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HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,
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SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM,
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KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— of inventorship (Rule 4.17(iv))

Published:

— with international search report (Art. 21(3))

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12 November 2015

(54) Title: EXTRACTION OF METALS FROM METALLIC COMPOUNDS

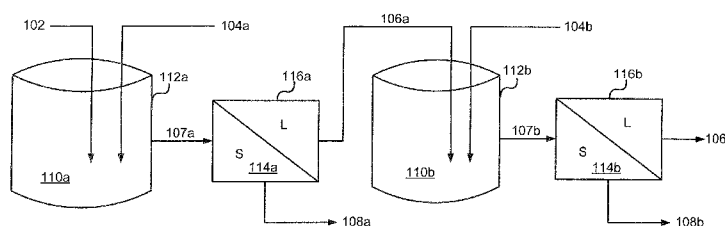


FIG. 2

(57) Abstract: Methods for the extraction of metals such as rare earth metals and thorium from metal compounds and solutions. The methods may include the selective precipitation of rare earth elements from pregnant liquor solutions as rare earth oxalates. The rare earth oxalates are converted to rare earth carbonates in a metathesis reaction before being digested in an acid and treated for the extraction of thorium. A two-step extraction method may be applied to precipitate thorium as thorium hydroxide under controlled pH conditions such that pure thorium precipitate is recovered from a first step and a thorium-free rare earth solution is recovered at the subsequent step. The resulting rare earth solutions are of extremely high purity and may be processed directly in a solvent extraction circuit for the separation of rare earth elements, or may be processed for the direct production of a 99.9% bulk rare earth hydroxide/oxide concentrate.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2014/012153

A. CLASSIFICATION OF SUBJECT MATTER IPC(8) - C22B 3/06 (2014.01) USPC - 423/3 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) IPC(8) - C22B 3/00, 3/06, 3/10, 3/46, 26/00, 26/12, 34/00, 34/14, 58/00, 59/00 (2014.01) USPC - 423/3; 534/13 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched CPC - C22B 3/0005, 3/10, 59/00, 60/02; C01F 15/00 (2014.02) Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) Orbit, Google Patents, Google Scholar		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3,740,199 A (GAMMILL et al) 19 June 1973 (19.06.1973) entire document	1-11, 14, 15
Y		12, 13, 16-20, 22-29
Y	US 3,378,352 A (HANSEN) 16 April 1968 (16.04.1968) entire document	12, 13
Y	US 2,849,286 A (WELT et al) 26 August 1958 (26.08.1958) entire document	16-20, 22, 23
Y	US 2,988,421 A (KEMP et al) 13 June 1961 (13.06.1961) entire document	24, 25
Y	US 4,461,748 A (SABOT et al) 24 July 1984 (24.07.1984) entire document	26-29
A	US 3,087,948 A (CARTER et al) 30 April 1963 (30.04.1963) entire document	1-20, 22-29
A	WO 2012/149642 A1 (BOUDREAU et al) 08 November 2012 (08.11.2012) entire document	1-20, 22-29
☐ Further documents are listed in the continuation of Box C. ☐		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "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) "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 "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 "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 "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 "&" document member of the same patent family		
Date of the actual completion of the international search 20 May 2014		Date of mailing of the international search report 10 JUN 2014
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201		Authorized officer: Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2014/012153

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See Extra Sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-29

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2014/012153

<Continued from Box III: Observations where unity of invention is lacking>

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees need to be paid.

Group I: Claims 1-29 are drawn to a method for the extraction of thorium from an acidic solution containing solubilized thorium

Group II: Claims 30-47 are drawn to a method for extracting rare earth elements from a pregnant liquor solution

The inventions listed as Groups I and II do not relate to a single general inventive concept under PCT Rule 13.1 because under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

The special technical features of Group I, a method for the extraction of thorium from an acidic solution containing solubilized thorium, the method comprising the steps of: contacting the acidic solution with a hydroxide precipitant at a pH of at least about pH 3 and not greater than about pH 4 to precipitate at least a portion of the thorium as thorium hydroxide and form a thorium depleted solution and a thorium hydroxide product; and separating at least a portion of the thorium hydroxide product from the thorium depleted solution, are not found in Group II; the special technical features of Group II, a method for extracting rare earth elements from a pregnant liquor solution, comprising the steps of: contacting a pregnant liquor solution with oxalic acid; maintaining the pregnant liquor solution and the oxalic acid in contact at a first temperature to precipitate a metal oxalate product comprising REE-oxalate particulates from the pregnant liquor solution and form a mixture of the metal oxalate particulates in a REE-depleted solution; and separating the metal oxalate product from the REE-depleted solution, are not found in Group I.

Groups I and II shared the technical features of a method for the extraction of metal from an acidic solution, the method comprising the steps of: contacting the acidic solution with a compound to precipitate at least a portion of the metal and form a metal depleted solution and a metal precipitate product; and separating at least a portion of the metal precipitate product from the metal depleted solution. However, these technical features do not represent a contribution over the prior art.

Specifically, US 3,087,948 A to Gillian et al. teaches a method for the extraction of metal from an acidic solution (Col. 1, Lines 13-21; Col. 1, Lines 68-70; Claim 1), the method comprising the steps of: contacting the acidic solution with a compound (Col. 2, Lines 33-70, ...added to this leach liquor crystalline oxalic hydrate dehydrate...; Claim 1) to precipitate at least a portion of the metal and form a metal depleted solution and a metal precipitate product (Col. 2, Lines 33-70, ...The liquor was then stirred for 24 hours, and precipitate of crude thorium oxalate which had formed was filtered off...; Claim 1); and separating at least a portion of the metal precipitate product from the metal depleted solution (Col. 2, Lines 33-70, ...The liquor was then stirred for 24 hours, and precipitate of crude thorium oxalate which had formed was filtered off...; Claim 1).

Further, WO 2012/149642 A1 to Boudreault et al. teaches a method for the extraction of metal from an acidic solution (Paras. [0005]; [0080]; [00104]; [00152]; [0055]), the method comprising the steps of: contacting the acidic solution with a compound (Paras. [0005]; [00104]; [00152]; [0055]) to precipitate at least a portion of the metal and form a metal depleted solution and a metal precipitate product (Paras. [0005]; [00104]; [00104]; [00152]; [0055]); and separating at least a portion of the metal precipitate product from the metal depleted solution (Paras. [0005]; [00104]; [00104]; [00152]; [0055]).

The inventions listed in Groups I and II therefore lack unity under Rule 13 because they do not share a same or corresponding special technical feature.

<End Box III: Observations where unity of invention is lacking>