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(54) A method and apparatus for the production of uranium.

(57) A method of producing a metal comprising uranium. The method comprises reacting a chloride of uranium with sodium vapour to produce the metal and sodium chloride. The products of the reaction are cooled such that the sodium chloride product is below its vaporisation temperature. The metal produced is separated from the sodium chloride.

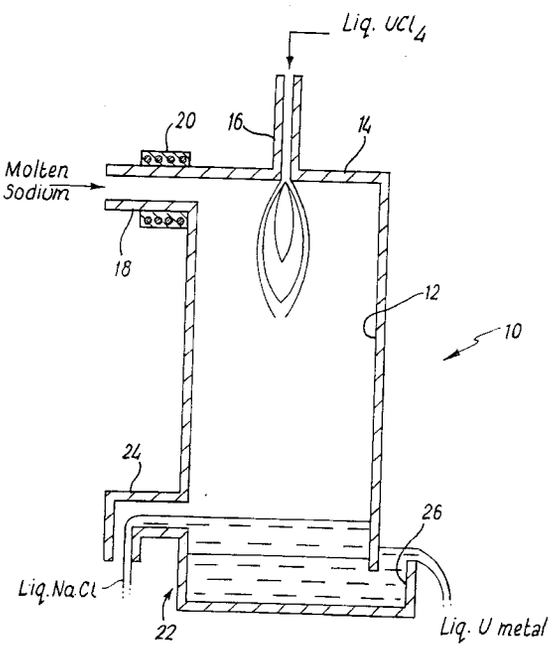

FIG. 1

EP 0 592 231 A1

This invention relates to the production of uranium, and more particularly to the production of uranium from a chloride of uranium.

According to one aspect of the present invention there is provided a method of producing a metal comprising uranium, the method comprising reacting a chloride of uranium with sodium vapour to produce the metal and sodium chloride, the products of the reaction being cooled such that the sodium chloride product is below its vaporisation temperature, and separating the metal produced from the sodium chloride.

Preferably, the chloride of uranium comprises UCl_3, or UCl_4.

Advantageously, another metal such as iron, for example up to 10% by weight, may be included with the chloride of uranium, and may comprise a metallic powder or a metal halide.

Preferably, the products of the reaction may be cooled rapidly so as to produce mixed solids thereof from which the uranium metal may be separated from the sodium chloride. Alternatively, liquid said metal may be separated from the sodium chloride.

In another aspect of the present invention, there is provided apparatus for the production of a metal comprising uranium, the apparatus comprising a reactor, means for feeding a chloride of uranium into the reactor, means for feeding sodium into the reactor to react with the chloride, and means for discharging from the reactor products from the reaction of the sodium and the chloride.

Preferably, the sodium feeding means includes means for heating molten sodium so as to vaporise the liquid sodium.

Advantageously, means may be provided for cooling the reactor so as to increase the rate of solidification of uranium metal produced in the reaction.

The discharging means may comprise a weir, or may be constituted by a rotary dispenser.

In one form of the apparatus, the reactor may be provided by a rotary kiln operating in a horizontal or near horizontal orientation.

It will be understood that the invention also includes a metal or alloy comprising uranium produced by the method of the invention.

The invention will now be further described by way of example only with reference to the accompanying drawings, in which:

Figure 1 shows a diagrammatic medial sectional representation of a reactor for producing uranium metal, and

Figure 2 shows a diagrammatical medial sectional representation of an alternative reactor.

Referring now to Figure 1, a reactor 10 is shown and comprises a cylindrical mild steel vessel 12 with a roof 14 having a central inlet 16. A side inlet 18 is at the top of the vessel 12 with an electric heater 20. A weir assembly 22 is arranged at the bottom of the vessel 12 with an upper overflow 23 and a lower overflow 26. A corrosion resistant coating (not shown) is applied to the internal surface of the vessel 12 to resist the corrosive effect of liquid uranium.

In use of the reactor 10, initially the vessel 12 is purged with an inert gas (eg. argon), and then a liquid chloride of uranium (eg. UCl_3, or UCl_4) is fed through the central inlet 16 at about 600°C. Molten sodium at about 200°C is fed through the side inlet 18 where it is heated to about 900°C by the heater 20 to vaporise the sodium which subsequently contacts and reacts with the liquid chloride of uranium. The temperature of the vessel 12 is controlled by means (not shown) such that the reaction products of uranium metal and sodium chloride are cooled below their vaporisation temperatures thereby avoiding corrosive attack on the internal surface of the vessel 12. The liquid reaction products of uranium metal and sodium chloride fall to the weir assembly 22, with the lighter sodium chloride flowing from the upper overflow 24 and the heavier liquid uranium flowing through the lower overflow 26. Soon after the initial reaction of the sodium vapour and the chloride of uranium has occurred, the exothermic heat from the reaction in the upper portion of the vessel 12 may be sufficient to vaporise incoming molten sodium without the continuing need for use of the electric heater 20.

Referring to Figure 2, a reactor 30 is shown having a relatively long Inconel cylindrical vessel 32 with a water-cooled cooling jacket 33, and a roof 34 having a central inlet 36. A side inlet 38 is at the top of the vessel 32 with an electric heater 40. A frusto-conical lower end 42 of the vessel 32 has a rotary dispenser in the form of a rotary valve 44 for discharging residues from the vessel 32. The upper portion of the internal surface of the vessel 12 may be coated with a corrosion resistant material (eg. yttria) to withstand the corrosive effect of liquid uranium.

Use of the reactor 30 to react sodium vapour with a chloride of uranium (eg. UCl_3, UCl_4) is similar to that of the reactor 10 of Figure 1. However, because of the effect of the cooling jacket 33, the liquid uranium metal and the sodium chloride produced by the reaction cool and solidify rapidly and collect as mixed powder in a residue with any unreacted sodium in the lower end 42 and from where the residue is discharged by the rotary valve 44. Subsequent treatment of the residue with methyl or ethyl alcohol removes the unreacted sodium, and heating of the mixed powder in a conventional vacuum casting furnace (not shown) to melt the uranium metal separates the sodium chloride which rises as a slag above a molten pool of uranium.

The particle size of the uranium metal powder in the residue is affected by: the cooling rate in the reactor 30 (eg. affected by the coolant temperature), residence time in the reactor 30 (ie. vessel 32 length), and turbulence patterns in the reactor 30.

The feed of the sodium relative to the liquid chlor-

ide of uranium should be at least stoichiometric but preferably is in excess in the reactors 10, 30.

Other ingredients may be included with the liquid chloride of uranium, for example, metal powder (eg. iron, preferably not exceeding 10% by weight) or metal halides to provide alloying constituents in the uranium produced in the reactors 10, 30.

It will be understood that the vessels 12, 32 may be constructed from alternative materials.

A form of the reactor 30 could be provided by a rotary kiln operating in a horizontal or near horizontal orientation, with conventional scrapers, etc, to assist the displacement of the residues from the reaction along the kiln.

Claims

1. A method of producing a metal comprising uranium characterised in that the method comprises reacting a chloride of uranium with sodium vapour to produce the metal and sodium chloride, the products of the reaction being cooled such that the sodium chloride product is below its vaporisation temperature, and separating the metal produced from the sodium chloride.

2. A method as in claim 1 characterised in that the chloride of uranium comprises UCl_3 or UCl_4.

3. A method as in claim 1 characterised in that another metal, up to 10% by weight, is included with the chloride of uranium, and comprises a metallic powder or a metal halide.

4. A method as in claim 1 characterised in that the products of the reaction are cooled rapidly so as to produce mixed solids thereof from which the uranium metal may be separated from the sodium chloride.

5. A method as in claim 1 characterised in that said liquid metal may be separated from the sodium chloride.

6. Apparatus for the production of a metal comprising uranium by the method of claim 1, characterised in that the apparatus comprises a reactor, means for feeding a chloride of uranium into the reactor, means for feeding sodium into the reactor to react with the chloride, and means for discharging from the reactor products from the reaction of the sodium and the chloride.

7. Apparatus as in claim 6 characterised in that the sodium feeding means includes means for heating molten sodium so as to vaporise the liquid sodium.

8. Apparatus as in claim 6 characterised in that means is provided for cooling the reactor so as to increase the rate of solidification of uranium metal produced in the reaction.

9. Apparatus as in claim 6 characterised in that the discharging means comprises a weir, or is constituted by a rotary dispenser.

10. Apparatus as in claim 6 characterised in that the reactor is provided by a rotary kiln operating in a horizontal or near horizontal orientation.

11. A metal or alloy comprising uranium produced by the method of claims 1 to 5.

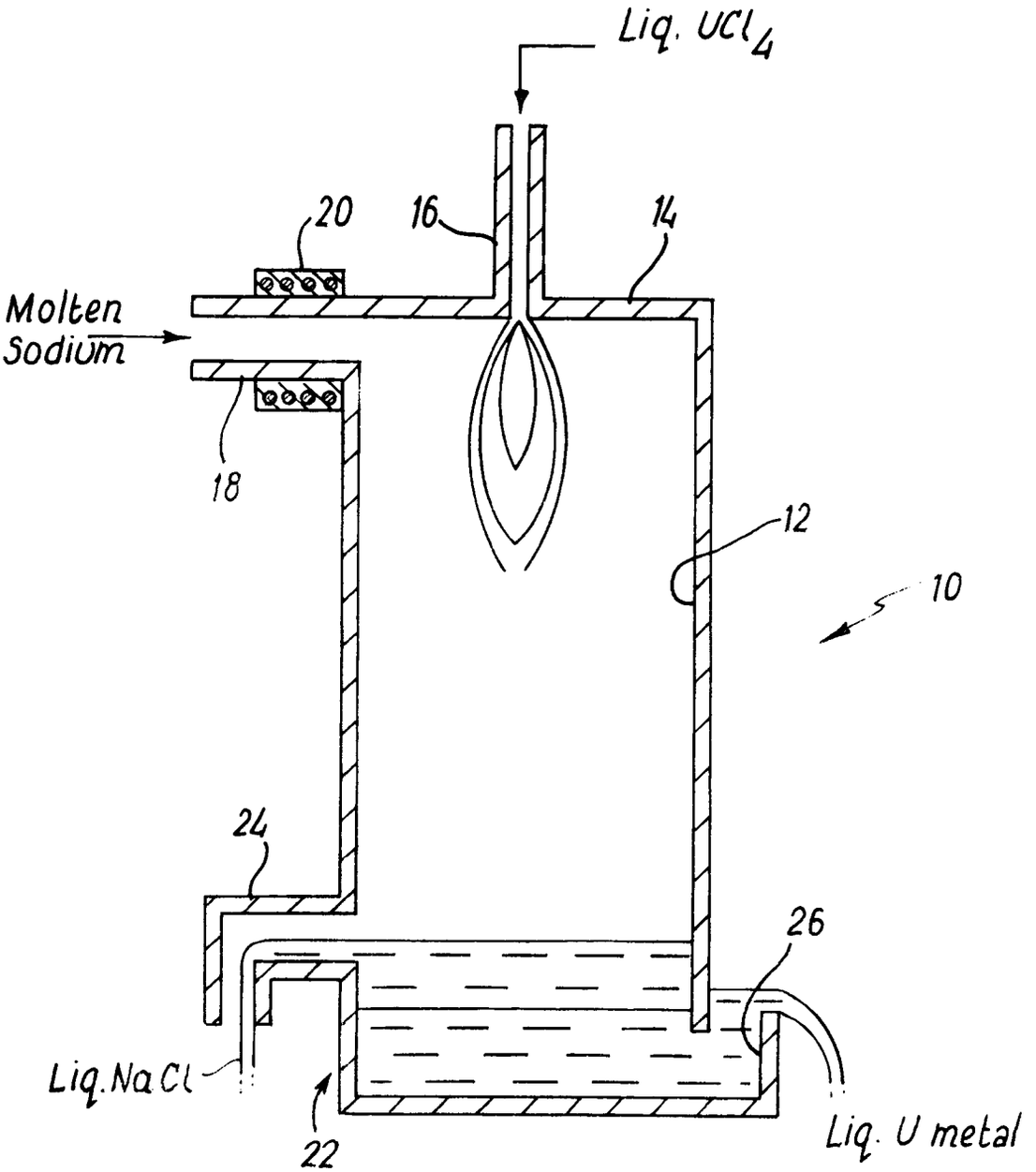
Liq. UCl4
20
16
14
Molten
Sodium
18
12
10
24
26
Liq. NaCl
22
Liq. U metal

FIG. 1

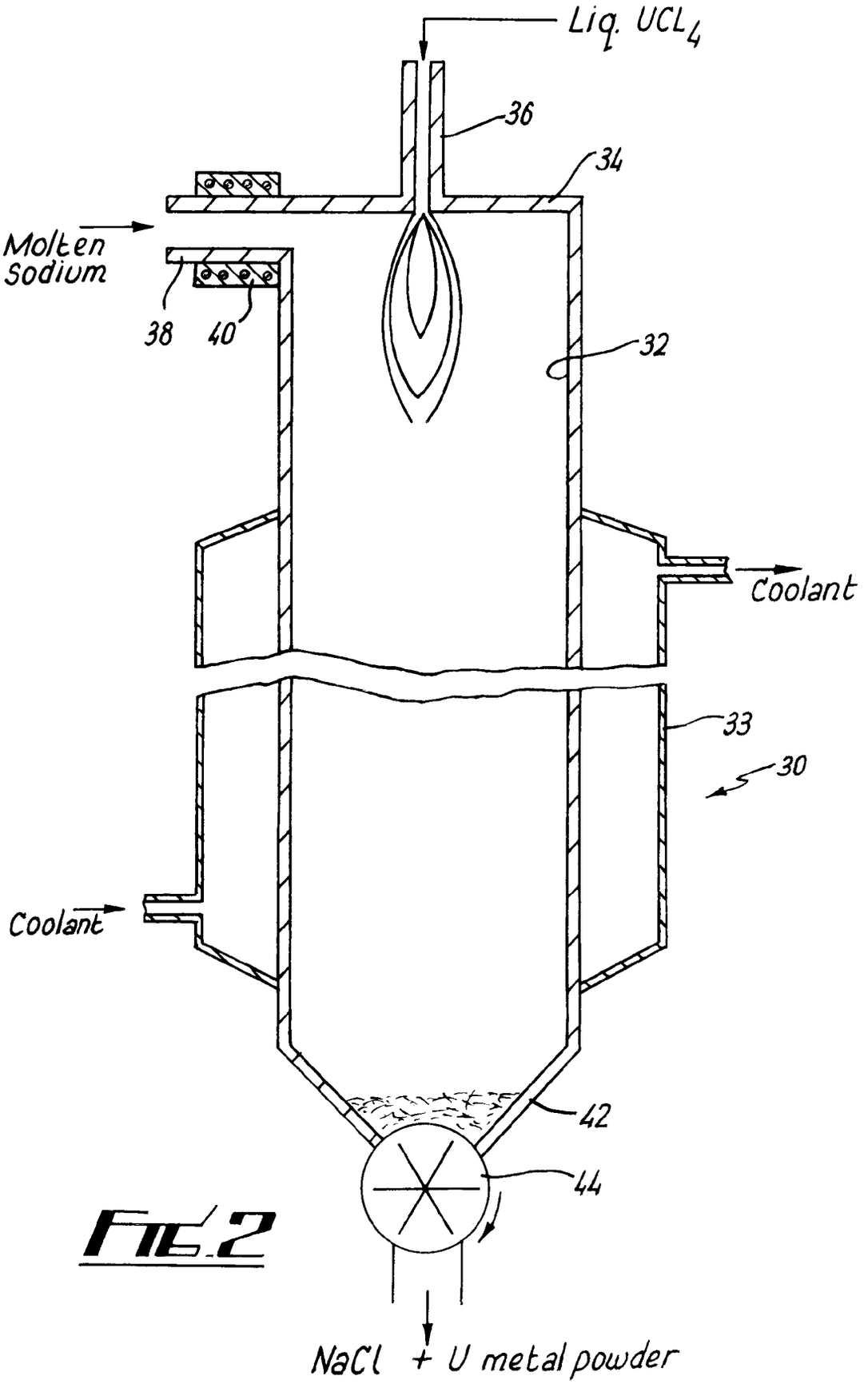
Liq. UCL4
36
34
Molten Sodium
38
40
32
Coolant
33
30
Coolant
42
44
NaCl + U metal powder

FIG.2

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 93 30 8009

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	EP-A-0 408 468 (CEZUS ET AL.) * claims 19-21 *	1	C22B60/02
A	GB-A-814 195 (UNITED KINGDOM ATOMIC ENERGY AUTHORITY) * claims 1,2 *	1	
A	GB-A-883 160 (UNITED STATES ATOMIC ENERGY COMMISSION) * claim 1; figure *	1,6	
A	FR-A-2 461 014 (COCKERILL) * claims 1,11 *	1	
A	US-A-3 847 596 (G.W.HOLLAND ET AL.) * claims 1,8 *	1,3	
A	US-A-2 997 385 (C.H.WINTER,JR.)		

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

C22B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	15 NOVEMBER 1993	SUTOR W.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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L : document cited for other reasons

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