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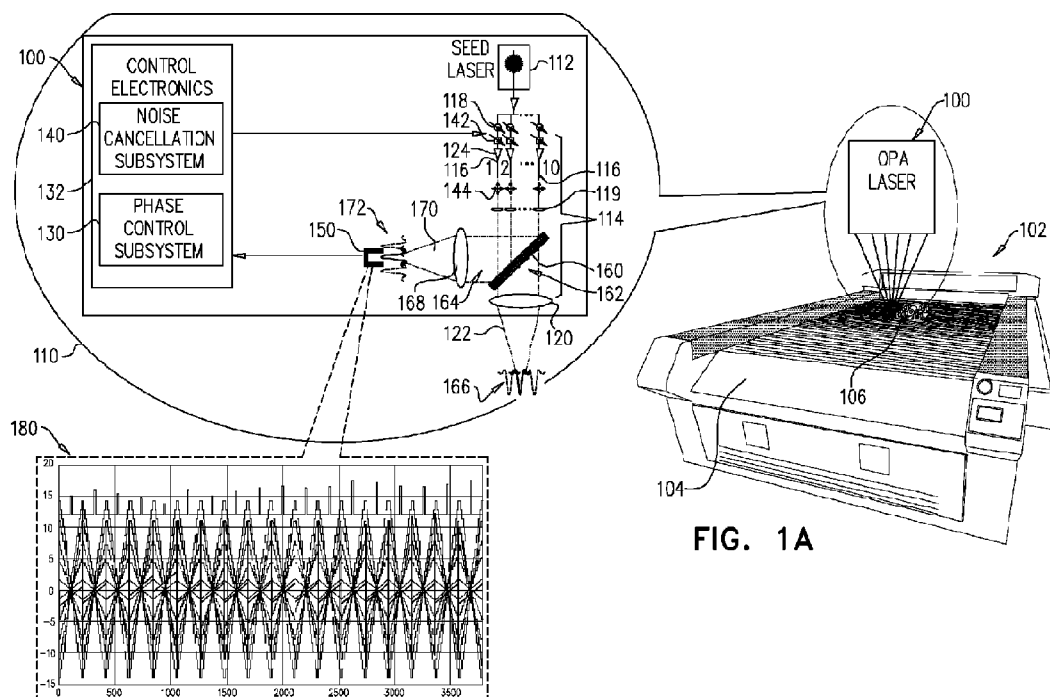
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(54) Title: OPTICAL PHASED ARRAY DYNAMIC BEAM SHAPING WITH NOISE CORRECTION



(57) Abstract: A laser system including a seed laser, a laser beam splitting and combining subsystem receiving an output from the seed laser and providing a combined laser output having noise and a noise cancellation subsystem operative to provide a noise cancellation phase correction output based on taking into consideration the noise at intermittent times, the laser beam splitting and combining subsystem varying a phase of the combined laser output during time interstices between the intermittent times.

MG, MK, MN, 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, SM, ST, SV, SY, TH, TJ, TM, TN,
TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/IL2018/051184

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - H01S 5/06; H01S 3/10; H01S 3/13; H01S 3/23; H01S 5/40 (2019.01)

CPC - H01S 5/06817; G02B 27/106; G02F 1/0121; H01S 3/10023; H01S 3/10053; H01S 3/10084; H01S 3/13; H01S 5/005; H01S 5/0656 (2019.02)

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

USPC - 359/333; 372/29.023; 372/29.01 (keyword delimited)

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 2009/0296751 A1 (KEWITSCH et al) 03 December 2009 (03.12.2009) entire document	1-4, 21-24
A	US 2013/0107343 A1 (SHEKEL et al) 02 May 2013 (02.05.2013) entire document	1-4, 21-24
A	US 9,502,854 B1 (RAYTHEON COMPANY) 22 November 2016 (22.11.2016) entire document	1-4, 21-24
A	US 2014/0368832 A1 (HEXAGON TECHNOLOGY CENTER GMBH) 18 December 2014 (18.12.2014) entire document	1-4, 21-24
A	US 2014/0376001 A1 (SWANSON) 25 December 2014 (25.12.2014) entire document	1-4, 21-24
A	US 2013/0221211 A1 (WITZENS et al) 29 August 2013 (29.08.2013) entire document	1-4, 21-24



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

26 March 2019

Date of mailing of the international search report

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Name and mailing address of the ISA/US

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/IL2018/051184

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.: 5-20, 25-28, 30-39, 44, 45, 49, 50, 55-63, 68-76, 81-84, 89-92, 98-101, 104-108, 114-124, 134, 138, 150-154,
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(s).

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.:
1-4, 21-24

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/IL2018/051184

Continued from Box No. 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 must be paid.

Group I, claims 1-4 and 21-24, are drawn to a laser system comprising: a noise cancellation subsystem operative to provide a noise cancellation phase correction output based on taking into consideration said noise.

Group II, claims 41-43 and 46-48, are drawn to a laser system comprising: a plurality of detectors detecting said combined laser output at intermittent times during said varying of said phase of said combined laser output; and a plurality of optical pathways between said combined laser output and said plurality of detectors for providing therealong said combined laser output to said plurality of detectors.

Group III, claims 51-54 and 64-67, are drawn to a laser system comprising: an optical mask comprising at least one of a transmissive region and a reflective region for respectively providing therethrough and therefrom said combined laser output to said at least one detector.

Group IV, claims 77-80 and 85-88, are drawn to a laser system comprising: a voltage-to-phase correlation subsystem for correlating a voltage applied to said phase modulation subsystem to a phase modulating output produced by said phase modulation subsystem and for providing a voltage-to-phase correlation output useful in calibrating said phase modulation subsystem.

Group V, claims 93-97, 102-103 and 109-113, are drawn to a laser system comprising: a phase modulation subsystem grouping at least a portion of ones of said plurality of sub-beams into a multiplicity of groups of sub-beams, said phase modulation subsystem: in parallel across said multiplicity of groups of sub-beams, varying a phase of each sub-beam within each group relative to phases of other sub-beams within said group so as to vary a phase of each group.

Group VI, claims 125-130, are drawn to a laser system comprising: said laser beam splitting and combining subsystem varying a phase of said combined laser output to focus said combined laser output on a substrate.

Group VII, claims 131-133 and 135-137, are drawn to a laser amplifier system comprising: an amplifying subsystem receiving said laser output from said seed laser along a first optical path and providing an amplified laser output; and a detector subsystem receiving said laser output from said seed laser along a second optical path, said detector subsystem being operative to deactivate said amplifying subsystem upon detection by said detector subsystem of at least one fault in said laser output.

Group VIII, claims 139-149 and 155-159, are drawn to a laser amplifier system comprising: a first amplifier arranged to receive said laser output from said seed laser, said first amplifier providing a first amplified laser output upon receipt of said laser output from said seed laser and providing one of amplified spontaneous emission and an additional laser output upon cessation of receipt of said laser output from said seed laser.

The inventions listed as Groups I-VIII 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 feature of the Group I invention: a noise cancellation subsystem operative to provide a noise cancellation phase correction output based on taking into consideration said noise at intermittent times, said laser beam splitting and combining subsystem varying a phase of said combined laser output during time interstices between said intermittent times as claimed therein is not present in the invention of Groups II-VIII. The special technical feature of the Group II invention: a plurality of detectors detecting said combined laser output at intermittent times during said varying of said phase of said combined laser output; and a plurality of optical pathways between said combined laser output and said plurality of detectors for providing therealong said combined laser output to said plurality of detectors, a spatial density of said plurality of optical pathways being greater than a spatial density of said plurality of detectors as claimed therein is not present in the invention of Groups I, III-VIII. The special technical feature of the Group III invention: an optical mask comprising at least one of a transmissive region and a reflective region for respectively providing therethrough and therefrom said combined laser output to said at least one detector as claimed therein is not present in the invention of Groups I, II, IV-VIII. The special technical feature of the Group IV invention: a voltage-to-phase correlation subsystem for correlating a voltage applied to said phase modulation subsystem to a phase modulating output produced by said phase modulation subsystem and for providing a voltage-to-phase correlation output useful in calibrating said phase modulation subsystem, said correlating being performed periodically during said varying of said phase as claimed therein is not present in the invention of Groups I, II, III or V-VIII. The special technical feature of the Group V invention: a phase modulation subsystem grouping at least a portion of ones of said plurality of sub-beams into a multiplicity of groups of sub-beams, said phase modulation subsystem: in parallel across said multiplicity of groups of sub-beams, varying a phase of each sub-beam within each group relative to phases of other sub-beams within said group so as to vary a phase of each group, and varying said phase of each group relative to phases of other ones of said multiplicity of groups, thereby varying a phase of said combined laser output as claimed therein is not present in the invention of Groups I-IV, VI-VIII. The special technical feature of the Group VI invention: said laser beam splitting and combining subsystem varying a phase of said combined laser output to focus said combined laser output on a substrate, said combined laser output not being focused on said substrate in the absence of said varying of said phase as claimed therein is not present in the invention of Groups I-V, VII-VIII. The special technical feature of the Group VII invention: an amplifying subsystem receiving said laser output from said seed laser along a first optical path and providing an amplified laser output; and a detector subsystem receiving said laser output from said seed laser along a second optical path, said detector subsystem being operative to deactivate said amplifying subsystem upon detection by said detector subsystem of at least one fault in said laser output, a first time of flight of said laser output along said first optical path from said seed laser to said amplifying subsystem being greater than a combination of a second time of flight of said laser output along said second optical path from said seed laser to said detector subsystem and a time taken for said detector subsystem to deactivate said amplifying subsystem as claimed therein is not present in the invention of Groups I-VI or VIII. The special technical feature of the Group VIII invention: an amplifying subsystem receiving said laser output from said seed laser along a first optical path and providing an amplified laser output; and a detector subsystem receiving said laser output from said seed laser along a second optical path, said detector subsystem being operative to deactivate said amplifying subsystem upon detection by said detector subsystem of at least one fault in said laser output, a first time of flight of said laser output along said first optical path from said seed laser to said amplifying subsystem being greater than a combination of a second time of flight of said laser output along said second optical path from said seed laser to said detector subsystem and a time taken for said detector subsystem to deactivate said amplifying subsystem as claimed therein is not present in the invention of Groups I-VII.

Groups I, II, III, IV, V, VI, VII and VIII lack unity of invention because even though the inventions of these groups require the technical feature of a laser system comprising: a seed laser; a laser beam splitting and combining subsystem receiving an output from said seed

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laser and providing a combined laser output, this technical feature is not a special technical feature as it does not make a contribution over the prior art.

Specifically, US 2013/0107343 to Shekel teaches a laser system comprising: a seed laser; a laser beam splitting and combining subsystem receiving an output from said seed laser and providing a combined laser output (Paras, [0110-0120]).

Since none of the special technical features of the Group I, II, III, IV, V, VI, VII or VIII inventions are found in more than one of the inventions, unity of invention is lacking.

It is noted that claims 5-20, 25-39, 44-45, 49-50, 55-63, 68-76, 81-84, 89-92, 98-101, 104-108, 114-124, 134, 138, 150-154 and 160-164 are objected because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).