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⑦ Applicant: **THE EXPANDED METAL COMPANY LIMITED, 1, Butler Place, London SW1H 0PS (GB)**

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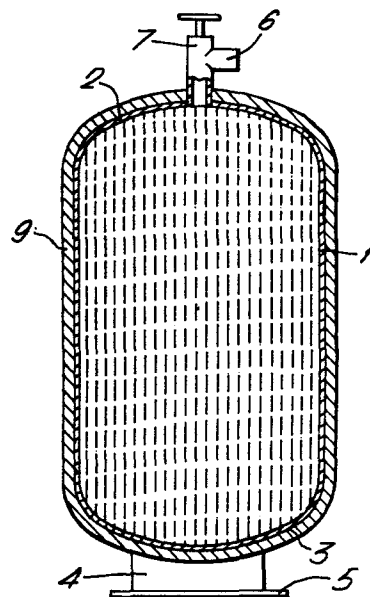
⑧ Inventor: **Fryer, Kevin Chamberlain, 76, Hounslow Road, Feltham Middlesex (GB)**
Inventor: **Strookman, Huibertus, Kon. Wilhelminalaan 233, Voorburg (NL)**

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⑨ Representative: **Brunner, Michael John et al, Gill Jennings & Every 53 to 64, Chancery Lane, London WC2A 1HN (GB)**

④ **Container for pressurized gases.**

⑤ The invention relates to a container for liquified petroleum gas, the container having, internally, an at least partial filling of expanded metal mesh (8) and, externally, an intumescent coating (9). The mesh (8) may be arranged so as to extend substantially completely throughout the container or may be arranged so as to form a lining for the container against the wall thereof.



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THE EXPANDED METAL COMPANY LIMITED GJE 5178/035.

"CONTAINER FOR PRESSURIZED GASES".

The present invention relates to containers intended primarily for liquified petroleum gases such as butane, propane, ethylene oxide, hydrazine, vinyl acetate and many others. The invention

5. is directed to a construction of the container which will either completely prevent or significantly delay the time to explosion of such a container when subjected to intense heat in for example a fire.

- In recent years it has been found to be
10. possible to protect containers containing inflammable gas/air or vapour/air mixtures against combustive explosion by filling the interior of the container with expanded aluminium foil. Such containers, for example vehicle petrol tanks, usually contain sufficient oxygen
15. to support combustion and permit the flame front to reach detonation velocities and the expanded foil prevents the ignition explosion of the gas or vapour mixtures by conducting heat away from the point of combustion so quickly that the flame front cannot
20. spread.

- Liquid petroleum gas (LPG) containers are always at a pressure above atmosphere in order to maintain the gas in the liquid phase as a liquid and in such a case it is not possible for air to enter to
25. form an explosive mixture. However there have been a

number of serious incidents when LPG containers, such as railway tank cars, have been involved in a fire, and, the resulting explosions have been of frightening proportions, for example producing "fireballs" 200 feet or more in diameter. Such explosions are known as boiling liquid expanding vapour explosions (BLEVE) and investigations into such explosions have shown them to be the result of a particular sequence of events. Firstly, there is an initial accident, for example, derailment of an LPG container train and secondly a fire is caused by the burning of leaking LPG or the contents of other rail cars. This, in turn, causes heating of the outside of one or more of the LPG containers. As the temperature rises the liquid phase boils and the pressure in the vessel increases until the, normally present, relief valve opens. The stream of gas being emitted from the safety valve becomes ignited. Also, the ignited stream of gas from a leak in or relief valve on one container plays on another container. As the heating of the pressurized vessel above the internal liquid level continues the (usually steel) wall of the container is heated to a temperature at which its tensile strength is so reduced that it ruptures. When the rupture occurs, the container pressure is reduced rapidly and the liquid very quickly evaporates and expands into a large gas cloud which is ignited by the fire, causing a devastating fireball. At the same time, the burning gas being ejected from the ruptured container will very often propel it many hundreds of feet. If, for any reason, the relief valve fails to open or, due to inversion of the container, is below the liquid level bursting may be caused sooner by a simple pressure burst, but with the same devastating results. This is also true for containers without relief valves.

According to the present invention a container, particularly a pressure container for containing liquified petroleum gas, has an at least partial filling of expanded metal mesh and, externally
5 an intumescent coating.

Small containers such as gas bottles for portable stoves may have a complete filling of expanded foil if it is more convenient to fit it in this way. Larger vessels may be partially filled to
10 produce the same effective protection against BLEVE. This partial fill will be cheaper, displace less and weigh less.

Depending upon the efficiency of heat conduction of the expanded metal used inside the
15 container it may be possible simply to line the inside of the container with expanded metal mesh, leaving the central part of the container free from filling. This will reduce the volume which will be taken up by the expanded metal and if necessary will permit a thicker
20 material to be used.

The intumescent coating, particularly for mobile or portable containers should be highly resistant to impact or abrasion.

Intumescent paints or varnishes are known and used particularly in buildings to delay the burning of
25 timber materials and to delay the overheating of steel structures. The intumescent coatings foam and carbonize forming a heat insulating barrier. An intumescent coating system may include just a single layer or may have a plurality of layers including under and top
30 coats as required depending on the particular container protection required etc.

Intumescent coatings normally comprise a carbonific, a spumific, a catalyst and a resinous binder. The carbonific is a chemical compound which
35 by reaction with the catalyst forms a large volume of carbonaceous char. This foamable carbon produces

the non-combustible barrier which is so characteristic of intumescent coatings. A typical carbonific is di/tri pentaerythritol. The spumific or "blowing agent" releases non-combustible gas on decomposition which occurs at a given temperature. Suitable spumifics are chlorinated paraffin and crystalline melamine. The catalyst is a material which contains a high percentage of phosphorus and which decomposes with the application of heat to yield phosphoric acid below the decomposition temperature of the carbonific. Commonly used materials are ammonium polyphosphate and melamine phosphate. Suitable binders are chlorinated rubber and vinyl toluene/acrylate.

The mechanism of intumescence comprises a number of steps which may occur simultaneously:- decomposition of the catalyst; reaction of the resulting acid with the carbonific to produce the carbonaceous char; softening of the binder to form a skin to prevent escape of the non-combustible gases given off by the spumific; foaming of the carbon material to produce a honey-comb blanket which results in high effective insulation.

It was initially felt that applying an intumescent coating to a container already containing expanded metal mesh might decrease the time to explosion in a fire because the insulation provided could prevent the heat being conducted out of a cooler part of the container wall.

However, it has been found out that the heat is transmitted into the LPG where the energy is used to convert the liquid into gas and the limitation of heat entering the container wall is of great importance.

As the insulating effect of the coating prior to intumescence is small, in use, where heat is drawn in through the container wall to vapourise

the liquid for use it does not inhibit normal operation.

Of course, containers to be protected by the proposed method can vary in size from underground storage tanks to gas containers for camping stoves, and aerosols. Freon, which has normally been used as the pressurizing gas in aerosols of all sorts has come under criticism for various reasons in many countries and it has been suggested to replace the Freon by the example, butane, but, of course, the explosion hazard of such containers is a serious problem, which is not present with Freon as it is non-combustible.

The requirement for large scale storage facilities for LPG has resulted in many more potential hazards where aerosol filling factories are located.

It is believed that the mechanism involved in preventing BLEVE of containers according to the present invention during a fire, involves firstly a delay in the speed at which heat is supplied to the exterior of the container, caused by the presence of the intumescent coating, and, secondly, rapid conduction of heat away from the container wall, by means of the expanded metal, into the liquid which by evaporating absorbs much heat energy.

Additionally, when the container has a relief valve, when the relief valve opens some liquid gas evaporates and in so doing uses large quantities of heat energy which is drawn in through the walls of the container, through the expanded metal mesh into the liquid. Because the wall of the container is externally insulated by the foamed intumescent coating the temperature of the container wall is significantly lowered from its previous temperature. The walls of the container are thereby prevented from reaching a temperature at which there is a significant weakening and the internal pressure in the container is not able therefore to burst the wall. The cooling effect will also increase the time between closing and opening of the relief valve thus reducing the quantity of gas

being released.

In addition, with non-stable gases such as ethylene oxide, which may be explosive as a 100% gas with no additional oxygen and which can auto-ignite at relatively low temperatures, perhaps as a result of decomposition, the expanded metal may prevent any point of the liquid gas reaching an auto-ignition temperature. Ethylene oxide in particular is extremely hazardous as, once it has reached a temperature of 560° Centigrade explosive decomposition is initiated and continues even though the temperature source is removed. Therefore, decomposition can continue, without this being apparent, until auto-ignition is achieved. It will be appreciated that the expanded metal, by its inherent ability to dissipate heat quickly, prevents the initiation temperature being reached so that the hazard is greatly reduced.

An expanded aluminium mesh pack with a weight of 25g per litre will have up to 500 times the conducting capability of a petroleum gas and will thus transmit heat from the container wall 500 times faster than if only the gas were present. However because the gas is in contact with the wall of the container at all points on its surface except where the expanded metal is in contact with the wall it is believed that the greater part of the heat is conducted from the wall into the gas and then immediately into the expanded metal mesh. Tests have shown that the expanded metal mesh may be in contact with the wall of the container at relatively few points. This is significant as, with transportable containers, there may be some breaking away of the expanded metal from the wall of the container due to vibration for example and if the expanded metal were the prime conductor of heat from the wall this would be a serious problem.

Various tests have been carried out to establish the degree of protection afforded by containers according to the invention and Figure 1 illustrates a test rig used in these tests.

The tests were carried out on standard dome-shaped ventless steel camping gas cartridges containing 200 grams of liquid butane. The test rig itself is simple and comprises a protective steel plate A through which projects a gas torch B and to which is attached a clamp C for the gas containers D. The flame E from the gas torch is arranged to be directed onto the top and side of the container at such a point that it is above the level of liquid.

10 A first test was carried out with a cartridge as normally supplied, with no protection. After 31 seconds the domed bottom F of the container inverted and the container burst after 2 minutes and 26 seconds. The container burst not because of weakening of the container wall, but simply due to the very high pressure generated by the expanding gas.

20 A second container including a complete fill of expanded aluminium alloy mesh of .04 mm thickness was tested and the time to inversion of the bottom of the container was 54 seconds and a pressure burst occurred at 4 minutes 18 seconds.

Two further tests were then carried out. Firstly a container with the same expanded aluminium internally, but with a 15 mm thick insulating coating (the coating used is manufactured by Sigma Coatings B.V. of Holland and is known by the name "Firescreen") was tested. The bottom of the container did not invert until 23 minutes and 51 seconds had elapsed and there was no bursting of the container.

30 The fourth container was substantially the same as the third, but included a further intumescent finish coating ("Firescreen Finish") 700 microns thick. Inversion of the bottom occurred at 33 minutes and again there was no burst.

35 From the above figures it will be appreciated that a significant reduction in the hazard from

bursting can be provided by a construction according to the invention.

A further series of tests was carried out with a heating torch which had a better flame and
5 which produced more heat and, at the same time, the ambient atmosphere in which the second series of tests was carried out was very much lower, in the order of 10 to 15°C causing greater difference in the liquid/gas phases. An unprotected cartridge split
10 at its side, producing a true BLEVE, at 45 seconds and a cartridge filled with foil alone also burst producing a true BLEVE, but at 50 seconds. A third cartridge, with foil filling and a 15mm. Firescreen coating and a 700 micron Firescreen finish eventually blew
15 its bottom off at 26 minutes and 45 seconds under the high internal pressure. There was no splitting of the side of the container due to weakening of the wall, the action of the bottom blowing off being more akin to the a pressure relieving action such as occurs
20 when a pressure release valve is present. It will be appreciated however that a significant delay in the pressure burst was achieved.

Examples of containers constructed in accordance with the present invention will now be
25 described with reference to the accompanying drawings in which:-

Figures 2A and B show, diagrammatically, in elevation and plan view respectively, a portable LPG container of the type such as used for stoves in
30 caravans and the like;

Figure 3A shows, diagrammatically, a cross-section through a rail car type of container;

Figure 3B shows, diagrammatically, a cross-section through a second rail car type of
35 container; and, Figure 3C shows a transverse section of the container shown in Figure 3B.

The container shown in Figures 2A and B is of a basic well-known type and comprises an elongate cylindrical wall 1 which, has domed ends 2 and 3, the lower end 3 having attached thereto a cylindrical sectioned base 4 having a lower flange 5 to enable the container to stand on the ground securely. The upper end of the container has a gas outlet 6 at which is positioned a valve unit 7 having a manually operable valve and a pressure relief valve. These elements of the container are quite standard. However, in addition, internally, the container has a spirally wound coil 8 of expanded aluminium alloy foil which, although actually occupying only between 1 and 2 per cent of the internal volume of the container, extends throughout the container so as to enable conduction of heat from the walls of the container into the liquid gas in the container, whatever the orientation of the container. The expanded aluminium alloy mesh has a thickness of .04 mm and a strand width of 1.78 mm. In the longitudinal direction of the mesh, that is to say along the length of the diamond-shaped apertures produced in the mesh during the expanding process each aperture has a length of approximately 15 mm. The width of each aperture is approximately 8.4 mm when expanded. Such a mesh, when wound into a coil has a density of approximately .03 grams/cm³.

Externally of the container there is provided an intumescent coating 9 which may be of either a single or multi-layer type, such as used in the tests described above.

In Figure 3A there is shown a cross-section through a much larger container of the type which is normally mounted on a railway car. Again, the container has a generally cylindrical wall 11 and domed, spherical ends 12 and 13 such as shown in Figure 3C. Unlike the

portable container shown in Figure 2A and B the rail car container of the present example lies with the major axis of the cylinder substantially horizontal and includes a pressure release valve (not shown).

- 5 Externally, the container has a single or multi layer intumescent coating 14 as in the previous example, but, internally, has only a partial filling of expanded metal mesh 15, the mesh being provided in the form of large coils 16 separately supported in an annular
10 array by expanded metal mesh radially extending sheets 17 and by a pair of substantially semi-cylindrical expanded metal mesh sheets 18.

- Figures 3B and C show an alternative example to that shown in Figure 3A. In this example
15 the expanded metal mesh is provided in a number of layers 19 to form an annulus against the wall of the container and is supported internally by a cylinder 20 of expanded metal mesh of larger all round dimensions braced internally by cross-bars 21.

- 20 It will be appreciated that the arrangement of the expanded metal mesh within a container can be varied from application to application and depending upon the size of the container.

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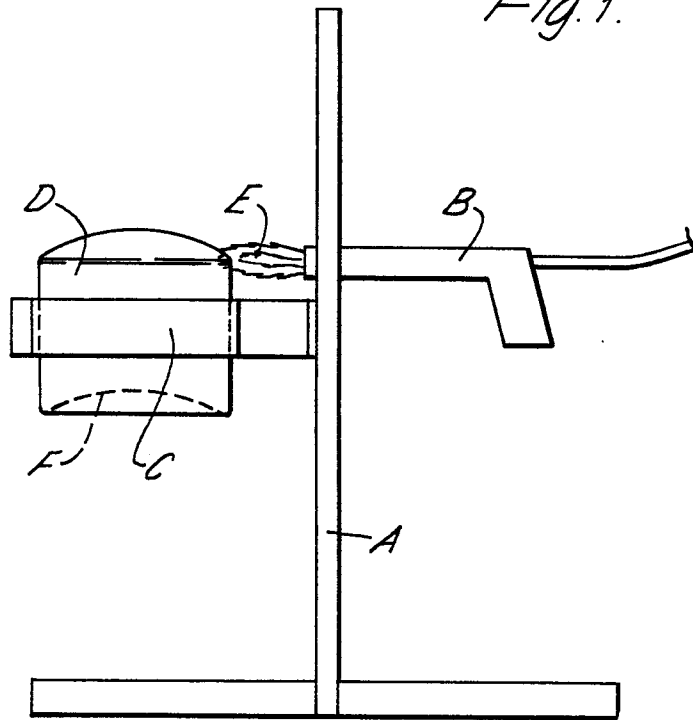
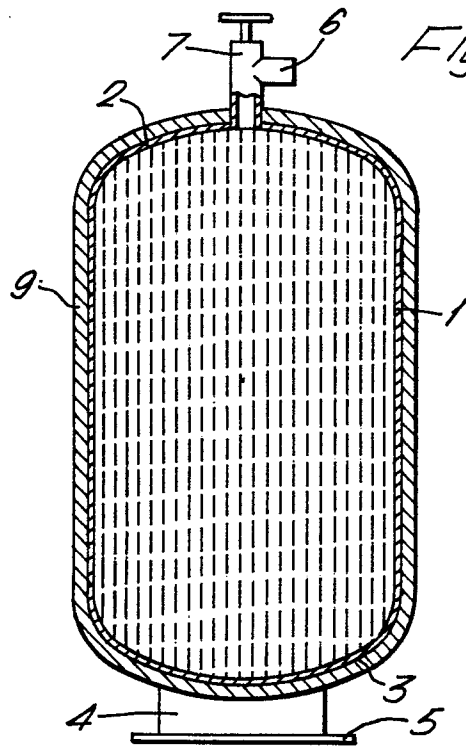
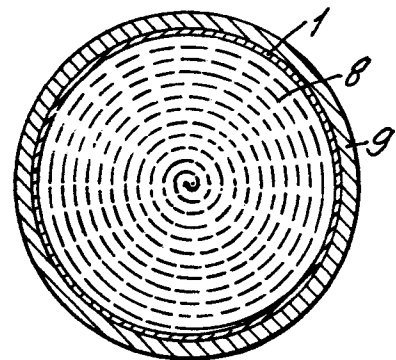
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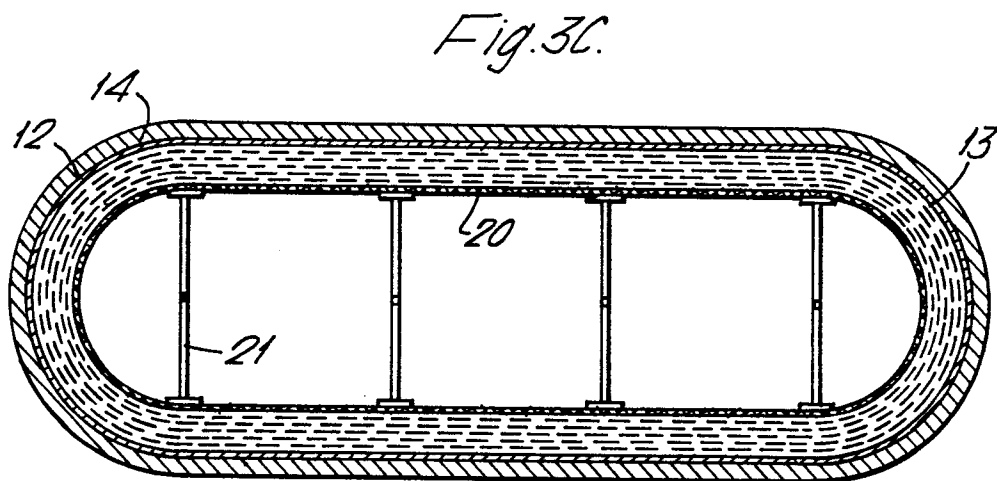
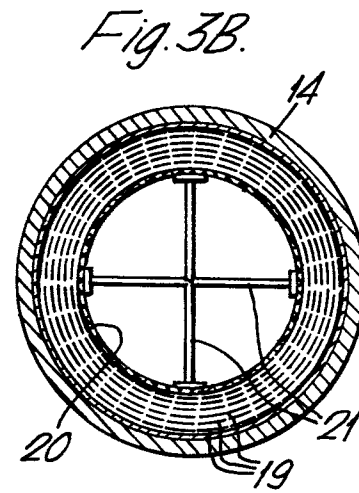
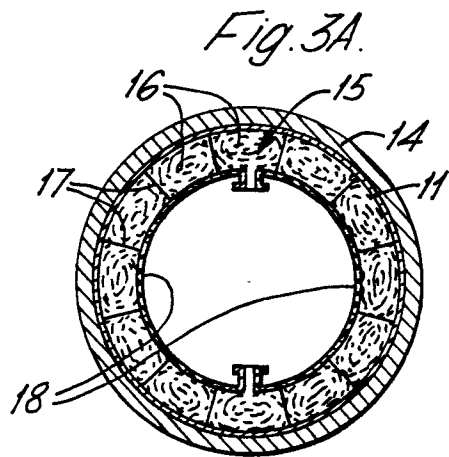
C L A I M S

1. A container having an at least partial filling of expanded metal mesh (8) and, externally, an intumescent coating (9).
2. A container according to claim 1, the
5 container comprising a pressure container for liquified petroleum gas.
3. A container according to claim 1 or claim 2, having a complete filling of expanded metal mesh(8).
4. A container according to claim 1 or claim
10 2 wherein the expanded metal mesh filling (8) comprises a lining to the container.
5. A container according to anyone of the preceding claims wherein the expanded metal mesh (8) is an expanded aluminium foil.
- 15 6. A container according to any of the preceding claims, the container comprising a gas bottle.
7. A container according to any one of claims 1 to 5, the container comprising a rail or road transporter tank.
- 20 8. A container according to any one of claims 1 to 5, the container comprising a fixedly mounted storage tank.
9. A container according to any one of claims 1 to 5, the container comprising an aerosol can.
- 25 10. A container according to any of the

preceding claims, wherein the intumescent coating (9) comprises a single layer.

11. A container according to any one of claims 1 to 9, wherein the intumescent coating (9) comprises
5 a plurality of layers.

Fig. 1.*Fig. 2A.**Fig. 2B.*





European Patent
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EUROPEAN SEARCH REPORT

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DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl. ²)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
A	<u>US - A - 3 069 042</u> (H.L. JOHNSTON) * Column 1, lines 13-17; column 1, line 60 - column 2, line 2; column 2, lines 17-33; column 3, line 41 - column 4, line 1; figures 1-4 * ---	1,3,5,8	F 17 C 13/12 A 62 C 3/12
A	<u>US - A - 3 733 289</u> (A.J. BURNS et al.) * Abstract; column 1, lines 47-58; example 1; column 7, lines 48-57; claims 1-4 * ---	1,10,11	TECHNICAL FIELDS SEARCHED (Int.Cl.²) F 17 C 13/12 13/00 1/00 1/12 1/14 A 62 C 3/08 3/12 B 60 K 15/02 15/08 B 64 D 37/02 37/06 37/08 37/32 45/02
A	<u>GB - A - 121 762</u> (A.W. TORKINGTON) * Page 1, lines 4-34 * ---	1,4,7	
A	<u>FR - A - 1 268 538</u> (SOC. DES FORGES) * Page 1, column 1, lines 1-18; column 1, line 38 - column 2, line 9; figure 5 * ----	1,2,6-8	CATEGORY OF CITED DOCUMENTS X: particularly relevant A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: conflicting application D: document cited in the application L: citation for other reasons
☒ The present search report has been drawn up for all claims			&: member of the same patent family, corresponding document
Place of search		Date of completion of the search	Examiner
The Hague		08-05-1979	SIEM