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(54) Title: IN-SITU QUALITY ASSURANCE AND SPECTRUM ANALYSIS BY PROMPT GAMMA NEUTRON ACTIVATION ANALYSIS FOR MATERIAL SAMPLES

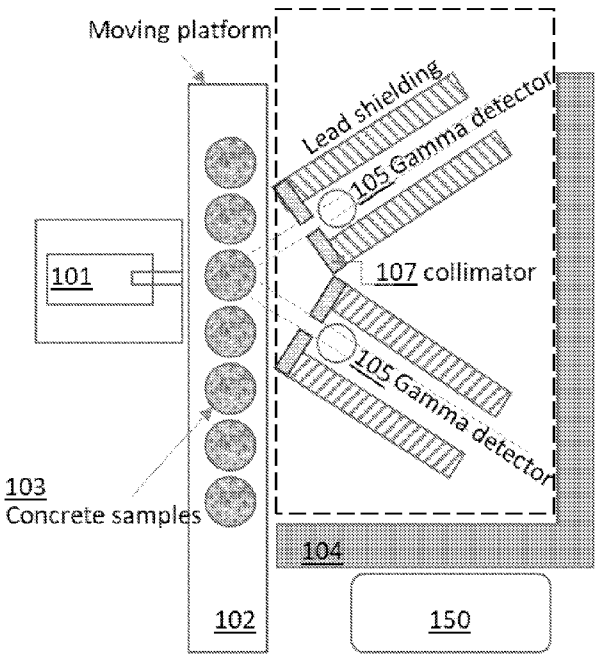


FIG. 1

(57) Abstract: A method of non-destructive testing (NDT) using prompt gamma neutron activation analysis (PGAA) and a suite of algorithms based on various mathematical algorithms, includes: analyzing stored spectra for net peak areas; determining aggregate type from the analyzed stored spectra; calculating dominant element ratios; solving for dominant element mass fractions; calculating elemental mass fractions; solving a linear equations system including a coefficient matrix; and determining material components.

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[Continued on next page]

DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

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— *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))*

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07 August 2025 (07.08.2025)

# INTERNATIONAL SEARCH REPORT

International application No
PCT/US2024/059161

**A. CLASSIFICATION OF SUBJECT MATTER**

INV. G01N23/222
ADD. G01N33/38

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)
G01N

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

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

EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | US 2023/152250 A1 (WAKABAYASHI YASUO [JP] ET AL) 18 May 2023 (2023-05-18) | 1,2,4,5 |
| A | paragraph [0079]; figure 1 | 3,6-12 |
| | ----- | |
| X | US 2021/033542 A1 (WAKABAYASHI YASUO [JP] ET AL) 4 February 2021 (2021-02-04) | 7,8 |
| A | figure 1 | 1-6,9-12 |
| | ----- | |
| | -/-- | |

[x] Further documents are listed in the continuation of Box C.

[x] 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

"E" earlier application or patent but published on or after the international filing date

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"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

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"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 26 June 2025 | 09/07/2025 |

| Name and mailing address of the ISA/ | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040,<br>Fax: (+31-70) 340-3016 | Mauritz, Jakob |

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Form PCT/ISA/210 (second sheet) (April 2005)

# INTERNATIONAL SEARCH REPORT

International application No
PCT/US2024/059161

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | EFTEKHARI-ZADEH E ET AL: "Hybrid combination of multi-layer perceptron and neutron activation analysis in cement prediction", PRAMANA, SPRINGER INDIA, NEW DELHI, vol. 88, no. 2, 4 January 2017 (2017-01-04), pages 1-6, XP036155332, ISSN: 0304-4289, DOI: 10.1007/S12043-016-1327-2 [retrieved on 2017-01-04] the whole document | 1-12 |
| A | US 2014/346366 A1 (NAQVI AKHTAR ABBAS [SA] ET AL) 27 November 2014 (2014-11-27) abstract | 1-12 |
| X | KR 2012 0086078 A (KOREA ATOMIC ENERGY RES [KR]) 2 August 2012 (2012-08-02) | 9-12 |
| A | paragraph [0048] - paragraph [0052]; figures 2b,3 | 1-8 |

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2024/059161

**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 additional 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 an 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.:

**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.

**FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210**

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-6

determine material components

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2. claims: 7-12

automate spectrum peak search

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# INTERNATIONAL SEARCH REPORT

**Information on patent family members**

**International application No**
PCT/US2024/059161

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
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| KR 20120086078 A | 02-08-2012 | NONE | |