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FRAGMENTATION OF UNDERGROUND METALLIC SILOS SUBJECTED TO INTERNAL BLAST

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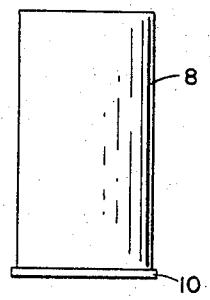

FIG. 1
(PRIOR ART)

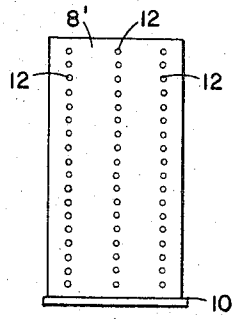

FIG. 2

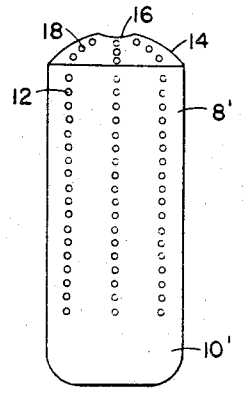

FIG. 3

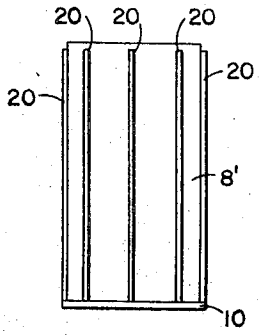

FIG. 4

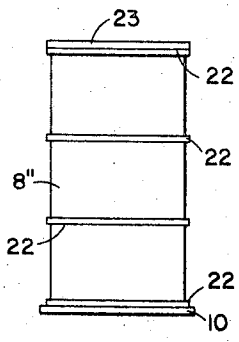

FIG. 6

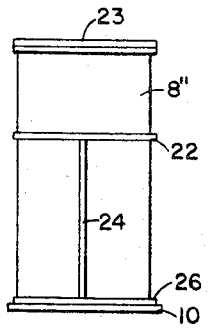

FIG. 7

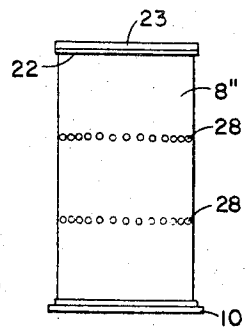

FIG. 8

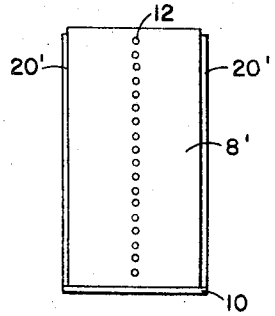

FIG. 5

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FRAGMENTATION OF UNDERGROUND METALLIC SILOS SUBJECTED TO INTERNAL BLAST

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10 Claims. (Cl. 220—18)

This invention relates to underground storage containers subjected to accidental detonation of explosives where controlled fragmentation is desirable and particularly to underground metallic silos subjected to internal blast.

Underground metallic silos are used as explosive storage containers. Their proximity to inhabited areas commands a safety zone around them in case of an accidental in-container explosion. As the sites may be located in heavily populated districts, real estate costs could prove to be quite high. Therefore, the greatest possible reduction in safety zone radius is desirable.

The size of the safety zone radius is mainly a function of both the overpressure generated by an explosion and the accompanying debris formed.

For the case of circular cylindrical metal containers placed above ground and used as explosive storage containers, standard tables are available to determine the safety zone radius. This radius, of course, satisfies both the overpressure and debris requirements.

The use of a barricade at least as high as the explosive storage container and at least a minimum and less than a maximum distance away has long been employed to reduce the safety zone radius. However, it is desirable to reduce the safety zone radius even more.

In the case of underground emplacement, the designer can consider the container as being underground at all times. This is because the explosive is above ground for an appreciable length of time only at a test site or in a war situation. At a test site, land is in abundance and the lowering of the safety zone radius is not a basic consideration. In a war situation, ordinary safety considerations are disregarded.

Accordingly, the principal object of this invention is to produce an improved design for underground cylindrical containers which will prevent flying debris and minimize overpressure in case of an in-container explosion.

A particular object of this invention is to provide a container having means for directing the forces resulting from an explosion of material enclosed in the container.

Another particular object of this invention is to provide a container which will rupture along predetermined lines instead of disintegrating into fragments.

Other objects and many of the attendant advantages of this invention will be appreciated more readily as the same becomes understood by reference to the following detailed description, when considered in connection with the accompanying drawing, wherein:

FIGURE 1 is an elevational view of an ordinary cylindrical silo;

FIGURE 2 is an elevational view of an alternative embodiment of this invention;

FIGURE 3 is an elevational view of the preferred embodiment of this invention;

FIGURE 4 is an elevational view of another alternative embodiment of this invention;

FIGURE 5 is an elevational view of another alternative embodiment of this invention;

FIGURE 6 is an elevational view of a modified cylindrical silo;

FIGURE 7 is an elevational view of another modified cylindrical silo; and

FIGURE 8 is an elevational view of still another modified cylindrical silo.

The apparatus of this invention achieves the direction of the forces resulting from an explosion and the consequent rupturing along predetermined lines by means of sudden changes of thickness of the cylindrical container in a longitudinal (parallel to the cylinder axis) direction.

Referring now to FIGURES 1 through 8, FIGURE 1 shows an ordinary cylindrical silo **8** of the prior art. It is a thin cylindrical shell of uniform thickness. A flat bottom plate **10** is shown attached to the bottom of the shell.

FIGURE 2 shows an alternative embodiment of a cylindrical silo **8'** of this invention. The sudden changes in cylinder wall thickness are achieved by means of longitudinal rows of drilled holes (cavities) **12** of desired size, depth, and spacing. Other methods such as slitting can also be used. Preferably, eight longitudinal rows are employed, as in this embodiment. In the event of an explosion, the ripping occurs along these rows of cavities, no loose fragments are generated and the generated strips hang to the bottom plate **10**.

FIGURE 3 shows the preferred embodiment of a cylindrical silo **8'** of this invention. A top cover **14** is employed. A top cover is not required, but if used, the top portion of the cylinder should have a tie-in to the top cover without undue stress concentration. Thus, the explosive gas pressure will not tear the cover off before stresses have caused it to open in longitudinal cracks and release gas pressure into the soil. The preferred embodiment of this invention employs a top cover having a central hole **16** and from where structurally weakened portions **18** radiate to the intersection of respective rows **12** with the upper end of the cylinder.

Similar considerations as applied to the top cover of the cylinder applies to a bottom cap. If a bottom cap **10'** is used (as in the preferred embodiment of this invention), it should connect with a cylindrical portion of its own onto the cylindrical shell. This cylindrical portion of the bottom cap **10'** should change into an approximately ellipsoidal shape further down. Preferably, this ellipsoidal end should have a flat central area. Thus, plastic hinging along rows **12** of silo **8'** is achieved. This shape is preferred, although almost any concave upwards shape can be used.

Such an end cap may be used in the preferred embodiment or combined with any of the alternative embodiments of this invention. If used, it is substituted for end plate **10**.

FIGURE 4 shows an alternative embodiment of this invention employing reinforcing bars **20** extending longitudinally along a cylindrical silo **8'**. Such a bar may be part of the silo itself and accordingly is defined herein to include such.

FIGURE 5 shows an alternative embodiment of this invention employing two reinforcing bars **20'** extending longitudinally along cylindrical silo **8'**, and rows of drilled holes **12** (only one shown) extending longitudinally along

cylindrical silo 8'. This combination of weakening and strengthening in the same cylindrical silo has been found to produce optimum results for the case of a cylindrical silo without a top cover. Preferably, in this alternative embodiment, the drilled holes and parallel reinforcing bars are in alternate positions around the silo.

FIGURE 6 shows a cylindrical silo 8'' employing reinforcing rings 22 latitudinally placed and a top plate 23 that is secured in a conventional manner such as by bolts (not shown) to the top reinforcing ring.

FIGURE 7 shows a cylindrical silo 8'' employing a reinforcing ring 22 connected by a reinforcing bar 24 to an anchoring member 26.

FIGURE 8 shows a cylindrical silo 8'' employing latitudinally placed, structurally weakened ring portions 28.

The structures 8'' in FIGURES 6–8, employing sudden changes in thickness latitudinally, all proved unsuccessful, contrary to expectations.

From the viewpoint of minimization of debris and overpressure, the technically optimum container will have to look pretty much like a cylindrical pressure vessel with one or two dished end plates, of which the upper one contains a central hole, from which structurally weakened portions radiate. This is the preferred embodiment of this invention.

The apparatus of this invention can be utilized in any case of an underground container subject to accidental detonation where controlled fragmentation is desirable.

What is claimed is:

1. A silo for use underground in storing explosives, said silo comprising a cylindrical metal container having longitudinal rows of sudden changes of thickness with each row extending in a direction parallel to the axis of said container, said rows being generally equally spaced apart about the circumference of said cylindrical metal container whereby when sufficient force is applied internally of said cylindrical container, said cylindrical container will rupture along predetermined lines to form strips.

2. A silo as set forth in claim **1** wherein said sudden changes of thickness comprise reinforcing bar means along said container.

3. A silo as set forth in claim **2** wherein said sudden changes of thickness further include at least one structurally weakened portion along said container, said structurally weakened portion being parallel to said reinforcing bar means.

4. A silo as set forth in claim **1** wherein said sudden changes of thickness comprise a first plurality of structurally weakened portions and a second plurality of reinforcing bar means, and wherein said reinforcing bar means and said structurally weakened portions alternate around said container.

5. A silo as set forth in claim **4** wherein said first plurality and said second plurality each equal two.

6. A silo as set forth in claim **1** wherein said sudden changes in thickness comprise structurally weakened portions along said container.

7. In combination with a silo as set forth in claim **6**, a top cover attached to the upper end of said silo, said top cover having structurally weakened portions emanating from the center of said top cover and approximately intersecting respective ones of said structurally weakened portions of said container approximately at said upper end of said silo, in order to minimize fragmentation and cause rupturing along predetermined lines approximating said structurally weakened portions of said top cover and said silo in case of an explosion.

8. In combination with a silo as set forth in claim **7**, a bottom cap attached to the lower end of said silo, said bottom cap being shaped concave upwards.

9. A silo as set forth in claim **1** wherein said sudden changes in thickness comprise structurally weakened portions along said container, and a bottom cap attached to the lower end of said silo, said bottom cap being shaped concave upwards.

10. In combination with a silo as set forth in claim **1**, a bottom plate attached to the lower end of said silo.

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