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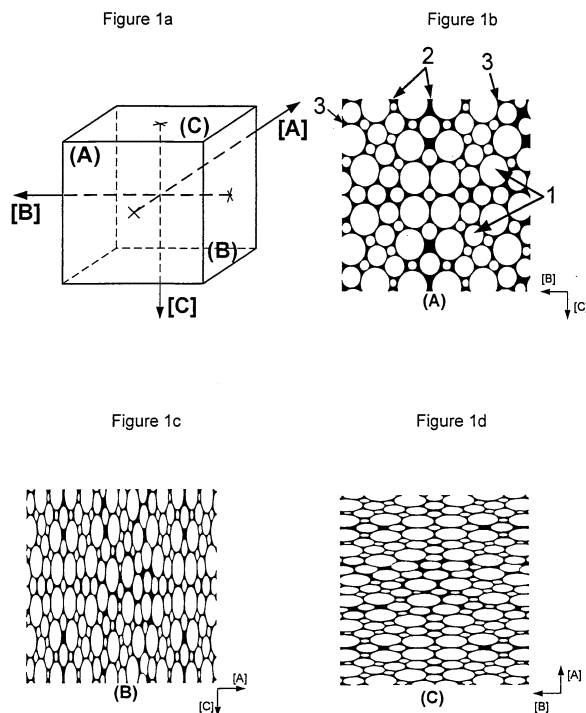
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 Amended claims in accordance with Rule 86 (2)
 EPC.

(54) **Flow management open-celled structures**

(57) The present invention relates to a three-dimensional, anisotropic, open-celled structure, specifically to an open-celled foam. It also relates to methods for man-

ufacturing an anisotropic, open-celled metallic foam, and to a heat exchanger, particularly to a two-fluid heat exchanger.

Figure 1



Description

[0001] The present invention relates to a three-dimensional, anisotropic, open-celled structure, specifically to an open-celled foam. It also relates to methods for manufacturing an anisotropic, open-celled metallic foam, and to a heat exchanger, particularly to a two-fluid heat exchanger.

[0002] Heat exchangers including open-celled metallic foam structures through which a liquid or gas phase can flow are already known. Such structures show a significant potential regarding the heat transfer performance mainly because they provide a high surface area per unit volume for effectively exchanging heat. The basic structures of such a kind are isotropic foams with properties being independent from any direction. However, in a disadvantage manner, these structures with high heat transfer performance show a flow resistance that is too large.

[0003] For this reason, further developments also propose gradient foams. DE 101 23 456 A1 has disclosed a heat exchanger consisting of metallic open-celled gradient foam. The cells of the disclosed foam are connected in such a way that a fluid can flow through it. The volume of the foam cells can vary along the path of the heat flux to be dissipated. Hence, a gradient and consequently an anisotropy in the thermal conductivity and in the flow resistance are achieved. It is intended to vary the cell volume depending on the temperature difference or the velocity of the heat transport, according to this invention. Further heat exchanger components are connected to the foam, whereas the components and the open-celled metallic foam can be cast in one piece.

[0004] DE 39 06 446 A1 has also disclosed a heat exchanger with a heat exchanger body containing channels the media can flow through. The inside of said channels are provided with a body made of foam through which the fluids can flow. The foam body has a variable pore size in radial direction relative to the channel axis. If the pore size increases in radial direction, then an increased flow of the medium will occur in the outside areas of the radius.

[0005] In addition, WO 02/42707 A1 discloses a heat exchanger including gradient metallic foam. The heat exchanger comprises flow passages for a first fluid, the outer wall of these passages being in heat-transferring contact with a body made of metallic foam through which a second fluid flows. This metal foam has a gradient regarding the volume density of the metal, so that it is possible to achieve a favorable equilibrium between heat transfer and conduction, on the one hand, and flow resistance, on the other hand.

[0006] Nevertheless, a disadvantage of gradient and isotropic foams remains in the comparatively large flow resistance obtained with the heat transfer performance.

[0007] The general objective of the invention is to improve the performance of open-celled foam structures and to manufacture the same cost-efficiently for various

applications.

[0008] The invention is described regarding the open-celled structure by the characteristics of claim 1, regarding the method of manufacturing by the characteristics of claim 11, 12, 15, and 16, and regarding the heat exchanger by the characteristics of claim 17 and 20. The further claims mentioned thereunder specify advantageous embodiments and further developments of the invention.

[0009] The invention includes the technical teaching to specify a three-dimensional, anisotropic, open-celled structure, wherein the properties of said structure remain constant in any individual direction in space. Particularly the structure according to the invention can be an open-celled foam.

[0010] This invention proposes an open-celled structure which is considered as anisotropic in its entirety and with regard to its spatial extension. Conventional anisotropic structures known under the state of the art are gradient foam structures as described above, wherein, for example, the size of the pores and/or the size of the ligaments varies continuously with regard to some of their cross sections. For this purpose, the open-celled structures according to this invention distinguish in that the three-dimensional network of ligaments and node points on which the open-celled structure is based is provided with a translation invariance, so that the macroscopic properties will remain constant in any individual direction in space. Macroscopic properties do not refer to single pores, but to volumes consisting of at least 3 pores in each direction in space. The arising difference in macroscopic properties with regard to the direction in space results from the anisotropy. In this invention the structure is considered anisotropic when the largest difference in the pore number, measured in two different linear direction in the same structure, does exceed 20%. In other words: The structure appears to be homogeneous in any direction in space, for example, homogeneous with regard to the shape, permeability or thermal conductivity. The structure has, for example, an appearance which is similar to an isotropic foam which is plastically deformed at least in one direction. As a result, the pores can take on a substantially lens-like or rod-like shape. In dependence upon the cut position, the open pores appear to be circular or ellipsoidal.

[0011] One particular advantage of such structures resides in the high thermal performance obtained with a small flow resistance. Boundary conditions such as the geometry, weight, flow resistance, and heat transfer are frequently defined depending on the application. Because of the variable foam geometry described in the present invention, it is possible to realize an easy and cost-effective adaptation to the mentioned criteria. This adaptability is for instance very important on the air side for air/refrigerant heat exchangers.

[0012] It is of particular interest for numerous applications to adjust said structures to the fluid flow. This is of particular interest in heat exchangers, because the heat

transfer performance is directly linked to the fluid flow. Fluids are liquid and gaseous media or mixtures thereof. A preferred embodiment in this respect is the property of a constant flow resistance when a fluid flows through. Due to the anisotropic structure, the fluid flow may encounter a different flow resistance, however, in view of the respective direction, said flow resistance is constant.

[0013] In general, a large number of materials can be considered to be suitable for open-celled structures. They can be selected for each specific application, whereby particularly the easy and cost-effective processing properties of the material should be considered. A particularly advantageous and thus preferred embodiment of the invention proposes that the open-celled structure can be made of metal, carbon or further ceramics, or composites. Different material combinations also guarantee a sufficient variability with regard to the respective constructive design.

[0014] Both, the entire volume of the pores as well as the distribution of pores play a significant role for the flow resistance encountered by flowing fluids. In an advantageous manner, the porosity, being defined as the ratio of the empty volume over the total volume, ranges between 80 % and 99 %. The spatial limitation of the individual pores volume lacks in case of open-celled structures. However, the volume of the pores can be defined by the space limited by ligaments and node points. The extent of the pore volumes and their distribution is usually described in the literature by the pore number of the structure, measured in any linear direction of the structure. According to a preferred embodiment of the invention, the number of pores can range between 1 and 100 ppi (pores per inch), measured in any linear direction. It is particularly advantageous to select a pore number between 5 and 60 ppi.

[0015] In case of open-celled structures, the geometry of the pores is predetermined by a three-dimensional cross-linking of ligaments and their shape. Normally, rounded ligaments are formed during manufacturing the structure, meeting each other at the node points. The ligaments are partially tapered, whereas the node points are thickened. A preferred embodiment of the invention proposes that it is possible to develop the ligaments cross section of said structure substantially in oval or polygonal shape. Through this embodiment, the boundary layer of the fluid flow can be developed either favorable or even inhibiting to the flow, in order to possibly regulate the heat transfer between the ligament materials and the fluid and in particular to promote it.

[0016] In a preferred manner, the ligaments can either be hollow or full. In fact hollow ligaments allow with relatively small material amount for a particular stability of the structure against mechanical stress, as well as for high surface area per unit volume.

[0017] A particularly advantageous and thus preferred modification of the invention provides to arrange additional macroscopic flow channels, partially or entirely penetrating the open-celled structure. Additional

channels are considered to be macroscopic if their volume differs from the pore volume of at least a factor of 5. Through this modification, fluids, especially liquid/gas mixtures can be drained off the structure favorably and easily during phase-change processes in heat exchangers. This is very important in case of condensation or evaporation processes.

[0018] Straight flow channels represent the easiest constructive design. In a preferred manner, the flow channels can also extend in meander or zigzag shape, wherein the fluid flow in the open-celled structure will be optimized.

[0019] A further aspect of the invention is a method for manufacturing an anisotropic, open-celled, metallic foam with full ligaments, comprising the following steps:

- using an open-celled foam, particularly a plastic foam, preferably a polyurethane foam, as a mold,
- casting a material, preferably a heat resistant material in liquid state, into the three-dimensional cavities of the mold and subsequently hardening it,
- removing the mold-forming material by appropriate treatment, particularly by heating or burning; wherein the remaining cast material then represents a negative form with cavities,
- pressure casting liquid metal in the remaining cavities and solidifying it, and,
- removing the negative form.

[0020] Heat resistant and dissolvable materials such as plaster, salt or ceramics can be used as cast material. The dissolution of these materials by appropriate solvents has to be free from any residues. Foams with full ligaments provide both a highly structural strength and a particularly high thermal conductivity.

[0021] As an alternative for foams with hollow ligaments, a further aspect of the invention proposes a method for manufacturing an anisotropic, open-celled metallic foam, comprising the following steps:

- using an open-celled foam, particularly a plastic foam, preferably a polyurethane foam, as a mold,
- spraying the mold with metallic particles to achieve a full and homogeneous coating of the mold surface,
- sintering the metallic particles, and removing the mold by appropriate treatment, particularly heat treatment.

[0022] To enable a homogeneous coating of the mold with metal particles, glue can for example be applied first to the surface. Foams with hollow ligaments provide a weight saving and are thus very advantageous.

[0023] According to a preferred development of the invention, a foam compressed in at least one direction is being used as a mold for the method for manufacturing a three-dimensional, anisotropic, open-celled structure. Compressed foams can either be deformed per-

manently or - as an alternative - elastic deformations can also be suitable if an appropriate supporting device is provided during the deformation process to stabilize this deformation. Deformations in one direction usually lead to lens-shaped pore structures, whereas deformations in two directions preferably perpendicular to one another lead to rod-shaped and rounded structures.

[0024] A preferred embodiment proposes the use of an anisotropic foam as a mold. This structure possesses already the constant properties in each direction in space according to the invention.

[0025] As an alternative for foams with full ligaments, a further aspect of the invention proposes a method for manufacturing an anisotropic, open-celled metallic foam, comprising the following steps:

- mixing and compacting space holders, particularly of heat-resistant material, with metallic particles, solvents and/or binders,
- removing the space holders, and then
- sintering the compacted metallic structure.

[0026] The space holders can originally have the geometrical shape of the pores generated during the sintering process. In this case, dissolvable materials such as plaster, salts, ceramics or resins are particularly appropriate as space holder material.

[0027] As an alternative for foams with full ligaments, a further aspect of the invention proposes a method for manufacturing an anisotropic, open-celled, metallic foam, comprising the following steps:

- compacting space holders, in particular of heat resistant material,
- pressure-casting liquid metal in the remaining cavities, and
- removing the space holders.

[0028] The space holders are made of a heat resistant material, withstanding the temperatures arising during the pressure cast process. Again, the geometrical shape of the space holders corresponds to the pores generated in the further course of the manufacture. And again, dissolvable materials, such as plaster, salts or ceramics are suitable.

[0029] According to a further aspect of the invention, a heat exchanger, in particular a two-fluid heat exchanger is provided which comprises a three-dimensional, anisotropic, open-celled structure according to the present invention. The foam used can serve different functions. On the one hand, the foam serves, for instance, for improving the heat transfer in the fluid flow. On the other hand, the foam can also be used for reducing the noise arising from the flow in the heat exchanger, e.g. at the air outlet of air/refrigerant heat exchangers. Furthermore, such foams can be used as supporting or stabilizing components in the constructive design.

[0030] According to a preferred embodiment, the heat

exchanger has at least one distribution element suitable for two-phase flows and at least one distribution element is partially or fully filled with a three-dimensional, anisotropic, open-celled structure. The structure serves for homogeneously distributing the liquid/gas mixture into the respective channels of the heat exchanger.

[0031] In an advantageous manner, the structure is shaped to provide favorable flow features, in particular of two-phase flows. In the use of foam structures according to the invention in two-phase heat exchangers, it means that the foam insert is shaped in order to reduce the flow resistance. For condensation processes the forming liquid has to be drained effectively out of the foam insert, whereas for evaporation processes, the forming vapor has to be disengaged rapidly out of the foam insert.

[0032] A further aspect of the invention proposes a heat exchanger, in particular a two-fluid heat exchanger, comprising on at least one fluid side a multi-layered structure of different three-dimensional, open-celled foams, wherein at least one layer is composed of a foam according to the invention. Each layer provides another function, for instance, regarding the heat transfer, noise reduction, or stability.

[0033] Exemplified embodiments of the invention will be described hereinafter in more detail with reference to the appended drawings, in which:

Figure 1a shows a cubic foam body with three directions in space perpendicular to one another in order to illustrate precisely the following figures;

Figures 1b-d show schematically the cross-section of an anisotropic foam structure, which section is perpendicular to the direction in space [A], [B], and [C], respectively, shown in Figure 1a;

Figure 2 shows schematically a cutout of a two-fluid heat exchanger according to the invention;

Figure 3 shows schematically a cutout of a two-fluid heat exchanger according to the invention, with additional macroscopic flow channels;

Figure 4 shows schematically a cutout of a two-fluid heat exchanger according to the invention, with foam inserts designed to provide favorable flow features.

[0034] In all figures, the corresponding components are provided with the same reference numbers.

[0035] Figure 1a shows a cubic body made of a foam structure with three directions in space [A], [B], and [C], perpendicular one to another. The directions in space

are perpendicular to the corresponding cross sections (A), (B), and (C). The aim of this figure is to precise the illustrations of the following figures.

[0036] Fig. 1b shows schematically the cross section of an anisotropic foam structure perpendicular to the direction [A]. The illustrated open-celled structure shows pores 1 in different sizes, whose sizes correspond to a statistical distribution. The porosity is defined by the ligaments 2 and the conjuncture of ligaments through node points 3. This cross section represents an isotropic structure.

[0037] Another cross section (B) of the anisotropic foam structure is shown in Figure 1c. The anisotropy is clarified in this cross-section, since the structure appears to be compressed in direction [A]. A compression in this direction affects the cross section (C), as shown in Figure 1d, so that it exhibits the same appearance than cross section (B).

[0038] Figures 2a and b show schematically a cutout of two cross-sections extending perpendicular to one another of a two-fluid heat exchanger according to the invention; the cutout is taken at a location where the heat exchange takes place. The illustration shows foam inserts 5 made of anisotropic, open-celled foam structure according to the invention, disposed between separating walls 4. In this example, flat tubes are utilized as separating walls 4. A first fluid 6 and a second fluid 7 flow through the foam structure and the tubes, respectively, so that both fluids run in cross flow, separated one from another. The anisotropic, open-celled foam according to the invention is oriented to provide simultaneously a small flow resistance for the first fluid 6 and enough heat exchange surface. Furthermore, this type of structure provides enough material at the contact areas between foam structure 5 and separating walls 4, where the heat needs essentially to be dissipated.

[0039] Figure 3a-c illustrates schematically a cutout of a two-fluid heat exchanger, similar to Figure 2. A first fluid 6 and a second fluid 7 flow again through the foam structure and the tubes, respectively, yet so that both fluids run in counterflow, separated one from another. The anisotropic open-celled foam is also oriented to simultaneously provide a small flow resistance for the first fluid 6 and enough heat exchange surface. In addition, macroscopic flow channels 8 are placed in the foam structure. Said channels allow fluids during phase-change processes, such as condensation or evaporation, to drain off the foam structure particularly favorably and easily. The flow channels 8 can have different rounded, squared or also stretched cross-sections, as shown in Figure 4b. Figure 4c shows examples for the channel run, such as a straight, a meander and a zigzag shape.

[0040] Figure 4a-c shows schematically a cutout of a two-fluid heat exchanger, similar to Figure 2. The anisotropic open celled-foam is again oriented to provide simultaneously a small flow resistance for the first fluid 6 and enough heat exchange surface. In addition, the

foam insert 5 is shaped for favorable flow, in particular for two-phase flows, such as condensation and evaporation. As an example, the wedge form void part at the exit of the flow channel (see Figure 4c) assists the forming vapor to exit the foam structure quicker, and hence enhances the evaporation process.

Nomenclature

[0041]

- 1 pores
- 2 ligaments
- 3 node points
- 4 separating wall
- 5 foam insert
- 6 first fluid
- 7 second fluid
- 8 macroscopic flow channels

[A], [B], [C] direction in space
(A), (B), (C) cross-section

Claims

1. A three-dimensional, anisotropic, open-celled structure, particularly an open-celled foam, **characterized in that** the properties of said structure remain constant in any individual direction in space.
2. An open-celled structure according to claim 1, **characterized in that** one of said properties is the constant flow resistance of fluids flowing through.
3. An open-celled structure according to claims 1 or 2, **characterized in that** said structure is made of metal, carbon or other ceramic, or composites.
4. An open-celled structure according to any one of the claims 1 to 3, **characterized in that** the porosity of said structure is between 80 and 99 %.
5. An open-celled structure according to any one of the claims 1 to 4, **characterized in that** the pore number of said structure, measured in any linear direction, ranges between 1 and 100 ppi.
6. An open-celled structure according to claim 5, **characterized in that** the pore number of said structure ranges between 5 and 60 ppi.
7. An open-celled structure according to any one of the claims 1 to 6, **characterized in that** the ligaments cross sections of said structure are substantially in oval or polygonal shape.
8. An open-celled structure according to any one of

the claims 1 to 7,

characterized in that the ligaments of said structure are hollow or full.

9. An open-celled structure according to any one of the claims 1 to 8, **characterized in that** said structure comprises additional macroscopic flow channels. 5
10. An open-celled structure according to claim 9, **characterized in that** said flow channels run in meander or zigzag fashion. 10
11. A method for manufacturing an anisotropic, open-celled, metallic foam according to any one of the claims 1 to 10, having full ligaments, comprising the following steps: 15
 - using an open-celled foam, in particular a plastic foam, preferably a polyurethane foam, as a mold, 20
 - casting a material, preferably a heat-resistant material in liquid state, into the three-dimensional cavities of the mold and subsequently hardening it, 25
 - removing the mold-forming material by way of appropriate treatment, particularly by heating or burning; wherein the remaining cast material then constitutes a negative form with cavities, 30
 - pressure casting the liquid metal in the remaining cavities and solidifying it, and, 35
 - removing the negative form.
12. A method for manufacturing an anisotropic, open-celled, metallic foam according to any one of the claims 1 to 10, having hollow ligaments, comprising the following steps: 40
 - using an open-celled foam, in particular a plastic foam, preferably a polyurethane foam, as a mold, 45
 - layering the mold with metallic particles to achieve a full and homogeneous coating of the entire mold surface,
 - sintering the metallic particles, and removing the mold by way of appropriate treatment, particularly heat treatment.
13. A method for manufacturing a three-dimensional, anisotropic, open-celled structure according to claim 11 or 12, **characterized in that** a foam compressed in at least one direction is used for said mold. 50
14. A method for manufacturing a three-dimensional, anisotropic, open-celled structure according to claim 11 or 12, **characterized in that** an anisotropic foam is used for said mold. 55

15. A method for manufacturing an anisotropic, open-celled, metallic foam according to any one of the claims 1 to 10, having full ligaments, comprising the following steps:

- mixing and compacting space holders, particularly of heat resistant material, with metallic particles, solvents and/or binders,
- removing the space holders, and then
- sintering the compacted metallic structure.

16. A method for manufacturing an anisotropic, open-celled, metallic foam according to any one of the claims 1 to 10, having full ligaments, comprising the following steps:

- compacting space holders, in particular of heat resistant material,
- pressure casting the liquid metal in the remaining cavities, and
- removing the space holders.

17. A heat exchanger, particularly a two-fluid heat exchanger, **characterized in that** said heat exchanger is provided with a three-dimensional, anisotropic, open-celled structure according to one of the preceding claims 1 to 10.

18. A heat exchanger according to claim 17, **characterized in that** said heat exchanger comprises at least one distribution element for two-phase flows and that at least one distribution element is partially or fully filled with a three-dimensional, anisotropic, open-celled structure.

19. A heat exchanger according to claim 17 or 18, **characterized in that** said structure is shaped to provide favorable flow features, in particular for two-phase flows.

20. A heat exchanger, particularly a two-fluid heat exchanger, **characterized in that** said heat exchanger comprises a multi-layered structure of different three-dimensional, open-celled foams on at least one fluid side, wherein at least one layer is composed of a foam according to one of the preceding claims 1 to 10.

Amended claims in accordance with Rule 86(2) EPC.

1. A two-fluid heat exchanger, **characterized in that** said heat exchanger is provided with a three-dimensional, anisotropic, open-celled foam consisting of a three-dimensional network of ligaments and node points forming lens-like or rod-like shaped pores.

2. A two-fluid heat exchanger, **characterized in that** said heat exchanger comprises a multi-layered structure of different three-dimensional, open-celled foams on at least one fluid side, wherein at least one layer is composed of an anisotropic foam consisting of a three-dimensional network of ligaments and node points forming lens-like or rod-like shaped pores. 5
3. A two-fluid heat exchanger according to claims 1 or 2, **characterized in that** said foam is made of metal, carbon or other ceramic, or composites. 10
4. A two-fluid heat exchanger according to any one of the claims 1 to 3, **characterized in that** the porosity of said foam is between 80 and 99 %. 15
5. A two-fluid heat exchanger according to any one of the claims 1 to 4, **characterized in that** the pore number of said foam, measured in any linear direction, ranges between 1 and 100 ppi. 20
6. A two-fluid heat exchanger according to claim 5, **characterized in that** the pore number of said foam ranges between 5 and 60 ppi. 25
7. A two-fluid heat exchanger according to any one of the claims 1 to 6, **characterized in that** the ligaments cross sections of said foam are substantially in oval or polygonal shape. 30
8. A two-fluid heat exchanger according to any one of the claims 1 to 7, **characterized in that** the ligaments of said foam are hollow or full. 35
9. A two-fluid heat exchanger according to any one of the claims 1 to 8, **characterized in that** said foam comprises additional macroscopic flow channels. 40
10. A two-fluid heat exchanger according to claim 9, **characterized in that** said flow channels run in meander or zigzag fashion. 45
11. A two-fluid heat exchanger according to any one of the claims 1 to 10, **characterized in that** said heat exchanger comprises at least one distribution element for two-phase flows and that at least one distribution element is partially or fully filled with a three-dimensional, anisotropic, open-celled foam. 50
12. A two-fluid heat exchanger according to any one of the claims 1 to 11, **characterized in that** said foam is shaped to provide favorable flow features, in particular for two-phase flows. 55
13. A method for manufacturing an anisotropic, open-celled, metallic foam for a two-fluid heat exchanger according to any one of the claims 1 to 12,

having full ligaments, comprising the following steps:

- using an anisotropic open-celled foam, in particular a plastic foam, preferably a polyurethane foam, as a mold,
- casting a material, preferably a heat-resistant material in liquid state, into the three-dimensional cavities of the mold and subsequently hardening it,
- removing the mold-forming material by way of appropriate treatment, particularly by heating or burning; wherein the remaining cast material then constitutes a negative form with cavities,
- pressure casting the liquid metal in the remaining cavities and solidifying it, and,
- removing the negative form.

14. A method for manufacturing an anisotropic, open-celled, metallic foam for a two-fluid heat exchanger according to any one of the claims 1 to 12, having hollow ligaments, comprising the following steps:

- using an anisotropic open-celled foam, in particular a plastic foam, preferably a polyurethane foam, as a mold,
- layering the mold with metallic particles to achieve a full and homogeneous coating of the entire mold surface,
- sintering the metallic particles, and removing the mold by way of appropriate treatment, particularly heat treatment.

15. A method for manufacturing a three-dimensional, anisotropic, open-celled foam according to claim 13 or 14, **characterized in that** the foam used for said mold is compressed in at least one direction.

16. A method for manufacturing an anisotropic, open-celled, metallic foam for a two-fluid heat exchanger according to any one of the claims 1 to 12, having full ligaments, comprising the following steps:

- mixing and compacting lens-like or rod-like shaped space holders, particularly of heat resistant material, with metallic particles, solvents and/or binders,
- removing the space holders, and then sintering the compacted metallic structure.

17. A method for manufacturing an anisotropic, open-celled, metallic foam for a two-fluid heat exchanger according to any one of the claims 1 to 12, having full ligaments, comprising the following steps:

- compacting lens-like or rod-like shaped space holders, in particular of heat resistant material,
- pressure casting the liquid metal in the remaining cavities, and removing the space holders.

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Figure 1

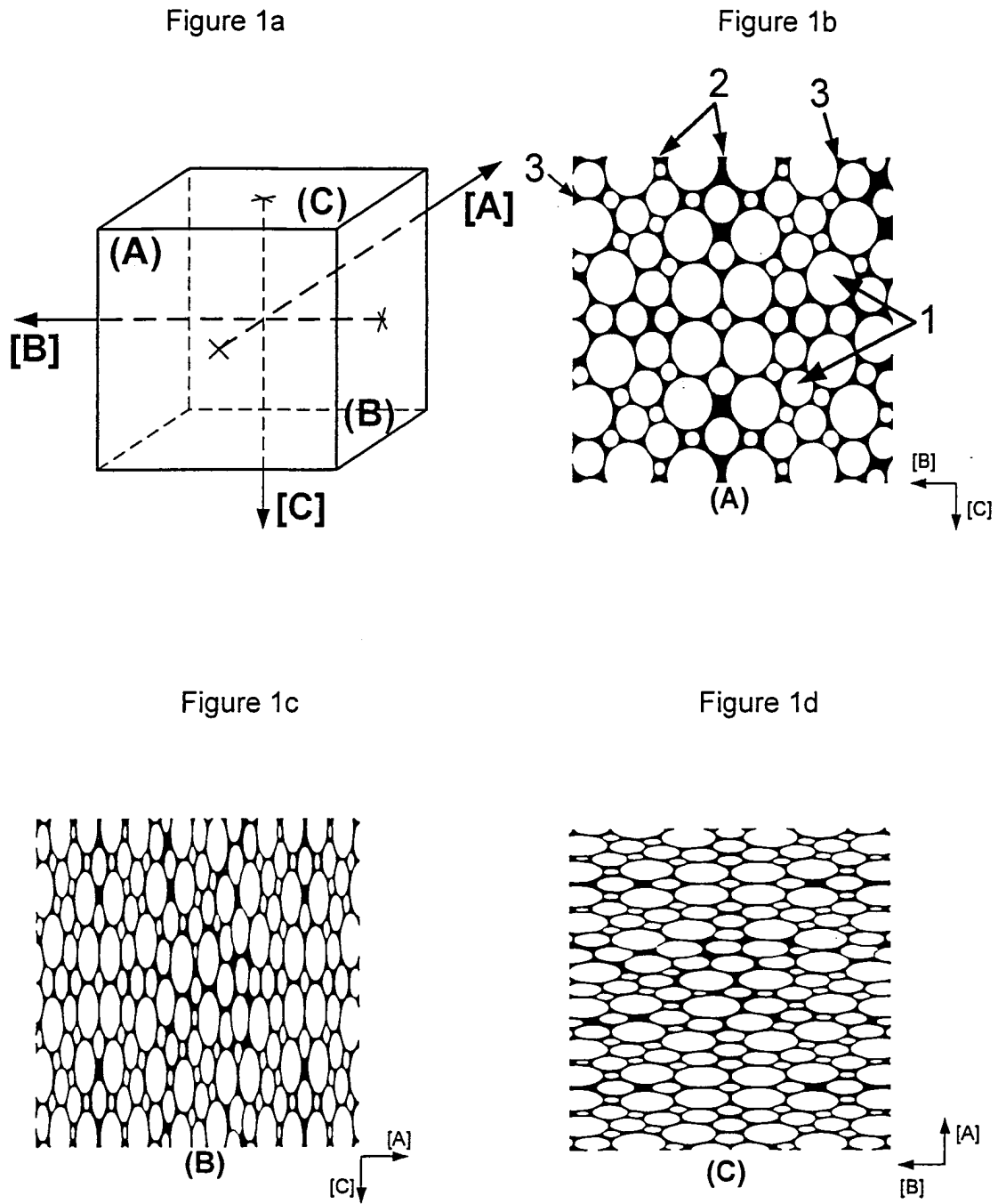


Figure 2

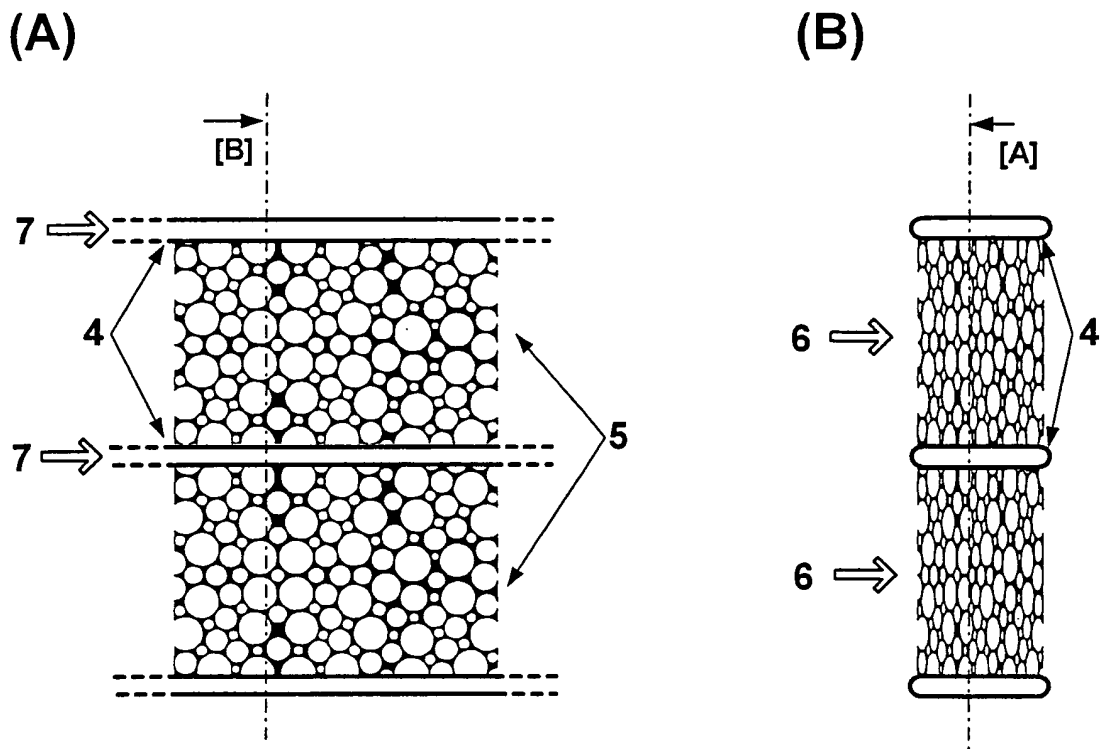


Figure 3

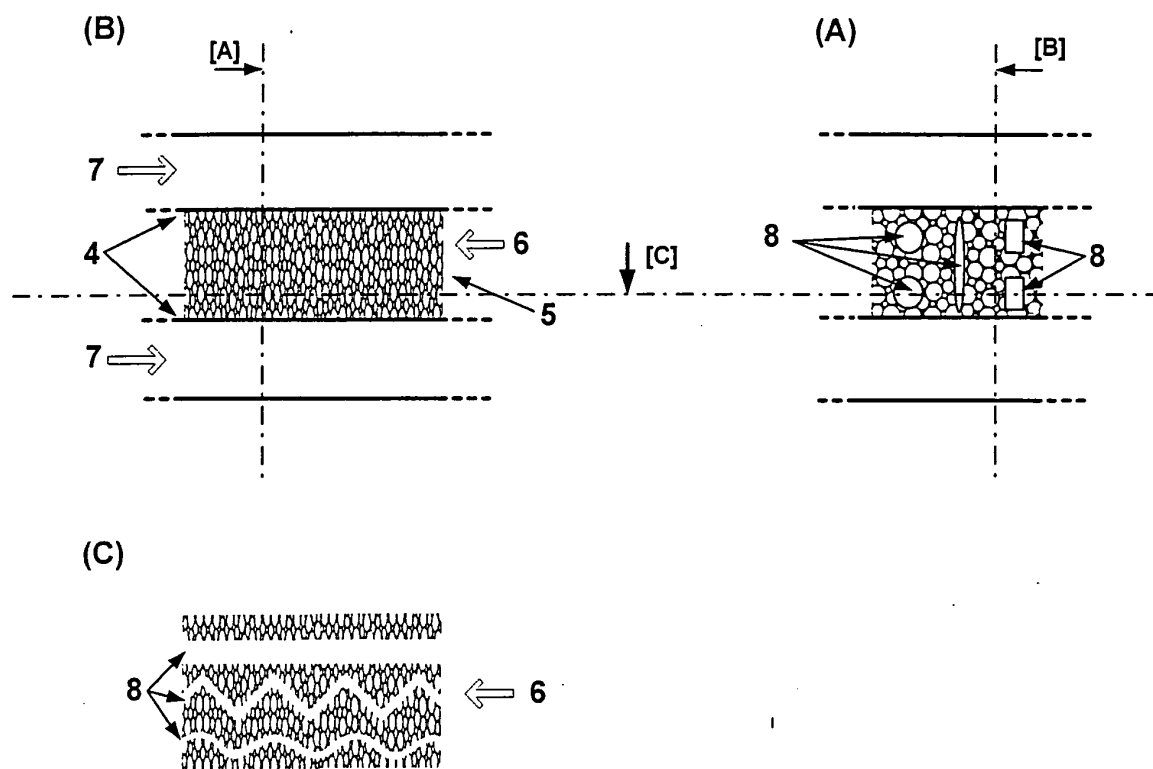
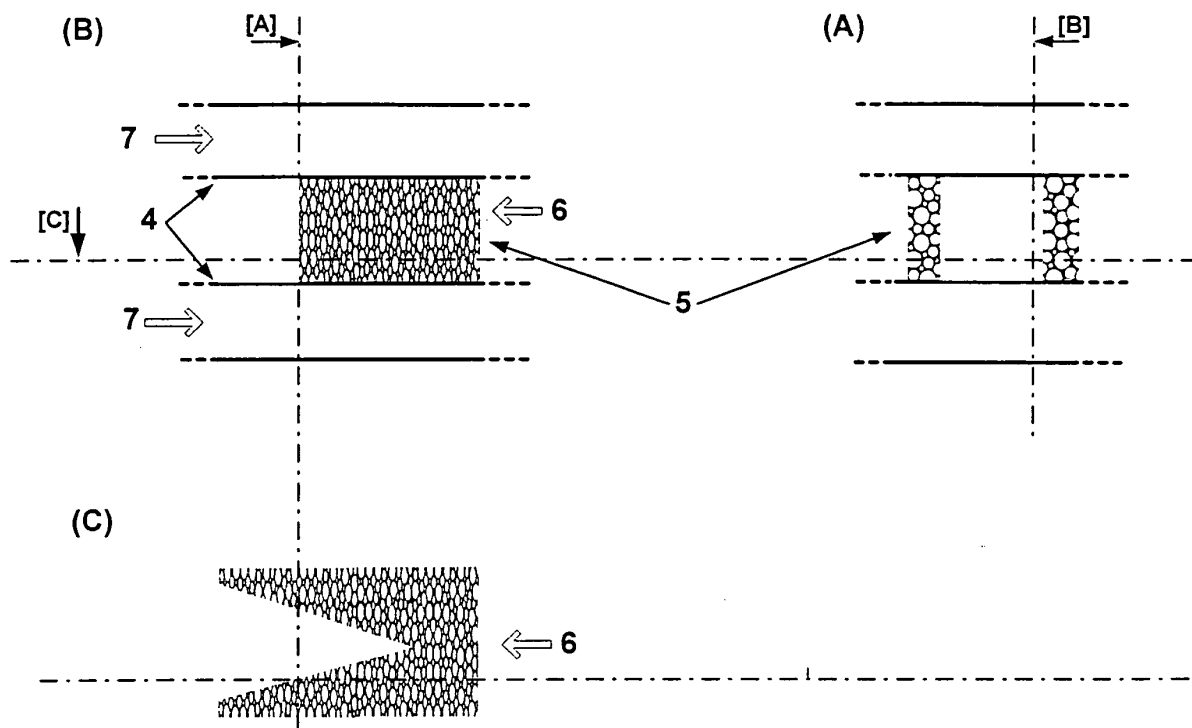


Figure 4





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 03 02 6915

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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The present search report has been drawn up for all claims			
Place of search MUNICH		Date of completion of the search 13 May 2004	Examiner Mellado Ramirez, J
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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EPO FORM 1503 03 82 (P04C01)



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Application Number
EP 03 02 6915

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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