[11] **3,573,462**

[72] Inventors [illegible]
Augusta, Ga.;
Franklin D. R. King, Aiken, S.C.

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[73] Assignee **The United States of America as represented by the United States Atomic Energy Commission**

[54] SEALED CONTAINER WITH PRESSURE RELIEF FOR HAZARDOUS MATERIAL

7 Claims, 9 Drawing Figs.

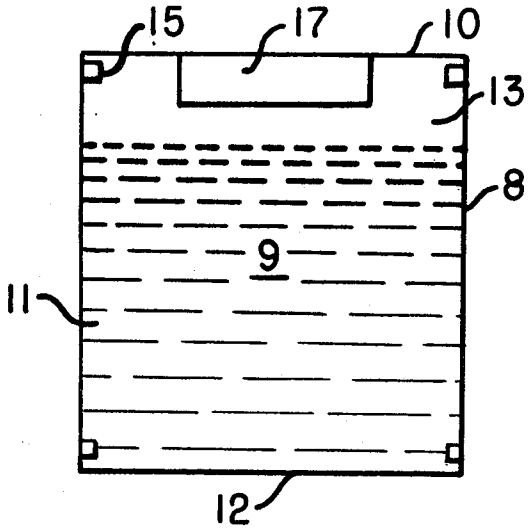
[52] **U.S. Cl.** **250/108,** 206/1, 250/106
[51] **Int. Cl.** **G21f 3/00,** G21f 5/00
[50] **Field of Search** ..... 250/108, 106; 206/1 (X); 99/171 (h)

References Cited
UNITED STATES PATENTS

2,633,284	3/1953	Moffett et al.	206/46 (FX)
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Primary Examiner—James W. Lawrence
Assistant Examiner—Morton J. Frome
Attorney—Roland A. Anderson

ABSTRACT: A sealed vessel for containing a hazardous liquid or a liquid shield for radioactive material is provided with fusible plug assemblies within the vessel walls for melting and relieving internal pressure on high temperature exposure without loss of unvaporized liquid. The fusible plug assemblies are designed such that only those fusible plugs contacting the vapor space above the liquid will melt and are arranged such that at least one fusible plug will contact the vapor space regardless of container orientation.



Patented April 6, 1971 3,573,462

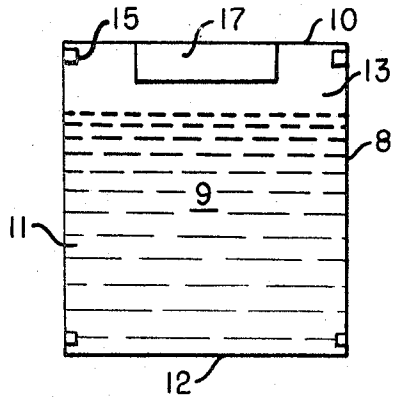


Fig 1a

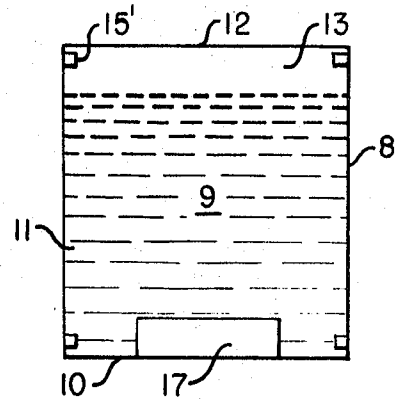


Fig 1b

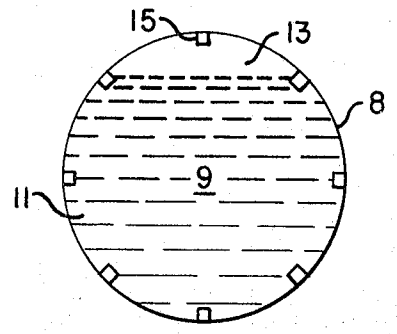


Fig 1c

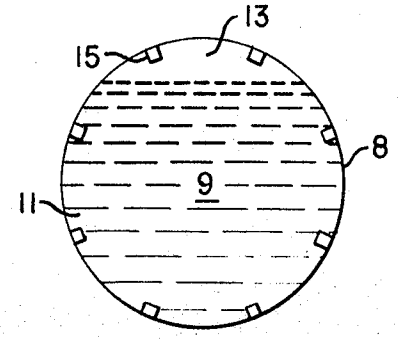


Fig 1d

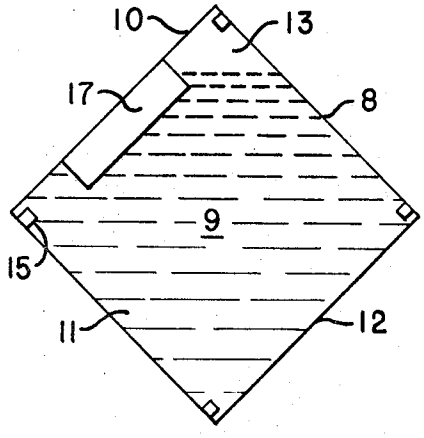


Fig 1e

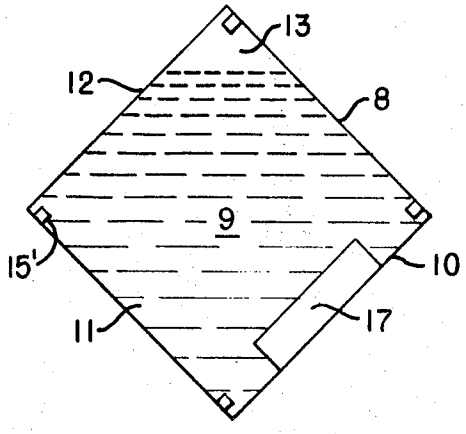


Fig 1f

INVENTOR.
Charles A. Wilkins
Franklin D. R. King
BY
Attorney:

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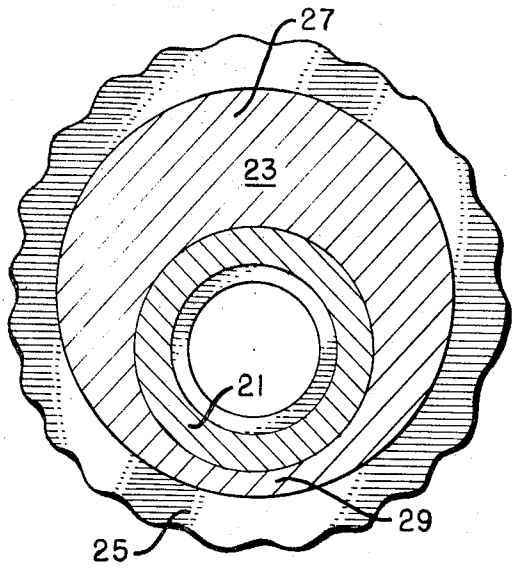


Fig 2b

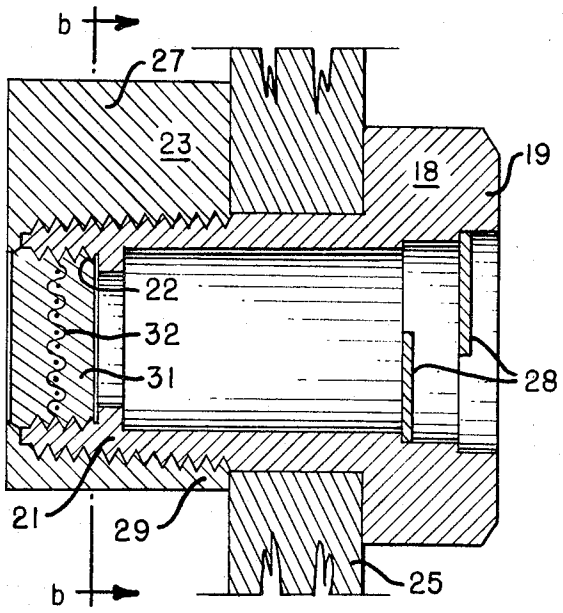


Fig 2a

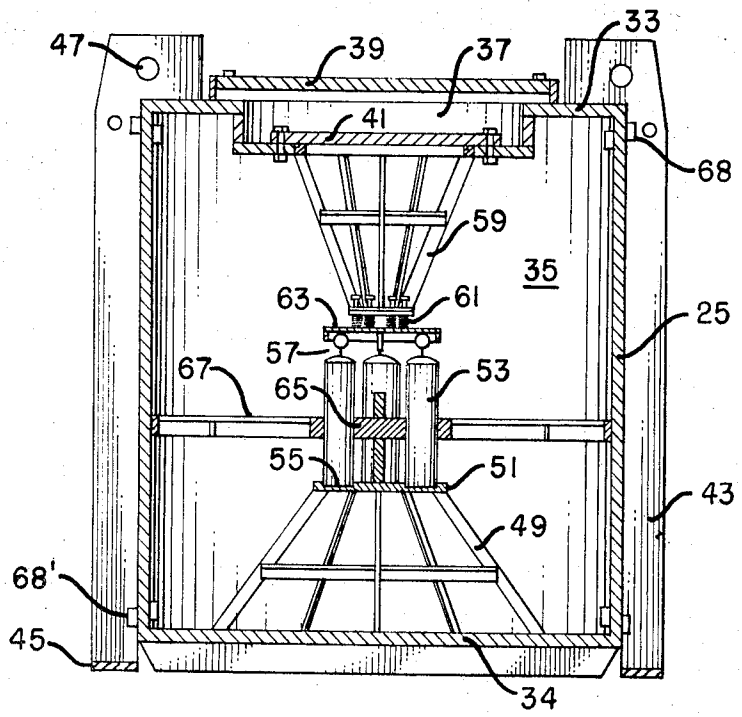


Fig 3

INVENTOR.
Charles A. Wilkins
Franklin D. R. King
BY
Attorney:

SEALED CONTAINER WITH PRESSURE RELIEF FOR HAZARDOUS MATERIAL

BACKGROUND OF THE INVENTION

The invention described herein was made in the course of or under a contract with the U.S. Atomic Energy Commission.

1. Field of the Invention

This invention relates generally to liquid-containing vessels requiring pressure relief without loss of unvaporized liquid. More specifically, the invention pertains to a vessel for containing a liquid shield surrounding a radiation source.

2. Description of Prior Art

Liquids are often stored and transported in sealed containers with sufficient vapor space left unfilled to provide for possible expansion of the liquid without rupture of the container. A pressure-relief system is also necessary in the event of high temperature exposure to prevent container failure resulting from elevated vapor pressure. In such occurrences, safety considerations may require minimum or delayed loss of the liquid. For instance, combustible or corrosive liquids should be contained when involved in a fire-producing accident at least until the fire can be extinguished. Liquids or readily meltable solids used as a radiation shield must also be contained for an interval to prevent an immediate and unprovided-for release of hazardous radiation.

Containers for radioactive materials, particularly neutron emitters, often include water or other hydrogenous materials surrounding the radioisotope or radiation source as an inexpensive neutron shield. Typically, neutron radiation is produced by the spontaneous fission of transplutonium isotopes such as californium–252 or by the action of alpha or gamma radiation on light nuclei, for instance the (α, n) reaction with oxygen–18 in $^{244}CmO_2$. The liquid shield also serves to prevent a heat producing radioisotope from reaching an excessive temperature and possibly escaping through diffusion or vaporization.

There are a number of known devices for providing pressure relief in these normally sealed containers in event of fire or other intense heat exposure. Ordinary pressure-relief valves can be used for this purpose, but since they are generally spring biased and have sliding mechanisms they are susceptible to sticking or jamming which may prevent proper operation. Fusible plugs and rupture discs can be used in such containers without risk of mechanical failure, but liquid as well as vapor is readily vented through such devices. If a fusible plug or rupture disc melts or bursts, the liquid down to the level of the plug or disc may be lost allowing dangerous radiation or a hazardous liquid to escape. The fusible plug or disc can be located near the top of the container to retain most of the liquid on melting but in case of a carrier-vehicle accident the container can become overturned. Consequently, a significant amount of the liquid can be lost.

SUMMARY OF THE INVENTION

Therefore, it is an object of the present invention to provide a container for liquids having provisions for relief of pressure resulting from elevated temperatures while retaining unvaporized liquid regardless of container orientation.

It is also an object to provide a container for a liquid shield surrounding a radiation source having provisions for pressure relief with delayed loss of the liquid shield in event of an accident producing high temperatures and container overturn.

It is a further object to provide a fusible plug assembly for a container which will selectively melt on exposure to vapor in preference to melting on exposure to liquid.

In accordance with the present invention there is provided a container for hazardous liquids or a liquid surrounding radioactive material. The container includes a plurality of fusible plug assemblies extending through the container walls into the liquid and vapor contained therein. Each assembly contains a plug of fusible material for melting and thereby relieving the internal pressure when a predetermined temperature is reached. The fusible plug assemblies are arranged so that at least one fusible plug will contact the vapor space above the liquid level at any container orientation or attitude. The fusible plug assemblies are constructed with the fusible plug disposed in spaced relationship to the container wall in a prescribed manner such that the presence or absence of liquid contact will determine whether or not the plug melts.

DESCRIPTION OF THE DRAWINGS

FIGS. 1*a* to FIG. 1*f* are schematic cross-sectional views in various orientations showing one arrangement of fusible plug assemblies within a container embodying the present invention.

FIG. 2*a* is a fragmentary view in cross section of one embodiment of a fusible plug assembly of the present invention.

FIG. 2*b* is a fragmentary view in cross section taken along line b–b of FIG. 2*a*.

FIG. 3 is an elevation view partially in cross section of a container for a radiation source embodying the present invention.

DESCRIPTION OF PREFERRED EMBODIMENT

FIGS. 1*a* to 1*f* illustrate schematically a vessel or cylindrical container in various orientations or attitudes. Like reference characters are used to designate like parts throughout the several views of FIG. 1. It will be clear from the following description that other than cylindrically shaped containers such as a sphere or a cube can also operably embody the present invention.

The container of FIGS. 1*a* to 1*f* includes a cylindrical wall **8** having end walls **10** and **12** to define an internal chamber **9**. Internal chamber **9** is partially filled with a liquid **11** to form a vapor space **13** above the surface of the liquid. Vapor space **13** not only provides space for expansion of the contained liquid but also determines which of the fusible plugs will melt in event of high temperature exposure. Fusible plug assemblies **15** and **15'** penetrate wall **8** into internal chamber **9** and preferably are equally spaced around opposite ends of cylindrical wall **8**. The plug assemblies **15** and **15'** are disposed as close as practical to end wall **10** and end wall **12** to provide a maximum volume for liquid **11**. Alternatively, the plug assemblies may be similarly installed through end walls **10** and **12**. The number of fusible plug assemblies required is determined by the volume of liquid relative to volume of vapor which is to occupy the internal chamber **9** of the container. For a given vapor space capacity, the fusible plug assemblies **15** and **15'** must be sufficiently close together that at least one fusible plug assembly will be included in the vapor space at any container attitude. A minimum number of fusible plugs are required when an equally spaced symmetrical arrangement is adopted.

FIGS. 1*a* to 1*f* show a separate compartment **17** to distinguish the top from the bottom of the container in the different views and orientations. Compartment **17** can be included to provide impact protection to a sealed opening into the internal chamber of the container and will be more fully described in conjunction with FIG. 3.

FIG. 1*a* shows an upright container in its normal attitude resting on bottom end wall **12**. The fusible plug assemblies **15** disposed near the top end wall **10** are exposed to the vapor space and are susceptible to melting in event of high temperature exposure. FIG. 1*b* shows the completely overturned container resting on its top end wall **10** with the fusible plug assemblies **15'** disposed near end wall **12** exposed to the vapor space. FIG. 1*c* and FIG. 1*d* illustrate the container resting on its cylindrical sidewall **8** and exposing two or four fusible plug assemblies respectively to the vapor space. FIG. 1*e* and FIG. 1*f* show the container in a tilted orientation as it might assume when leaning against another member (not shown). One or more fusible plugs in the uppermost edges of the tilted container contact vapor space **13** and accordingly will melt when necessary to prevent excessive internal pressure. It should be

clear from the above description that the maximum operable amount of liquid which can be filled into the container is determined by the location and spacing of the fusible plug members. If a large number of fusible plug assemblies are uniformly spaced close together near end walls **10** and **12**, the container can be more completely filled with liquid than if fewer plugs are employed at greater intervals or spaced from the end walls.

A preferred embodiment of the fusible plug assembly is shown in detail in FIGS. **2***a* and **2***b*. A tubular member **18** is supplied with a flanged end portion **19** and an opposite threaded end portion **21**. A socket member **23** is suitably attached to the internal surface of the container wall **25**. End portion **21** of tubular member **18** penetrates through wall **25** and is threaded or otherwise removably attached into socket member **23** for support. In a container for a radiation source, socket member **23** can be provided with a thicker wall section **27** towards the radiation source than the opposite wall section **29** to supplement shielding where tubular member **18** penetrates wall **25**.

A fusible plug **31** is precast into end portion **21** of tubular member **18** in inwardly spaced relationship to container wall **25**. The plug can be structurally reenforced by a perforated screen or grid **32** imbedded in the plug casting The internal surface **22** of tubular member **18** is threaded or serrated to provide a strong leak-tight bond to the fusible plug **31**. Plug **31** is composed of any suitable solid material having a sufficiently low melting point to melt before excessive pressure is generated as a result of heating the container. However, the melting point of plug **31** must be substantially above the boiling point of the liquid within the container at atmospheric or ambient pressure to prevent melting of submerged plugs. For example, an eutectic composition of about 61.9 percent tin by weight and about 38.1 percent lead which melts at about 362° F. can be used in a water-filled container. A melted fusible plug is easily replaced by removing tubular member **18** from socket member **23**.

Overlapping or perforated baffles **28** are optionally attached within tubular member **18** to partially occlude and thereby shade the fusible plug **31** from external heat radiation. Heating of the fusible plug is thus substantially limited to conduction through its mounting members and the possibility of melting a submerged plug is diminished. In addition, the baffles provide impact protection for the fusible plug and can be prepared sufficiently thick to minimize radiation emission through tubular member **18** after fusible plug **31** has melted and opened tube **18**.

The fusible plug is arranged in the assembly to distinguish contact with the vapor space from contact with the liquid within the container by melting only when in contact with the vapor space. When the container exterior is exposed to a high temperature flame (e.g. up to 1,700° F.), the vessel walls absorb heat and the temperature rises. However, the portion of the container walls in contact with the vapor rises in temperature faster than the portions in contact with the liquid. As is well known, the liquid has a higher heat capacity than the vapor and the heat transfer coefficient to the liquid is higher than to the vapor. The fusible plug assemblies exposed to the vapor also are heated faster than the fusible plug assemblies exposed to the liquid. Heat is conducted toward each plug through the mounting members of the fusible plug assembly. However, not all of the heat reaches the plugs because of heat losses to the surrounding fluid. Heat is lost faster from the assembly members exposed to the liquid than from the members exposed to the vapor. The plug in the vapor space will thus rise in temperature and melt before a similar plug in the liquid. After the vessel has been vented, the temperature of the liquid will not rise appreciably above the boiling point of the liquid. The boiling liquid will then continue to cool the submerged plugs.

The fusible plug assembly is designed so that the liquid at its boiling temperature provides adequate cooling to prevent melting of the submerged fusible plugs. One design parameter affecting the cooling rate is the surface area of the fusible plug assembly in contact with the liquid. This area, along with the cooling rate, can be increased by elongating the fusible plug assembly and spacing the fusible plug away from the container wall. Furthermore, the resistance to heat flow to the fusible plug is increased by disposing the fusible plug in spaced relationship to the container wall. Other design variables affecting the resistance to heat flow to the fusible plug are the cross-sectional area of the members conducting heat to the plug and the thermal conductivity of the construction material. The dimensions and materials specified for the fusible plug assembly can be varied to provide a number of operable fusible plug assembly arrangements. Suitable dimensions and materials can be determined by experiment or estimated by methods outlined in standard heat transfer texts (see *Jokob, Heat Transfer* 1949 1st Ed.).

Although specific dimensions are not critical, it has been found that an operable fusible plug assembly for a water-filled container can include a stainless steel socket member of about 3⅛-inch outside diameter and a stainless steel tubular member of about 1⅜-inch inside diameter. The total cross-sectional area of these mounting members can be about 6.2 square inches. An about one-half-inch-thick fusible plug composed of about 61.9 percent tin and about 38.1 percent lead can be cast into the tubular member. The fusible plug can be spaced about 1 -inch from the inside face of the container wall to the opposing surface of the plug. A fusible plug assembly of this design installed in a 1-inch stainless steel wall exposed to a 1,500° F. fire was found to melt in a short time when in the vapor space but to remain solid when submerged in the liquid.

A radioisotope storage or shipping container embodying the present invention is shown in FIG. **3**. The container has a cylindrical wall **25** with end walls **33** and **34** defining an internal chamber **35**. Walls **25**, **33** and **34** can be of suitable material and thickness for blocking beta and gamma radiation. An impact shield **39** closes an access opening through end wall **33**. A vented compartment **37** is enclosed below impact shield **39** and is sealed from internal chamber **35** by a gasketed lid **41** covering an access opening into chamber **35**. Collision or impact to the top of the container will be absorbed by the shield **39** rather than the gasketed lid **41** to minimize risk of seal failure.

Cooling fins **43** are provided on the outside surfaces of walls **25**, **33** and **34** for impact protection and for dissipating excess heat produced by the radioisotope. Platens or feet **45** affixed to the bottom of the container provide support and stability. Suitably lifting eyes **47** are formed in fins **43** for loading and transporting the container.

A lower supporting structure **49** inside chamber **35** is affixed to the bottom portion of the container. Structure **49** supports a platform or table **51** for holding capsules **53** containing the radioisotopes or radiation sources. Platform **51** can be counter bored to provide recessed surfaces or indentations **55** for receiving and stabilizing the capsules **53**. Capsules **53** are of any suitable shape and have an eye or ring **57** affixed at the top thereof for attaching a lifting device (not shown).

An upper supporting structure **59** is attached at one end to lid **41** and disposed above capsules **53**. A bearing plate **63** is held at the other end of structure **59** by compression spring members **61**. Plate **63** is forced downwardly by members **61** to engage and stabilize capsules **53**.

Fusible plug assemblies **68** and **68'** are of the type described in FIGS. **2***a* and **2***b* and are spaced around the uppermost and lowermost practical circumferences of the cylindrical wall **25**. The assemblies **68** and **68'** penetrate wall **25** to place the fusible plugs in contact with the liquid or the vapor in internal chamber **35** as described in conjunction with FIGS. **1***a—f* and **2***a—b*. The tubular members **18** (FIG. **2***a*) are installed normal to wall **25** so that direct radiation from capsules **53** will be blocked even after a fusible plug has melted.

Although specific dimensions are not critical, it has been found that a suitable container for $^{244}CmO_2$ can be about 6 feet long, 5 feet in diameter and contain about 700 gallons of

water. Sixteen fusible plug assemblies of the type described above can be equally spaced about opposite ends of the container. When exposed to a very intense flame (e.g. 1,500° F.), a fusible plug in the vapor space was found to melt before excessive pressure was produced in the container. Sufficient water shield was retained in the container for at least one-half hour after the plug melted.

Although this invention is described in detail with reference to its preferred embodiment, it is contemplated that obvious modifications will occur to those skilled in the art and that such may be made without departing from the scope of this invention which is limited only as indicated by the appended claims.

We claim:

1. A sealed vessel for hazardous material having walls defining an internal chamber adapted to contain a liquid and a vapor space above said liquid, and having provisions for relieving pressure resulting from increased temperature without loss of unvaporized liquid comprising:

a. a plurality of fusible plug assemblies penetrating said vessel walls to communicate with said internal chamber, said fusible plug assemblies arranged in spaced relationship about said vessel walls, at least one of said fusible plug assemblies being in contact with said vapor space and the remainder of said plug assemblies being in contact with said liquid regardless of the orientation of said vessel; and

b. fusible plugs having a melting point above the boiling point of said liquid at ambient pressure sealingly disposed in said fusible plug assemblies at locations within said internal chamber in spaced relationship to the internal walls of said vessel, said plugs being capable of preferentially melting when in contact with said vapor space and exposed to elevated temperatures to vent said internal chamber.

2. The sealed vessel of claim 1 wherein said vessel has longitudinally extending side cylindrical walls, and said fusible plug assemblies are equally spaced around the perimeters of said side cylindrical walls at opposite longitudinal end portions of said vessel.

3. A container for radioactive material comprising:

a. a housing having internal walls defining an internal chamber adapted to contain a liquid for shielding said radioactive material and a vapor space above said liquid;

b. structural means disposed within said chamber for supporting radioactive material;

c. a plurality of fusible plug assemblies penetrating said walls to communicate with said internal chamber, said fusible plug assemblies arranged in spaced relationship about said housing walls, at least one of said fusible plug assemblies being in contact with said vapor space and the remainder of said fusible plug assemblies being in contact with said liquid regardless of the orientation of said vessel; and

d. fusible plugs having a melting point above the boiling point of said liquid at atmospheric pressure sealingly disposed in said fusible plug assemblies at locations within said internal chamber in spaced relationship to the internal walls of said housing, said plugs being capable of preferentially melting at elevated temperature when in contact with said vapor space to vent said internal chamber without loss of unvaporized liquid.

4. The container of claim 3 wherein said fusible plug assemblies comprises:

a. socket members affixed to the internal walls of said housing;

b. tubular members inwardly penetrating said vessel walls and removably fastened into said socket members; and

c. fusible plugs sealingly disposed in said tubular members in inwardly spaced relationship from said internal walls of said housing.

5. The container of claim 4 wherein baffles are disposed within said tubular members at locations outside said fusible plugs to shade said plugs from external radiant heat.

6. The container of claim 4 wherein said socket members have wall sections of increased thickness between said radioactive material and said tubular members.

7. The container of claim 4 wherein said fusible plugs consist essentially of an eutectic alloy composition of about 38 percent lead and about 62 percent tin by weight.

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,573,462 Dated April 6, 1971

Inventor(s) Charles A. Wilkins and Franklin D. R. King

It is certified that error appears in the above-identified patei and that said Letters Patent are hereby corrected as shown below:

In The Claims:

Claim 2, column 5, line 36, delete "cylindrical";

line 38, delete "cylindrical".

Signed and sealed this 10th day of August 1971.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents