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**Lampe**

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[54] **RADIOACTIVE WASTE DISPOSAL PACKAGE**


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[73] Assignee: **The United States of America as represented by the United States Department of Energy**, Washington, D.C.



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[51] **Int. Cl.**[4] ..... **G21C 19/00**; G21C 13/00

[52] **U.S. Cl.** ..... **376/272**; 252/633; 250/506.1

[58] **Field of Search** ..... 376/272, 287–289; 252/628, 633; 250/506.1, 507.1, 515.1



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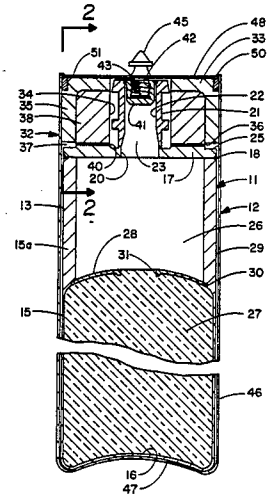
[57] **ABSTRACT**

A radioactive waste disposal package comprising a canister for containing vitrified radioactive waste material and a sealed outer shell encapsulating the canister. A solid block of filler material is supported in said shell and convertible into a liquid state for flow into the space between the canister and outer shell and subsequently hardened to form a solid, impervious layer occupying such space.


**12 Claims, 4 Drawing Figures**





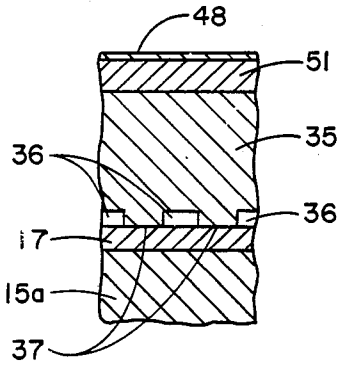

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FIG. 2

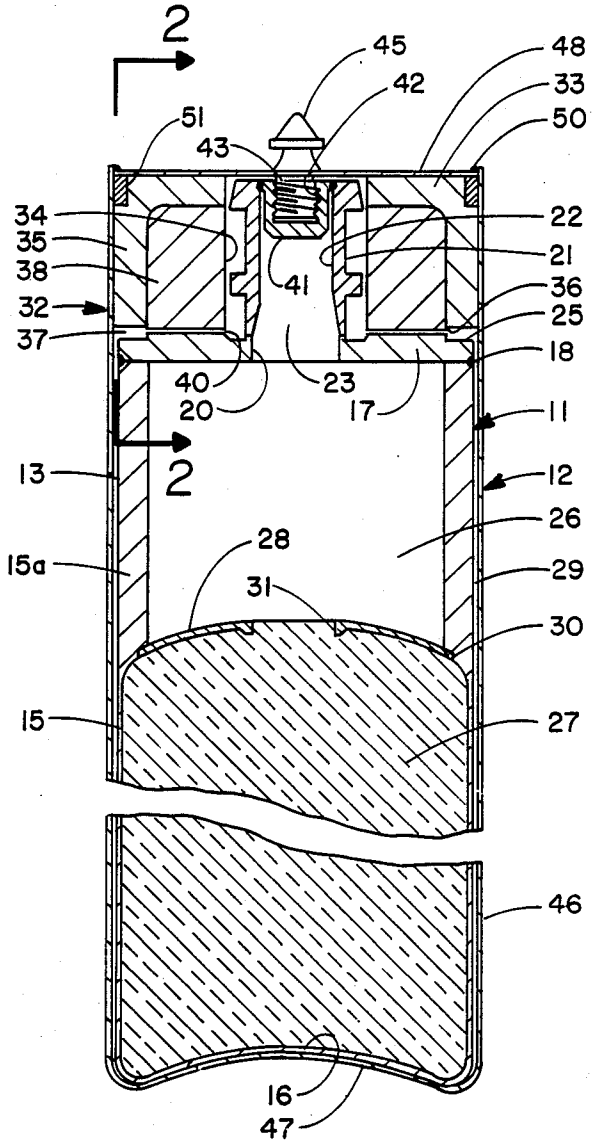
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FIG. 1

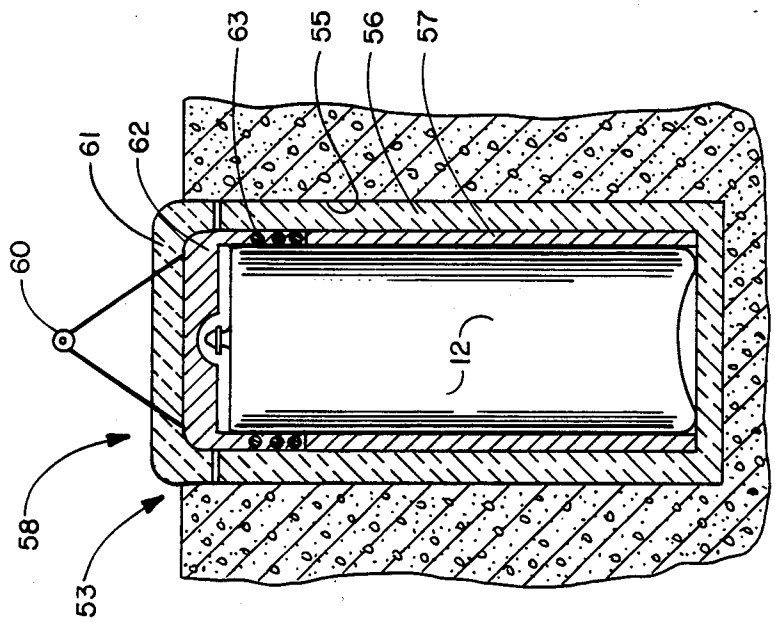


FIG. 4

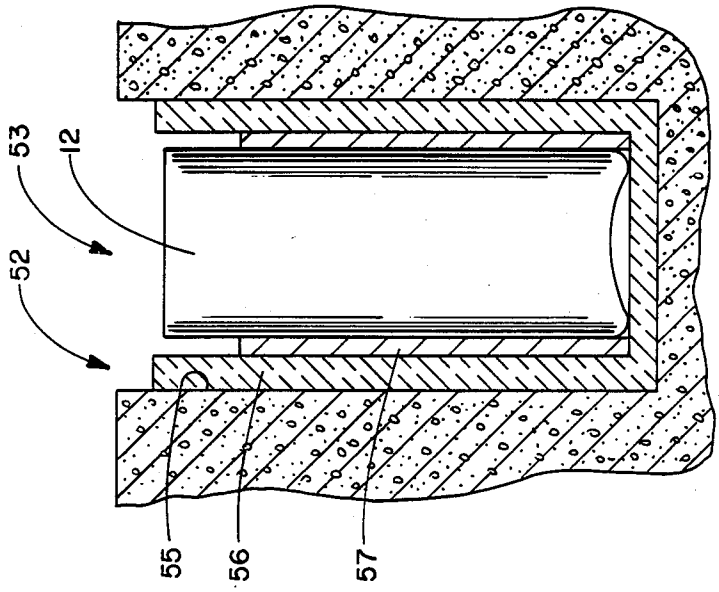


FIG. 3

# RADIOACTIVE WASTE DISPOSAL PACKAGE

## BACKGROUND OF THE INVENTION

This invention relates generally to a waste container and, more particularly, to a container or package for storing radioactive waste materials for long periods of time. The U. S. Government has rights in this invention pursuant to Contract No. E512-06400 between the U. S. Department of Energy and Westinghouse Electric Corporation.

The safe and effective management of radioactive waste is one of the most critical problems facing the nuclear industry today. In view of the many hazards and problems associated with the management of high-level radioactive waste, numerous Federal Regulations have been promulgated and/or are being developed to govern the permanent storage of such waste in containers for burial in suitable repositories that have yet to be selected. A major task resides in the development of a container or comprehensive waste package capable of safely containing such waste in a manner consistent with the above-mentioned regulations. In accordance with these regulations, the waste package, in addition to satisfying radiation, criticality, fire and handling safety requirements, must provide for: (1) positive containment of the radionuclides until the activity of the material decays significantly (estimated at about 1,000 years), (2) the release of radioactive material after the above-mentioned containment period to the geologic setting at a gradual rate sufficiently retarded to permit the barriers provided by the underground location and natural geologic materials to protect man and his environment, and (3) the retrievability of the waste material for a significant period of time (about 150 years) after initial emplacement.

Various attempts have been made to design waste packages meeting the above criteria. Some of these efforts include multi-layered constructions formed of inner and outer shells to minimize the release rate of radionuclides in the event that the outer shell or containment barrier, often referred to as an "overpack", is breached. A serious problem associated with these known multi-layered packaged constructions is that the outer shell or overpack is not adequately supported internally to prevent outer shell deformation resulting from the external pressure loads associated with repository conditions. Also, these known waste packages generally are vulnerable to crushing forces since they lack the necessary compressive strength to resist external pressure loads.

Accordingly, it is a primary object of the present invention to overcome the above noted shortcomings by providing a new and useful self-stabilizing radioactive waste disposal package.

It is another object of this invention to provide a radioactive waste package utilizing the compressive strength of the waste material to resist the external crushing forces resulting from dynamic repository conditions.

It is still another object of the present invention to provide a fully internally supported radioactive waste package preventing deformation to the outer shell of the package.

It is a further object of this invention to provide the foregoing radioactive waste package with a self contained filler completely occupying all spaces and voids between the inner and outer shells of the package.



These and other objects, advantages, and characterizing features of the present invention will become clearly apparent from the ensuing detailed description of an illustrative embodiment thereof, taken together with the accompanying drawings wherein like reference characters denote like parts throughout the various views.

## SUMMARY OF THE INVENTION

A waste package comprising a sealed canister for containing radioactive waste material in the form of an inert, insoluble glass product containing radionuclides. The canister is disposed within a sealed shell or container in radially spaced relation thereto and a metallic filler completely occupies the annular space between the canister and the container. The filler material is initially cast in solid form at one end of the canister and subsequently heated to liquefy the filler material for flow into the above mentioned space.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a vertical sectional view of a self-stabilizing radioactive waste disposal package constructed in accordance with this invention;

FIG. **2** is a fragmentary sectional view taken along line **2—2** of FIG. **1**;

FIG. **3** is a vertical sectional view, showing the initial stage of assembling the waste package of this invention; and

FIG. **4** is a view similar to FIG. **2**, showing the final stage of assembly in fabricating the waste package of the present invention.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now in detail to the illustrative embodiment depicted in the accompanying drawings, there is shown in FIG. **1** a self stabilized disposal container or package, comprehensively designated **10**, adapted to contain and store radioactive waste material including spent nuclear fuel for long periods of time. The package **10** also is constructed in a manner facilitating the manipulation thereof by suitable remote handling apparatus, as well as meeting the criteria for the safe transport of such materials.

As shown in FIG. **1**, the waste package **10** comprises an inner, specially reinforced canister **11** completely encapsulated by a corrosion resistant metallic shell **12**, often referred to as an "overpack". The reinforced canister **11** is fabricated by welding together the necessary component parts or segments that have been prefabricated from 304 L stainless steel into a cup-shaped, cylindrical body **13** having a cylindrical sidewall **15** and an inwardly dished or concave bottom wall **16** formed integral with the sidewall **15**. In lieu of 304 L stainless steel, the canister body **13** can be formed of carbon steel or Ti Code −12 material, if desired, to reduce costs or extend the corrosion life of the canister.

The upper end of canister **11** is provided with a top wall **17** in the form of a thick circular plate welded, as at **18**, to the upper end of body **13** and formed with a central opening **20** to provide access to the interior of the canister **11**. The canister **11** terminates at its upper end in a neck portion **21** welded or otherwise fixedly secured to top wall **17** adjacent the opening **20**. The neck **21** is formed with a throat portion or bore **22** tapering outwardly adjacent its lower end to merge with the

opening **20** and form therewith a continuous passage or inlet **23** for the flow of waste material into the interior of canister **11**. The upper surface of top wall **17** adjacent the periphery thereof is formed with an annular recess **25** for a purpose that will hereinafter be more fully explained.

A significant feature of this invention resides in strengthening the canister **11** sufficiently to react radial and axial forces generated by external pressure loads. To this end, the upper portion of body **13**, which is devoid of waste material to form an empty space or overfill volume **26**, is reinforced while the bottom portion of body **13** takes advantage of the waste form to provide the desired reactive compressive strength. Accordingly, the upper portion of body **13** is formed with a wall portion **15***a* of substantially greater thickness than the remainder of wall **15** to reinforce the same. For the same reason, the top wall **17** also has a thickness approximating the thickness of the sidewall portion **15***a*. It should be understood that the length of thickened wall portion **15***a* is determined by and approximates the depth of the unoccupied space **26** to provide the desired reinforcement for this portion of the canister **11**.

The bottom portion of body **13** houses the radioactive waste material in the form of glass **27** and retains the glass in a shape that can react external pressure loads even if the glass develops cracks. As is well known, radioactive waste materials can be converted into an inert, solid form by a glass vitrification process in which the radionuclides are contained within the formed glass product. Since this technique is well known, no further description or amplification thereof is believed necessary. However, the canister **11** of the present invention advantageously utilizes this glass form of radioactive waste to enhance the compressive strength of the canister **11**.

In order to retain the shape of the glass, an internal stiffener, in the form of a concave disk **28**, is provided at the top of the waste glass **27**. The stiffener disk **28** is welded or otherwise fixedly secured along its peripheral edge **30** to the lower portion of the thickened wall portion **15***a* and is formed with a central opening **31** to pass the molten waste glass therethrough during the canister filling operation. This stiffener, in conjunction with the canister sidewall **15** and bottom wall **16**, serves to structurally encapsulate or confine the entire body of waste glass. This encapsulated glass, even if cracked, possesses high compressive strength and serves to react any external pressure loads acting against the lower portion of the canister **11**. Thus, the combination of the thickened wall at the upper empty end of the canister and the waste glass deposited in the remainder of the canister offers sufficient compressive strength to withstand any external pressure loads resulting from dynamic repository conditions.

The top wall **17** of canister **11** supports along its periphery a collar assembly, generally designated **32**, having an end wall **33** and a cylindrical skirt or sidewall **35**. The end wall **33** is provided with a central opening **34** for accommodating the neck **21** of canister **11**. As best shown in FIG. **2**, the lower end of the skirt **35** has a castellated or tooth-like formation comprising alternating recesses **36** and projections **37**. The projections **37** are received in annular recess **25** and suitably affixed thereto, while the recesses **36** define openings in the skirt **35**. The collar assembly **32** also houses a thick, circular block of solid filler material **38**, preferably lead, cast or otherwise fixedly secured to the end wall **33** and skirt **35** and disposed about the neck **21**. The bottom of the block of filler material **38** is slightly spaced above the upper surface of canister top wall **17** to define assembly clearance and an annular passage **40** communicating with the recesses **36** for a purpose that will hereinafter become apparent.

A tapped bushing **41**, located within the upper end of inlet **23**, is welded to the inner surface of neck **21** after the canister is filled with the waste product to seal the canister closed. The bushing **41** is formed with a tapped opening **42** for receiving the threaded shank **43** of a pintle **45** subsequently utilized for lifting or otherwise handling the waste package by suitable remotely controlled handling apparatus (not shown).

The canister **11** is completely enveloped by the outer shell **12**, which comprises a cylindrical side wall **46**, a dished, concave bottom wall **47** complementary in shape to the bottom wall **16** of canister **11**, and a top closure plate **48** to which is rigidly secured the pintle **45**. The top closure plate **48** is welded, as at **50**, along its peripheral edge to the shell side wall **46**. An annular, titanium backing ring **51** is positioned adjacent the juncture of the closure plate periphery and cylindrical side wall **46** to facilitate welding. The thin outer shell **12** preferably is formed of corrosion resistant titanium to provide the necessary long-term resistance to corrosion and other deleterious effects encountered in underground repository sites.

An important feature of the present invention resides in the provision of a low melting point, self contained, filler material **38** disposed in solid form in the collar assembly **32**. After the complete waste package **10** is sealed closed by welding the closure plate **48** onto the shell **12**, the upper portion of the package is heated to melt and liquefy the filler material **38** and cause it to flow via passage **40** and the openings defined by recesses **36** into the narrow, annular space **29** between canister **11** and shell **12**. In its molten state, the filler material completely fills this annular space, positively eliminating any voids between the canister **11** and shell **12**. After heating, the filler material cools and solidifies to provide structural support for the thin shell **12** and stabilize it against buckling or deformation from external pressure loads. Additionally, the metal filler material offers thermal conduction to facilitate the flow of decay heat from canister **11** to shell **12**, which is then dissipated into the repository environment. Moreover, the lead filler serves as a gamma and neutron shield for attenuating the neutrons and gamma rays emitted from the radioactive waste material in the canister **11**.

In assembling the waste package **10**, molten radioactive waste glass material is poured through inlet **23** into the fabricated canister **11** up to the level of stiffener disk **28** with any foaming of the molten glass being accommodated in the volume **26**. After filling the canister, the contents are allowed to cool and harden. The canister **11** is then sealed closed by resistance welding the bushing **41** in place within neck **21**. The sealed canister **11** can now be inserted into the shell **12**.

As shown in FIGS. **3** and **4**, the overpacking operation preferably is accomplished by placing an empty shell **12** in a cylindrical holding fixture, generally designated **52**, located in a hot cell. The fixture **52** includes an assembly pit **53** having a cylindrical cavity **55** formed therein. While the assembly pit **53** shown is formed of concrete below the floor level of the hot cell, it should be appreciated that the pit can be formed of other suitable materials including carbon steel and disposed

above the cell floor level, if desired. A cylindrical sleeve **56** of suitable insulation is placed in the cavity of pit **53** and, in turn, receives a positioning sleeve **57** for holding and maintaining an empty shell **12** (FIG. **3**) in the proper upright attitude. The sealed canister **11**, along with the collar assembly **32**, is then lowered into the shell **12** with nominal clearance provided between the canister peripheral surface and the inner surface of shell **12** to facilitate easy entry thereinto. The projections **37** of the collar assembly skirt **35** disposed within the annular recess **25** of canister top wall **17** serve to accurately center the collar assembly **32** relative to the canister **11**. The top closure plate **48**, which includes the pintle **45**, is then brought into position and welded onto the shell **12**.

After closure is completed, the head or upper portion **58** (FIG. **4**) of the fixture **52** is lowered by means of a lifting device **60** into place. This head portion of the fixture **52** includes an insulation cap **61** and a positioning head **62** adapted to mate with the insulation sleeve **56** and positioning sleeve **57**, respectively. A heater coil **63** is mounted within the skirt of positioning head **62** and is energized for raising the temperature of the package **10** sufficiently, approximately 400° C., to melt the lead filler material **38**. The lead liquefies and flows via passage **40** and recesses **36** into the annular space **51** and completely fills the same to eliminate any voids between the canister **11** and shell **12**. Upon completion of this heating step, the head portion **58** is lifted and the package **10**, after cooling, is removed from the assembly pit and available for emplacement in an underground repository.

While lead preferably is employed as the filler material because of its low melting point (327° C.) and its gamma and neutron shielding properties, it should be appreciated that any suitable filler material possessing similar properties can be used in lieu of lead, if desired. The reason for liquefying the lead after complete closure is to eliminate any problems associated with lead vapor in an open system.

From the foregoing, it is apparent that the objects of the present invention have been fully accomplished. As a result of this invention, a new and useful self-stabilizing radioactive waste disposal package is provided for meeting all of the requirements of Federal Regulations as to integrity, long-term radionuclide containment, gradual radionuclide release after the containment, and retrievability. By taking advantage of the waste product form, together with the reinforcement of certain portions of the canister, sufficient compressive strength is realized to effectively resist the external crushing forces associated with anticipated dynamic repository conditions. Internal support for the outer shell to preclude buckling or deformation thereof is provided by a self-contained solid filler material convertible after completely sealing the package into a liquid state for filling the space between the canister and shell to positively eliminate any voids therebetween.

The foregoing description of a preferred embodiment of this invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed, and obviously many modifications and variations are possible in light of the above teaching. The embodiment was chosen and described in order to best explain the principles of this invention and its practical application to thereby enable others skilled in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the claims appended hereto.

I claim:

**1**. A waste package comprising: a canister for containing vitrified radioactive waste material, said canister having a side wall, an end wall terminating in a neck for defining an inlet, a closure member sealing said inlet closed, a sealed outer shell completely encapsulating said canister in radially spaced relation to said canister side wall and defining a space therebetween, means adjacent said neck for supporting a metallic filler in solid form, said metallic filler convertible into a liquid state for flow into said space after said outer shell has been sealed and then subsequent hardened to form a solid layer completely occupying said annular space.

**2**. A waste package according to claim **1**, wherein said canister comprises a side wall and opposite end walls, said vitrified radioactive waste material occupying the major portion of said canister from one of said end walls to a predetermined level spaced from said other end wall and offering resistance to external pressure loads.

**3**. A waste package according to claim **2**, wherein said side wall is formed with a reinforced portion extending from said level of vitrified radioactive waste material to said other end wall.

**4**. A waste package according to claim **1**, including means for retaining said vitrified radioactive waste material in a desired shape.

**5**. A waste package according to claim **4**, wherein said retaining means comprises a disk secured about the periphery thereof to said sidewall for confining in conjuction with said sidewall and said one end wall said vitrified radioactive waste material in said desired shape.

**6**. A waste package according to claim **1**, including a collar assembly mounted within said shell about said canister neck.

**7**. A waste package according to claim **6**, said collar assembly supporting said solid filler material prior to converting said filler material into a liquid state.

**8**. A waste package according to claim **7**, wherein said collar assembly comprises a skirt having a castellated edge supported on an external surface of said one end of said canister.

**9**. A waste package according to claim **8**, wherein said castellated edge defines openings establishing communication with said space for flow of said filler material when in a liquid state.

**10**. A waste package according to claim **1**, wherein said shell is formed of a corrosion resistant material.

**11**. A waste package according to claim **10**, wherein said corrosion resistant material is titanium.

**12**. A waste package according to claim **1**, wherein said metallic filler is lead.

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