical rows adjacent

each lateral edge 15a and 15b.

The loops 16 are arranged to receive, in use, a plurality of support straps 17 as shown in Figure 5. The support straps 17 are formed of elongated flexible flat metal straps having
5 holes 17a in each end thereof, as shown in Figure 6.

Each support strap 17 is, in use, threaded through each of the horizontally corresponding loops 16, as shown in Figure 5.

It is intended that the support straps 17 be of such length as to enable them to be threaded through loops 16 of more
10 than one panel member 11, such as a bank of 3 panel members 11. Thus, the straps 17 align and retain, in side by side overlapped manner, a number of panel members 11, such as 3 panel members 11.

Individual banks of panel members 11 are connected together
15 by first overlapping their adjacent outer lateral edges 15a and 15b and securing corresponding straps 17 with bolt assemblies 18 arranged through the holes 17a of overlapping straps 17.

Any number of panel members 11 may be connected in this
20 manner to form an endless wall storage tank 10.

As is particularly shown in Figure 2 the support straps 17 are not equally spaced over the height of the panel member 11. It has been found that an equal spacing of the support straps 17 results in an unequal distribution of load thereon
25 imparted by an outward force due to the contents of tank 10.

In particular it has been found that for a tank 10 comprising 6 support straps 17 equally spaced up the panel members 11 a large force acts against the second lowest support strap from the bottom of the tank (Figure 5). The other support straps then have progressively less load the higher up the tank 10 they are situated.

It is preferred to maintain substantially equal load on each of the support straps 17. To accomplish substantially equal support strap loading more closely spaced straps 17 are required toward the lower end of the tank 10. Figure 2 shows an arrangement for 6 support straps 17 to achieve substantially equal distribution of load over the four support straps 17 located within the uppermost and lowermost support straps 17.

In the arrangement of Figure 2 the uppermost and lowermost support straps 17 have substantially less load than the remaining support straps 17.

The height of the panel member 11 is designated H and the distance between adjacent support straps 17 is designated H1, H2, H3, H4, H5 and H6. The distance between the uppermost strap 17 and an uppermost edge of the panel member 11 is designated as H7. Typically the ratio of the panel height to the distance between adjacent support straps 17 is about 21 for $\frac{H}{H1}$, about 9.2:1 for $\frac{H}{H2}$, about 7.7:1 for $\frac{H}{H3}$, about 6.2:1 for $\frac{H}{H4}$, about 4.1:1 for $\frac{H}{H5}$, about 4.1:1 for $\frac{H}{H6}$, and about 15.6:1 for $\frac{H}{H7}$.

For a panel member height H of 2100mm the support straps 17

are typically spaced such that H1 is about 100mm, H2 is about 227mm, H3 is about 273mm, H4 is about 338mm, H5 is about 510mm, H6 is about 517mm and H7 is about 135mm.

It is envisaged that the ratio $\frac{H}{H_1}$ be in the range of 14:1 to 21:1. That is, it is envisaged that the height H1 of the lowest strap 17 could be altered by up to about 50mm.

The preferred location of the support straps 17 is mainly dependent upon the height of the panel members 11. Thus, the ratios may be applied to produce a tank 10 of a different height with substantially even loading on the support straps 17. However, it is to be understood that a scaling of the height and strap location of the tank 10 will result in corresponding scaling of the load bearing capability of the tank 10. For example, an increase in the height of the tank 10 will lead to a corresponding decrease in the load bearing capability of the straps 17 and the tank 10.

In order to enable the tank 10 to store liquids, solids or powders of different densities it is generally only necessary to alter the support straps 17. For example, to enable the tank to store a dense liquid such as oil relatively stronger support straps 17 may be used than would be necessary in the storage of water or grain such as wheat.

When the tank 10 is used to store liquids the load on the support straps 17 is principally dependent on the head of water and the diameter of the tank 10. It is to be understood that the capacity of the tank 10 is also dependent on wind loading and wave formation (for stored liquids and bearing and shear forces on the soil and the like.

It follows that the load bearing capability of the tank 10 may be increased by increasing the size, gauge and yield strength of the support straps 17, the panel member 11 and the dimensional parameter of the tank 10 described herein.

- 5 When the tank 10 is used to store solids or powders the load on the support straps 17 is principally dependent on the height of the solids or powders and the angle at which it will stack. That is, solids and powders can be substantially self supporting except for a periphery in which the solids or powders
10 tend to slide under force of gravity. The angle of slope of the solids or powders at which no sliding occurs is called the stack angle.

The load due to solids or powders on the support straps 17 is only secondarily dependent on the diameter of the tank 10.

- 15 Therefore, the capacity of the tank with respect to solids and powders for a given strength of support straps is substantially dependent on the height of the solids and powders. Thus, to increase the capacity of the tank 10 in respect of storage of solids and powders it is generally
20 necessary only to increase the diameter of the tank 10 whilst maintaining the height of the tank 10 substantially constant. An important point to note in regard to the storage of solids and powders is that the load on the support straps 17 may not be constant. For example, where a tank 10
25 containing grain has some of the grain removed via an outlet located at the side of the tank 10 the load on the support straps 17 located opposite the outlet may be substantially greater than that near the outlet. Such non uniform loading

of the tank 10 must be considered in determining the load capability of the tank. Thus, the actual capacity of the tank in respect of solids and powders is also dependent on the likely non uniform loading caused by the stacking effect of its contents. It is to be understood that an even distribution of support straps 17 could be used. In such a case it is also understood that an evenly distributed arrangement of support straps 17 generally results in a lower load bearing capacity of the tank 10. It follows from this that relatively smaller tanks 10 could comprise such an arrangement of support straps 17.

The storage tank 10, in use, is intended to have a liner 20 formed of a resilient material such as a polyvinyl chloride plastics material or the like, as shown in Figures 2 and 5. Preferably, the liner 20 has resistance to U.V. light. The liner 20 is intended to be located inside the storage tank 10 and secured to the top of each panel member 11 by a securing means 22.

The securing means 22 comprises a capping angle 24 and a plurality of securing plates 26. The capping angle 24 is laid, in use, on the wall of the tank 10 on top of the liner 20. The capping angle 24 is secured to the uppermost one of the support straps 17 by the securing plates 26 and thus secures the liner 20 in place. The capping angle 24 also provides an amount of rigidity to the upper reaches of the tank 10. Such rigidity may be necessary in situations when the tank 10 is substantially empty.

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It is envisaged that patches may be required to cover the inside of the storage tank 10, at locations corresponding to the loops 16, to protect the liner 20.

The storage tank 10 may have a cover (not shown) positioned atop.

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The cover may conveniently be formed of material similar to the liner 20.

The cover may be arranged so that substantially all of its area is in close proximity with a stored liquid.

It is envisaged that a flotation means (not shown) would be useful to communicate the liquid level to the cover.

5 Thus, the cover could be maintained substantially at the same level as the liquid.

In this way the volume of air between the cover 22 and the liquid may be maintained as small as possible. It is desired to reduce the volume of air above the liquid to
10 reduce the growth of algae and the like in the liquid.

It is further envisaged that the storage tank 10 could comprise a roof means (not shown) to seal its contents from the outside environment. The roof means could also be sealed to the capping angle 24 to render the tank 10
15 substantially air tight.

It is preferred that, in use, the raised ribs 14 and 15 of the panel member 11 be disposed inwardly of the storage tank 10. It has been found that such an arrangement has preferable features compared to an arrangement with outwardly
20 disposed ribs. In particular, it results in a more evenly distributed outward force on the panel members 11 and on the support straps 17. Such even distribution of force occurs since the support straps 17 contact the flat portions 12 of the panel members 11.

25 If the raised ribs 14 and 15 extend outwardly of the storage tank 10 the support straps 17 may be drawn through slots 16

in the raised ribs 14 and 15. Such an arrangement is not preferred since the plurality of slots 16 result in much friction in drawing the straps 17 therethrough. Also, in use, such an arrangement would result in deformation of flat portions 12 of the panel members 11 under the force of the contents of the tank 10.

Also, the preferred arrangement yields less stretch on the liner 20 about the raised ribs 14 and 15 when the storage tank 10 has a store of liquid or solids or powders, such as water, grain or cement powder. That is, since the raised ribs 14 extend inwardly of the storage tank 10 the liner 20 is not forced into the raised ribs 14 and 15 and so is not subjected to as much stretching as otherwise may occur.

In use, an unassembled tank 10 is taken to a desired location and a number of panel members 11, such as 3 panel members 11, are laid in side by side arrangement with adjacent raised ribs 15 overlapped.

Then the support straps 17 are threaded through horizontally corresponding loops 16 of the overlapped panel members 11.

Once the straps 17 are threaded the bank of panel members 11 are stood up and the bank bent to a desired amount of curvature. The amount of curvature desired is that which will ultimately yield a storage tank 10 of desired radius once a plurality of banks are secured together.

The banks are secured together by the bolt assemblies 18, shown in Figure 5, engaged with the holes 17a (Figure 6) of

overlapping straps 17.

When the wall of the storage tank 10 is completed, by the bolting together of the first and the last panel members 11, the liner 20 and the roof may be placed in and on the storage tank 10.

It has been found that a support base is not essential in supporting the apparatus of the present invention, as the outward force of the stored substance is usually sufficient to prevent sinkage of the panel members 11 into the ground.

However, it is to be understood that a lip may be formed on the lower edge of the panel members 11 to further assist in the vertical support of the storage tank 10.

Preferably, the storage tank 10 is to be erected on a bed of dense sand 40 spread over a permeable underlay 42 on top of the ground 44 as shown in Figures 2 and 5. It has been found that sinkage of the panel member 11 is least likely when erected on a dense sand 40 rather than a clay based soil 44. Further, the permeable underlay 42 is preferred to reduce the occurrence of the dense sand 40 combining with the lower soil 44. Also, if the liner 20 develops a leak the underlay 42 will allow a liquid stored in the tank 10 to flow away substantially without erosion of the dense sand 40.

If an underlay 42 is not used it is predicted that a leak could cause considerable erosion of the supporting sand 40 and ground 44 and could result in the collapse of the tank 10.

If the storage volume of the storage tank 10 is to be increased or reduced one may effect such a change by respectively adding or removing panel members 11 or banks of panel members 11 and support straps 17.

- 5 It is envisaged that the tank 10 of the present invention could comprise inlet means and outlet means for entry and exit of the substances stored therein.

Also, it is envisaged that the tank 10 could be adapted, with the addition of doors and the like and the deletion of the liner 20, as a
10 dwelling. The dwelling could require some form of insulation and/or ventilation.

Other modifications and variations of the storage tank as described above are possible. For example, panel members 11 of a shape other than that described hereinabove could be used provided the straps 17
15 could still retain the panel members 11 secured in side by side overlapping alignment.

It is envisaged that the lower reaches of the storage tank 10 would be coated with a corrosion resistant substance such as polyurethane. Also, panel members 11 of a width other than 1200 mm could be used
20 and thus may require ratios other than those mentioned hereinabove.

In the context of the present invention, "smooth", in relation to the portions 12 is defined to mean of generally uniform profile between adjacent raised ribs 14, 15. That is smooth means that the portions 12 are relatively smooth in comparison with the shape of the raised
25 ribs 17.



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CLAIMS

1. A storage tank comprising:
 - a) an endless wall formed of a plurality of panel members each having:
 - 5 i) one or more smooth portions;
 - ii) a first lateral edge and a second lateral edge opposite a first lateral edge;
 - iii) a plurality of upright raised ribs each located laterally of one or two smooth portions, all of the
10 upright raised ribs projecting in the same direction from the or each smooth portion;
and
 - iv) one or more integral loops formed from two
15 substantially parallel slits made in the smooth portions and having intervening material between the slits deformed in a direction opposite to that of the upright raised ribs;
the panel members being disposed in overlapping manner;
and
 - 20 b) at least one elongated endless support strap extending substantially horizontally around the endless wall and disposed through and retained by a plurality of said loops to retain and align adjacent panel members in vertical and side by side overlapped
25 relation and to provide support to the endless wall.
2. A storage tank according to Claim 1, in which one



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of the upright raised ribs is located adjacent the first lateral edge and another of the upright raised ribs is located adjacent the second lateral edge, the panel members being disposed in overlapping manner with the upright raised rib adjacent the first lateral edge of one of the panel members being cupped by the upright raised rib adjacent the second lateral edge of an adjacent one of the panel members.

3. A storage tank according to Claim 2, in which said cupping of the said upright raised ribs is the sole engagement between adjacent panel members.

4. A storage tank according to any one of the preceding claims in which each panel member has at least two of said loops disposed at equal heights on the panel member in order to receive one of the endless support straps.

5. A storage tank according to Claim 4, in which one of the said at least two loops is located adjacent the first lateral edge and one other of the said at least two loops is located adjacent the second lateral edge.

6. A storage tank according to any one of the preceding claims, in which each endless support strap is disposed about the endless wall and contiguous with the smooth portions of the panel members.

7. A storage tank according to any one of the preceding claims, in which each endless support strap is formed



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- of a plurality of support straps joined end to end, wherein each of the support straps extends through the loops of a plurality of the panel members so as to retain and align said panel members in side by side overlapped relation.
- 5
8. A storage tank according to Claim 7, in which adjacent support straps of each endless support strap are connected at or adjacent troughs created by the upright raised ribs.
- 10
9. A storage tank according to any one of the preceding claims, in which the or each smooth portions are formed of a single skin thickness of material and the substantially parallel slits are made in the single skin of the generally flat portions.
- 15
10. A storage tank substantially as herein described with reference to the accompanying drawings.
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