

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

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| Applicant's or agent's file reference 1304-0002 | FOR FURTHER ACTION | see Form PCT/ISA/220 as well as, where applicable, item 5 below. |
| International application No. PCT/US 18/38956 | International filing date (<i>day/month/year</i>) 22 June 2018 (22.06.2018) | (Earliest) Priority Date (<i>day/month/year</i>) 30 June 2017 (30.06.2017) |
| Applicant ABLER, JEFFREY ALAN | | |

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 5 sheets.

It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

a. With regard to the **language**, the international search was carried out on the basis of:

the international application in the language in which it was filed.

a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

b. This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6bis(a)).

c. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. **Certain claims were found unsearchable** (see Box No. II).

3. **Unity of invention is lacking** (see Box No. III).

4. With regard to the **title**,

the text is approved as submitted by the applicant.

the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

the text is approved as submitted by the applicant.

the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. With regard to the **drawings**,

a. the figure of the **drawings** to be published with the abstract is Figure No. 1

as suggested by the applicant.

as selected by this Authority, because the applicant failed to suggest a figure.

as selected by this Authority, because this figure better characterizes the invention.

b. none of the figures is to be published with the abstract.

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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:
Group 1: Claims 1-2, directed to a system for powder bed fusion additive manufacturing comprising: a platen having an additive manufacturing powder material spread thereon; a plurality of energy beams; an optical relay system comprising: fixed and moving optics that maintain focus of the plurality of energy beams at the surface of the additive manufacturing powder material; beam steering system that actively corrects the flight of the plurality of energy beams; a rotating polygon mirror that reflects the plurality of energy beams for fast scanning motion.

Continued in supplemental box

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.:
1-2

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.

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Box No. IV Text of the abstract (Continuation of item 5 of the first sheet)

A method and system are disclosed for powder bed fusion additive manufacturing that enables faster processing speeds, larger work volumes, and greater precision relative to the state of the art in that field. A two dimensional pattern of laser beams is scanned across each layer of a powder bed with the power of the beams independently controlled in a manner such that the three dimensional temperature distribution of the material being processed and the adjacent previously processed material maintain a maximum value between the points of complete melting and boiling for the given material, while simultaneously controlling the capillary flow of the molten material and thus the melt pool geometry by managing its surface tension through the induced thermal gradients on the surface of the molten material.

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A. CLASSIFICATION OF SUBJECT MATTER
 IPC(8) - B22F 3/105, B23K 15/00, B23K 15/02 (2018.01)
 CPC - B22F 2003/1057, B22F 3/105, B22F 3/1055

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. |
|-----------|--|-----------------------|
| X | US 2017/0021455 A1 (IPG PHOTONICS CORPORATION) 26 January 2017 (26.01.2017) Abstract, para[0009], [0035], [0041], [0044], [0047], [0059]-[0060], [0065], [0070], [0080], [0105], [0112], [0121]; Figures 1, 19 | 1-2 |
| A | US 2017/0113303 A1 (GENERAL ELECTRIC COMPANY) 27 April 2017 (27.04.2017) Entire document | 1-2 |
| A | US 2014/0163717 A1 (DAS et al.) 12 June 2014 (12.06.2014) Entire document | 1-2 |
| A | US 2016/0136730 A1 (RENISHAW PLC) 19 May 2016 (19.05.2016) Entire document | 1-2 |
| A | WO 2016/077250 A1 (VELO3D, INC.) 19 May 2016 (19.05.2016) Entire document | 1-2 |
| A | US 2017/0129052 A1 (VELO3D, INC.) 11 May 2017 (11.05.2017) Entire document | 1-2 |

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

"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

27 August 2018

Date of mailing of the international search report

05 NOV 2018

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. 571-273-8300

Authorized officer:

Lee W. Young

PCT Helpdesk: 571-272-4300
 PCT OSP: 571-272-7774

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Continuation of:

Box NO. III: Observations where unity of invention is lacking

Group II: Claims 3-25, directed to a method for powder bed fusion additive manufacturing for the fabrication of three dimensional structures through a succession of multiple powder bed build layers utilizing a succession of parallel scans of a pattern of energy beams where the length and width of the beam pattern are more than 5 times the depth of the powder bed build layers and each build layer consists of a union of parallel channels of melted or sintered volume having lengths corresponding to the distances between structure surfaces as measured in the plane of the build layer in the direction of the scanning motion where the lengths of the channels are not necessarily limited to discrete values, and the combination of the scan speed and the power settings for the beams generate and maintain powder bed surface temperatures between the point of complete melting and the initiation of boiling for the fabrication material during the scan engagement.

The inventions listed as Groups I-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:

Special Technical Features:

Group I requires a platen having an additive manufacturing powder material spread thereon; a plurality of energy beams; an optical relay system comprising: fixed and moving optics that maintain focus of the plurality of energy beams at the surface of the additive manufacturing powder material; beam steering system that actively corrects the flight of the plurality of energy beams; a rotating polygon mirror that reflects the plurality of energy beams for fast scanning motion, not required by group II.

Group II requires utilizing a succession of parallel scans of a pattern of energy beams where the length and width of the beam pattern are more than 5 times the depth of the powder bed build layers and each build layer consists of a union of parallel channels of melted or sintered volume having lengths corresponding to the distances between structure surfaces as measured in the plane of the build layer in the direction of the scanning motion where the lengths of the channels are not necessarily limited to discrete values, and the combination of the scan speed and the power settings for the beams generate and maintain powder bed surface temperatures between the point of complete melting and the initiation of boiling for the fabrication material during the scan engagement, not required by group I.

Common Technical Features:

Groups I-II share the technical features of powder bed fusion additive manufacturing for the fabrication of three dimensional structures through a succession of multiple powder bed build layers using scans of energy beams.

However, these shared technical features do not represent a contribution over prior art because the shared technical feature is being anticipated by US 2017/0021455 A1 to IPG PHOTONICS CORPORATION (hereinafter "IPG"). IPG discloses powder bed fusion additive manufacturing (Abstract, ...systems and methods for multiple beam additive manufacturing...to expose layers of powder material...para[0044], ...as used herein, powder materials refers to a material in the form of particles suitable for use in powder bed fusion additive manufacturing...) for the fabrication of three dimensional structures through a succession of multiple powder bed build layers using scans of energy beams (para[0047], ...when forming a build layer in the exposed powder layer on the powder bed 102, an exposure by one or more of the light beams 131 melts the exposed powder material...para[0112], ...laser diode was used with a power of about 65 W...and scanning speeds...to melt various metal powders...Abstract, ...to expose layers of powder material in selected regions until the powder material fuses to form voxels, which form build layers of a three-dimensional structure...para[0009], ...a method is provided for multiple beam additive manufacturing of a three-dimensional structure formed by a plurality of build layers...).

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