# CLAIMS

1. An apparatus comprising:
a neutron moderator, and
a cladding material.

2. The apparatus of claim 1 in which the moderator and cladding are part of a molten salt nuclear reactor.

3. The apparatus of claim 1 in which the cladding material has gas permeability less than 10^-6 square meters per second.

4. The apparatus of claim 1 in which the cladding comprises a ceramic material.

5. The apparatus of claim 1 in which the cladding comprises a metal.

6. The apparatus of claim 1 in which the cladding is a composite material comprising metal and ceramic.

7. The apparatus of claim 4 in which the cladding comprises silicon carbide.

8. The apparatus of claim 7 in which the cladding is a silicon carbide composite material.

9. The apparatus of claim 8 in which the cladding is a silicon carbide composite material comprised of beta-phase silicon carbide and silicon carbide fibers.

10. The apparatus of claim 1 in which the cladding is filled with gas.

11. The apparatus of claim 10 that also incorporates a pressure sensor or indicator.

12. The apparatus of claim 11 in which the pressure sensor or indicator is used to signal damage to the moderator or cladding.

13. The apparatus of claim 1 in which the cladding is capable of resisting a pressure differential.

14. The apparatus of claim 13 in which a composite cladding includes a fiber layer to resist a pressure differential.

15. The apparatus of claim 5 in which the cladding comprises reinforcing fibers.

16. The apparatus of claim 15 in which the cladding comprises ceramic reinforcing fibers.

17. The apparatus of claim 5 in which the metal comprises rolls of thin foil wrapped around the moderator material.

18. The apparatus of claim 17 in which the metal material is sealed using end caps, plugs, melted or crimped the foil ends.

19. The apparatus of claim 5 in which the metal comprises a sputtered metal.

20. The apparatus of claim 1 in which the cladding comprises multiple sections of cladding joined together.

21. The apparatus of claim 20 comprising sections of ceramic cladding produced via chemical vapor deposition, and joined together using microwave joining.

22. The apparatus of claim 21 in which the sections of ceramic cladding are joined together using microwave joining.

23. A method of assembling an apparatus with a neutron moderator, and a cladding material, the method comprising producing the moderator and the cladding separately and subsequently assembling the moderator and the cladding.

24. The method of claim 23 in which each layer of the moderator is produced as a tube of varying diameters and thicknesses.

25. The method of claim 24 in which the tubes are cut to length and assembled with the moderator in the center and inserted into progressively wider tubes.

26. The method of claim 25 in which the tubes are sealed using end caps, plugs, or lids that may be wider, narrower, or the same inner or outer width as the tube to be sealed.

27. The method of claim 23 in which the assembly process comprises a pre- or post-annealing step, an inter-layer adhesive, a crimp step, and/or a gas-filling or pressurization step.

28. The apparatus of claim 1 in which the cladding or moderator is colored, marked, bar-coded, or labeled.

29. The apparatus of claim 28 in which a permanent bar code is applied to the cladding or moderator via subtractive means.

30. The apparatus of claim 1 in which the moderator-cladding assembly or subassemblies comprises narrowed, threaded, grooved, and/or slotted regions meant to guide or arrange the internal layers, and/or aid assembly, physically stabilize the layers, and/or provide stabilization against thermal shock.

31. The apparatus of claim 30 in which a moderator-cladding assembly or subassembly comprises an sacrificial tube with a plug at one end of the sacrificial tube, and one or more inner layer tubes disposed within the sacrificial tube.

32. The apparatus of claim 31 comprising mechanical guiding mechanisms on the plug.

33. The apparatus of claim 30 in which the regions are angled, notched, serrated or otherwise varied to provide varying levels of mechanical resistance.

34. The apparatus of claim 30 in which the plug includes mechanisms to facilitate insertion or impede extraction.

35. The apparatus of claim 34 in which the plug is inflatable, elastomeric, or mechanically expandable.

36. The apparatus of claim 34 in which the plug comprises a slot or handle which expands the plug diameter when turned.

37. The apparatus of claim 36 in which the expander can be ratcheted so that it cannot later collapse.

38. The apparatus of claim 36 in which the tube receiving the plug is grooved or has a raised portion on its inner or outer surface to receive or reinforce a portion of the cap or plug.

39. The apparatus of claim 30 in which a plug comprises a hook, a ring, or an inner grooved post to allow an overhead crane to raise and lower the moderator assembly, facilitating insertion, removal and inspection.

40. The apparatus of claim 39 in which the plug and/or tubes has mechanical features designed to allow installation into the reactor and/or to bracing or brackets provided within the reactor or as part of the reactor wall.

41. The apparatus of claim 30 in which the plug comprises a valve to facilitate gas-filling or pressurization of the moderator assembly.

42. The apparatus of claim 1 in which the plug comprises a material with a higher coefficient of thermal expansion than the tube.

43. The apparatus of claim 42 in which a plug is inserted to a specified depth into a tube and the depth of the plug in the tube can be inspected via visual inspection, or via a light, ultrasonic, and/or electromagnetic source.

44. The apparatus of claim 43 in which the depth of the plug can be inspected during operation.

45. The apparatus of claim 1 in which an outer tube extends past the plug and the moderator assemblies are seated on pegs that position the tubes within the reactor.

46. The apparatus of claim 45 in which the tube sits loosely on the peg and the plug is seated on or above the peg.

47. The apparatus of claim 1 in which the assembly comprises a plug that moves in response to the expansion of the moderator, the release of gas by the moderator, or the expansion of a filler liquid, gas or solid material which is not a moderator but which is provided within the moderator assembly and moves responsive to the condition of the reactor or moderator.

48. The apparatus of claim 1 in which the plug is formed at least in part from materials that yield or melt at temperatures higher than the operating temperature of the reactor, but lower than the upper temperature limit of the reactor or the plug comprises a sacrificial material designed to break or melt above a certain temperature.

49. The apparatus of claim 1 in which a material is provided between the plug and end of at least one layer of cladding and/or the end of the moderator such that the

moderator assembly is calibrated so that an out-of-condition temperature which is high enough will push the plug out of the tube.

50. The apparatus of claim 1 further comprising a spring-based pop-up indicator system, or a metal or other material with a high coefficient of thermal expansion, responsive to heat or pressure.

51. The apparatus of claim 1 in which the cladding is sealed using canning methods.

52. The apparatus of claim 1 in which the cladding is sealed using a double-seaming operation, flanging, curling, counter-sinking and/or die-cutting.

53. The apparatus of claim 1 in which a rubber or elastomeric material is used to enhance gas impermeability at higher temperatures and pressures.

54. The apparatus of claim 1 in which a post-sealing sealant is used to enhance gas impermeability at higher temperatures and pressures.

55. The apparatus of claim 1 in which the materials are packaged such that they are protected from corrosive environments or extremes of temperature or pressure.

56. The apparatus of claim 1 in which the cladding and/or moderator material is doped with other isotopes that may be used to trace potentially diverted materials.

57. The apparatus of claim 1 in which the cladding and/or moderator material is doped with burnable poisons such as boron, or other materials.

58. The apparatus of claim 1 in which the cladding incorporates sacrificial regions that fail when the internal pressure in the cladding rises above a certain value.

59. The apparatus of claim 1 in which the moderator comprises zirconium hydride, and the cladding material is silicon carbide.

60. The apparatus of claim 1 in which the molten salt, cladding, moderator and reactor geometry may be selected and arranged so that an accident condition will accelerate the destruction or failure of the cladding and the impairment or decomposition of the moderator.

61. The apparatus of claim 60 in which the cladding, moderator and/or reactor are designed so that a physical collapse of the reactor would tend to break the cladding.

62. The apparatus of claim 60 comprising a safety mechanism that causes destruction of the cladding by operator action.

63. The apparatus of claim 60 in which the reactor comprises ports through which a laser could strike the cladding and accelerate its failure.

64. The apparatus of claim 58 in which the sacrificial region comprises regions with a lower density of wrapping fibers than is present in the non-sacrificial regions, and/or

a weaker type of ceramic fiber than is present in the non-sacrificial regions, and/or being thinner than the non-sacrificial regions.

65. The apparatus of claim 58 in which the cladding is designed to fail by rupture radially, axially, and/or in a spiral pattern.

66. The apparatus of claim 1 in which the moderator material is tuned to promote or discourage the release of gasses at high temperatures.

67. The apparatus of claim 66 in which a zirconium hydride moderator is manufactures with a specific hydrogen-to-zirconium ratio tuned to promote or discourage the release of gasses at high temperatures.

68. The apparatus of claim 1 in which the moderating material varies within the reactor core and/or within a given moderator pin.

69. The apparatus of claim 60 in which a zirconium hydride moderator has differing levels of hydration depending in its position within the reactor core or moderating pin.

70. The apparatus of claim 1 in which the moderating material is movablethroughout the reactor core.

71. The apparatus of claim 1 in which the cladding and/or moderator is replaceable .

72. The apparatus of claim 1 comprising sensors measuring the resistivity of the cladding and/or moderator or monitoring the salt for significant traces of cladding and/or moderator materials.

73. The apparatus of claim 1 in which a section of the cladding is held in place, and moderator can flow through the cladding tube.

74. The apparatus of claim 1 in which sections of moderator encased in cladding are moveable within the reactor.

75. The apparatus of claim 1 in which the cladding and/or moderator materials are stored or transported in any receptacle suitable for intermediate-level or high-level nuclear waste following removal from the reactor.

76. The apparatus of claim 1 in which the used cladding and/or moderator are packaged so as to minimize thermal and/or mechanical stress on the components.

77. The apparatus of claim 1 in which the materials used in the moderators and cladding are reclaimed by a variety of pyrochemical, aqueous, or electrorefining processes known to those skilled in the art.

78. The apparatus of claim 1 in which the used moderating material is removed from the cladding, reprocessed, and put back into the previously-used cladding or new cladding.

79. The apparatus of claim 1 in which suitable tooling (comprising come combination of: radiation-hardened, controllable, and able to manipulate the pins without damaging them) is used to insert and remove the cladding and moderator to and from the reactor.

80. The apparatus of claim 4 in which the ceramic consists of a ceramic other than silicon carbide, such as titanium carbide, zirconium carbide, ternary titanium silicon carbide, or graphite, applied either singly, as a mixture, or in layers.

81. The apparatus of claim 9 in which the cladding comprises an inner layer of beta-phase silicon carbide, an inner layer of silicon carbide fibers, and an outer layer of beta-phase silicon carbide.

82. The apparatus of claim 81 in which the inner layer is applied using the chemical vapor deposition method (CVD), or any other suitable technique (potentially including sintering, sputtering, electrolysis/electroplating, physical and physical-chemical vapor deposition, thermal decomposition or pyrolysis, or formed in situ during the silicon carbide production process).

83. The apparatus of claim 81 in which the fiber-matrix layer is pre-stressed.

84. The apparatus of claim 83 in which the fiber-matrix layer is coated with a layer of a material such as pyrolytic carbon to facilitate pre-stressing the system by allowing the fibers to slip against one another during pre-loading.

85. The apparatus of claim 83 in which an additional layer of silicon carbon is be applied to the layer.

86. The apparatus of claim 81 in which a layer of silicon carbide is applied to the fiber-matrix layer using chemical vapor infiltration, polymer infiltration and pyrolysis, or a combination of these methods.

87. The apparatus of claim 81 in which an outer layer is applied using the chemical vapor deposition method (CVD), sintering, sputtering, electrolysis/electroplating, physical and physical-chemical vapor deposition, thermal decomposition or pyrolysis, or formed in situ during the silicon carbide production process).

88. An article of manufacture comprising a moderating material and a cladding material wherein the cladding material extends the life of the moderator after exposure of the article to molten salt.

89. A method comprising:

providing solid moderator assemblies comprising a moderator and cladding prior to first commissioning of a nuclear reactor; and

providing additional solid moderator assemblies for replacement.

90. A container for shipping the assembly of claim 1 which is airtight, watertight or both.

91. A method comprising marking a moderator assembly of claim 1 to indicate its identity, intended orientation, or other property prior to its use in a nuclear reactor.

92. An article of manufacture or racking system comprising mechanisms for holding multiple moderator assemblies as described in claim 1, wherein said article or system does not remain in the nuclear reactor during normal use.

93. The article of claim 92 wherein said article or system remains in the nuclear reactor during normal use.

94. An assembly for a molten salt nuclear reactor that comprises a moderator and a safety feature.

95. The apparatus of claim 1 in which the moderator and cladding are used in conjunction with pebble fuel.

96. The apparatus of claim 95 in which the fuel kernels are embedded in a zirconium hydride matrix.

97. The apparatus of claim 95 in which the fuel kernels and zirconium hydride kernels are embedded in another matrix material.

98. The apparatus of claim 95 in which the relative densities of any of the fuel, moderator, matrix, and cladding are varied.

99. The apparatus of claim 95 in which the kernels are coated with a cladding material.

100. The apparatus of claim 95 in which the pebbles are coated with a cladding material.

101. The apparatus of claim 1 in which the moderator and cladding are used in conjunction with plate fuel.

102. The apparatus of claim 101 in which the fuel kernels are embedded in a zirconium hydride matrix.

103. The apparatus of claim 101 in which the fuel kernels and zirconium hydride kernels are embedded in another matrix material.

104. The apparatus of claim 101 in which the relative densities of any of the fuel, moderator, matrix, and cladding are varied.

105. The apparatus of claim 101 in which the kernels are coated with a cladding material.

106. The apparatus of claim 101 in which the plates are coated with a cladding material.

107. The apparatus of claim 1 in which the moderator and cladding are used in conjunction with prismatic fuel.

108. The apparatus of claim 107 in which the fuel kernels are embedded in a zirconium hydride matrix in fuel cylinders.

109. The apparatus of claim 107 in which the fuel kernels and zirconium hydride kernels are embedded in another matrix material in fuel cylinders.

110. The apparatus of claim 107 in which the relative densities of any of the fuel, moderator, matrix, and cladding are varied in the fuel cylinders.

111. The apparatus of claim 107 in which the relative densities of any of the fuel, moderator, matrix, and cladding are varied in the prisms.

112. The apparatus of claim 107 in which the kernels are coated with a cladding material.

113. The apparatus of claim 107 in which the cylinders are coated with a cladding material.

114. The apparatus of claim 107 in which the prisms are coated with a cladding material.

115. The apparatus of claim 107 in which the prism consists of zirconium hydride.

116. The apparatus of claim 107 in which the prism consists of zirconium hydride kernels in a matrix made of another material.

117. The apparatus of claim 1 in which a surface treatment was applied to the cladding to promote a particular flow regime in any fluid interacting with the cladding.

118. The apparatus of claim 1 in which a surface treatment was applied to the moderator to remove potential undesirable surface effects.

119. The apparatus of claim 1 in which the moderator, cladding, and/or fuel form an involute shape.

120. A mechanism of varying the relative densities of any of the fuel, moderator, matrix, and cladding using a multi-stage heating and sintering process.

121. A cladding material comprising: silicon carbide and zirconium carbide

122. The cladding material of claim 121 comprising a silicon carbide - silicon carbide – zirconium carbide composite.

123. The cladding material of claim 122 wherein the silicon carbide - silicon carbide - zirconium carbide composite comprises a SiC monolithic inner diameter, surrounded by bound SiC fibers in an SiC matrix.

124. The cladding material of claim 122 wherein the silicon carbide - silicon carbide - zirconium carbide composite comprises a SiC monolithic inner diameter, surrounded by bound SiC fibers in an SiC matrix clad within a monolithic layer of zirconium carbide.

125. An integral molten salt fueled reactor comprising:

a reactor vessel at least partially filled with fuel salt and containing inner structures that provides a continuous flow pattern;

a moderator;

a moderated region in which the fuel salt is in a critical configuration; and

at least one heat exchanger.

126. The reactor of claim 125 in which the moderator is a metal hydride.

127. The reactor of claim 125 in which the moderator is zirconium hydride.

128. The reactor of claim 125 further comprising at least one component selected from the group consisting of: control rods; a control rod drive mechanism; a pump; and a reflector .

129. The reactor of claim 125 in which the flow pattern is annular, with upflow occurring in the central region of the reactor vessel, and downflow occurring in the outer portion of the annulus.

130. The reactor of claim 125 in which the heat exchangers are located in an upflow region.

131. The reactor of claim 125 in which the heat exchangers are located in a downflow region.

132. The reactor of claim 125 in which the flow is driven by natural circulation.

133. The reactor of claim 125 in which the flow is driven by pumps.

134. The reactor of claim 133 in which the pumps are positioned upstream of the heat exchangers, downstream of the heat exchangers, or between multiple sets of heat exchangers.

135. The reactor of claim 125 further comprising a sealing flange comprising penetrations for electrical connections, cooling for motor windings, bearing, or other components, heating traces, hydraulic connections, and/or pneumatic connections.

136. The reactor of claim 125 further comprising a lower plenum.

137. The reactor of claim 125 further comprising flow shaping structures.

138. The reactor of claim 125 further comprising an upper plenum.

139. The reactor of claim 125 further comprising a comb or grid element to direct the flow of material contained within the fuel salt, gas bubbles, slag, and/or precipitates.

140. The reactor of claim 139 in which gaps in the comb and/or grid elements are spaced more narrowly than the distance between the moderator elements.

141. The reactor of claim 125 further comprising a cover gas region and/or a demister.

142. The reactor of claim 141 in which the cover gas region is operable to modify reduction-oxidation potential in the salt, to provide monitoring of reduction-oxidation potential in the salt, to provide a fluid connection to a rupture valve, to provide a salt overflow region, and/or to provide a fluid connection to salt processing, particularly to fission product processing.

143. The reactor of claim 125 further comprising a catch basin and/or an auxiliary containment system.

144. The reactor of claim 125 further comprising one or more backflow valves in the center region or outer region of the vessel.

145. The reactor of claim 125 operable to load follow.

146. The reactor of claim 145 comprising a control system operable to implement load following by varying the speed of the circulating pumps.

147. The reactor of claim 125 in which multiple integral reactor units are installed together, either in one containment structure or in multiple separate containment structures, and are operated either independently or as a unit.

148. An apparatus comprising:
a nuclear reactor, and
two or more freeze valves.

149. The apparatus of claim 148 in which the nuclear reactor is a molten salt reactor.

150. The apparatus of claim 148 in which the nuclear reactor is a molten salt cooled reactor.

151. The apparatus of claim 148 in which the nuclear reactor is a liquid-metal cooled reactor.

152. The apparatus of claim 148 in which the freeze valves are connected to the primary loop of a nuclear reactor.

153. The apparatus of claim 148 in which the freeze valves are connected to an intermediate loop of a nuclear reactor.

154. The apparatus of claim 148 in which one or more of the freeze valves is cooled in such a manner that it melts at a pre-defined temperature.

155. The apparatus of claim 154 in which the freeze valves are cooled in such a manner that a first freeze valve melts at a first temperature and a second freeze valve melts at a second temperature that is different than the first temperature.

156. The apparatus of claim 148 in which the multiple freeze valves have different cross-sectional areas.

157. The apparatus of claim 156 in which a freeze valve designed to melt at a higher pre-defined temperature has a larger cross-sectional area than a freeze valve designed to melt at a lower pre-defined temperature.

158. The apparatus of claim 148 in which one or more auxiliary tanks connected to one or more of the freeze valves are sized such that the volume of the one or more auxiliary tanks is large enough to contain the entire volume of liquid in the reactor loop connected to the one or more freeze valves.

159. The apparatus of claim 148 in which one or more auxiliary tanks connected to one or more of the freeze valves are sized such that the volume of the one or more auxiliary tanks is not large enough to contain the entire volume of liquid in the reactor loop connected to the one or more freeze valves.

160. The apparatus of claim 148 in which an auxiliary tank is connected to a reactor loop to refill the reactor loop after the reactor loop has had liquid material drained from it via a freeze valve.

161. The apparatus of claim 160 in which the auxiliary tank is filled with a non-radioactive salt, and the reactor loop is filled with a radioactive salt.

162. The apparatus of claim 160 in which the auxiliary tank is filled with a liquid at a lower temperature than the temperature in the reactor loop.

163. The apparatus of claim 160 in which the auxiliary tank introduces salt into the loop using a pump.

164. The apparatus of claim 160 in which the auxiliary tank introduces salt into the loop using gravity feeding.

165. An apparatus comprising: a liquid-fueled nuclear reactor with a variable active core volume.

166. The apparatus of claim 165 comprising a molten salt and dissolved fissile material.

167. The apparatus of claim 165 comprising heavy and/or light water with dissolved fissile material.

168. The apparatus of claim 165 in which the reactor core comprises an active and passive region.

169. The apparatus of claim 168 in which the active and passive regions are separated from one another using a movable separator plate.

170. The apparatus of claim 169 in which the range of motion of the separator plate is limited by the length of an extender pipe.

171. The apparatus of claim 168 in which the passive region contains a filling material.

172. The apparatus of claim 171 in which the filling material is transported via pump and/or gravity feed from an auxiliary tank.

173. The apparatus of claim 172 in which moving material from the auxiliary tank to the passive region while simultaneously moving material from the primary loop

into the holding tank increases the volume of the passive region and decreases the volume of the active region, or vice-versa.

174. The apparatus of claim 172 in which the separator plate is moved by adjusting the relative pressure on either side of the separator plate.

175. The apparatus of claim 169 in which the separator plate is held stationary using the following, either singly or in any combination:

pumps used to induce pressure on the separator plate, and/or

static pressure used to induce pressure on the separator plate, and/or

gravitational forces of the liquid fuel or filler material used to induce pressure on the separator plate, and/or

systems of mechanical, electric, or magnetic bearings or clamps to hold the separator plate in place.

176. The apparatus of claim 165 in which the additional safety mechanisms are also in place, either singly or in any combination:

inclusion of a valve to transfer additional clean salt from an auxiliary reservoir, and/or

removal of excess heat through heat exchangers, and/or

use of freeze valves and/or staged freeze valves to drain fuel salt from the primary loop.

177. A load following nuclear reactor comprising the apparatus of claim 165 .

178. A method comprising using the apparatus of claim 165 to implement medium-term and/or long-term reactivity control.

179. A method comprising mass-producing reactors that can have their power levels adjusted at the plant site.

180. An apparatus comprising:

a heat exchanger with a gap between its primary and secondary sides, and

a filling material suitable for reducing tritium transport across the heat exchanger.

181. The apparatus of claim 180in which the filling material has a high thermal conductivity.

182. The apparatus of claim 180in which the walls surrounding the heat exchanger gap or other parts of the heat exchanger are composed of, lined with, or coated with a barrier material that has a low tritium permeability.

183. The apparatus of claim 182 in which the barrier material comprises a ceramic particularly a ceramic comprising Al2O3, Cr2O3, SiO2, TiN, and/or TiC.

184. The apparatus of claim 182 in which the surface of the heat exchanger is aluminized to generate a surface layer of either aluminide or iron-aluminum alloy, or a combination of these two.

185. The apparatus of claim 182 in which a barrier coating on the walls surrounding the heat exchanger gap or other parts of the heat exchanger is formed via a chemical reaction between the heat exchanger base material and a fluid flowing through the heat exchanger.

186. The apparatus of claim 185 in which the base material forms an oxide with a spinel structure (XY2O4), such as FeCr2O4 or MnCr2O4.

187. The apparatus of claim 185 in which the base material forms an oxide with a non-spinel structure.

188. The apparatus of claim 180comprising a permeation window.

189. The apparatus of claim 188 in which the permeation window comprises a metallic materials, in particular, Pd, Ta, V, Zr, or Nb.

190. The apparatus of claim 188 in which the permeation window comprises polymeric membranes, ceramic membranes, or electronic membranes.

191. The apparatus of claim 180comprising a capture system, particularly wherein the capture system comprises as a getter bed or a chemical separation unit.

192. The apparatus of claim 180in which the filler material within the gap serves as a getter bed.

193. The apparatus of claim 192 in which this filler material has a high thermal conductivity.

194. The apparatus of claim 192 in which the filler material is a metal that can form hydrides and/or have hydrogen dissolve into it.

195. The apparatus of claim 192 in which the filler material is zirconium, tungsten, palladium, nickel, platinum, titanium, or an alloy or laminate of these materials.

196. The apparatus of claim 192 comprising a mechanism for applying heat to the getter material to induce it to release absorbed and/or adsorbed hydrogen.

197. The apparatus of claim 192 in which the filler material is configured to trap other products migrating from the primary side of the heat exchanger, such as the gaseous fission products xenon and krypton.

198. The apparatus of claim 180in which the filling material is formed into conductor plates that cross the gap.

199. The apparatus of claim 198 in which the conductor plates are designed to resist stresses induced by thermal cycling.

200. The apparatus of claim 198 in which the conductor plates are straight.

201. The apparatus of claim 198 in which the conductor plates are angled.

202. The apparatus of claim 198 in which the conductor plates are bent.

203. The apparatus of claim 198 in which the conductor plates are corrugated.

204. The apparatus of claim 198 in which the conductor plates are attached to the heat exchanger walls using grooves and/or welding.

205. The apparatus of claim 198 in which the conductor plates are designed to vary the pressure they induce on the heat exchanger walls as a result of temperature or stress.

206. The apparatus of claim 198 in which the conductor plates are bimetallic.

207. The apparatus of claim 180comprising a gas in circulated through the portions of the gap that do not contain solid material.

208. The apparatus of claim 207 comprising a conduit connecting the portions of the gap that do not contain solid material with a detector particularly wherein the detector is a Geiger counter or neutron activation analysis equipment, which could be used to detect elements (such as fuel salt components) that would indicate a leak in the heat exchanger.

209. The apparatus of claim 180comprising a mechanism operable to introduce hydrogen into the system downstream of the heat exchanger.

210. The apparatus of claim 180comprising a system operable to monitor integrity of the heat exchanger and its plates by evaluating changes in material properties of the components.

211. The apparatus of claim 210 in which the conductor plates comprise a metal that becomes brittle and changes its electrical resistance when it absorbs tritium.

212. The apparatus of claim 211 comprising a system operable to monitor plates' resistance is monitored so that the plates may be removed and replaced when their electrical resistance (and corresponding brittleness) rises above a certain value.

## CLAIMS

1. A molten salt nuclear reactor comprising:

a molten fuel-salt,

a neutron moderator material, and

cladding material surrounding the neutron moderator material and separating the neutron moderator material from the molten fuel-salt, the cladding material having gas permeability less than 10^-6 square meters per second.

2. The apparatus of claim 1 in which the cladding comprises a ceramic material.

3. The apparatus of claim 1 in which the cladding comprises a metal.

4. The apparatus of claim 2 in which the cladding comprises silicon carbide.

5. The apparatus of claim 1 in which the cladding is capable of resisting a pressure differential.

6. The apparatus of claim 1 in which the molten fuel-salt, cladding, neutron moderator material and geometry of the molten-salt reactor may be selected and arranged so that an accident condition will accelerate the destruction or failure of the cladding and the impairment or decomposition of the neutron moderator material.

7. The apparatus of claim 6 in which the cladding, the neutron moderator material, and/or the molten-salt reactor are designed so that a physical collapse of the molten-salt reactor would tend to break the cladding.

8. The apparatus of claim 6 comprising a safety mechanism that causes destruction of the cladding by operator action.

9. The apparatus of claim 6 in which the molten-salt reactor comprises ports through which a laser could strike the cladding and accelerate its failure.

10 The apparatus of claim 1 in which the neutron moderator material is tuned to promote or discourage the release of gasses at high temperatures.

11. The apparatus of claim 1 in which the neutron moderator material varies within a core of the molten-salt reactor and/or within a given moderator pin.

12. The apparatus of claim 1 in which the neutron moderator material is movable throughout a core of the molten-salt reactor.

13. The apparatus of claim 1 in which the cladding and/or the neutron moderator material is replaceable.

14. The apparatus of claim 1 in which sections of moderator encased in cladding are moveable within the molten-salt reactor.

15. The apparatus of claim 1 in which the used cladding and/or neutron moderator material are packaged so as to minimize thermal and/or mechanical stress on the components.

16. The apparatus of claim 2 in which the ceramic consists of a ceramic other than silicon carbide, such as titanium carbide, zirconium carbide, ternary titanium silicon carbide, or graphite, applied either singly, as a mixture, or in layers.

17. An article of manufacture for a molten-salt reactor, the article comprising a moderating material and a cladding material wherein the cladding material extends the life of the moderating material after exposure of the article to molten fuel-salt by inhibiting contact between the moderating material and the molten fuel-salt during operation of the molten-salt reactor.

18. A method comprising:

providing solid moderator assemblies comprising a moderator and cladding prior to first commissioning of a molten fuel-salt reactor, the moderator and the cladding being configurable such that the cladding inhibits contact between the moderator and a molten fuel-salt during operation of the molten fuel-salt reactor; and

providing additional solid moderator assemblies for replacement.

19. The apparatus of claim 1 in which a surface treatment was applied to the cladding to promote a particular flow regime in any fluid interacting with the cladding.

20. The apparatus of claim 1 in which a surface treatment was applied to the neutron moderator material to remove potential undesirable surface effects.

21. The apparatus of claim 1 in which the neutron moderator material, cladding, and/or molten fuel-salt form an involute shape.