(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
18 October 2012 (18.10.2012)

WIPO | PCT

(10) International Publication Number
WO 2012/142456 A4

(51) International Patent Classification:
G01N 23/203 (2006.01) *G01V 5/02* (2006.01)

(21) International Application Number:
PCT/US2012/033585

(22) International Filing Date:
13 April 2012 (13.04.2012)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/475,994 15 April 2011 (15.04.2011) US

(71) Applicant *(for all designated States except US)*: **AMERICAN SCIENCE AND ENGINEERING, INC.** [US/US]; 829 Middlesex Turnpike, Billerica, MA 01821 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **SCHUBERT, Jeffrey, R.** [US/US]; 23 Elm Street, Unit 107, Somerville, MA 02143 (US). **CASON, William, Randall** [US/US]; 5 Butler Avenue, Danvers, MA 01923 (US).

(74) Agents: **SUNSTEIN, Bruce, D.** et al.; Sunstein Kann Murphy & Timbers LLP, 125 Summer Street, Boston, MA 02110-1618 (US).

(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, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

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

— *with amended claims and statement (Art. 19(1))*

[Continued on next page]

(54) **Title**: BACKSCATTER SYSTEM WITH VARIABLE SIZE OF DETECTOR ARRAY

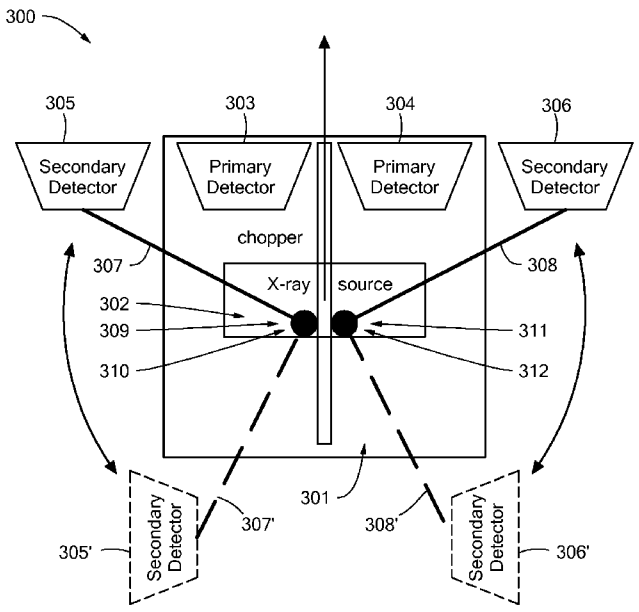

FIG. 3

(57) **Abstract**: A variable-geometry backscatter inspection system has a radiation detector array including one or more backscatter radiation detectors. The position of a second backscatter radiation detector is variable with respect to the position of a first backscatter radiation detector, so that the size of the detector array may be varied by moving the second radiation detector into or out of a predefined alignment with the first radiation detector. The system may include a movable base, and at least one of the detectors is movable with respect to the base. Methods of inspecting an object include forming a detector array by moving a second radiation detector into a predefined alignment with a first radiation detector, illuminating the object with a pencil beam of penetrating radiation, and detecting backscattered radiation with the detector array.

WO 2012/142456 A4

WO 2012/142456 A4

(88) Date of publication of the international search report: 17 January 2013

Date of publication of the amended claims and statement: 21 March 2013

AMENDED CLAIMS
received by the International Bureau on 29 January 2013 (29.01.2013)

What is claimed is:

1. A variable geometry backscatter inspection system for inspecting a surface o 'an object, the system comprising:

a conveyance configured to move along a line of travel;

a source of a pencil beam of penetrating radiation, the source coupled to the conveyance and having an axis of emission;

a variable geometry detector array, the array comprising:

a first detector coupled to the conveyance and having a first alignment vector, the first alignment vector parallel to the line of travel;

a second detector movably coupled to the conveyance and having a second alignment vector, the second detector movable between a first position and a second position, wherein the second alignment vector is parallel to the line of travel in the first position;

such that the array presents a first solid angle when viewed from a point on the line of travel when the second detector is in the first position, and a smaller solid angle when the second detector is in the second position.

2. The variable geometry backscatter inspection system of claim 1, wherein the second detector movably coupled to the conveyance by a movable member.

3. The variable geometry backscatter inspection system of claim 1, wherein the movable member comprises an arm, the arm comprising:

a first end rotatably coupled to the conveyance; and

a second end coupled to the second detector.

4. The variable geometry backscatter inspection system of claim 1, wherein the second detector comprises a first unit and a second unit, the second unit foldable to face the first unit.

5. The variable geometry backscatter inspection system of claim 2, wherein the movable member comprises:

AMENDED SHEET (ARTICLE 19)

a detector frame defining the second alignment vector parallel to the first alignment vector, and movable with respect to the conveyance such that the second alignment vector remains parallel to the first alignment vector in both the first and second position.

6. The variable geometry backscatter inspection system of claim 5, wherein the detector frame is adapted for motion parallel to a surface on which the conveyance is located.

7. The variable geometry backscatter inspection system of claim 5, wherein the detector frame is adapted for motion perpendicular to a surface on which the conveyance is located.

8. The variable geometry backscatter inspection system of claim 5, wherein the detector frame is adapted for motion diagonally with respect to a surface on which the conveyance is located.

9. A variable geometry backscatter inspection system for inspecting a surface of an object, the system comprising:

a conveyance;

a source of a pencil beam of penetrating radiation, the source coupled to the conveyance;

a primary detector coupled to the conveyance, the primary detector having a first location relative to the radiation source and a first alignment vector;

a movable member movably coupled to the conveyance, the movable member comprising an arm, the arm having a first end rotatably coupled to the conveyance, and a second end; and

a secondary detector coupled to the second end of the arm, the secondary detector having a second alignment vector, such that the arm is rotatable between an open position in which the second alignment vector is parallel to the first alignment vector, and a retracted position in which the second alignment vector is not parallel to the first alignment vector,

such that the alignment vector of the secondary detector is configured for reorientation with respect to the alignment vector of the primary detector in such a manner that the sensitivity of the system to radiation scattered from the object is substantially maximized when the first and second alignment vectors are substantially parallel.

10. The variable geometry backscatter inspection system of claim 9, wherein the second alignment vector is perpendicular to the first alignment vector when the second arm is in the retracted position.

11. The variable geometry backscatter inspection system of claim 9 wherein the secondary detector comprises a first unit and a second unit, the second unit foldable to face the first unit.

12. A variable geometry backscatter inspection system for inspecting a surface of an object, the system comprising:

a conveyance;

a source of a pencil beam of penetrating radiation, the source coupled to the conveyance;

a primary detector coupled to the conveyance, the primary detector having a first location relative to the radiation source and a first alignment vector;

a movable member movably coupled to the conveyance; and

a secondary detector coupled to the movable member, the secondary detector having a second alignment vector,

such that the alignment vector of the secondary detector is configured for reorientation with respect to the alignment vector of the primary detector in such a manner that the sensitivity of the system to radiation scattered from the object is substantially maximized when the first and second alignment vectors are substantially parallel; and

wherein the movable member comprises:

a detector frame defining a secondary alignment vector parallel to the first alignment vector and movable with respect to the conveyance such that the secondary alignment vector remains parallel to the first alignment vector.

13. The variable geometry backscatter inspection system of claim 12, wherein the detector frame is adapted for motion parallel to a surface on which the conveyance is located.

14. The variable geometry backscatter inspection system of claim 12, wherein the detector frame is adapted for motion perpendicular to a surface on which the conveyance is located.

15. The variable geometry backscatter inspection system of claim 12, wherein the detector frame is adapted for motion diagonally with respect to a surface on which the conveyance is located.

16. A method for inspecting an object with backscatter radiation, the method comprising:

providing a conveyance comprising a source of a pencil beam of penetrating radiation;

providing a first detector of backscatter radiation, the first detector having a fixed position relative to the conveyance, and the first detector having a first alignment vector;

providing a second detector of backscatter radiation, the second detector movably coupled to the conveyance, and the second detector having a second alignment vector;

orienting the second detector such that the second alignment vector intersects the first alignment vector;

illuminating the object with a pencil beam of radiation from the source;

detecting radiation scattered by the source with the first detector and the second detector;

generating a first image of the object using data representing the radiation scattered by the source and detected by the first detector; and

generating a second image of the object using data representing the radiation scattered by the source and the second detector.

17. The method of claim 16, further comprising producing a compound image by combining data from the first image with data from the second image.

18. The method of claim 17, wherein producing a compound image by combining data from the first image with data from the second image includes producing a dynamically variable image by adjusting the proportion of the first image and the proportion of second image combined to produce the compound image.

19. The method of claim 16, wherein orienting the second detector such that the second alignment vector intersects the first alignment vector comprises orienting the second detector such that the second alignment vector intersects the first alignment vector the angle at a right angle.

Statement under Article 19(1)

The Written Opinion of the International Searching Authority concluded that original claim 9 lacks novelty, but that dependent claims 10 and 13 (among others) are n ›vel and involve inventive step. In this amendment, claims 10 and 13 have been re-writt n in independent form and claims 10-20 have been renumbered, as reflected in the at ached listing of claims on replacement pages 24-28.