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(54) Title: CHEMICAL REACTION ACTIVATED EXPANDING MATERIAL FOR UNDERWATER DEPLOYABLE STRUCTURES

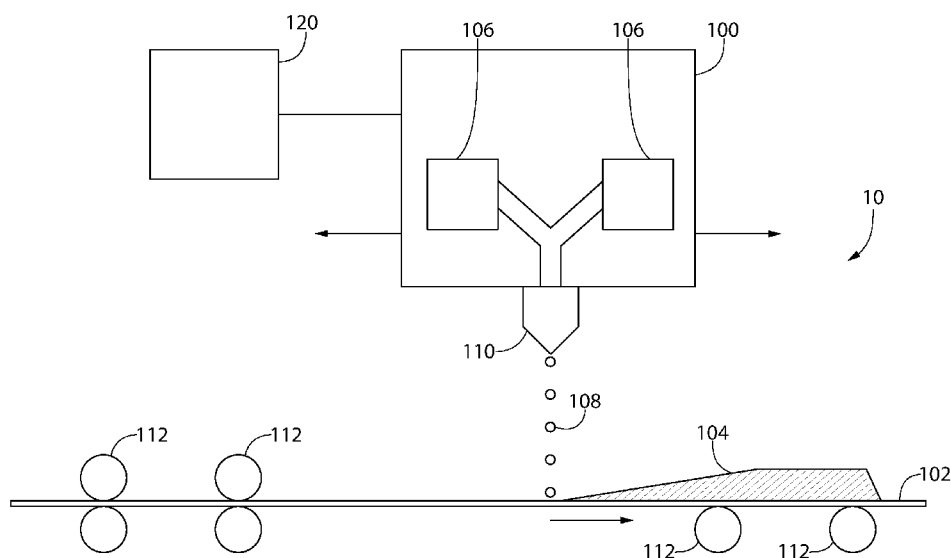


FIG. 5

(57) **Abstract:** Moisture-activated expanding foams used with Underwater Deployable Structures (UDSs) are useable on site as they are designed for use in wet environments and do not deteriorate over a period of days, months or even several years. These foams begin as polyurethane-based resins of low viscosity, and react in the presence of water to become solid foam. In their final forms, the foams exist as open- or closed- cell, and vary in strength, elasticity, and rigidity. The foams may be deposited on a substrate using a 3D printer or a mixer having an outlet to dispense the expandable foam. Substrates may be part of UDSs having cavities for the foam to support or expand the UDS to a usable structure. The foams may also be use in other manners, including with a buoyancy engine that may raise or lower a UDS to a desired depth.



SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN,
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 19/45905

A. CLASSIFICATION OF SUBJECT MATTER

IPC - B63G 8/00; G01V 1/38 (2020.01)

CPC - B63G 8/001; B63G 8/16; G01V 1/247; G01V 1/3808; G01V 1/3852

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.
Y --- A	US 2006/0159523 A1 (Dixon et al.) 20 July 2006 (20.07.2006) Entire document, especially Abstract, para [0019]; [0134]	1, 8-9 ----- 2-7, 10
Y --- A	US 4,333,898 A (Schmidtchen) 8 June 1982 (08.06.1982) Entire document, especially Abstract, col 1 ln 58-63; col 2 ln 3-6; col 3 ln 25-30; col 4 ln 4-6	1, 8-9 ----- 2-7, 10
A	US 5,026,736 A (Pontiff) 25 June 1991 (25.06.1991) Entire document, especially col 20 ln 62-65	1
A	-- Sauerbrunn et al. "Thermosets: How to Avoid Incomplete Curing." American Laboratory, American Laboratory, 1 Jan. 2010, www.americanlaboratory.com/913-Technical-Articles/482-Thermosets-How-to-Avoid-Incomplete-Curing/.	8
A	US 3,837,171 A (Scurlock) 24 September 1974 (24.09.1974) Entire document	1-10
A	US 3,803,540 A (Mar et al.) 9 April 1974 (09.04.1974) Entire document	1-10
A	US 6,254,445 B1 (Jones) 3 July 2001 (03.07.2001) Entire document	1-10

☒ 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

"D" document cited by the applicant in the international application

"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

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INTERNATIONAL SEARCH REPORT

International application No.

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2015/0119480 A1 (Royal Adhesives & Sealants Canada Ltd.) 30 April 2015 (30.04.2015) Entire document, especially Abstract, para [0018]; [0022]; [0059]	1-10

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 19/45905

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:

-- 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.:
1-10

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 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 searched, the appropriate additional search fees must be paid.

Group I: Claims 1-10 directed to a method of making a foam object for an underwater deployable structure, the method comprising depositing a moisture-activated foam substance onto a substrate, the moisture-activated foam substance being expandable in volume from an unexpanded state to an expanded foam; and activating a chemical reaction of the moisture-activated foam substance with moisture to expand the moisture-activated substance in volume to the expanded foam.

Group II: Claims 11-14 directed to a method for underwater deployment of an underwater deployable structure in unexpanded configuration having a plurality of beams coupled together, the beams being mechanically expandable underwater from the unexpanded configuration to an expanded configuration, the beams having an outer wall with hallowed sections therein defining cavity wells, the method comprising: inserting a moisture-activated substance located within a cavity well of a first beam, the moisture-activated substance being expandable in volume from an unexpanded state to an expanded foam; and activating a chemical reaction of the moisture-activated substance with moisture to expand the moisture-activated substance in volume to the expanded foam and fill the hallowed section of the cavity well.

Group III: Claims 15-20 directed to an underwater deployable structure buoyance device, comprising: an underwater deployable structure; a buoyance container attached to the underwater deployable structure, the buoyance container including moisture-activated substance being expandable in volume from an unexpanded state to an expanded foam via chemical reaction; and a deployment mechanism adjacent the moisture-activated substance that allows moisture to access the moisture-activated substance and chemically react with the moisture activated substance to expand the moisture-activated substance in volume from the unexpanded state to the expanded foam, the underwater deployable structure deployable to a first underwater depth with the moisture-activated substance in the unexpanded state, the expanded foam being lighter than water and configured to raise the underwater deployable structure from the first underwater depth to a second underwater depth shallower than the first underwater depth.

The inventions listed as Groups I-III 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 method of making a foam object for an underwater deployable structure, the method comprising: depositing a moisture-activated foam substance onto a substrate, the moisture-activated foam substance being expandable in volume from an unexpanded state to an expanded foam; and activating a chemical reaction of the moisture-activated foam substance with moisture to expand the moisture-activated substance in volume to the expanded foam, not specifically required by Groups II or III.

Group II requires a method for underwater deployment of an underwater deployable structure in unexpanded configuration having a plurality of beams coupled together, the beams being mechanically expandable underwater from the unexpanded configuration to an expanded configuration, the beams having an outer wall with hallowed sections therein defining cavity wells, the method comprising: inserting a moisture-activated substance located within a cavity well of a first beam, the moisture-activated substance being expandable in volume from an unexpanded state to an expanded foam; and activating a chemical reaction of the moisture-activated substance with moisture to expand the moisture-activated substance in volume to the expanded foam and fill the hallowed section of the cavity well, not specifically required by Groups I or III.

Group III requires an underwater deployable structure buoyance device, comprising: an underwater deployable structure; a buoyance container attached to the underwater deployable structure, the buoyance container including moisture-activated substance being expandable in volume from an unexpanded state to an expanded foam via chemical reaction; and a deployment mechanism adjacent the moisture-activated substance that allows moisture to access the moisture-activated substance and chemically react with the moisture activated substance to expand the moisture-activated substance in volume from the unexpanded state to the expanded foam, the underwater deployable structure deployable to a first underwater depth with the moisture-activated substance in the unexpanded state, the expanded foam being lighter than water and configured to raise the underwater deployable structure from the first underwater depth to a second underwater depth shallower than the first underwater depth, not specifically required by Groups I or II.

Common Technical Features:

Groups I-III share the technical feature of an underwater deployable structure.

Groups I and II share the technical feature of depositing a moisture-activated foam substance onto a substrate, the moisture-activated foam substance being expandable in volume from an unexpanded state to an expanded foam; and activating a chemical reaction of the moisture-activated foam substance with moisture to expand the moisture-activated substance in volume to the expanded foam.

However, these shared technical features do not represent a contribution over prior art, because the shared technical feature is being anticipated by US 2006/0159523 A1 to Dixon et al. (hereinafter 'Dixon'). Dixon discloses an underwater deployable structure (Abstract - '...Apparatus for providing an enclosure, for example as a housing or to provide buoyancy, at underwater locations is disclosed...').

-- See Extra Sheet --

Continuation of Box III: Observations where unity of invention is lacking

However, these shared technical features do not represent a contribution over prior art, because the shared technical feature is being anticipated by US 2015/0119480 A1 to Royal Adhesives & Sealants Canada Ltd. (hereinafter 'Royal'). Royal discloses depositing a moisture-activated foam substance onto a substrate (para [0022] - '...it is believed that upon exposure to moisture, the polymer cross-links to build viscosity and cure, simultaneously water molecules are adsorbed onto the surface and pores of the molecular sieve forcing the desorption of other gaseous adsorbates leading to the expansion of the polymer...'), the moisture-activated foam substance being expandable in volume from an unexpanded state to an expanded foam (Abstract - '...A one-component moisture curing composition expands and cures under ambient conditions without the use of external blowing agents...'); and activating a chemical reaction of the moisture-activated foam substance with moisture to expand the moisture-activated substance in volume to the expanded foam (para [0018] - '... a catalyst compound can be used to promote the reaction between atmospheric water and the moisture curing functional group of the polymer...'; para [0059] - '...Since both the curing and the foaming reactions require the presence of water or other atmospheric gases, controlling their abundance, or lack thereof, during the manufacture of the foam is important...').

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-III lack unity under PCT Rule 13.