PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : A62D 3/00	A1	(11) International Publication Number: WO 95/32025
		(43) International Publication Date: 30 November 1995 (30.11.95)

(21) International Application Number: PCT/US95/03405

(22) International Filing Date: 20 March 1995 (20.03.95)

(30) Priority Data:
246,412 20 May 1994 (20.05.94) US

(71) Applicant: STIR-MELTER, INC. [US/US]; 995 Fourth Street, Ampoint Industrial Park, Perrysburg, OH 48552 (US).

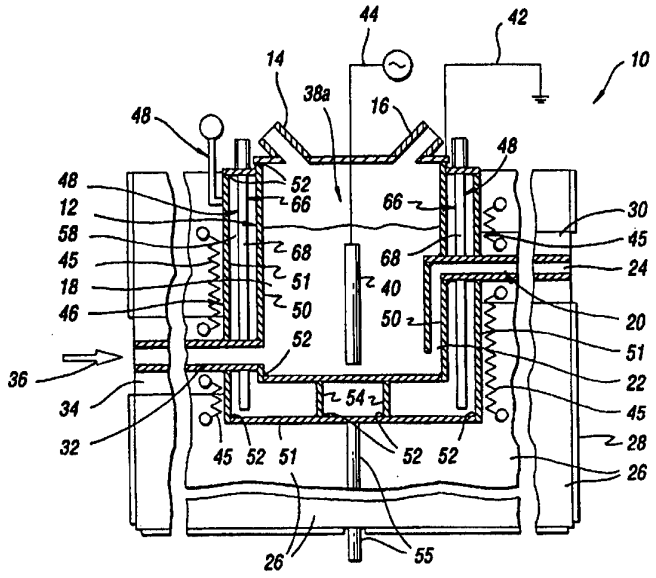
(72) Inventors: WETMORE, Kenneth, H.; 647 Oak Knoll Drive, Perrysburg, OH 43551 (US). KORMANYOS, Kenneth, R.; 8165 Timothy, Sylvania, OH 43560 (US). COX, Stephen, F.; 27811 Glenwood Road, Perrysburg, OH 43551 (US).

(74) Agent: KUSHMAN, James, A.; Brooks & Kushman, 22th floor, 1000 Town Center, Southfield, MI 48075 (CA).

(81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MN, MW, MX, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TT, UA, UG, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW, SD, SZ, UG).

Published
With international search report.

(54) Title: APPARATUS AND METHOD FOR VITRIFICATION OF HAZARDOUS WASTE



(57) Abstract

Apparatus (10) and a method for vitrifying hazardous waste includes a melting vessel (12) into which hazardous waste is introduced for heating by a heater (38), and a metallic containment vessel (46) of the apparatus receives the melting vessel so as to receive and contain any material that exits the melting vessel upon failure. Failure of the melting vessel (12) is detected by a sensor (48). A stirrer (39) mixes the material (18) during the heating. The containment vessel (46) is preferably hermetically sealed around the melting vessel (12) to contain gases and any melted material received from the failed melting vessel (12). The sensing of the failure is by a pressure change in the hermetically sealed chamber (58) or sensing of the presence of material received by the containment vessel (46) from the failed melting vessel (12) by electrical circuit type detection.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	**GB**	United Kingdom	**MR**	Mauritania
AU	Australia	**GE**	Georgia	**MW**	Malawi
BB	Barbados	**GN**	Guinea	**NE**	Niger
BE	Belgium	**GR**	Greece	**NL**	Netherlands
BF	Burkina Faso	**HU**	Hungary	**NO**	Norway
BG	Bulgaria	**IE**	Ireland	**NZ**	New Zealand
BJ	Benin	**IT**	Italy	**PL**	Poland
BR	Brazil	**JP**	Japan	**PT**	Portugal
BY	Belarus	**KE**	Kenya	**RO**	Romania
CA	Canada	**KG**	Kyrgystan	**RU**	Russian Federation
CF	Central African Republic	**KP**	Democratic People's Republic of Korea	**SD**	Sudan
CG	Congo			**SE**	Sweden
CH	Switzerland	**KR**	Republic of Korea	**SI**	Slovenia
CI	Côte d'Ivoire	**KZ**	Kazakhstan	**SK**	Slovakia
CM	Cameroon	**LI**	Liechtenstein	**SN**	Senegal
CN	China	**LK**	Sri Lanka	**TD**	Chad
CS	Czechoslovakia	**LU**	Luxembourg	**TG**	Togo
CZ	Czech Republic	**LV**	Latvia	**TJ**	Tajikistan
DE	Germany	**MC**	Monaco	**TT**	Trinidad and Tobago
DK	Denmark	**MD**	Republic of Moldova	**UA**	Ukraine
ES	Spain	**MG**	Madagascar	**US**	United States of America
FI	Finland	**ML**	Mali	**UZ**	Uzbekistan
FR	France	**MN**	Mongolia	**VN**	Viet Nam
GA	Gabon				

APPARATUS AND METHOD FOR VITRIFICATION OF HAZARDOUS WASTE

TECHNICAL FIELD

This invention relates to apparatus and a method for vitrifying hazardous waste.

BACKGROUND ART

Vitrification of waste materials has previously been accomplished in ceramic lined melting vessels that are capable of being heated to relatively high temperatures such as on the order of about 1500°C to 1600°C. Such heating as disclosed by United States Patent 4,820,328 Roberts et al can be utilized to vitrify waste asbestos by a high temperature melting process. Furthermore, as disclosed by United States Patent 5,100,453 Richards such high temperature melting can be utilized to recycle glass fibers such as of the type utilized for building insulation. Likewise, incinerator fly ash can also be vitrified by such high temperature melting in a ceramic melting vessel. During such processing, the waste and any other necessary components to form a glassy material upon heating are introduced into the ceramic melting vessel, and the melted material permeates into seams or any cracks in the ceramic melting vessel sufficiently to cool and thereby seal the vessel so that there is no leakage.

Vitrification of hazardous waste at a lower temperature such as on the order of about 1000 to 1100°C has also previously been done by heating thereof within a metallic melting vessel. When hazardous waste such as nuclear waste or heavy metals etc. is vitrified, the resultant melted mixture can be delivered into a

container for storage upon cooling. However, the metallic melting vessel can fail during use and, in such case, hazardous waste in the melting vessel can contaminate the facility in which the processing is being performed. Such contamination can be a particular problem when nuclear waste processing is involved. Furthermore, heating in a metallic melting vessel has previously been done by passing an electrical current through the melted material between the metallic melting vessel and a stirrer that mixes the material being heated. Thus, the metallic melting vessel and the stirrer act as the electrodes between which the current flows for the heating as mixing takes place. This type of heating is believed to provide superior results due to the direct generation of heat within the melted material by the passage of electric current uniformly through the melt between the stirrer and the melting vessel.

DISCLOSURE OF INVENTION

Objects of the present invention are to provide improved apparatus and a method for vitrifying hazardous waste in a manner that provides containment of the waste in case of failure of the melting vessel in which the hazardous waste is heated for the vitrification.

In carrying out the above objects, apparatus for vitrifying hazardous waste in accordance with the present invention includes a metallic melting vessel for receiving hazardous waste and any other necessary components for forming a glassy material upon heating. A heater of the apparatus provides heating of material in the melting vessel. The apparatus also includes a metallic containment vessel in which the melting vessel

is located so the containment vessel upon failure of the melting vessel receives and contains any material that exits the failed melting vessel. A sensor of the apparatus is also provided for detecting the failure of the melting vessel.

Different embodiments of the heater are disclosed. One type of heater disclosed passes electrical current through molten material within the melting vessel to provide the heating, with one such heater embodiment having an electrical voltage across the melting vessel and an electrode within the molten material in the melting vessel to pass the electrical current through the molten material to provide heating thereof, and with another such embodiment having an electrical voltage across a pair of electrodes in the molten material in the melting vessel to pass an electrical current through the molten material to provide heating thereof. Another embodiment of the heater includes induction coils for heating the material within the melting vessel by induction heating of the melting vessel. A further embodiment of the heater includes electrical resistance elements for heating the material within the melting vessel by electric resistance heating of the melting vessel.

The apparatus for vitrifying hazardous waste is also disclosed as including a stirrer for mixing the material being heated.

In the preferred construction of the apparatus, the containment vessel is hermetically sealed around the melting vessel to form an enclosed chamber that contains gases as well as any other material that exits the failed melting vessel.

Different embodiments of the sensor are disclosed. In one embodiment, the sensor is communicated with the hermetically sealed chamber between the melting vessel and the containment vessel to detect a change in pressure within the hermetically sealed chamber when the melting vessel fails to thereby detect such failure. In other embodiments, the sensor for detecting failure of the melting vessel senses the presence of material received by the containment vessel from the failed melting vessel and preferably includes an electrical circuit that detects the presence of material received by the containment vessel from the failed melting vessel. In one embodiment, the electrical circuit of the sensor includes a pair of electrical probes that are located between the melting and containment vessels and are normally electrically isolated from each other until material received by the containment vessel from the failed melting vessel electrically connects the probes to each other. In another embodiment, the electrical circuit includes a flow path that is located between the melting and containment vessels and that is normally closed but is opened by the presence of material received by the containment vessel from the failed melting vessel.

In the preferred construction, the apparatus also includes another sensor for sensing failure of the melting vessel so as to provide a fail-safe detection of the melting vessel failure. Thus, there is a pair of sensors for detecting the failure of the melting vessel, and each sensor is preferably either a sensor that is communicated with the hermetically sealed chamber between the melting vessel and the containment vessel to sense a change in pressure when the melting vessel fails, or a sensor including an electrical circuit that

senses the presence of material received within the containment vessel from the failed melting vessel.

In carrying out the objects of the invention, the method for vitrifying hazardous waste is performed by introducing hazardous waste and any other necessary components for forming a glassy material upon heating into a metallic melting vessel. Heating of the material within the melting vessel is performed in any suitable manner. The melting vessel is also located within a metallic containment vessel so as to contain any material that exits the melting vessel upon failure of the melting vessel. Sensing for a failure of the melting vessel is also performed to provide an indication that the processing should be terminated so that the hazardous waste does not contaminate the facility in which the processing is being performed.

The method for vitrifying hazardous waste can be performed with the heating conducted in different ways including: (a) passing electrical current through molten material within the melting vessel; (b) using induction heating; and (c) using electric resistance heating.

In performing the method for vitrifying hazardous waste, the material can also be stirred during the heating.

In one preferred practice of the method, the sensing for failure of the melting vessel is performed by detecting a change in pressure of the hermetically sealed chamber between the melting and the containment vessels.

In another preferred practice of the method, the sensing for failure of the melting vessel is performed by detecting the presence of material received within the containment vessel from the failed melting vessel. The presence of material received within the containment vessel from the failed melting vessel is disclosed as being detected by an electrical circuit.

The most preferred practice of the method utilizes a pair of sensors to detect failure of the melting vessel so that this detection is performed in a fail-safe manner.

The objects, features and advantages of the present invention are readily apparent from the following detailed description of the best modes for carrying out the invention when taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

FIGURE 1 is an elevational view taken in section through apparatus constructed in accordance with the present invention to provide the method thereof for vitrifying hazardous waste;

FIGURE 2 is a partial view similar to FIG. 1 but with another type of heater which like the FIG. 1 embodiment also passes electrical current through molten material within the melting vessel to provide the heating;

FIGURE 3 is a view similar to FIG. 2 but of another embodiment which includes an induction heater;

FIGURE 4 is also a view similar to FIG. 2 but of a further embodiment which includes an electric resistance heater;

FIGURE 5 is a view similar to each of FIGS. 1-4 and illustrates a stirrer which can be utilize to provide mixing of the material being heated regardless of which type of heater is utilized;

FIGURE 6 is a view that illustrates a pressure sensor for detecting failure of a melting vessel of the apparatus;

FIGURE 7 is a view that illustrates a normally open electrical circuit sensor for sensing the failure of the melting vessel; and

FIGURE 8 is a view that illustrates a normally closed electrical circuit sensor for sensing the failure of the melting vessel.

BEST MODES FOR CARRYING OUT THE INVENTION

With reference to FIG. 1, apparatus 10 constructed in accordance with the present invention performs the method thereof for vitrifying hazardous waste such as nuclear waste, heavy metals etc. This apparatus includes a metallic melting vessel 12 having an inlet 14 for receiving hazardous waste and any other necessary components for forming a glassy material upon heating as is hereinafter more fully described. The melting vessel 12 also has a gas outlet 16 through which gases generated by the processing can flow outwardly for any necessary treatment prior to being released to the atmosphere. Molten material 18 within the vessel 12 is delivered through an outlet 20 with a lower entry end 22

and an upper outer exit end 24 with a construction that functions like a teapot spout. Outlet 20 which has a tubular construction outwardly of the melting vessel 12 extends through a suitable heating insulation 26 secured by an outer shell 28, and the outlet 20 is also surrounded by a heater 30 to maintain the material molten until it is delivered to a suitable container for cooling and consequent solidification. Likewise, a lower drain 32 of a metallic tubular construction extends through the insulation 26 and is surrounded by an associated heater 34 with its outer end closed by a water cooled plug 36 that can be removed to permit drainage of the melting vessel 12 when necessary.

Heating of the material within the melting vessel 12 of apparatus 10 is accomplished by a heater 38a providing electric current flow through the materials in the molten state contained within the melting vessel. In the embodiment disclosed, current flow through the molten material is established between an electrode 40 and the vessel 12 by the application of electrical potentials 42 and 44. In order to commence current flow, it is necessary to introduce a preliminary amount of solid material through the feed port 14 to contact the electrode 40. Auxiliary electrical resistance heaters 45 within the insulation 26 provide sufficient heat to the solid material to bring it to a molten state capable of conducting electric current between the electrode and the melting vessel. Following the start of electric melting via current flow between the electrode and the melting vessel, additional solid material is fed to the melting vessel for continuous processing. Also, an alternating current functions best in that it prevents plating of components on the electrode 40 or the melting vessel 12.

A metallic containment vessel 46 of the apparatus 10 shown in FIG. 1 is located around the melting vessel 12 so the containment vessel upon failure of the melting vessel receives and contains any material that exits the failed melting vessel. Thus, any hazardous waste component of material that exits the failed melting vessel 12 will not contaminate the facility in which the apparatus 10 is located but, rather will be contained within the containment vessel 46 which can then be properly processed during a clean-up operation. Furthermore, apparatus 10 also includes at least one sensor 48 for detecting failure of the melting vessel as is hereinafter more fully described.

With continuing reference to FIG. 1, it will be noted that both the metallic melting vessel 12 and metallic containment vessel 46 are respectively made from metal plates 50 and 51 that are secured by welds 52 with these two vessels essentially being unitized with each other after completion of the assembly. Lower supports 54 provide the necessary support between the floor plates 50 and 51 while a support rod 55 extends downwardly from the containment vessel floor plate 51 through the insulation 26 to provide support for the unitized melting and containment vessels 12 and 46. Suitable unshown supports between the sidewall plates 50 and 51 of the melting and containment vessel 12 and 46 are also provided and like all of the plates and supports are secured by associated welds.

The metal plates 50 and 51 are made from high temperature resistant metal alloys such as alloys of nickel and chromium. Specific alloys that can be used are sold by Inco Alloys International, Inc. of Huntington, West Virginia, United States of America under the trademark INCONEL. One such alloy is

designated INCONEL 601 and has a composition in parts by weight of: aluminum - 1 part, chromium - 23 parts, iron - 14 parts, and nickel - 61 parts. Another such alloy is designated INCONEL 690 and has a composition in parts by weight of: chromium - 29 parts, iron - 9 parts, and nickel - 62 parts.

With reference to FIG. 2, another embodiment of the apparatus has the same construction as the previously described embodiment and its heater 38b like the previously described embodiment passes an electrical current through molten material 18 within the melting vessel 12. However, this embodiment of the heater 38b includes a pair of electrodes 40 and 41 located within the molten material 18 and having a voltage applied across the electrodes by potentials 42 and 44 so as to provide the electrical current flow. Otherwise the embodiment of FIG. 2 functions the same as the embodiment of FIG. 1.

With reference to FIG. 3, another embodiment of the apparatus 10 has the same construction as the previously described embodiments except that its heater 38c is of the induction heating type including induction coils 56 that provide induction heating of the melting vessel 12 and the material 18 within the melting vessel 12.

With reference to FIG. 4, a further embodiment of the apparatus has the same construction as the previously described embodiment except that its heater 38d is of the electric resistance heating type including electric resistance heaters 57 that provide the heating of the melting vessel 12 and the material 18 within the melting vessel 12.

As illustrated in FIG. 5, the apparatus 10, which is shown as having a heater 38 that may be of any of the previously described types, can also be provided with a stirrer 39 for mixing the material 18 being heated such as by rotation as shown by arrow 39'. It is also possible for the stirrer 39 to be an electrode and for the metallic melting vessel 12 to be another electrode across which an electrical potential is applied so that electrical current flow through the molten material 18 provides the heating as mixing takes place.

With reference to FIG. 1, the containment vessel 46 is preferably hermetically sealed around the melting vessel 12 to form an enclosed chamber 58. Such an enclosed chamber is preferable to having an open space between the two vessels since any gas that exits the failed melting vessel 12 will then also be contained within the containment vessel 46 which would not be the case if the vessels are not hermetically sealed.

With additional reference to FIG. 6, one embodiment of the sensor 48a is illustrated as having a conduit 60 communicated with the hermetically sealed chamber 58 between the melting vessel 12 and the containment vessel 46 to detect a change in pressure within the hermetically sealed chamber when the melting vessel fails to thereby detect such failure. More specifically, the sensor 48a has a pressure gauge 62 which can detect the pressure change when there is a failure such as illustrated at 64 between the floor and side wall plates 50 of the melting vessel 12. Such pressure change may be an increase in pressure if a vacuum is initially drawn in the chamber 58 or may also be a decrease in pressure if the chamber is initially pressurized.

With reference to FIGS. 7 and 8, two further embodiments 48b and 48c of the sensor are constructed to detect failure of the melting vessel 12 by sensing the presence of material 18 received by the containment vessel 46 from the failed melting vessel 12. Each of the sensors 48b and 48c includes an electric circuit 66 that detects the presence of material received by the containment vessel 46 from the failed melting vessel 12.

In the embodiment of the sensor 48b shown in FIG. 7, the electrical circuit 66 includes a pair of electrical probes 68 that are located between the melting and containment vessels 12 and 46 and are normally electrically isolated from each other with their lower ends suspended just above the containment vessel floor plate 51 in a spaced relationship thereto and with respect to each other. Material 18 received from the melting vessel 12 upon failure thereof such as through the failure 64 indicated electrically connects the lower ends of the probe 68 to complete the electrical circuit 66 and thereby provide an indication of the failure.

With reference to FIG. 8, the embodiment of the sensor 48c has the electrical circuit 66 thereof located between the melting and containment vessels 12 and 46 and having a meltable fuse 70 extending between the lower ends of the probes 68. When the material 18 is received from the failed melting vessel 12 such as through the failure 64 shown, the fuse 70 is melted to open the circuit 66 as the probes 68 then become electrically isolated from each other as compared to being electrically connected when the fuse is in place for the relative level of electric potential between the electrical probes.

In the preferred construction of the apparatus 10 shown in FIG. 1, there are at least two of the sensors for sensing the failure of the melting vessel 12. These sensors are most preferably of the type illustrated in FIGS. 6, 7 and 8. More specifically, as illustrated, there are two of the sensors 48 having the electrical circuit 66 and are located at opposite sides of the unitized melting and containment vessels 12 and 46. Suitable openings may be provided in the floor supports 54 so that the material received can flow back and forth so that failure at any part of the melting vessel 12 will activate these material presence sensing type sensors. Furthermore, the apparatus 10 is illustrated as having the pressure sensor 48 at its upper left side as well as the other two sensors. Suitable openings can also be provided in the unshown supports between the side wall plates 50 and 51 as well as in the floor supports 54 so that the entire extent of the hermetically sealed chamber 58 is communicated with the pressure sensor 48a for its operation when this type of sensor is used.

The hazardous waste vitrifying method of the invention is performed by introducing the hazardous waste and any other necessary components for forming a glassy material upon heating through the inlet 14 into the metallic melting vessel 12. Heating of the material 18 within the melting vessel 12 is performed while locating the melting vessel within the metallic containment vessel 46 to contain any material that exits the melting vessel upon failure of the melting vessel. Sensing of this failure by at least one of the sensors 48 provides an indication that the processing should be terminated.

The heating performed during the method can be done in any suitable way such as by any of the types of heaters previously described. More specifically, the heating can be performed by passing electrical current through the molten material 18 within the melting vessel 12, by using induction heating, or by using electric resistance heating, etc.

In performing the method for vitrifying hazardous waste, the material 18 can be stirred as previously described in connection with FIG. 5 during the heating. Other conventional methods of mixing can also be utilized such as bubbling.

As discussed above, the sensing for the failure of the melting vessel 12 can be performed by detecting a change in the pressure of the hermetically sealed chamber 58 between the melting and containment vessels 12 and 46 and can also be performed by detecting the presence of material received within the containment vessel from the failed melting vessel, with this latter type of detection preferably being performed by an electrical circuit. Furthermore, as previously mentioned, the method is most preferably performed by utilizing a pair of the sensors to detect failure of the melting vessel 12 in a fail-safe manner.

While the best modes for practicing the invention have been described in detail, those familiar with the art to which this invention relates will recognize various alternative designs and embodiments for practicing the invention as defined by the following claims.

WHAT IS CLAIMED IS:

1. Apparatus for vitrifying hazardous waste, comprising:

a metallic melting vessel for receiving hazardous waste and any other necessary components for forming a glassy material upon heating;

a heater for heating material within the melting vessel;

a metallic containment vessel in which the melting vessel is located so the containment vessel upon failure of the melting vessel receives and contains any material that exits the failed melting vessel; and

a sensor for detecting failure of the melting vessel.

2. Apparatus as in claim 1 wherein the heater is selected from the group consisting of: (a) a heater that passes electrical current through molten material within the melting vessel to provide heating thereof; (b) a heater that has an electrical voltage across the melting vessel and an electrode within molten material in the melting vessel to pass an electrical current through the molten material to provide heating thereof; (c) a heater that has an electrical voltage across a pair of electrodes in molten material in the melting vessel to pass an electrical current through the molten material to provide heating thereof; (d) a heater that includes induction coils for heating the melting vessel and the material within the melting vessel; and (e) a heater that includes electric resistance elements for heating the material within the melting vessel.

3. Apparatus for vitrifying hazardous waste as in claim 1 further including a stirrer for mixing the material being heated.

4. Apparatus for vitrifying hazardous waste as in claim 1 wherein the containment vessel is hermetically sealed around the melting vessel to form an enclosed chamber.

5. Apparatus for vitrifying hazardous waste as in claim 4 wherein the sensor is communicated with the hermetically sealed chamber between the melting vessel and the containment vessel to detect a change in pressure within the hermetically sealed chamber when the melting vessel fails to thereby detect such failure.

6. Apparatus for vitrifying hazardous waste as in claim 1 wherein the sensor for detecting failure of the melting vessel senses the presence of material received by the containment vessel from the failed melting vessel.

7. Apparatus for vitrifying hazardous waste as in claim 6 wherein the sensor includes an electrical circuit that detects the presence of material received by the containment vessel from the failed melting vessel.

8. Apparatus for vitrifying hazardous waste as in claim 7 wherein the electrical circuit of the sensor includes a pair of electrical probes that are located between the melting and containment vessels and are normally electrically isolated from each other until material received by the containment vessel from the failed melting vessel electrically connects the probes to each other.

9. Apparatus for vitrifying hazardous waste as in claim 7 wherein the electrical circuit of the sensor includes a flow path that is located between the

melting and containment vessels and that is normally closed but is opened by the presence of material received by the containment vessel from the failed melting vessel.

10. Apparatus as in claim 1 further including another sensor for sensing failure of the melting vessel.

11. Apparatus for vitrifying hazardous waste material as in claim 10 wherein the sensors for detecting a failure of the melting vessel are each selected from the group consisting of: a sensor that is communicated with a hermetically sealed chamber between the melting vessel and the containment vessel to sense a change in pressure when the melting vessel fails, and a sensor including an electrical circuit that senses the presence of material received within the containment vessel from the failed melting vessel.

12. A method for vitrifying hazardous waste comprising:

introducing the hazardous waste and any other necessary components for forming a glassy material upon heating into a metallic melting vessel;

heating material within the melting vessel;

locating the melting vessel within a metallic containment vessel so as to contain any melted material that exits the melting vessel upon failure of the melting vessel; and

sensing for a failure of the melting vessel.

13. A method for vitrifying hazardous waste as in claim 12 wherein the heating is performed by processes selected from the group consisting of: (a) passing electrical current through molten material

within the melting vessel; (b) using induction heating; and (c) using electric resistance heating.

14. A method for vitrifying hazardous waste as in claim 12 wherein the material is stirred during the heating.

15. A method for vitrifying hazardous waste as in claim 12 wherein the sensing for failure of the melting vessel is performed by detecting a change in pressure of a hermetically sealed chamber between the melting and containment vessels.

16. A method for vitrifying hazardous waste as in claim 12 wherein the sensing for failure of the melting vessel is performed by detecting the presence of material received within the containment vessel from the failed melting vessel.

17. A method for vitrifying hazardous waste as in claim 16 wherein the presence of material received within the containment vessel from the failed melting vessel is detected by an electrical circuit.

18. A method for vitrifying hazardous waste as in claim 12 wherein a pair of sensors are utilized to detect failure of the melting vessel.

Fig. 1

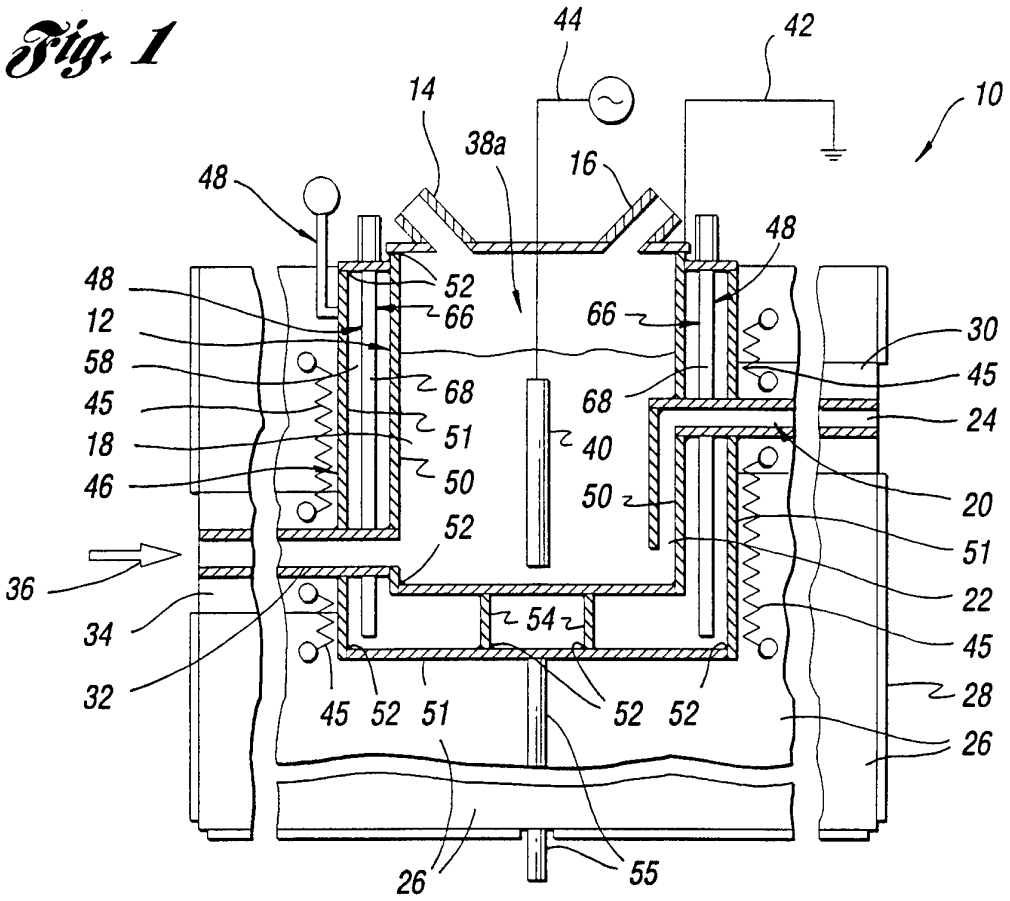

44
42
10
14
38a
16
48
48
52
66
66
30
48
12
58
45
18
46
68
51
50
68
40
50
45
24
20
51
22
45
28
26
36
34
32
52
54
45
52
51
52
52
26
55

Fig. 2

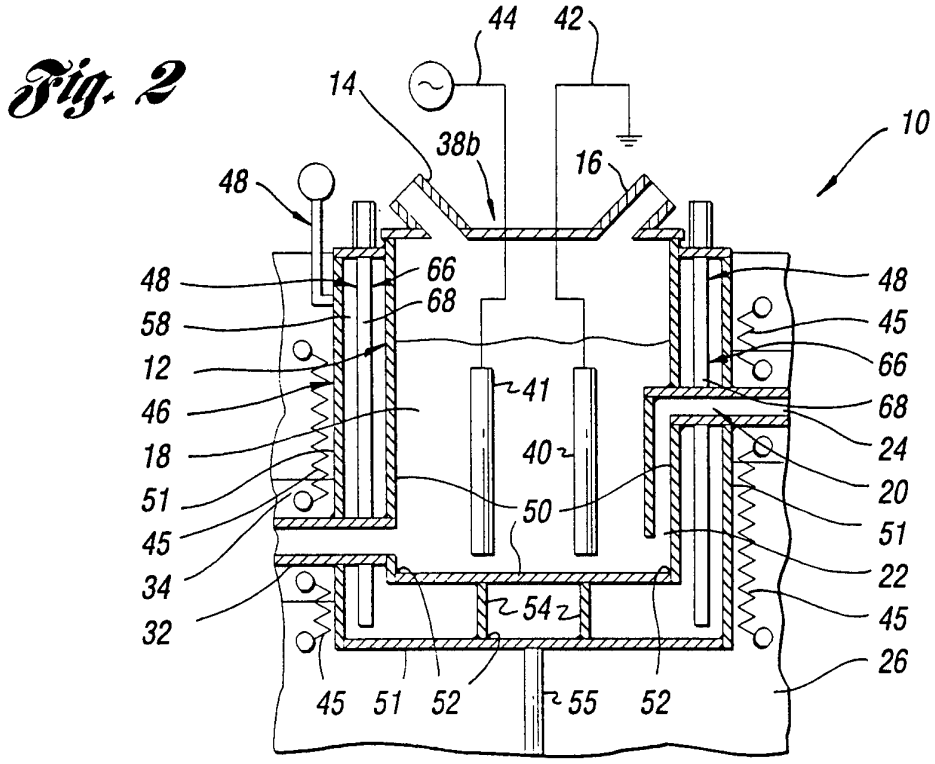

44
42
14
38b
16
10
48
48
66
68
48
58
12
46
18
51
45
34
32
41
40
50
54
45
66
68
24
20
51
22
45
26
45
51
52
55
52

Fig. 3

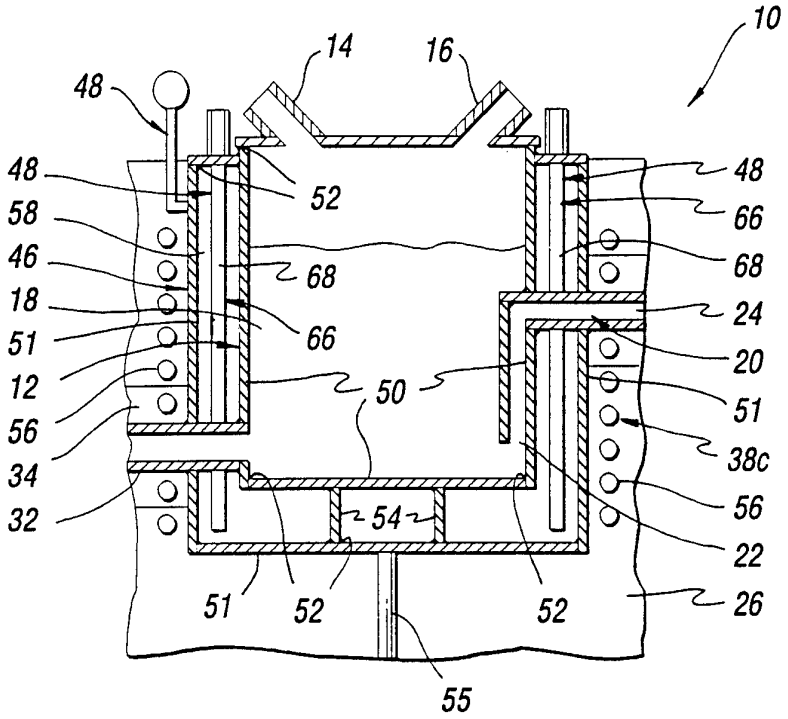
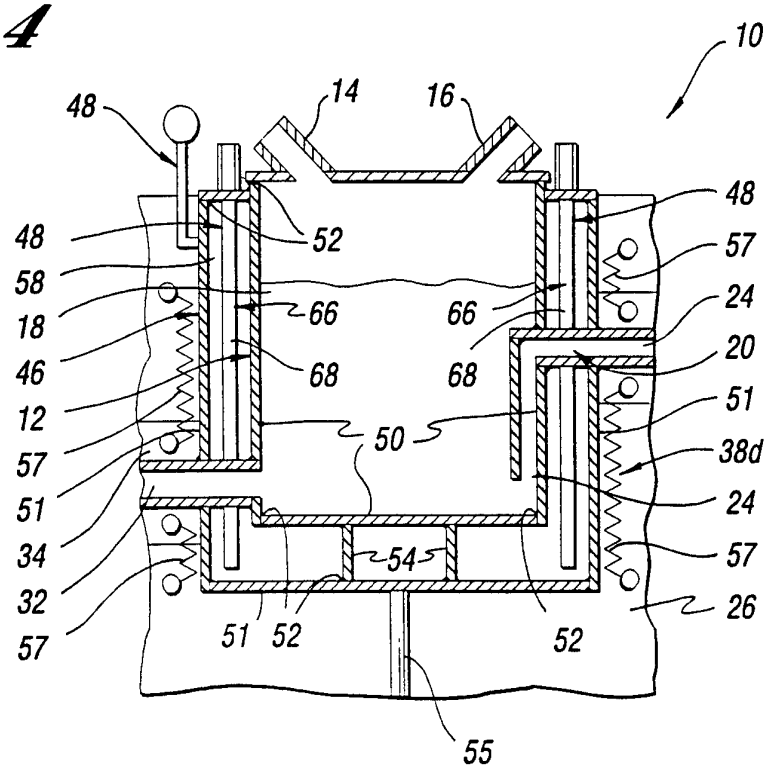

10
14
16
48
48
52
48
58
66
46
68
68
18
66
24
51
20
12
50
51
56
38c
34
56
32
54
22
51
52
52
26
55

Fig. 4


10
14
16
48
48
52
48
58
57
66
66
24
18
20
46
68
68
12
51
50
57
38d
51
24
34
54
57
32
26
57
51
52
52
55

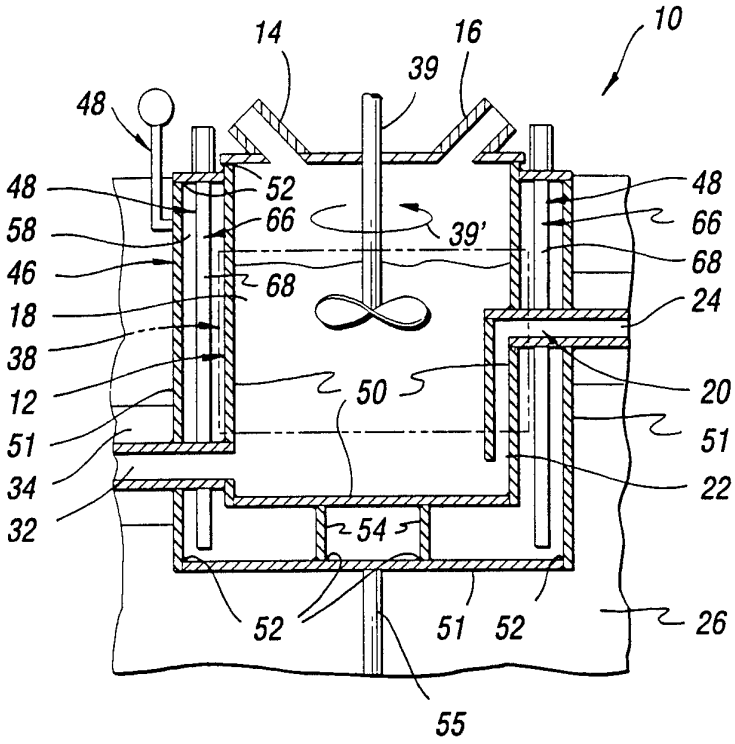


Fig. 5

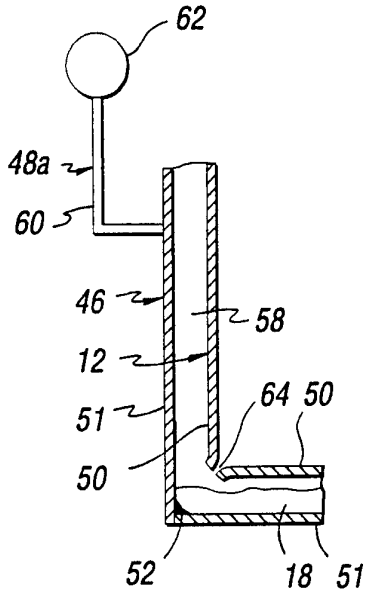


Fig. 6

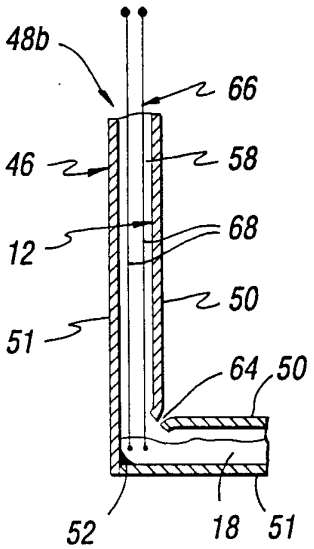


Fig. 7

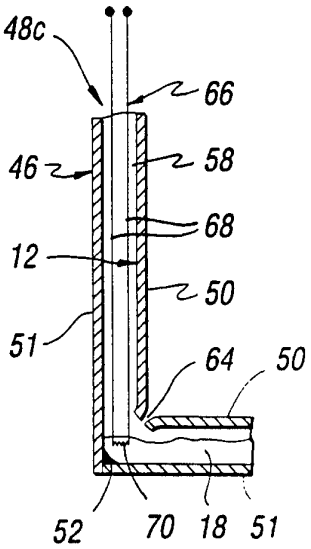


Fig. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/03405

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :A62D 3/00
US CL :588/252, 249; 405/128, 131; 65/27
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 588/252, 249; 405/128, 131; 65/27, 134.8, 135.6

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

none

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 4,672,366 (Butts) 09 June 1987 See the entire document	1-18
Y	US, A, 4,820,328 (Roberts et al) 11 April 1989 See the entire document	1-18
Y	US, A, 5,100,453 (Richards) 31 March 1992 See the entire document	1-18

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 28 JUNE 1995	Date of mailing of the international search report 14.07.95
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer DENNIS L. TAYLOR Telephone No. (703) 308-2168

Form PCT/ISA/210 (second sheet)(July 1992)*