(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 296 855 A2**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 88305733.3

(51) Int. Cl.4: **G21F 5/00 , G21F 9/36**

(22) Date of filing: 23.06.88

(30) Priority: 23.06.87 US 65803
26.06.87

(43) Date of publication of application:
28.12.88 Bulletin 88/52

(84) Designated Contracting States:
CH DE LI SE

(71) Applicant: **AUSTRALIAN NUCLEAR SCIENCE AND TECHNOLOGY ORGANISATION**
New Illawarra Road
Lucas Heights New South Wales 2234(AU)

(72) Inventor: **Ramm, Eric John**
10 Immarna Street
Lilli Pilli New South Wales, 2229(AU)

(74) Representative: **Ben-Nathan, Laurence Albert et al**
Urquhart-Dykes & Lord 91 Wimpole Street
London W1M 8AH(GB)

(54) A method of storing radioactive waste material.

(57) In the illustrated embodiment, a non-deformable inner vessel 60 retains safely radioactive waste and a suitable dense metal sheath is formed around the inner vessel 60 at relatively low temperatures and pressures and, most importantly, the melting point of the material forming the sheath 74 is substantially lower than the melting point of the inner vessel 60 or the outer vessel 70 so that the sheath 74 can be removed in a suitable furnace thereby permitting retrieval of the inner vessel 60 and the waste for reprocessing.

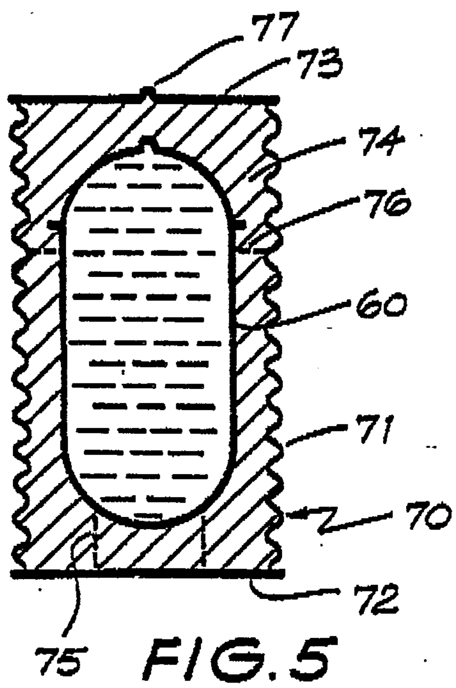

FIG.5

EP 0 296 855 A2

A METHOD OF STORING RADIOACTIVE WASTE MATERIAL

The present invention relates to an encapsulation method suitable for safe storage of radioactive waste such as high level waste products, spent nuclear fuel rods, spent fuel and generally any radioactive product which is usually in a solid form. The method is particularly directed to providing a containment structure which is readily susceptible to waste retrieval whereby the radioactive waste material can be retrieved for reprocessing at a later point in time.

High level wastes and spent nuclear fuel rods contain valuable radioactive materials and reprocessing may be desired. However, this reprocessing may not be required for many years and in the meantime safe storage is necessary.

One prior proposal is for immobilising the waste by mixing a calcine of the waste with synthetic rock precursor elements and subjecting the mixture to very high temperatures and pressures for extending periods of time to form a synthethic rock. Methods for achieving this include hot isostatic pressing (for example as disclosed in U.S. patents 4,172,807 (Larker), 4,409,029 (Larker and Tegman) 4,642,204 (Burstrom and Tegman) and uniaxial pressing including hot upward uniaxial pressing using bellows-like containers (see U.S. patent 4,645,624 issued to Australian Atomic Energy Commission and The Australian National University).

However, new and useful alternative methods of safe storage are required and, in particular, the development of a method which will permit retrieval of the waste material after a period of time is now perceived as being desirable.

According to the present invention, there is provided a method of encapsulation of radioactive waste products which not only is directed to providing safe long term storage and containment, but also is specifically adapted to permit retrieval of the waste products at a much later date when reprocessing may be required. Many high level types of radioactive waste contain very valuable components and after a period of many years storage, during which decay of certain components takes place, it may be desired to retrieve the material and reprocess.

A novel method for achieving such a containment is provided by a method which uses a substantially non-deformable inner vessel for containing the radioactive waste material securely during the method and during storage, the inner vessel being placed within a deformable outer vessel and a protective metal sheath (highly resistant to corrosion) being formed between the inner and outer vessels by placing in this zone metal material which has a substantially lower melting point than the inner vessel and the outer vessel and which is capable of forming a dense matrix; the method further ccmprises closing the outer vessel and subjecting the structure to sufficiently elevated temperature and pressure for sufficient time to compress the outer container and the metal material to form a dense sheath, whereby at any subsequent time the outer container may be opened and subjected to a heating process to remove the metal material, thereby releasing the inner vessel for removal of its contents.

Relating to reversible encapsulation of waste materials, it is preferred that the outer vessel has a cylindrical outer wall or a bellows like outer wall.

In a preferred embodiment of this method any one or more and preferably most or all of the following features are used:

(a) The outer vessel is cylindrical with a bellows-like side wall;

(b) The inner vessel is cylindrical with domed ends to form a pressure vessel;

(c) After closure of the inner and outer vessels both are evacuated and then sealed before the pressing process which is an isostatic process;

(d) The metal material is a copper or copper alloy or other corrosion resistant relatively low melting point metal or metal alloy suppled in powder form;

(e) The processing conditions are typically 800 °C, 20 MPa and a time of about 1 hour.

The invention will now be illustrated, by way of example only, with reference to the accompanying drawings of which:-

Figure 1 illustrates filling an inner vessel with2particulate material for a further embodiment of the invention;

Figure 2 illustrates closure of the vessel of Figure 1;

Figure 3 illustrates an alternative to Figure 1 in which an inner vessel receives spent nuclear fuel rods;

Figure 4 illustrates closure of the vessel shown in Figure 3;

Figure 5 illustrates the inner vessel located within the outer vessel and surrounded by metal powder and prior to a hot pressing process;

Figure 6 illustrates the structure of Figure 5 after the hot pressing process; and

Figure 7 illustrates a method of removing the sheath to permit retrieval of the inner vessel, the inner vessel being that shown in Figures 1 and 2.

Figure 8 illustrates the inner vessel of Figure 1 with annular strengthening collars.

In the illustrated embodiment, a non-deformable inner vessel retains safely radioactive waste and a suitable dense metal sheath is formed around the inner vessel at relatively low temperatures and pressures and, most importantly, the melting point of the material forming the sheath is substantially lower than the melting point of the inner vessel or the outer vessel so that the sheath can be removed in a suitable furnace thereby permitting retrieval of the inner vessel and the waste for reprocessing.

Figure 1 shows a cylindrical metal vessel 60 having domed ends with an aperture 61 at the top end for receiving high level radioactive waste in the form of calcine 63 and an annular collar 62 around the upper end of the vessel to permit it to be lifted and moved. The vessel 60 is of a metal which is highly resistant to corrosion, substantially non-deformable in the process and retains high strength at temperatures in the process. A suitable metal would be Inconel 601. After the vessel has been filled with calcine 63, its upper end is closed with a top cap 64 having an evacuation tube 65 through which gas is evacuated from the vessel 60 and, in a welding process, the tube 65 is sealed off.

Figures 3 and 4 show an alternative embodiment in which a large aperture 66 is provided at the top of the vessel whereby a bundle of spent nuclear fuel rods 67 can be inserted within the vessel. As shown in Figure 4 the vessel is closed in a similar manner by a top cap 68, evacuated and sealed.

As shown in Figure 5 the inner vessel 60 is located within a cylindrical outer vessel 70 having a bellows-like side wall 71 and planar end walls 72 and 73. In this embodiment copper powder 74 is used for forming the protective sheath since it is highly corrosive resistant, will form a dense matrix, is economic and has a suitably low melting point. A perforated cylinder 75 of the same material namely copper is disposed in the central lower region of the bellows container 71 and supports the inner vessel 60. A perforated annular disk 76 also of copper is provided in the upper region for centralising the inner vessel 60.

Figure 5 shows the assembly after the copper powder 74 has been poured into the space between the vessels, vibration assisting the establishment of a good packing density. The top end wall 73 is welded into position and gases within the bellows container 71 evacuated through evacuation tube 77, which is then welded to seal the structure.

Hot isostatic pressing is conducted in this example, typical conditions being 800°C, 20 MPa and a time of about 1 hour. The resultant end structure is generally as shown in Figure 6, the bellows container 71 being axially compressed but not disorted or substantially deformed in the radial direction. A dense copper sheath 78 is formed between the vessels and provides a massive barrier for safe containment of the radioactive waste. The copper sheath is highly corrosion resistant and can also conduct away heat generated during radioactive decay of the material in the inner vessel 60.

The outer bellows container 71 is formed of a metal having a good strength at high temperatures, a convenient metal being Inconel 601. However, safe containment of the radioactive material does not depend on the bellows container 71 as the copper sheath 78 is the essential safety element, even though normally the bellows container 71 will provide a reliable and complete containment structure.

Figure 7 illustrates the method of recovering the high level waste for reprocessing. The base 72 of the bellows container 71 is removed and the assembly supported in an induction furnace having coils 80 and a suscepter sleeve 81. At a temperature of about 1080°C the copper matrix 78 is melted and flows into a receiving crucible located below the furnace thereby releasing the inner vessel 60 for processing. Providing the copper is not contaminated it may be re-used.

Figure 8 illustrates the inner vessel of Figure 1 having three annular strengthening collars 82.

Claims

1. A method of storing radioactive waste material comprising placing the waste material in a substantially non-deformable sealed inner vessel 60 of a material which has substantial strength at the elevated temperatures used in the method, locating said vessel within a deformable outer container 70 and spaced from the walls thereof, the outer container having substantial strength at the elevated temperatures used in the method, filling the space between said vessel 60 and said outer container 70 with a metal material 74 which is highly corrosion resistant and which, in the method, will provide a dense thick sheath around the inner vessel and will melt at the temperatures employed in the method whereby an assembly is produced, and subjecting the assembly to elevated temperature and pressure to cause compressive deformation of the outer container, formation of the metal into a dense corrosive resistant sheath around the inner vessel and leave the inner vessel substantially undeformed, whereby safe long term storage of the radioactive waste is provided and retrieval of the inner vessel and its contents is achievable by making an opening 61 in the outer container 71, subjecting the assembly to similar temperatures as those employed in the initial method and removing the molten metal from around the inner vessel.

2. A method of storing radioactive waste material according to claim 1 wherein the outer vessel is cylindrical with a bellows-like side wall 71.

3. A method of storing radioactive waste material according to claim 1 or 2 wherein the inner vessel is cylindrical with domed ends 68 to form a pressure vessel.

4. A method of storing radioactive waste material according to any preceding claim wherein after closure of the inner 60 and outer vessels 70 both are evacuated and then sealed before the pressing process which is an isostatic process.

5. A method of storing radioactive waste material according to any preceding claim, wherein the metal material is a copper or a copper alloy 74 supplied in powder form.

6. A method of storing radioactive waste material according to any preceding claim, wherein the processing conditions are typically 800°C, 20 MPa and a time of about 1 hour.

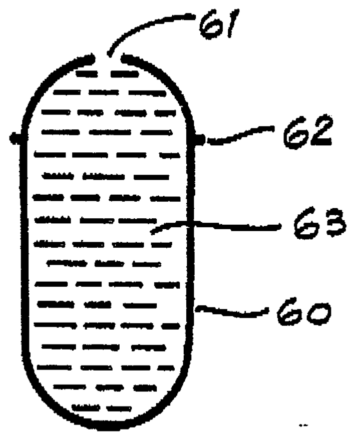

FIG. 1

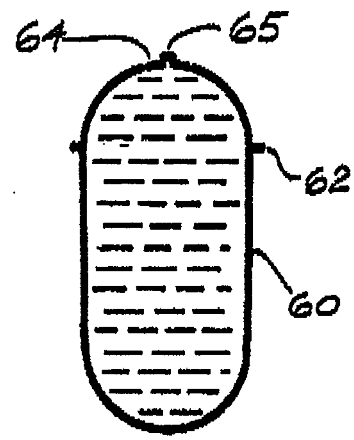

FIG. 2

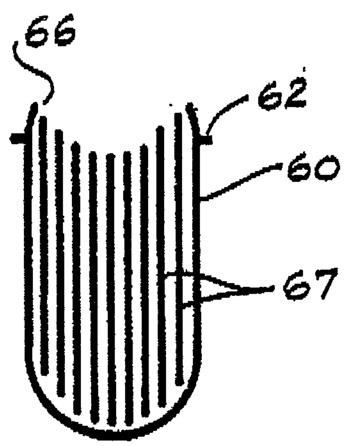

FIG. 3

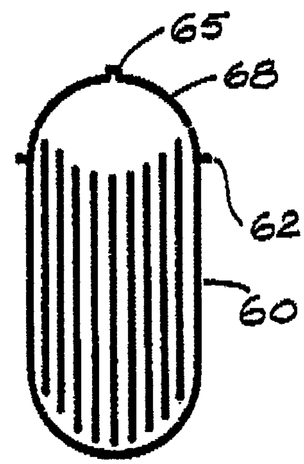

FIG. 4

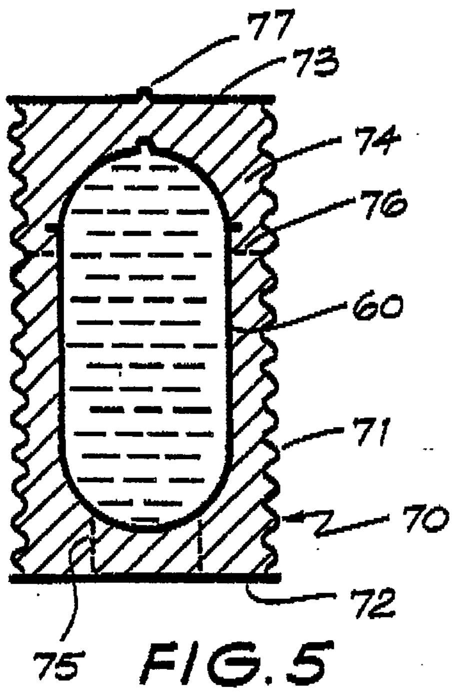

FIG.5

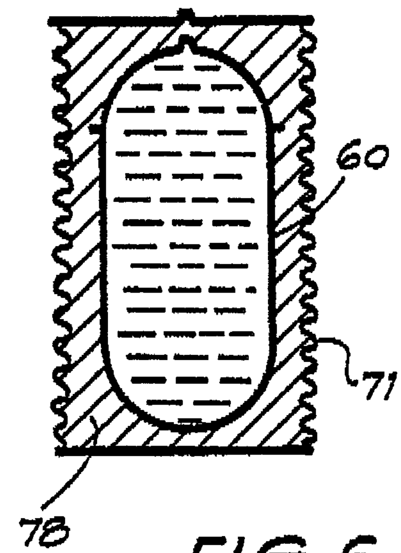

FIG.6

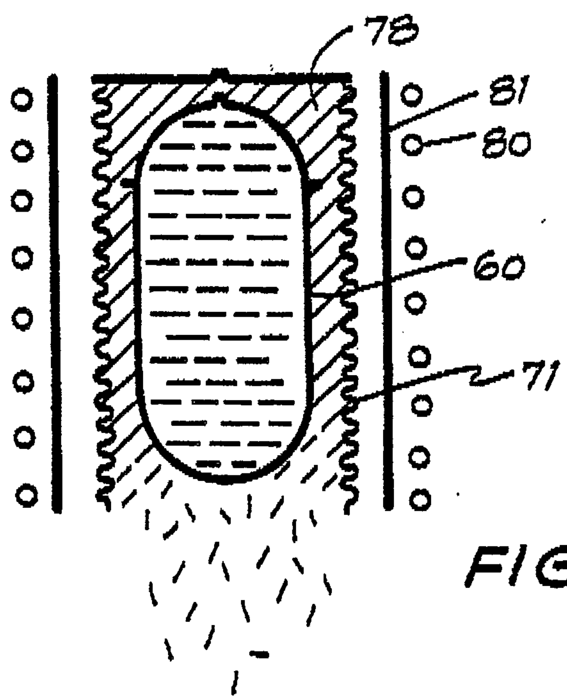

FIG.7

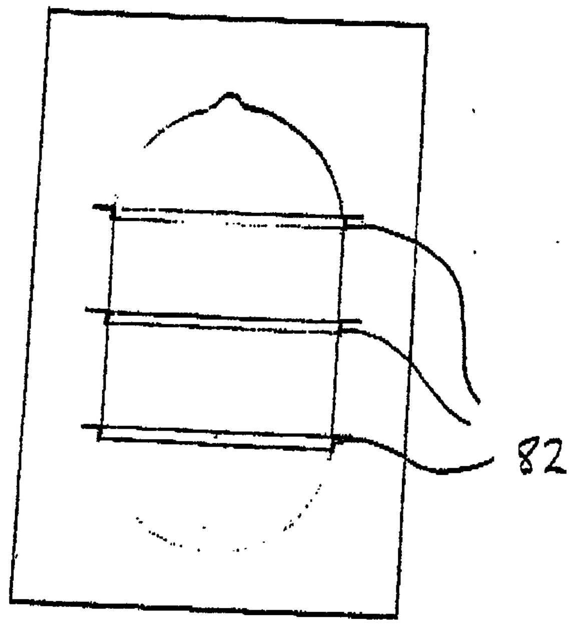

FIG. 8