United States Patent [19]

Boldt

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[54] **RADIOACTIVE WASTE STORAGE**

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[52] **U.S. Cl.**..... **250/506,** 250/518, 252/301.1 W

[51] **Int. Cl.**..... **G21f 9/00**

[58] **Field of Search**..... 250/506, 507, 518; 252/301.1 W

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[57] **ABSTRACT**

High-level radioactive wastes are stored in a heavy walled metal cask which is stored in the open where natural convection of air over the cask removes the decay heat. If the waste is solely from plutonium-recycle pressurized-water reactors, the high neutron dose rate around the cask must be reduced by surrounding the cask in its storage position with crushed graphite or placing cooling fins on the cask and employing neutron shielding material such as polyethylene between the fins.

7 Claims, 3 Drawing Figures

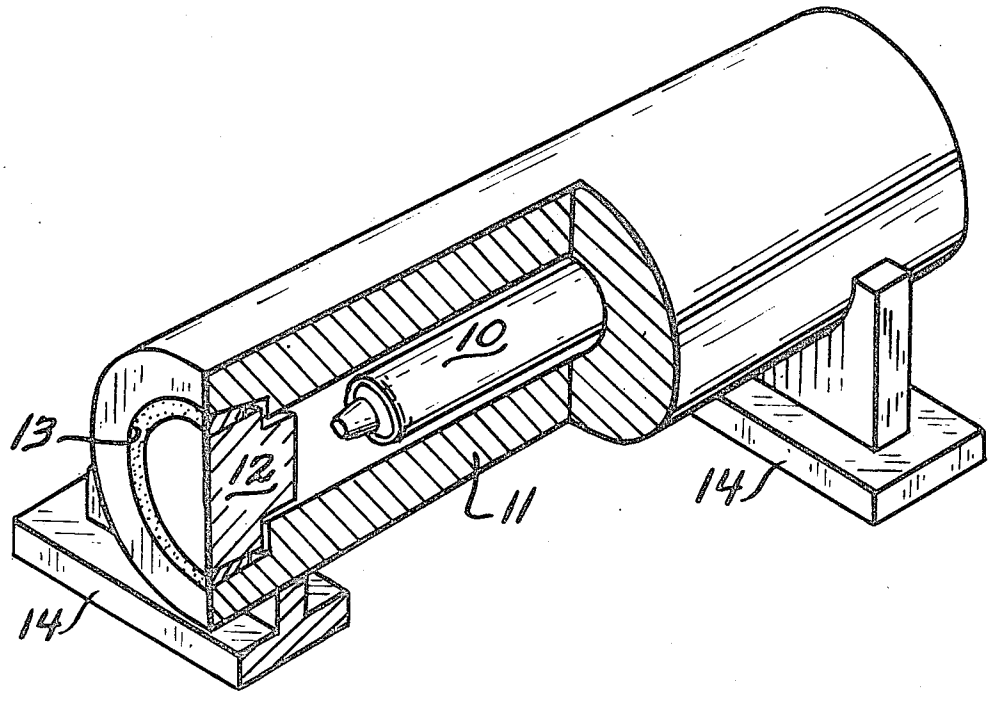


Fig — 1

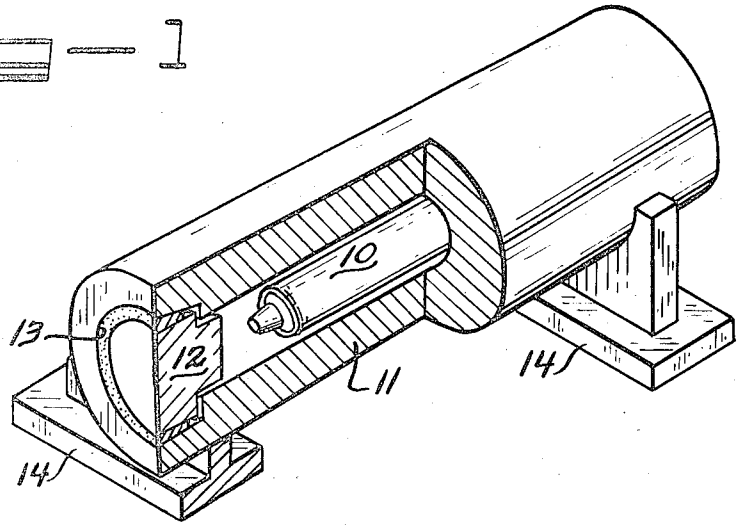


Fig — 2

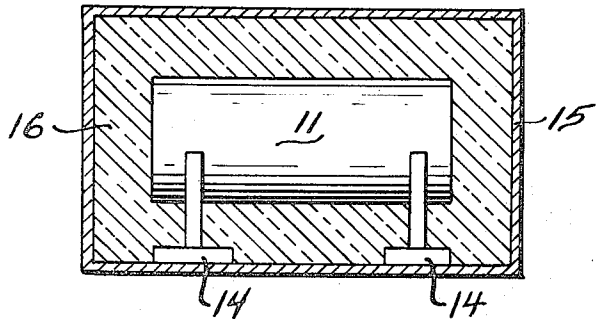
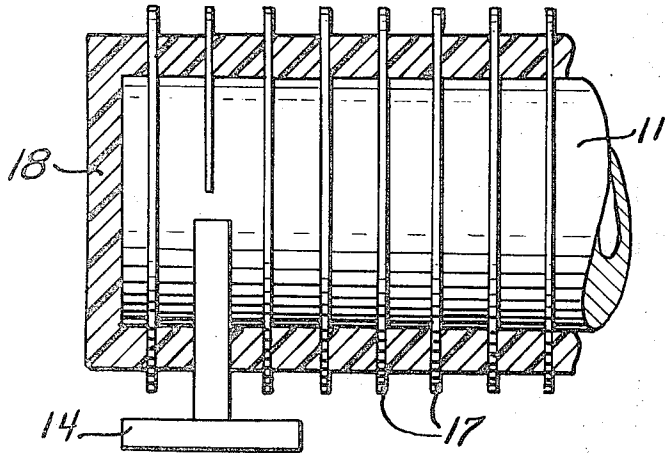


Fig — 3



RADIOACTIVE WASTE STORAGE

CONTRACTUAL ORIGIN OF THE INVENTION

The invention described herein was made in the course of, or under, a contract with the UNITED STATES ATOMIC ENERGY COMMISSION.

BACKGROUND OF THE INVENTION

This invention relates to the storage of high-level radioactive wastes for an extended period of time. The invention also relates to a cask useful for said storage and to a method of disposing of high-level radioactive wastes.

A problem facing the nuclear industry which has received much attention is how to dispose of radioactive wastes so that they will never contaminate the biosphere with radioactivity. While disposal of these wastes in a form and in an environment in which no contamination of the biosphere is possible under any conceivable circumstances for the entire period that radioactivity is at a dangerous level is the ultimate objective of waste management engineers, no such disposal procedure has as yet gained wide acceptance. As an alternative or supplement to ultimate disposal, an engineered storage employing buildings, vaults, tanks, etc., which require continuous surveillance and maintenance may be employed. For example, large volumes of liquid waste have been and are being stored in large tanks. Due to the tremendous cost of storing liquids, a program has already been started for solidifying these wastes. Unacceptably high costs result from the storage and dispersal of high-level wastes developing a significant amount of decay heat in a large engineered structure wherein heat conduction through the walls and roof to the atmosphere is relied on to dissipate the heat developed in the wastes. Thus, engineered structures for the storage of high-level wastes have always heretofore been provided with positive means for cooling the wastes including, for example, pumps, fans and heat exchangers, this being in addition to ventilation filters and radiation shielding required due to the high level of radiation. Thus, at best, any engineered storage system heretofore suggested is expensive and, due to the expense and to the finite life of the containers, all such systems heretofore suggested can only be considered interim solutions to the problem of radioactive waste disposal.

SUMMARY OF THE INVENTION

According to the present invention, high-level radioactive wastes are stored in a heavy walled metal cask which is stored in the open where natural convection of air over the cask removes the decay heat. After about 150 years the cask can be removed to a hard rock mine since the thermal conductivity of rock is sufficient that excessive temperature increases in the wastes will not occur. If the waste is solely from plutonium-recycle pressurized-water reactors, the high neutron dose rate around the cask must be reduced by surrounding the cask in its storage position with crushed graphite or placing cooling fins on the cask and employing neutron shielding material such as polyethylene between the fins.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a partially broken away perspective view of a storage cask as employed according to the present invention.

FIGS. 2 and 3 are views showing modifications thereof.

SPECIFIC EMBODIMENT OF THE INVENTION

Referring now to the drawing a container **10** for high-level radioactive wastes is disposed within a thick walled metal cask **11** which is provided with a massive shielding plug **12** deep-penetration welded into an opening **13** in the end of cask **11.** For a container **10** which is 12 inches in diameter and 10 feet long and holds radioactive wastes giving off 5 kilowatts of decay heat, a low carbon steel cask **11,** which is 45 inches in diameter and 13 feet long, has 16 inch thick walls and weighs about 35 tons is suitable. Low carbon steel is specified as the material of construction to keep the cost of the cask down. Preferably, approximately 0.25 percent copper has been added to the steel to improve corrosion resistance by promoting the formation of a tightly held oxide coating. Other metals such as lead or uranium could also be utilized. To keep costs as low as possible, cask **11** is fabricated by casting in a mold. It is acceptable to take the casks as a raw casting with a minimum of inspection and/or testing to assure the absence of cracks, lamination or large voids. A hand grinder can be used to remove slag and oxides from the weld area prior to insertion of the plug.

The decay heat from the waste material is removed from the cask by natural convection of air around the cask and to promote natural convection the cask is supported on precast support saddles **14.** No backup or emergency cooling systems are required. The external cask temperature is about 275°F. and the wall temperature of the internal waste container is approximately 550°F. for a 5 kw container assuming radiant heat transfer only between the waste container and the internal cask wall. The difference in temperature between the inner and outer wall of the cask is about 10°F.

The amount of shielding provided by the 16-inch thick steel walls of the cask will reduce the exterior gamma dose rate to 1 mr/hr for typical uranium wastes. It is expected that the neutron dose rate will be approximately 30 mr/hr at a distance of 6 feet from the cask.

Storage of the casks is outside exposed to the environment. Placing the cask inside a building would restrict free diffusion of heated air into the atmosphere and would result in a temperature increase. Preferably the casks will be stored in a dry, arid climate where the life of a cask exposed to the atmosphere will be approximately 10,000 years.

An analysis of a cask with 16-inch thick steel walls indicates that the cask will withstand all credible natural phenomena such as tornado, earthquake, flood, etc. The cask should also withstand any credible accident such as fire or aircraft impact. Since the casks are vulnerable to sabotage and in view of the dose rate present outside of the casks, which though limited is appreciable, a restricted access storage area is necessary and the primary expense of a waste facility containing a number of these casks would be a guard force to prevent access by the public to the area.

The encapsulated wastes in the casks are suitable for disposal in geologic structures if they are decayed in the sealed cask for 150 years or greater. The 150 years' decay reduces the heat output to a degree where structures with low thermal conductivities — hard rock mines for example — can be utilized with a relatively high storage density and without excessive temperature increases. It is expected that a proper geologic structure can be selected that would allow retrieval of the steel casks in usable condition tens of thousands of years later.

Using the cask and method heretofore described to store waste from plutonium recycle pressurized water reactors only would produce an unacceptably high neutron dose rate exterior to the cask (~300 mr/hr). The neutron exposure is caused by the ^{244}Cm content of the waste and will decay out with an 18-year half-life. This high neutron dose rate can be avoided by employing the embodiments of FIG. **2** or FIG. **3.** As shown in FIG. **2,** a steel box **15** is placed around cask **11** in its storage position and this box is filled with crushed graphite **16.** The graphite provides neutron shielding and the high thermal conductivity of graphite will prevent excessive overheating of the cask and waste container. An alternative solution is illustrated in FIG. **3** wherein cooling fins **17** are cast on the cask **11** at the time of fabrication and slabs of neutron shielding material **18** such as polyethylene are provided between and at the base of the fins.

The operation of a waste repository facility for receiving waste storage casks according to the present invention would be as follows:

a. The receiving facility will unload containers of solid radioactive waste from shipment casks in a hot cell.
b. The waste containers will be transferred by in-cell crane through a cell floor port into an open cask.
c. A massive cask shielding end plug will be fitted into the top of the cask thus providing full gamma shielding.
d. The loaded cask will be moved on a transporter to a contact operated plug welding station.
e. A gamma survey will be made of the exterior of the cask to verify the absence of voids in the cask wall.
f. The end shieldng plug will be welded to the cask body with a deep penetration weld (e.g., 8 to 12 inches) to provide a large corrosion allowance in the weld area similar to the cask body. An inital survey of welding methods indicates that the electroslag welding process is very suitable for this application.
g. The weld quality will be checked.
h. The cask will be checked for external contamination.
i. The cask will be transported by a rubber tired or tracked carrier to a storage location in the field and positioned on support saddles as shown in FIG. **1.**

This procedure has an operating problem of neutron exposure but it is expected that this can be overcome by placement of local neutron shielding at work stations. Based on neutron dose rates developed by ORNL for waste shipping casks when the neutron shield is lost, it is estimated that the neutron dose rate for a "typical" cask will be approximately 30 mr/hr at a distance of 6 feet from the cask. This can be reduced to reasonable levels in the encapsulating facility and at the driver's seat on the transporter by the use of local neutron shields. At the storage positions in the field, it is believed that the relatively high neutron dose rates are acceptable as the storage location is not a normal occupancy area.

Advantages of this Procedure

a. The total capital and operating costs for the sealed cask storage are significantly lower than the costs for prior art engineered structures with separate shielding, confinement, and heat removal systems.
b. This procedure provides containment versus the controlled release confinement systems of other engineered storage systems.
c. Personnel required for surveillance are estimated at 10 percent or less of that required for other engineered storage systems.
d. This procedure offers a life greatly in excess of 1,000 years vs. the approximately 100-year life of other engineered storage systems.
e. This procedure does not require emergency cooling systems unlike other engineered storage systems.
f. Decommissioning costs are expected to be much less for sealed cask storage vs. decommissioning other engineered storage systems.
g. The encapsulated wastes in the casks are suitable for disposal in geologic structures if they are decayed in the sealed cask surface storage system for 150 years or greater.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A storage cask for solid high-level radioactive wastes consisting of a thick walled unitary carbon steel cask including a plug sealed in place with a deep penetration weld, the thickness of the walls of the cask being sufficient to reduce radiation levels to a tolerable level and to permit storage of the cask out-of-doors.

2. The storage cask according to claim **1** wherein the walls of the cask are 16 inches thick.

3. The storage cask according to claim **2** wherein cooling fins are provided on the cask and the cask is surrounded by neutron absorbing material placed between the fins.

4. The storage cask according to claim **2** and including a steel box filled with crushed graphite in which the storage cask is immersed.

5. A method of storing high-level radioactive wastes comprising inserting containers of solid radioactive waste into the storage cask of claim **1,** deep penetration welding an end plug into the cask body, and storing the casks in a restricted access storage area out-of-doors in an arid climate where cooling with air by natural convection occurs.

6. The method of claim **5** wherein the casks are positioned on concrete support saddles to allow free convection of air around the casks and reduce soil corrosion of the casks.

7. The method of claim **5** wherein the casks are stored out-of-doors for about 150 years, and are then placed in a hard rock mine.

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