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(71) Applicant: **COLORADO STATE UNIVERSITY RESEARCH FOUNDATION** [US/US]; 2537 Research Blvd., Suite 200, Fort Collins, Colorado 80526 (US).

(72) Inventor: **YOURDKHANI, Mostafa**; 2537 Research Blvd., Suite 200, Fort Collins, Colorado 80526 (US).

(74) Agent: **PANNELL, William C.**; Robinson IP Law, PLLC, 9724 Kingston Pike, STE 1102, Knoxville, Tennessee 37922 (US).

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(54) Title: RAPID MANUFACTURING OF COMPOSITE STRUCTURES USING FILAMENT WINDING TECHNIQUES

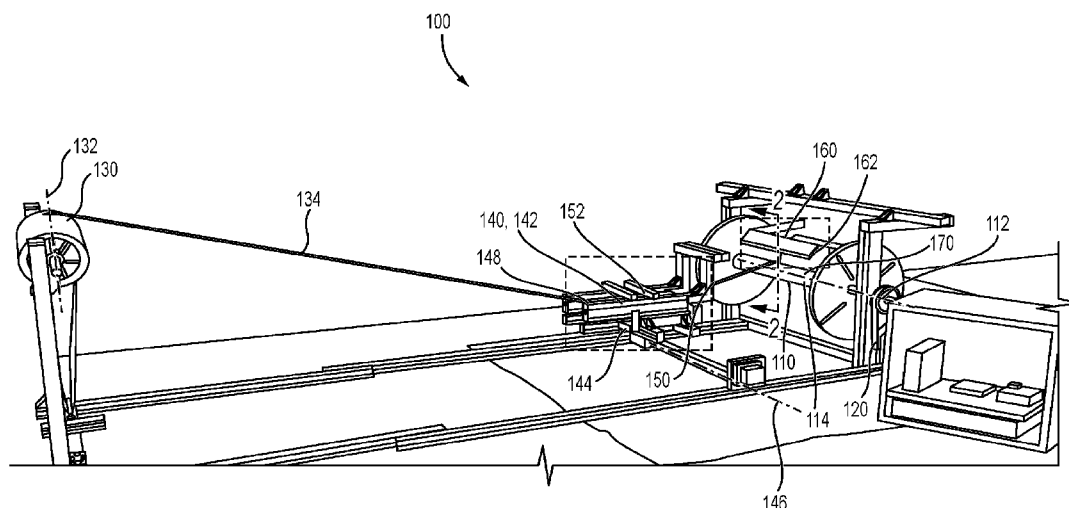


FIG. 1A

(57) Abstract: Various implementations include a filament winding system. The system includes a mandrel, a motor, and an energy source. The mandrel has a rotational axis. The mandrel has an outer surface extending circumferentially around the rotational axis. The motor is for causing the mandrel to rotate about the rotation axis. The energy source is for directing energy toward a fiber wound around the outer surface of the mandrel.



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INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER

IPC - INV. B29C 53/82, B29C 53/62, B29C 53/66, B29C 53/80, B29C 53/84 (2024.01)

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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 --- Y	CN 113895022 A (Weiping), 07 January 2022 (07.01.2022), entire document, especially Figs 1-11	1, 3, 15-16, 20 ----- 4, 7, 9-10
X --- Y	US 2010/0062249 A1 (Harazono et al), 11 March 2010 (11.03.2010), entire document, especially Figs 1-23	1-2, 15, 17 ----- 18-19
X --- Y	EP 3711915 A1 (CENTRE TECHNIQUE DES INDUSTRIES MECANIQUES), 23 September 2020 (23.09.2020), entire document, especially Figs 1-4	1, 5, 15 ----- 6
X --- Y	CN 114872183 A (FUJIAN NACHUAN PIPE INDUSTRY TECHNOLOGY CO., LTD. et al.), 09 August 2022 (09.08.2022), entire document, especially Figs 1-22	1, 11-12, 15, 20-23 ----- 8, 13-14, 24-36
Y	US 5,266,139 A (Yokota et al.), 30 November 1993 (30.11.1993), entire document, especially Figs 1-9	4, 6-7
Y	US 2019/0077109 A1 (Nissan Motor Co., Ltd.), 14 March 2019 (14.03.2019), entire document, especially Figs 1-7	8
Y	US 2019/0100623 A1 (SABIC Global Technologies B.V), 04 April 2019 (04.04.2019), entire document, especially Figs 1-16	9-10

☒ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:

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"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

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"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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Authorized officer

Kari Rodriguez

Telephone No. PCT Helpdesk: 571-272-4300

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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.
Y	US 2010/0043764 A1 (Jones), 25 February 2010 (25.02.2010), entire document, especially Figs 1-15	13
Y	US 2021/0114283 A1 (Technip N-Power), 22 April 2021 (22.04.2021), entire document, especially Figs 1-13	14
Y	US 2014/0072740 A1 (GENERAL PLASTICS & COMPOSITES, L.P), 13 March 2014 (13.03.2014), entire document, especially Figs 1-3	18-19
Y	US 4,876,050 A (Horton), 24 October 1989 (24.10.1989), entire document, especially Figs 1-10	24
Y	WO 2022223614 A1 (PLASTIC OMNIUM NEW ENERGIES FRANCE), 27 October 2022 (27.10.2022), entire document, especially Figs 1-4	25-26
Y	'Vitrimers: The reprocessible thermoset' (Sloan), 28 September 2020 (28.09.2020), [online], retrieved from <URL:https://www.compositesworld.com/articles/vitrimers-the-reprocessible-thermoset>, entire document	27
Y	US 2021/0101326 A1 (GM GLOBAL TECHNOLOGY OPERATIONS LLC), 08 April 2021 (08.04.2021), entire document, especially Figs 1-3	28-31
Y	US 2008/0020193 A1 (Jang et al.), 24 January 2008 (24.01.2008), entire document, especially Figs 1-5	32-35
Y	US 2012/0071586 A1 (Thunhorst et al.), 22 March 2012 (22.03.2012), entire document,	36
A	US 2014/0027046 A1 (Mathon et al.), 30 January 2014 (30.01.2014), entire document	1-36
A	US 6,350,204 B1 (Yasui et al.), 26 February 2002 (26.02.2002), entire document	1-36

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 24/10114

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 I: Claims 1-36, directed to a filament winding system having a mandrel, a motor, and an energy source.

Group II: Claims 37-77 directed to a method of forming a hollow composite structure comprising providing a filament winding system, a mandrel, a motor, an energy source, and the steps of actuating the motor, causing a fiber to be fed to the mandrel outer surface, causing the fiber to be impregnated with a resin, and directing energy to the resin impregnated fiber that has been wound onto the outer surface of the mandrel.

Continued on 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.:
1-36

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****

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 II requires the special technical feature of a method of forming a hollow composite structure comprising: actuating the motor to cause the mandrel to rotate about the rotational axis; causing a fiber to be fed onto the outer surface of the mandrel as the mandrel rotates about the rotation axis; causing the fiber to be impregnated with a resin; and causing the energy source to direct energy toward the resin-impregnated fiber that has been wound onto the outer surface of the mandrel to cause the resin to cure into a hollow composite structure while disposed on the outer surface of the mandrel, not required by Group I.

COMMON TECHNICAL FEATURES

Groups I-II share the common technical features of a filament winding system, the system comprising:
a mandrel having a rotational axis, the mandrel having an outer surface extending circumferentially around the rotational axis;
a motor for causing the mandrel to rotate about the rotation axis; and
an energy source for directing energy toward a fiber wound around the outer surface of the mandrel.

However, this shared technical feature is known in the prior art as shown by US 2010/0062249 A1 to Harazono et al (hereinafter 'Harazono').

Harazono teaches a filament winding system (Fig 1, 3, Para [0055]: 'The two drive rollers 2A and 2B are used for guiding the reinforcing yarn 10 of the fiber roll 1 to the supporter 3'), the system comprising:
a mandrel having a rotational axis, the mandrel having an outer surface extending circumferentially around the rotational axis (3, Fig 1, rotational axis around 26a,);
a motor for causing the mandrel to rotate about the rotation axis (Para [0057]: 'The shaft portion 36A is coupled with the motor (not shown) in the control unit 35. Thus, a rotational force for rotating the supporter 3 can be input to the shaft portion 36A. '); and
an energy source for directing energy toward a fiber wound around the outer surface of the mandrel (Para [0070]: 'the pressing members 31 to 34 are heated by passing a heating medium through the through-holes 31A to 34A of the pressing members 31 to 34. Thus, the resin layer 61 is heated by the pressing members 31 to 34 and is softened so as to have a desired viscosity', heat is taught being directed to the inside of the mandrel 3 directing heat to the fiber wound around it).

As the common features were known in the art, they cannot be considered special technical features that would otherwise unify the groups.

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