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Case Number: T 2013/09 - 3.2.03

Application Number: 02800360.6

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IPC: F28D 7/02, F28D 9/02, B01D 69/08, B01D 63/02, H01L 21/00

Language of the proceedings: EN

Title of invention:
A thermoplastic heat exchanger and method of making the same

Applicant:
Entegris, Inc.

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step (no)"

Decisions cited:
-

Catchword:
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Case Number: T 2013/09 - 3.2.03

D E C I S I O N
of the Technical Board of Appeal 3.2.03
of 11 May 2012

Appellant: (Applicant)
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Decision under appeal:
Decision of the Examining Division of the European Patent Office posted 3 June 2009 refusing European patent application No. 02800360.6 pursuant to Article 97(2) EPC.

Composition of the Board:

Chairman: U. Krause
Members: C. Donnelly
I. Beckedorf

Summary of Facts and Submissions

I. The appeal lies from the decision of the examining division posted 3 June 2009 refusing the European application no. 02800360.6.

II. In its decision, the examining division held that the subject-matter of claim 1 of the main and auxiliary requests filed with letter of 8 April 2009 not only lacked an inventive step starting out from WO-A-0044479 (D10) as the nearest prior art in combination with US-A-5066397 (E2) and US-A-3963622 (D1) or US-A-4175153 (D3) or EP-A-193 946 (D4), but also when taking E2 as the nearest prior art in combination with either US-A-3963622 (D1) or US-A-4175153 (D3) or EP-A-193 946 (D4).

III. The applicant (hereinafter "the appellant") filed a notice of appeal against this decision by letter received on 3 August 2009. The appeal fee was paid the same day. The grounds of appeal were received on 23 September 2009.

IV. In a communication dated 19 January 2012, pursuant to Article 15(1) RPBA annexed to the summons to oral proceedings, the Board informed the appellant of its provisional opinion. In particular, it indicated that D10 appeared to constitute the nearest prior art since it seemed to disclose the same bonding technique as that of the application. The Board also referred to the relevance of D4 and E2 to the question of inventive step.

V. The appellant responded to the summons to oral proceedings by letter of 9 March 2012 and filed amended

description pages 1, 5 to 12 and 14. By letter of 2 May 2012 the appellant filed a further document WO/0044482.

VI. Oral proceedings before the Board were held on 11 May 2012. At the end of the discussions, the appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of one of the sets of claims filed as main request and as first and second auxiliary requests with letter of 23 September 2009.

VII. *Main Request*

Independent apparatus claim 1 according to the main request reads as follows:

"A heat exchanger comprising a housing and:
a plurality of non-porous perfluorinated thermoplastic hollow tubes, each of said hollow tubes having a first end portion and a second end portion and hollows passing therebetween;
characterised by:
said first end portions of said hollow tubes being fusion bonded at least at a periphery of said hollow tubes through a perfluorinated thermoplastic resin to form a first unified terminal end block in which the end portions of said hollow tubes are fluid tightly bonded together with the resin;
said second end portions of said hollow tubes being fusion bonded at least at a periphery of said hollow tubes through a perfluorinated thermoplastic resin to form a second unified terminal end block in which the end portions of said hollow tubes are fluid tightly bonded together with the resin;

said first unified terminal end block and said second unified terminal end block having through hole communication with the hollows of the unbonded portions of said hollow tubes;
said first unified terminal end block having a first fluid inlet connection to supply a first fluid to said hollow tubes and said second unified terminal end block having a first fluid outlet connection to remove said first fluid from said hollow tubes; and
said hollow tubes having the configuration of a cord of hollow tubes braided or plaited together;
said housing being a perfluorinated thermoplastic housing fusion bonded by said resin to form a single entity consisting solely of fusion bonded perfluorinated thermoplastic materials, and having a first housing port wherein a second fluid enters the exchange apparatus and a second housing port wherein said second fluid exits the housing."

Independent method claim 3 of the main request reads:

"A method of making the a(sic) heat exchanger of claim 1 or 2, the method comprising:
a) forming a bundle consisting of the plurality of hollow tubes, said hollow tubes having a first end and a second end and to form at least one cord,
b) fusion bonding the first end of one or more said bundles of hollow tubes with perfluorinated thermoplastic resin to a first end of the housing to form a first unified terminal end block;
c) fusion bonding the second end of one or more said bundles of hollow tubes with perfluorinated thermoplastic resin to a second end of said housing to form a second unified terminal end block;

d) opening the hollow tube ends of the first and second unified terminal end blocks to provide for fluid flow through the hollow tubes fused with the resin; said unified terminal end blocks forming a single entity consisting solely of perfluorinated thermoplastic materials."

VIII. *Auxiliary requests*

The first auxiliary request is limited to claims 1 and 2 of the main request.

The sole independent claim of the second auxiliary request reads:

"A method of making a heat exchanger comprising a housing and:
a plurality of non-porous perfluorinated thermoplastic hollow tubes, each of said hollow tubes having a first end portion and a second end portion and hollows passing therebetween;
the heat exchanger being characterised by:
said first end portions of said hollow tubes being fusion bonded at least at a periphery of said hollow tubes through a perfluorinated thermoplastic resin to form a first unified terminal end block in which the end portions of said hollow tubes are fluid tightly bonded together with resin;
said second end portions of said hollow tubes being fusion bonded at least at a periphery of said hollow tubes through a perfluorinated thermoplastic resin to form a second unified terminal end block in which the end portions of said hollow tubes are fluid tightly bonded together with the resin;

said first unified terminal end block and said second unified terminal end block having through hole communication with the hollows of the unbonded portions of said hollow tubes;
said first unified terminal end block having a first fluid inlet connection to supply a first fluid to said hollow tubes and said second unified terminal end block having a first fluid outlet connection to remove said first fluid from said hollow tubes; and
said hollow tubes having the configuration of a cord of hollow tubes braided or plaited together;
said housing being a perfluorinated thermoplastic housing fusion bonded by said resin to form a single entity consisting solely of fusion bonded perfluorinated thermoplastic materials, and having a first housing port wherein a second fluid enters the exchange apparatus and a second housing port wherein said second fluid exits the housing, the method comprising:

a) forming a bundle consisting of the plurality of hollow tubes, said hollow tubes having a first end and a second end and to form at least one cord,
b) fusion bonding the first end of one or more said bundles of hollow tubes with perfluorinated thermoplastic resin to a first end of the housing to form a first unified terminal end block;
c) fusion bonding the second end of one or more said bundles of hollow tubes with perfluorinated thermoplastic resin to a second end of said housing to form a second unified terminal end block;
d) opening the hollow tube ends of the first and second unified terminal end blocks to provide for fluid flow through the hollow tubes fused with the resin; said

unified terminal end blocks forming a single entity consisting solely of perfluorinated thermoplastic materials."

IX. *Main request - Summary of appellant's case*

Claim 1 has been amended such that it is directed at a heat exchanger in which the thermoplastic tubes are non-porous as opposed to the previous claim which specified an exchanger device in general including ones employing porous thermoplastic tubes.

Document D10, relied upon by the examining division, describes a fully perfluorinated thermoplastic hollow fibre membrane fluid-fluid contactor. However, D10 does not describe a heat exchanger and is specifically concerned with mass transfer devices. A reference is made to a non-porous membrane, however, this is in fact a semi-porous membrane since it allows gas-transfer by diffusion.

Furthermore, D10 does not disclose that the hollow tubes are fusion bonded. This is borne out by the fact that D10 states at page 13, line 23 that the potting and bonding process is made according to the method described in US patent application 60/117,853 which corresponds to WO00/44480 (E1). This document specifies at page 14, lines 16 to 21 that the "fibres are not melted or degraded during the potting procedure". Since the fibres are not melted they cannot be fusion bonded.

D10 also does not disclose braiding or plaiting of the hollow tubes.

Since D10 does not disclose a heat-exchanger it cannot be considered as the nearest prior art.

Document E2 is also not concerned with heat exchangers, but rather with filter membranes since the hollow tubes used in the device are porous.

The bonding method used in E2 relies on the use of filling the end portions of the tubes with an inorganic filler like gypsum or silicic acid which is then removed. However, it is inevitable that some traces would be left, rendering the device unsuitable for high-purity applications as confirmed in WO-A-0044480 (E1) at page 5, lines 12 to 16.

E2 also does not disclose braiding or plaiting of the hollow tubes.

D4 does not disclose a heat exchanger. Further, it does not teach a plurality of perfluorinated thermoplastic hollow tubes in a braided or plaited configuration, fusion bonded to a perfluorinated thermoplastic resin to form a single entity consisting solely of fusion bonded perfluorinated thermoplastic materials.

Consequently, US-A-3315740 cited in the application is the most relevant art and the new claim 1 has been delimited against it.

The problem to which the application is directed is to construct a heat exchanger with non-porous tubes, fusion bonded to the housing and potting resin, which exhibits enhanced fluid distribution without the use of baffles.

Devices formed of perfluorinated polymers are more difficult to seal than corresponding devices formed of other polymers since when molten they are very viscous and entrap gas bubbles. Thus, fusion bonding of such devices is advantageous since it provides a regular opening at the tube ends and fluid tight seals in comparison with other methods.

Reasons for the decision

1. *Novelty, Main request*

1.1 Claim 1 is now directed at a "heat exchanger" comprising non-porous tubes as opposed to just an "exchanger" with either porous or non-porous tubes. The appellant has argued that the skilled man would understand that this designation rules out any devices which allow any form of mass transfer or cross pollution between the two fluids. However, the terms porous and non-porous are relative and depend on the type of fluids being conveyed and the operating pressure, neither of which is specified in the claim.

1.2 As the appellant admits, "non-porous" is used in D10 to mean a membrane that will permit the passage of smaller gas molecules by permeation and/or diffusion, but not of larger molecules such as liquids. Further, there does not appear to be any support in the application as filed for interpreting "non-porous" to mean gas diffusion is prevented.

1.3 In conclusion, particularly in view of the fact that all the examples of heat-exchangers in the application are for liquid to liquid exchangers, the Board considers that the device comprising the non-porous membrane of D10 would also be suitable for such a use.

1.4 Thus, D10 discloses a device comprising non-porous tubes suitable for use as a heat-exchanger and constitutes the nearest prior art.

1.5 The appellant has also disputed that D10 discloses the feature of:

"said first end portions of said hollow tubes being fusion bonded at least at a periphery of said hollow tubes through a perfluorinated thermoplastic resin to form a first unified terminal end block in which the end portions of said hollow tubes are fluid tightly bonded together with resin"

1.6 The bonding methods for joining the hollow tubes to the end-block are described from page 12, line 1 to page 14, line 2 of the application. In particular, explicit reference is made to WO00/44479 (D10) as disclosing the method to be used in the preferred embodiment (see page 12, line 7). D10 (see page 13, line 13 to page 14, line 19) describes "unitary end structures, by which is meant that the fibres and the pot are bonded to housing to form a single entity" (see page 14, lines 7 to 8). These are formed by a potting method using hot perfluorinated resin flowing under gravity to encapsulate the fibres and fusion bonding to the housing. D10 employs almost identical wording to that used in the application, in particular the same

preferred potting material (Hyflon® MFA940 AX) heated to the same temperature (270°C to 280°C in the application and 275°C in D10) is specified.

1.7 The appellant has argued that the method used in D10 is in fact that specified in E1, which specifically rules out fusion bonding. However, D10 states at page 13, line 23 that the method used is "an adaptation of the method described in US Patent application 60/117,853" and not that the exact method is used. Thus, in view of the indications cited above, the Board is convinced that D10 directly and unambiguously discloses the disputed feature.

1.8 Consequently, the subject-matter of claim 1 differs from that of the device disclosed in D10 by:

- said hollow tubes having the configuration of a cord of hollow tubes braided or plaited together.

1.9 Thus, the subject-matter of claim 1 is new.

2. *Inventive step, Main request*

2.1 However, this distinguishing feature is generally known in the art and is, for example, disclosed along with its use to promote turbulent flow, in D4, see page 2, lines 8 to 12. Contrary to the view expressed by the appellant, D4 would be consulted by the skilled person since it discloses a device for heat and/or mass transfer using hollow fibres (see Title: "Vorrichtung zur Wärme- und/oder Stoffübertragung mit Hilfe von Hohlfäden" and page 1, paragraph 1) and comes from the same technical area.

2.2 In view of this, it would be obvious for the skilled person seeking to solve the problem of improving the heat-transfer of the device known from D10 to incorporate this feature, since D4 gives a direct hint to do so.

2.3 Thus, the subject-matter of claim 1 does not meet the requirements of Article 56 EPC since it does not involve an inventive step.

3. *Auxiliary requests*

3.1 Claim 1 of the first auxiliary request is identical to claim 1 of the main request; hence, it is not allowable for the same reasons as the main request.

3.2 The analysis applied to claim 1 of the main request is also valid for the independent method claim 1 of the second auxiliary request. The deletion of the term "comprised of" and its replacement by "consists of" is of no consequence with respect to D10, since, in contrast to the method described in E2, no fillers are used in the tubes during the bonding process.

3.3 Thus, neither of the auxiliary requests comprises subject-matter involving an inventive step.

Order

For these reasons it is decided that:

The appeal is dismissed.

Registrar: Chairman:

D. Hampe U. Krause