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Sahuarita, Arizona 85629 (US). **MICHALUK, Christopher** [US/US]; 7691 East Chase Park Loop, Tucson, Arizona 85710 (US).

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(74) Agent: **DAHL, Bruce E.**; Fennemore Craig, P.c, 1700 Lincoln Street, Suite 2900, Denver, Colorado 80203 (US).

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(71) Applicant (for all designated States except US): **CLIMAX ENGINEERED MATERIALS, LLC** [US/US]; 333 North Central Avenue, Phoenix, Arizona 85004 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **HONECKER, David** [US/US]; 800 East Pima Mine Road, Sahuarita, Arizona 85629 (US). **CARDUCCI, Michael** [US/US]; 800 East Pima Mine Road, Sahuarita, Arizona 85629 (US). **COX, Carl** [US/US]; 800 East Pima Mine Road,

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[Continued on next page]

(54) Title: POTASSIUM / MOLYBDENUM COMPOSITE METAL POWDERS, POWDER BLENDS, PRODUCTS THEREOF, AND METHODS FOR PRODUCING PHOTOVOLTAIC CELLS

(57) Abstract: A method for producing a composite metal powder according to one embodiment of the invention may comprise: Providing a supply of molybdenum metal powder; providing a supply of a potassium compound; combining the molybdenum metal powder and the potassium compound with a liquid to form a slurry; feeding the slurry into a stream of hot gas; and recovering the composite metal powder.

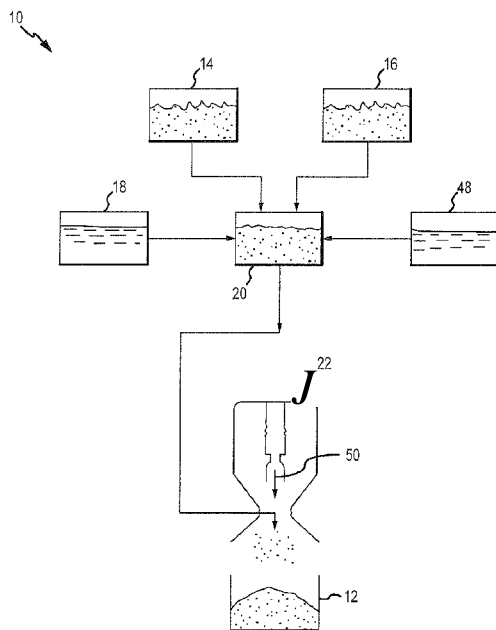


FIG. 1

WO 2012/006501 A3

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,
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— *before the expiration of the time limit for amending the
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INTERNATIONAL SEARCH REPORT

PCT/US 11/43312

A. CLASSIFICATION OF SUBJECT MATTER
 IPC(8) - C22C 27/04 (2012.01)
 USPC - 419/31 ; 419/38; 420/429
 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) ~ C22C 27/04 (2012.01)
 USPC - 419/31 ; 419/38; 420/429

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
 IPC(8) -- B22F; C22C 27/04; C22C; C23C (2012.01)
 USPC - 204/S; 419/31 , 38, S; 420/429

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
 PubWest (PGPB,USPT,USOC,EPAB,JPAB); DialogWeb (File 348 European Patents Fulltext; File 349 WIP\ PCT Patents Fulltext);
 USPTO; Espacenet; Google Patents; Google Scholar; Google -- K2M004 MOLYBDENUM POWDER POTASSIUM MOLYBDATE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 2009/0188789 A1 (Honecker et al.) 30 July 2009 (30.07.2009) Fig 1; para [0020]; [0021]; [0030]; [0031]; [0033]; [0040]	1 and 23 ----- 2-12,14,15
Y	US 2002/0078794 A1 (Bredthauer et al.) 27 June 2002 (27.06.2002) para [0007]; [0021]; [0029]	2-12,14,15
A	US 5,734,960 A (Patrician et al.) 31 March 1998 (31.03.1998) abstract	2-12,14,1 5
A	US 5,164,246 A (Tanaka et al.) 17 November 1992 (17.11.1992) col 2, ln 39-46	2-12,14,15

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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INTERNATIONAL SEARCH REPORT

PCT/US 11/43312

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:
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 1: claims 1-1 2, 14-1 5, 23 directed to a method for producing a composite metal powder, comprising:
providing a supply of molybdenum metal powder;
providing a supply of a Group IA alkali metal compound;
combining said molybdenum metal powder and said Group IA alkali metal compound with a liquid to form a slurry;
feeding said slurry into a stream of hot gas; and
recovering the composite metal powder, said composite metal powder comprising the Group IA alkali metal compound and molybdenum.

(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.:

Claims 1-12, 14, 15 and 23

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.

Continuation of Box No. III.

Group II: claims 13, 24-27, 29, 35-40, 65-67 directed to a method for producing a composite metal powder, comprising:
providing a supply of molybdenum metal powder;
providing a supply of a potassium molybdate powder;
combining said molybdenum metal powder and said potassium molybdate powder with water to form a slurry;
feeding said slurry into a stream of hot gas; and
recovering the composite metal powder.

Group III: claims 16-22, 33 directed to a method for producing a dry blend metal powder, comprising:
providing a powder supply of molybdenum metal;
providing a powder supply comprising a Group IA alkali metal;
milling at least one of said powder supply of molybdenum metal and said powder supply comprising a Group IA alkali metal to reduce a particle size of the at least one of said powder supplies; and
combining said powder supply of molybdenum metal powder and said powder supply comprising a Group IA alkali metal to form said dry blend metal powder.

Group IV: claims 28, 30-32, 34 directed to a potassium/molybdenum composite metal powder comprising a substantially homogeneous dispersion of sub-particles comprising potassium and molybdenum sub-particles that are fused together to form individual particles of said composite metal powder.

Group V: claims 41-62, 73-74 directed to a method for producing a metal article, comprising:
providing a supply of a potassium/molybdenum composite metal powder;
compacting the potassium/molybdenum composite metal powder under sufficient pressure to form a preformed article;
placing the preformed article in a sealed container;
raising the temperature of the sealed container to a temperature that is lower than an optimal sintering temperature of molybdenum; and
subjecting the sealed container to an isostatic pressure for a time sufficient to increase the density of the article to at least about 90% of theoretical density.

Group VI: claims 63-64 directed to a method for producing a metal article, comprising:-
providing a supply of a Group IA alkali/molybdenum dry powder blend;
filling a die with said supply of a Group IA alkali/molybdenum dry powder blend; and
compacting the Group IA alkali/molybdenum dry powder blend in the die under sufficient pressure to form a preformed article.

Group VII: claims 68-72 directed to a metal article comprising molybdenum and potassium, said potassium being present in an amount of at least about 2% by weight.

Group VIII: claims 75-82, 84-87 directed to a method for producing a photovoltaic cell, comprising:
providing a substrate;
depositing a molybdenum metal layer on said substrate;
depositing a potassium/molybdenum metal layer on said molybdenum metal layer;
depositing an absorber layer on said potassium/molybdenum metal layer; and
depositing a junction partner layer on said absorber layer.

Group IX: claim 83 directed to a photovoltaic cell comprising:
a CIGS absorber layer;
a conductor layer comprising a base conductor layer and a doped conductor layer, said doped conductor layer being positioned between said base conductor layer and said CIGS absorber layer, said base conductor layer consisting essentially of molybdenum, said doped conductor layer consisting essentially of molybdenum and a Group IA alkali metal, said Group IA alkali metal in said doped conductor layer being present in an amount sufficient to increase the conversion efficiency of said photovoltaic cell as a result of the diffusion of a portion of said Group IA alkali metal into said CIGS absorber layer.

Continuation from previous box

Groups I, II, III, IV, VI, VII, VIII and IX do not include the subjecting the sealed container to an isostatic pressure for a time sufficient to increase the density of the article to at least about 90% of theoretical density of group V.

Groups I, II, III, IV, V, VII, VIII and IX do not include the die of group VI.

Groups I, II, III, IV, V, VI, VIII and IX do not include the potassium being present in an amount of at least about 2% by weight of group VII.

Groups I, II, III, IV, V, VI, VII and VIII do not include a CIGS absorber layer nor a conductor layer comprising a base conductor layer and a doped conductor layer of group IX.

Groups VII, VIII and IX do not include the metal powder of groups I, II, III, IV, V and VI.

The common feature of all the groups of a composition comprising molybdenum and an alkali and the common feature of a metal powder of groups I, II, III, IV, V and VI are taught by US 2009/0188789 A1 to Honecker et al. (hereinafter 'Honecker') (para [0005]) and by US 2002/0078794 A1 to Bredthauer et al (hereinafter 'Bredthauer') (para [0013]).

The common features of groups I and II of the liquid slurry and hot gas method is taught by Honecker (para [0020]). The common feature of groups VIII and IX of photovoltaic cells is also taught by Honecker (para [0024]).

The common feature of potassium of groups II, IV, V, VII and VIII is taught by Bredthauer (para [0013]); therefore the common feature is not an improvement over the prior art.

Therefore, the inventions of Groups I - IX lack unity of invention under PCT Rule 13 because they do not share a same or corresponding special technical feature.