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Declarations under Rule 4.17:

— as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))

— as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))

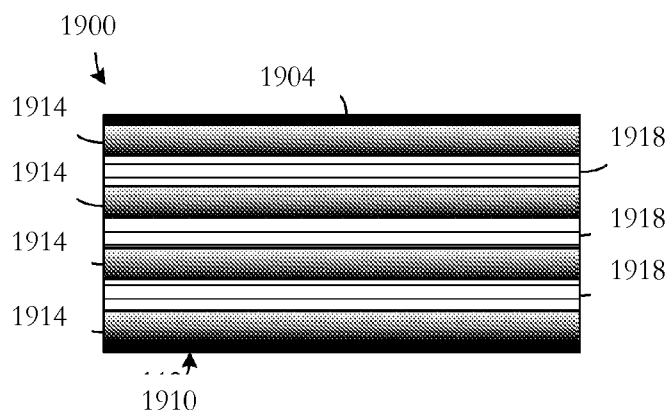
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(88) Date of publication of the international search report:

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(54) Title: GRADIENT NANOPARTICLE-CARBON ALLOTROPE POLYMER COMPOSITE

FIG. 19

(57) Abstract: Systems and methods are provided for protective devices. A protective equipment device may include a high mass member; and a nanoparticle shock wave attenuating material layer disposed on the high mass member. The nanoparticle shock wave attenuating material layer may include a gradient nanoparticle layer including a plurality of nanoparticles of different diameters that are arranged in a gradient array; and a carbon allotrope layer disposed in proximity to the gradient nanoparticle layer, the carbon allotrope layer comprising a plurality of carbon allotrope members suspended in a matrix.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 14/27822

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B32B 27/14, B82B 1/00, F16F 7/00, F41H 1/08, F41H 1/04, F41H 5/04 (2015.01)

CPC - B32B 27/14, B82B 1/00, F16F 7/00, F41H 1/08, F41H 1/04, F41H 5/04

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)

IPC(8)- B32B 27/14, B82B 1/00, F16F 7/00, F41H 1/08, F41H 1/04, F41H 5/04 (2015.01);

CPC- B32B 27/14, B82B 1/00, F16F 7/00, F41H 1/08, F41H 1/04, F41H 5/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC- 2/411, 89/36.02, 428/34.1, 428/323;

Patents and NPL (classification, keyword; search terms below)

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

Pub West (US EP JP WO), Pat Base (AU BE BR CA CH CN DE DK EP ES FI FR GB IN JP KR SE TH TW US WO), Google Patent, Google Scholar, Free Patents Online; search terms: helmet, shock, ballistic, armor, layer, multilayer, ply, matrix, array, nanoparticle, particle, carbon, fullerene, nanotube, graphite, graphene

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y	WO 2012/054472 A2 (GREENHILL et al.) 26 April 2012 (26.04.2012), Fig. 1; para [0009]-[0011], [0026]-[0035], [0042]	1-18, 42-47, 49 ----- 48
Y	US 2011/0192274 A1 (FINGERHUT) 11 August 2011 (11.08.2011), para [0004], [0007], [0008]	48
Y	US 2012/0291620 A1 (YESHURUN) 22 November 2012 (22.11.2012), para [0005]-[0114]	1-18, 42-49
Y	US 2011/0314997 A1 (CABBERRY et al.) 29 December 2011 (29.12.2011), para [0018]-[0056]	1-18, 42-49
Y	US 2011/0168003 A1 (KIM) 14 July 2011 (14.07.2011), para [0004]-[0133]	1-18, 42-49

☐ Further documents are listed in the continuation of Box C.

* 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

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Name and mailing address of the ISA/US

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 14/27822

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:

-- Please 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.:
1-18, 42-49

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/US 14/27822

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 1-18 and 42-49, drawn to a shock wave attenuating material as a helmet.

Group II: Claims 1-7 (in part), 19-26, and 42-49 (in part), drawn to a shock wave attenuating material as an armor unit.

Group III: Claims 1-7 (in part), 27-33, and 42-49 (in part), drawn to a shock wave attenuating material as a personal body armor unit.

Group IV: Claims 1-7 (in part), 34-41, 42-49 (in part), drawn to a shock wave attenuating material as a sports protective equipment device.

Group V: Claims 1-7 (in part), 42-49 (in part), and 50-76, drawn to a shock wave attenuating material as a coating for an electronic device.

The inventions listed as Groups I through V 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

Groups II, III, IV, and V do not require a helmet member configured to be worn by a user, as required by Group I.

Groups I, III, IV, and V do not require an armor unit comprising a structural element and an armor plate, as required by Group II.

Group I, II, IV, and V do not require a personal body armor unit, a ceramic plate, and a high mass member disposed adjacent to the ceramic plate, as required by Group III.

Group I, II, III, and V do not require a sports protective equipment device comprising a high mass member, as required by Group IV.

Group I, II, III, and IV do not require a coating for an electronic device, the coating comprising a surface of an electronic device nanoparticle layer comprises nanoparticles of approximately the same diameter, wherein at least two of the nanoparticle layers comprise nanoparticles of different diameters, as required by Group V.

Shared Common Features

The only feature shared by Groups I, II, III, IV, and V that would otherwise unify the groups is a shock wave attenuating material comprising a plurality of shock attenuating layers each comprising:

- (i) a gradient nanoparticle layer comprising a plurality of nanoparticles of different diameters arranged in a gradient array; and
- (ii) a carbon allotrope layer disposed in proximity to the gradient nanoparticle layer, the carbon allotrope layer comprising a plurality of carbon allotrope members suspended in a matrix. However, this shared technical feature does not represent a contribution over prior art, because the shared technical feature is anticipated by WO 2012/054472 A2 to Greenhill, et al. (hereinafter 'Greenhill'). Greenhill discloses a plurality of shock attenuating layers (para [0009]), each comprising: (i) a gradient nanoparticle layer comprising a plurality of nanoparticles of different diameters arranged in a gradient array (para [0009], [0010]); and
- (ii) a carbon allotrope layer disposed in proximity to the gradient nanoparticle layer, the carbon allotrope layer comprising a plurality of carbon allotrope members suspended in a matrix (para [0009], [0010]).

The only feature shared by Groups II and III that would otherwise unify the groups is a plate. However, this shared technical feature does not represent a contribution over prior art, because the shared technical feature is anticipated by Greenhill. Greenhill discloses a plate (para [0012]).

The only feature shared by Groups III and IV that would otherwise unify the groups is a high mass member. However, this shared technical feature does not represent a contribution over prior art, because the shared technical feature is anticipated by Greenhill. Greenhill discloses a high mass member (para [0012]).

As the technical features were known in the art at the time of the invention, this cannot be considered a special technical feature that would otherwise unify the groups. Groups I, II, III, IV, and V therefore lack unity under PCT Rule 13 because they do not share a same or corresponding special technical feature.