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24 April 2025 (24.04.2025)

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(54) Title: MODULAR MASS TRANSFER PACKING SYSTEM WITH INTEGRATED HEAT TRANSFER

(57) Abstract: A heat and mass transfer assembly is described, which in various implementations may be constituted as a packing element including a plate array including heat transfer plates and mass transfer plates in a modular structure in which the number of heat transfer plates and mass transfer plates may be varied to effect desired levels of heat and mass transfer, and multiple packing elements can be integrated in a heat and mass transfer packing assembly, to carry out a wide variety of fluid contacting processes.

INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER

IPC - INV. F28D 19/04 (2024.01)
ADD.

CPC - INV. F28D 19/042, F28D 19/041

ADD. F28D 19/04

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)
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 --- A	US 2021/0077978 A1 (UT-Battelle, LLC) 18 March 2021 (18.03.2021) Abstract, para [0042], [0065], [0068], [0070], [0075]-[0078], [0081], [0086]-[0090], Figure 1; Figure 2; Figure 4; Figure 5; Figure 6; Figure 7; Figure 9; Figure 10; Figure 11; Figure 12; Figure 16; Figure 17.	1, 3-5, 7-12, 21-31 ---------- 2, 6, 13-15, 19-20 ---------- 16-18, 32-39
Y	US 5,316,628 A (Collin et al.) 31 May 1994 (31.05.1994) Abstract, col 3 ln 28-29; col 4 ln 65 - col 5 ln 12; Figure 1.	2, 6, 20
Y --- A	US 3,744,320 A (White) 10 July 1973 (10.07.1973) Abstract, col 1 ln 61 - col 2 ln 2; Claim 1; Figure 1.	13-15, 19 ---------- 16-18, 32-33
Y	US 2016/0236992 A1 (United Technologies Corporation) 18 August 2016 (18.08.2016) Abstract, para [0007], [0054], [0083], Figure 1.	15
A	US 5,149,234 A (Durfee, Jr.) 22 September 1992 (22.09.1992) Abstract, col 4 ln 50-62; Figure 1; Figure 4.	16-18, 32-33

☒ 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

Date of the actual completion of the international search	Date of mailing of the international search report
2 October 2024	OCT 17 2024
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Kari Rodriquez 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.
A	US 2015/0233588 A1 (BE Power Tech LLC) 20 August 2015 (20.08.2015) Abstract, para [0089], Figure 1A; Figure 1B.	34-39
A	US 2,747,849 A (Colburn et al.) 29 May 1956 (29.05.1956) col 1 ln 15-17; col 2 ln 67 - col 3 ln 2; Figure 1.	34-39
A	WO 2013/094206 A1 (Sharp Kabushiki Kaisha) 27 June 2013 (27.06.2013) Entire Document.	1-39
A	US 6,179,276 B1 (Chen et al.) 30 January 2001 (30.01.2001) Entire Document.	1-39

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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 Supplemental Page)

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.:

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.

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Lack of Unity Box III:

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 1-24, directed to a heat and mass transfer assembly comprising a packing element.

Group II: Claims 25-31, directed to a fluid contacting process.

Group III: Claims 32-33, directed to a spot weld tufted heat and mass transfer plate.

Group IV: Claims 34-39, directed to a gas-liquid contacting plate array.

The group of inventions listed above 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 the special technical feature of an assembly comprising a packing element comprising a plate array including heat transfer plates and mass transfer plates arranged to contact respective fluids on the mass transfer plates, the heat transfer plates including interior heat exchange passages, the packing element further comprising heat exchange fluid flow circuitry connected to the heat transfer plates in the plate array to flow heat exchange fluid through the heat transfer plates in the interior heat exchange passages thereof and to discharge heat exchanged fluid from the heat transfer plates, not required by groups II-IV.

Group II requires the special technical feature of a fluid contacting process, comprising contacting fluids to effect mass transfer from one fluid to another fluid, wherein the contacting involves or mediates thermal effects, and wherein the contacting is carried out in a heat and mass transfer assembly, not required by groups I or III-IV.

Group III requires the special technical feature of a spot weld tufted heat and mass transfer plate comprising walls bonded to one another along their periphery and at spot welds spaced apart from one another so that the walls enclose and define an interior passage, a heat exchange fluid inlet and a heat exchange fluid outlet in communication with the interior passage, and an orifice in at least some of the spot welds, not required by groups I-II or IV.

Group IV requires the special technical feature of a gas-liquid contacting plate array comprising mass transfer plates arranged in substantially parallel horizontal alignment and vertically spaced apart relationship to one another in the plate array, with each mass transfer plate being perforate or permeable for gas upflow therethrough and having a top surface for support of liquid thereon, and with each mass transfer plate in the plate array terminating at a discharge edge above and overlying the top surface of a next-lower mass transfer plate in the plate array so that liquid discharged from an overlying mass transfer plate flows over the discharge edge thereof and falls through a discharge space onto the top surface of the next lower mass transfer plate in the plate array, the gas-liquid contacting plate array further comprising a heat pipe positioned so that a heat exchange section thereof is disposed in the discharge space of a mass transfer plate in the gas-liquid contacting plate array, not required by groups I-III.

Common Technical Features:

Groups I-IV share the technical feature of a heat and mass transfer assembly comprising: heat transfer plates and mass transfer plates in an array, at least some of the plates defining an interior passage.

These shared technical features, however, do not provide a contribution over the prior art, as being anticipated by US 2015/0233588 A1 to BE Power Tech LLC (hereinafter BE). BE teaches a heat and mass transfer assembly comprising: heat transfer plates and mass transfer plates in an array, at least some of the plates defining an interior passage (Figure 1A, 2011 and 2021; and Figure 1B; and Abstract, A heat and mass exchanger system is described; and para [0089], FIG. 1 a shows an embodiment of a heat and mass transfer device (2100) with distinct and separate heat transfer tubes (2001) and mass transfer tubes (2002), while FIG. 1 b is a cross-sectional view of FIG. 1 a The mass transfer tubes (2002) are retained by and sealed against two mass transfer manifold plates (2012). Longer heat transfer tubes (2001) are retained by and sealed against two heat transfer manifold plates (2011) and two mass transfer manifold plates (2012)... the coolant (2003) is introduced into heat transfer tubes (2001) parallel to and interspersed among mass transfer tubes (2002) carrying liquid desiccant (2004), which is introduced between the heat transfer manifold plate (2011) and the mass transfer manifold plate (2012); Note that Figure 1B depicts arrows that represent fluid flow through the heat transfer plates 2011 and the mass transfer plates 2012, thus defining interior passages).

As the technical features were known in the art, this cannot be considered a special technical feature that would otherwise unify the groups.

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