



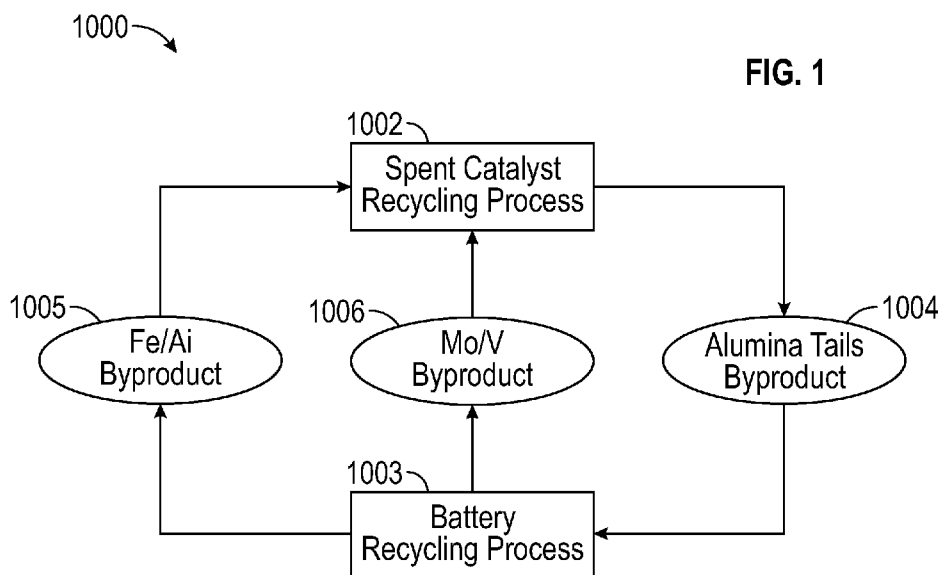
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(81) **Designated States** (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

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(54) **Title:** PROCESSES FOR RECYCLING SPENT CATALYSTS, RECYCLING RECHARGEABLE BATTERIES, AND INTEGRATED PROCESSES THEREOF



(57) **Abstract:** Integrated recycling method and processes including recycling spent catalyst to produce one or more water-soluble metal salts and one or more water-insoluble tail byproducts, and recycling rechargeable batteries to produce one or more battery-grade metals and one or more pure metallic byproducts, wherein the water insoluble tail byproduct is a feedstock in recycling the rechargeable batteries, the impure metallic byproduct is a feedstock in recycling the spent catalyst, or both.



Published:

- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(88) Date of publication of the international search report:

25 January 2024 (25.01.2024)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 23/24867

A. CLASSIFICATION OF SUBJECT MATTER

IPC - INV. B01J 8/00, C10G 11/18, C10G 51/02 (2023.01)

ADD. B01J 8/18 (2023.01)

CPC - INV. B01J 8/005, C10G 11/182, C10G 51/02

ADD. B01J 8/18

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)

See Search History document

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

See Search History document

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

See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2012/0279355 A1 (SUN ET AL.) 8 November 2012 (08.11.2012) - entire document especially para [0015], [0011], [0027], [0028], [0032], [0010] and abstract	1-11
A	WO 2022/029081 A1 (FUNDACION TECNALIA RESEARCH & INNOVATION) 10 February 2022 (10.02.2022) - entire document especially page 6, 26, 38, and abstract	1-11
P/X	US 11,682,801 B1 (ALEON RENEWBLE METALS, LLC) 20 June 2023 (20.06.2023) - entire document	1-11
A	US 8,616,475 B1 (TOXCO, INC.) 31 December 2013 (31.12.2013) - entire document	1-11
A	US 7,736,607 B2 (MARCANTONIO) 15 June 2010 (15.06.2010) - entire document	1-11
A	WO 2018/218358 A1 (LI-CYCLE CORP) 6 December 2018 (06.12.2018) - entire document	1-11
A	US 2016/0263544 A1 (UOP LLC) 15 September 2016 (15.09.2015) - entire document	1-11
A	US 2004/0028585 A1 (CARDARELLI ET AL.) 12 February 2004 (12.02.2004) - entire document	1-11

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"D" document cited by the applicant in the international application

"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

24 October 2023

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 23/24867

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.:
1-11

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.

Continuation of 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 searched, the appropriate additional search fees must be paid.

Group I: Claims 1-11 are directed towards an integrated recycling method comprising: recycling spent catalyst selected residue desulfurization catalyst (RDS), hydrodesulfurization catalyst (HDS), or both, to produce vanadium pentoxide, molybdenum trioxide, or both, and an alumina tail byproduct; and recycling rechargeable batteries to produce one or more battery-grade metals and one or more impure metallic byproducts, the one or more battery-grade metals selected from lithium carbonate, nickel sulfate, manganese sulfate, or cobalt sulfate, and the one or more impure metallic byproducts selected from impure vanadium or impure molybdenum, wherein the alumina tail byproduct is a feedstock in recycling the rechargeable batteries and the impure metallic byproduct is a feedstock in recycling the spent catalyst.

Group II: Claims 12-15 are directed towards a rechargeable battery recycling process comprising: processing a combination of black mass and a nickel-cobalt alloy through a nickel-cobalt recovery circuit of a hydrometallurgical process to recover one or more first battery grade metals; processing the combination of black mass and nickel-cobalt alloy through a lithium recovery circuit of the hydrometallurgical process to recover one or more second battery grade metals, wherein the nickel-cobalt recovery circuit and the lithium recovery circuit share an initial integrated step wherein lithium is pre-leached.

Group III: Claims 16-18 are directed towards a spent catalyst recycling process comprising: pretreating a spent catalyst to form a pretreated spent catalyst; blending the pretreated spent catalyst with sodium carbonate to form a blend; calcining the blend to form a calcine including one or more water-soluble metals; leaching the calcine to form an overflow including a strong solution including the one or more water-soluble metals and an underflow including the one or more insoluble metallic tail byproducts; treating the strong solution with one or more precipitating agents to remove impurities to form a purified strong solution; and recovering one or more water-soluble metal oxides from the purified strong solution via a vanadium recovery circuit, a molybdenum recovery circuit, or both.

The inventions listed as Groups I-III 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:

Special Technical Features:

Group I requires an integrated recycling method comprising: recycling spent catalyst selected residue desulfurization catalyst (RDS), hydrodesulfurization catalyst (HDS), or both, to produce vanadium pentoxide, molybdenum trioxide, or both, and an alumina tail byproduct; and recycling rechargeable batteries to produce one or more battery-grade metals and one or more impure metallic byproducts, the one or more battery-grade metals selected from lithium carbonate, nickel sulfate, manganese sulfate, or cobalt sulfate, and the one or more impure metallic byproducts selected from impure vanadium or impure molybdenum, wherein the alumina tail byproduct is a feedstock in recycling the rechargeable batteries and the impure metallic byproduct is a feedstock in recycling the spent catalyst, not required by Group II or III.

Group II requires processing a combination of black mass and a nickel-cobalt alloy through a nickel-cobalt recovery circuit of a hydrometallurgical process to recover one or more first battery grade metals; processing the combination of black mass and nickel-cobalt alloy through a lithium recovery circuit of the hydrometallurgical process to recover one or more second battery grade metals, wherein the nickel-cobalt recovery circuit and the lithium recovery circuit share an initial integrated step wherein lithium is pre-leached, no required by Group I or III.

Group III requires pretreating a spent catalyst to form a pretreated spent catalyst; blending the pretreated spent catalyst with sodium carbonate to form a blend; calcining the blend to form a calcine including one or more water-soluble metals; leaching the calcine to form an overflow including a strong solution; treating the strong solution with one or more precipitating agents to remove impurities to form a purified strong solution; and recovering one or more water-soluble metal oxides from the purified strong solution via a vanadium recovery circuit, a molybdenum recovery circuit, or both, not required by Group I or II.

Shared Technical Features:

Group I-II share the common technical features of a rechargeable battery recycling process comprising producing one or more first battery grade metals. However, these shared technical features do not represent a contribution over prior art because the shared technical features are anticipated by US 2004/0028585 A1 to Cardarelli et al. (hereinafter "Cardarelli"). Cardarelli teaches a rechargeable battery recycling process (abstract, The method relates to a pyrometallurgical and hydrometallurgical process for the recovery and recycling of lithium and vanadium compounds from a material comprising spent rechargeable lithium batteries) comprising producing one or more first battery grade metals (Abstract, The method involves...precipitating lithium carbonate; see instant specification page 4, paragraph 2, The battery grade metals include...lithium carbonate).

Group I-III share the common technical features of a spent catalyst recycling process comprising recycling spent catalyst and producing one or more water-soluble metals and one or more insoluble metallic tail byproducts. However, these shared technical features do not represent a contribution over prior art because the shared technical features are anticipated by US 4,298,581 A to Douglas et al. (hereinafter "Douglas"). Douglas teaches a spent catalyst recycling process (col 3, ln 24-30, The instant invention relates to the overall process for recovering chromium, molybdenum, tungsten, and vanadium values from a feed material...The feed material preferably comprises...spent catalysts) comprising recycling spent catalyst (col 3, ln 24-30, The instant invention relates to the overall process for recovering chromium, molybdenum, tungsten, and vanadium values from a feed material...The feed material preferably comprises...spent catalysts) and producing one or more water-soluble metals (page 12, ln 30-35, Sodium chromate is thus converted to sodium dichromate and sodium bicarbonate. Hence, the water-soluble metal is sodium bicarbonate) and one or more insoluble metallic tail byproducts (col 24, ln 38-40, The hydrated calcium sulfate tailings are washed. Hence, calcium sulfate is the insoluble metallic tail byproduct).

--see extra sheet--

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Continuation of Box III (Observations where unity of invention is lacking)

Group II-III share the common technical features of recovering/producing metal. However, these shared technical features do not represent a contribution over prior art because the shared technical features are anticipated by Cardarelli. Cardarelli teaches recovering/producing metal (Abstract, The method involves...precipitating lithium carbonate).

As the shared technical features were known in the art at the time of the invention, they cannot be considered special technical features that would otherwise unify the groups. Therefore, Groups I-III lack unity under PCT Rule 13.