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(54) **Heat exchanger and method of manufacure thereof**

Wärmetauscher und Herstellungsverfahren dafür

Échangeur thermique et son procédé de fabrication

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(56) References cited:
NL-C1- 1 014 832

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Description

[0001] The present invention relates to a heat exchanger and a method of manufacture thereof, and in particular to a hear exchanger for use in a vehicle.

[0002] Heat exchangers are used in vehicles to cool engine coolant, to cool charge air and to heat and/or cool refrigerant in a vehicle air conditioning system. The present invention has particular application to heat exchangers which are suitable for use as gas coolers or evaporators wherein a supercritical refrigerant, such as CO2, is used. Carbon dioxide refrigerant is being considered as a replacement refrigerant for use by the automotive industry for air conditioning, as well as in other applications, mainly due to the low toxicity of such refrigerant. However, carbon dioxide based systems have many challenges resulting from the fact that such systems operates in transcritical mode leading to high pressures and high compressor out temperatures. When CO2 is used as refrigerant, very high pressures in the range of up to more than 130 bar have to be produced. The pressure loading on individual components of an air-conditioning system therefore rises significantly.

[0003] The present invention relates to a heat exchanger, of the type shown in NL-C1-1014832, having a cooling core consisting of a plurality of heat exchanging tubes arranged in parallel rows extending between a pair of manifolds provided with slots, where the ends of said heat exchanging tubes are inserted into said slots to be in fluid connection with each manifold, each row including at least two tubes arranged side by side to provide a cross flow arrangement. A method of manufacturing such a heat exchanger manifold is also provided.

[0004] In a desire to improve efficiency, it is common to provide heat exchangers having a number of side by side tubes arranged across the width of the heat exchanger to provide a cross flow arrangement whereby a refrigerant or coolant can make several passes between the manifolds across the width of the core of the heat exchanger through adjacent side by side tubes in each row. Where separate tubes are used for each pass in a row, each tube needs to be inserted into a corresponding slot in each manifold. The slots are usually lanced into the manifold, forming localised deformation around the slot, in order to accommodate such deformation and provide sufficient strength and room for brazing, it is necessary to leave gap of at least 2 to 6mm between adjacent side by side tubes. This gap comprises wasted space and leads to a non-optimum overall heat exchanger core depth.

[0005] According to the present invention there is provided a heat exchanger comprising a cooling core consisting of a plurality of heat exchanging tubes arranged in parallel rows extending between a pair of manifolds provided with slots, where the ends of said heat exchanging tubes are inserted into said slots to be in fluid communication with each manifold, each row including at least two coplanar tubes arranged side by side for providing a cross flow arrangement, wherein an end region of a first tube in each row is offset orthogonally to the normal direction of flow of fluids through the cooling core in a first direction and an end region of a second tube in the same row is offset orthogonally to the normal direction of flow of fluids through the cooling core in a second direction, opposite to said first direction, such that the respective slots for receiving the ends of said first and second tubes are axially offset with respect to one another whereby the first and second tubes in each row can be located in abutting contact with one another.

[0006] Therefore the present invention solves the problem associated with the prior art by enabling the slots for receiving adjacent tubes to be axially offset from one another in overlapping manner, permitting the tubes in each row to be arranged in close abutting relationship, thus avoiding wasted space and optimising the depth of the heat exchanger core.

[0007] Preferably the orthogonal offset of each tube end region is such that the axial distance between adjacent manifold slots is substantially equal to half the spacing between adjacent rows of tubes.

[0008] Preferably the interior of each manifold is divided by means of at least one axially extending dividing wall extending between the ends of the adjacent tubes in each row, a side of the dividing wall adjacent the tube ends being serpentine in shape to fit between said respective slots.

[0009] Preferably fins are provided between the rows of tubes, the fins between each pair of adjacent rows each comprising a plate formed into a zigzag or wave-like configuration to extend between the respective adjacent rows of tubes. Preferably end regions of each plate are split into a first section extending between respective first tubes of the respective adjacent rows and a second section extending between respective second tubes of the respective adjacent rows.

[0010] According to a further aspect of the present invention there is provided a method of making a heat exchanger comprising providing a plurality of heat exchanging tubes arranged in parallel rows, providing a pair of manifolds having a plurality of tube receiving slots formed therein, inserting the ends of said heat exchanging tubes into said slots to be in fluid connection with each manifold, each row including at least two tubes arranged side by side for providing a cross flow arrangement, wherein an end region of a first tube in each row is offset orthogonally to the normal direction of flow of fluids through the cooling core in a first direction and an end region of a second tube in the same row is offset orthogonally to the normal direction of flow of fluids through the cooling core in a second direction, opposite to said first direction, such that the respective slots for receiving the ends of said first and second tubes are axially offset with respect to one another whereby the first and second tubes in each row can be located in abutting contact with one another.

[0011] A preferred embodiment of the present invention will now be described, by way of example only, with

reference to the accompanying drawings, in which:-

Fig. 1 is a perspective view of a heat exchanger according to an embodiment of the invention, an outer part of the manifold being omitted for clarity;

Fig. 2 is a side view of the heat exchanger of Fig. 1;

Fig. 3 is an end view of the heat exchanger of Fig. 1;

Fig. 4 is a perspective view of a manifold partition wall of the heat exchanger of Fig. 1;

Fig. 5 is a further perspective view of the partition wall of Fig. 4;

Fig. 6 is a perspective view of the heat exchanger of Fig.1 showing the position of the partition wall;

Fig. 7 is a side view of the heat exchanger of Fig. 1 showing the location of the fins;

Fig. 8 is a detail perspective view of the fins; and

Fig. 9 is a further perspective view of the fins.

[0012] Figs. 1 to 3 illustrate one side of a heat exchanger according to an embodiment of the present invention comprising a cooling core consisting of a plurality of heat exchanging tubes 2,4 arranged in parallel rows extending between a pair of manifolds 6 (only an inner wall of one side shown) provided with slots 8,10, where the ends of said heat exchanging tubes 2,4 are inserted into the slots 8,10 to be in fluid connection with each manifold.

[0013] Each row of tubes comprises a pair of coplanar tubes 2,4 arranged side by side for providing a cross flow arrangement, a first tube 2 providing a flow path in a first direction and a second tube 4 providing a parallel return flow path in an opposite direction.

[0014] An end region 12 of the first tube 2 in each row is offset orthogonally to the normal direction of flow of fluids through the cooling core in a first direction. An end region 14 of the second tube 4 in the same row is offset orthogonally to the normal direction of flow of fluids through the cooling core in a second direction, opposite to said first direction, again by a distance equal to half the row spacing, such that the respective slots for receiving the ends of said first and second tubes are axially offset with respect to one another by a distance A equal to half of the row spacing B, whereby the first and second tubes 2,4 in each row can be located in abutting side by side contact with one another while the slots can be formed in overlapping relationship without the side walls of adjacent slots interfering with one another.

[0015] In order to divide the manifold 6 into delivery and return chamber, a dividing wall 20 extends along the axial length thereof inside the manifold 6 to divide the manifold into two halves. To accommodate the overlap of the slots 8,10, a side region 22 of the wall 20 in contact with the slotted inner wall of the manifold is formed in a serpentine manner, as illustrated in Figs. 4 to 6.

[0016] As illustrated in Figs. 7 to 9, fins 30 are provided between adjacent rows of tube to provide reinforcement of the tubes and to enhance heat transfer. Such fins are typically formed from single sheets 32 for metal, folded or bent into a zigzag or wavy pattern to fit between the rows of tubes.

[0017] In order to the problem of air leakage between the offset end regions 12,14 of the first and second tubes 2,4 in adjacent rows, the end region of the sheets 32 defining the ribs are split so that the sheet is divided into two sections 34,36, a first section 34 extending between offset end regions 12 of respective pairs of first tubes 2 in adjacent rows and a second section 36 extending between offset end regions 14 of section of respective pairs of second tubes 4 in adjacent rows. Alternatively two parallel rows of fins may be provided, one for each adjacent pair of the first and second tubes 2,4.

[0018] Various modifications and variations to the described embodiment of the invention will be apparent to those skilled in the art without departing from the scope of the invention as defined in the appended claims. Although the invention has been described in connection with a specific preferred embodiment, it should be understood that the invention as claimed should not be unduly limited to such specific embodiment.

Claims

1. A heat exchanger comprising a cooling core consisting of a plurality of heat exchanging tubes (2.4) arranged in parallel rows extending between a pair of manifolds (6) provided with slots (8,10), where the ends of said heat exchanging tubes (2,4) are inserted into said slots (8,10) to be in fluid communication with each manifold (6), each row including at least two coplanar tubes (2,4) arranged side-by-side for providing a cross flow arrangement, **characterised in that** an end region (12) of a first tube (2) in each row is offset orthogonally to the normal direction of flow of fluids through the cooling core in a first direction and an end region (14) of a second tube (4) in the same row is offset orthogonally to the normal direction of flow of fluids through the cooling core in a second direction, opposite to said first direction, such that the respective slots (8,10) for receiving the ends of said first and second tubes are axially offset with respect to one another whereby the first and second tubes (2,4) in each row can be located in abutting contact with one another.

2. A heat exchanger as claimed in claim 1, wherein the orthogonal offset of each tube end region (12,14) is such that the axial distance (A) between adjacent manifold slots is substantially equal to half the spac-

ing (B) between adjacent rows of tubes (2,4).

3. A heat exchanger as claimed in claim 1 or claim 2, wherein the interior of each manifold (6) is divided by means of at least one axially extending dividing wall (20) extending between the ends of the adjacent tubes (2,4) in each row, a side (22) of the dividing wall (20) adjacent the tube ends being serpentine in shape to fit between said respective slots (8,10).

4. A heat exchanger as claimed in any preceding claim, wherein fins (30) are provided between the rows of tubes (2,4), the fins (30) between each pair of adjacent rows each comprising a sheet (32) formed into a zigzag or wave-like configuration to extend between the respective adjacent rows of tubes (2,4).

5. A heat exchanger as claimed in claim 4, wherein end regions of each sheet (32) are split into a first section (34) extending between respective first tube (2) of the respective adjacent rows and a second section (36) extending between respective second tube (4) of the respective adjacent rows.

6. A heat exchanger as claimed in any preceding claim, wherein of each of said plurality of heat exchanging tubes (2,4) comprises a flat tube having a plurality of parallel flow passageways extending therethrough.

7. A method of making a heat exchanger having a cooling core, comprising providing a plurality of heat exchanging tubes (2,4) arranged in parallel rows, providing a pair of manifolds (6) having a plurality of tube receiving slots (8,10) formed therein, inserting the ends of said heat exchanging tubes (2,4) into said slots (8,10) to be in fluid connection with each manifold (6), each row including at least two tubes (8,4) arranged side by side for providing a cross flow arrangement, **characterised in that** an end region (12) of a first tube (2) in each row is offset orthogonally to the normal direction of flow of fluids through the cooling core in a first direction and an end region (14) of a second tube (4) in the same row is offset orthogonally to the normal direction of flow of fluids through the cooling core in a second direction, opposite to said first direction, such that the respective slots (8,10) for receiving the ends of said first and second tubes are axially offset with respect to one another whereby the first and second tubes (2,4) in each row can be located in abutting contact with one another.

8. A method as claimed in claim 7, wherein the orthogonal offset of each tube end region (12,14) is such that the axial distance (A) between adjacent manifold slots (8,10) is substantially equal to half the spacing (B) between adjacent rows of tubes (2,4).

Patentansprüche

1. Wärmetauscher mit einem Kühlungskern, welcher aus mehreren, in parallelen Reihen angeordneten, und sich zwischen einem mit Schlitzen (8,10) versehenen Paar von Verteilern (6) erstreckenden Wärmerohren (2.4) besteht, wobei die Enden dieser Wärmerohre (2,4) in die Schlitze (8,10) eingesetzt sind, um mit jedem Verteiler (6) im laufenden Flüssigkeitsaustausch zu stehen, und jede Reihe zumindest zwei auf der gleichen Ebenen liegende, nebeneinander angeordnete Rohre (2,4) umfasst, um eine Querströmung bereitzustellen, **dadurch gekennzeichnet, dass** ein Endbereich (12) eines ersten Rohres (2) in jeder Reihe rechtwinklig zur normalen Flussrichtung der Flüssigkeiten durch den Kühlungskern in einer ersten Richtung angeordnet ist, und ein Endbereich (14) eines zweiten Rohres (4) in der gleichen Reihe rechtwinklig zur normalen Flussrichtung der Flüssigkeiten durch den Kühlungskern in einer zweiten, der ersten Richtung entgegengesetzten Richtung angeordnet ist, sodass die jeweiligen Schlitze (8,10) zum Empfang der Enden des ersten und zweiten Rohres im Verhältnis zueinander in einem axialen Abstand zueinander angeordnet sind, wobei das erste und zweite Rohr (2,4) in jeder Reihe einander benachbart sein und einander berühren können.

2. Wärmetauscher gemäß Anspruch 1, wobei der rechtwinklige Abstand jedes Rohrendbereichs (12,14) solchermaßen ist, dass der Achsenabstand (A) zwischen benachbarten Verteilerschlitzen überwiegend die Hälfte des Abstands (B) zwischen benachbarten Rohrreihen (2,4) beträgt.

3. Wärmetauscher gemäß Anspruch 1 oder 2, wobei das Innere jedes Verteilers (6) durch zumindest eine, sich entlang der Achse erstreckende Trennwand (20) abgeteilt wird, welche sich zwischen den Enden der benachbarten Rohre (2,4) in jeder Reihe erstreckt, und eine Seite (22) der Trennwand (20) den Rohrenden benachbart gewellt ist, um zwischen die jeweiligen Schlitze (8,10) zu passen.

4. Wärmetauscher gemäß einem der vorstehenden Ansprüche, wobei zwischen den Rohrreihen (2,4) Rippen (30) bereitgestellt werden, welche zwischen jedem Paar benachbarter Reihen jeweils ein zickzack-förmiges oder gewelltes Blech (32) umfassen, welches sich zwischen den jeweils benachbarten Rohrreihen (2,4) erstreckt.

5. Wärmetauscher gemäß Anspruch 4, wobei die Endbereiche jedes Blechs (32) in einen ersten, sich zwischen dem jeweils ersten Rohr (2) der benachbarten Reihen erstreckenden Bereich (34) und einem zweiten, sich zwischen dem jeweils zweiten Rohr (4) der

jeweils benachbarten Reihen erstreckenden Bereich (36) aufgeteilt werden.

6. Wärmetauscher gemäß einem der vorstehenden Ansprüche, wobei jedes der mehreren Wärmerohre (2,4) ein flaches Rohr mit mehreren parallelen Durchflusskanälen umfasst.

7. Verfahren, einen Wärmetauscher mit einem Kühlungskern zu versehen, mehrere Wärmerohre (2,4) umfassend, welche in parallelen Reihen angeordnet sind, und ein Paar von Verteilern (6) bereitzustellen, welche mehrere Schlitze (8,10) aufweisen, um Rohre aufzunehmen, wobei die Enden der Wärmerohre (2,4) in diese Schlitze (8,10) für den laufenden Flüssigkeitsaustausch mit jedem Verteiler (6) eingeführt werden, und jede Reihe zumindest zwei Rohre (8,4) umfasst, welche nebeneinander angeordnet sind, um eine Querströmung bereitzustellen, **dadurch gekennzeichnet, dass** ein Endbereich (12) eines ersten Rohres (2) in jeder Reihe rechtwinklig zur normalen Flussrichtung der Flüssigkeiten durch den Kühlungskern in einer ersten Richtung angeordnet ist, und ein Endbereich (14) eines zweiten Rohres (4) in der gleichen Reihe rechtwinklig zur normalen Flussrichtung der Flüssigkeiten durch den Kühlungskern in einer zweiten, der ersten Richtung entgegengesetzten Richtung angeordnet ist, sodass die jeweiligen Schlitze (8,10) zum Empfang der Enden des ersten und zweiten Rohres im Verhältnis zueinander in einem axialen Abstand zueinander angeordnet sind, wobei das erste und zweite Rohr (2,4) in jeder Reihe einander benachbart sein und einander berühren können.

8. Verfahren gemäß Anspruch 7, wobei der rechtwinklige Abstand jedes Rohrendbereichs (12,14) solchermaßen ist, dass der Achsenabstand (A) zwischen benachbarten Verteilerschlitzen (8,10) überwiegend die Hälfte des Abstands (B) zwischen benachbarten Rohrreihen (2,4) beträgt.

Revendications

1. Échangeur de chaleur comprenant un coeur de refroidissement constitué d'une pluralité de tubes échangeurs de chaleur (2, 4) agencés en rangées parallèles s'étendant entre une paire de collecteurs (6) dotés de fentes (8, 10), dans lequel les extrémités desdits tubes échangeurs de chaleur (2, 4) sont insérées dans lesdites fentes (8, 10) pour être en communication fluidique avec chaque collecteur (6), chaque rangée incluant au moins deux tubes coplanaires (2, 4) agencés côte à côte pour réaliser un agencement à flux croisés, **caractérisé en ce qu'**une région terminale (12) d'un premier tube (2) dans chaque rangée est décalée orthogonalement à la direction normale de l'écoulement des fluides à travers le coeur de refroidissement dans une première direction, et **en ce qu'**une région terminale (14) d'un second tube (4) dans la même rangée est décalée orthogonalement à la direction normale de l'écoulement des fluides à travers le coeur de refroidissement dans une seconde direction, opposée à ladite première direction, de sorte que les fentes respectives (8, 10) pour recevoir les extrémités dudit premier et dudit second tube sont axialement décalées l'une par rapport à l'autre, grâce à quoi le premier et le second tube (2, 4) dans chaque rangée peuvent être placés en contact en aboutement l'un avec l'autre.

2. Échangeur de chaleur selon la revendication 1, dans lequel le décalage orthogonal de chaque région terminale (12, 14) des tubes est tel que la distance axiale (A) entre des fentes adjacentes des collecteurs est sensiblement égale à la moitié de l'espacement (B) entre des rangées adjacentes de tubes (2, 4).

3. Échangeur de chaleur selon la revendication 1 ou 2, dans lequel l'intérieur de chaque collecteur (6) est divisé au moyen d'au moins une paroi de division (20) qui s'étend axialement entre les extrémités des tubes adjacents (2, 4) dans chaque rangée, un côté (22) de la paroi de division (20) adjacent aux extrémités des tubes ayant une forme en serpentin pour se loger entre lesdites fentes respectives (8, 10).

4. Échangeur de chaleur selon l'une quelconque des revendications précédentes, dans lequel des ailettes (30) sont prévues entre les rangées de tubes (2, 4), les ailettes (30) entre chaque paire de rangées adjacentes comprenant chacune une tôle (32) formée dans une configuration en zigzag ou une configuration ondulée pour s'étendre entre les rangées adjacentes respectives de tubes (2, 4).

5. Échangeur de chaleur selon la revendication 4, dans lequel des régions terminales de chaque tôle (32) sont fendues en une première section (34) s'étendant entre des premiers tubes respectifs (2) des rangées adjacentes respectives, et une seconde section (36) s'étendant entre des seconds tubes respectifs (4) des rangées adjacentes respectives.

6. Échangeur de chaleur selon l'une quelconque des revendications précédentes, dans lequel chacun de ladite pluralité de tubes échangeurs de chaleur (2, 4) comprend un tube plat ayant une pluralité de passages d'écoulement parallèles s'étendant à travers lui-même.

7. Procédé pour réaliser un échangeur de chaleur ayant un coeur de refroidissement, comprenant la fourniture d'une pluralité de tubes échangeurs de chaleur (2, 4) agencés en rangées parallèles, la four-

niture d'une paire de collecteurs (6) ayant une pluralité de fentes de réception de tubes (8, 10) formées en eux-mêmes, l'insertion des extrémités desdits tubes échangeurs de chaleur (2, 4) dans lesdites fentes (8, 10) pour être en connexion fluidique avec chaque collecteur (6), chaque rangée incluant au moins deux tubes (8, 4) agencés côte à côte pour réaliser un agencement à flux croisés, **caractérisé en ce qu'**une région terminale (12) d'un premier tube (2) dans chaque rangée est décalée orthogonalement à la direction normale de l'écoulement des fluides à travers le coeur de refroidissement dans une première direction, et qu'une région terminale (14) d'un second tube (4) dans la même rangée est décalée orthogonalement à la direction normale d'écoulement des fluides à travers le coeur de refroidissement dans une seconde direction, opposée à ladite première direction, de sorte que les fentes respectives (8, 10) pour recevoir les extrémités dudit premier et dudit second tube sont axialement décalées l'une par rapport à l'autre, grâce à quoi le premier et le second tube (2, 4) dans chaque rangée peuvent être placés en contact en aboutement l'un avec l'autre.

8. Procédé selon la revendication 7, dans lequel le décalage orthogonal de chaque région terminale (12, 14) des tubes est tel que la distance axiale (A) entre chaque fente adjacente (8, 10) des collecteurs est sensiblement égale à la moitié de l'espacement (B) entre des rangées de tubes adjacentes (2, 4).

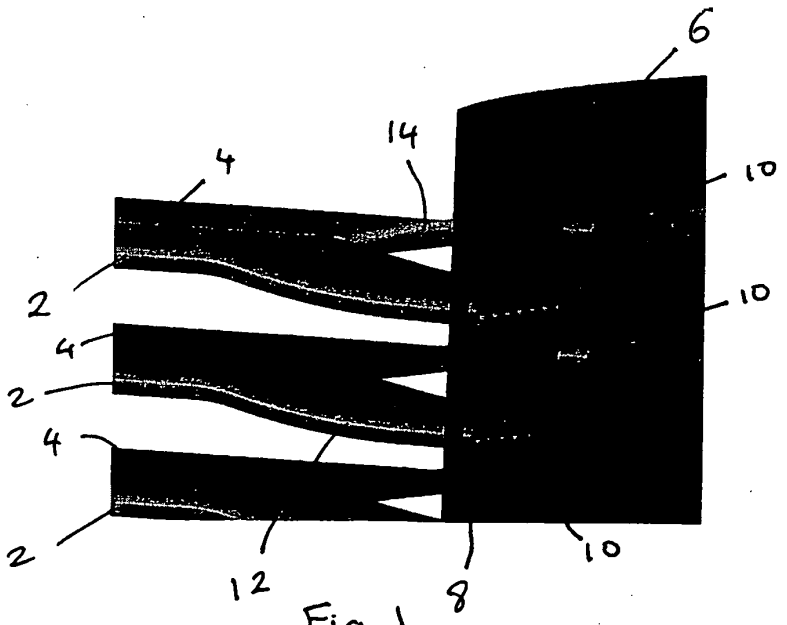


Fig. 1

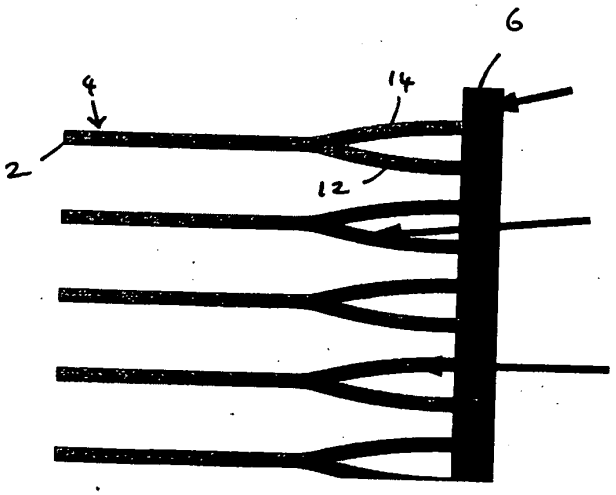


Fig. 2

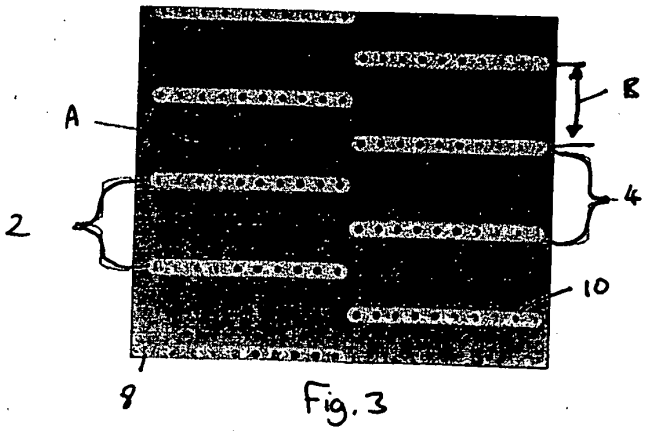


Fig. 3

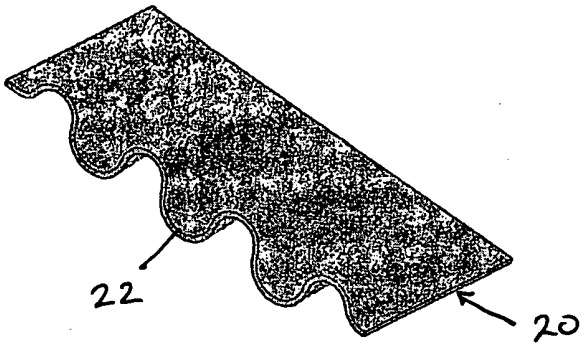


Fig. 4

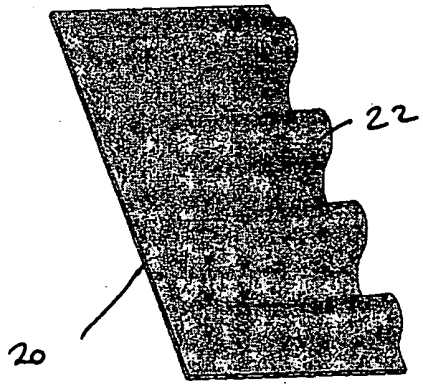


Fig. 5

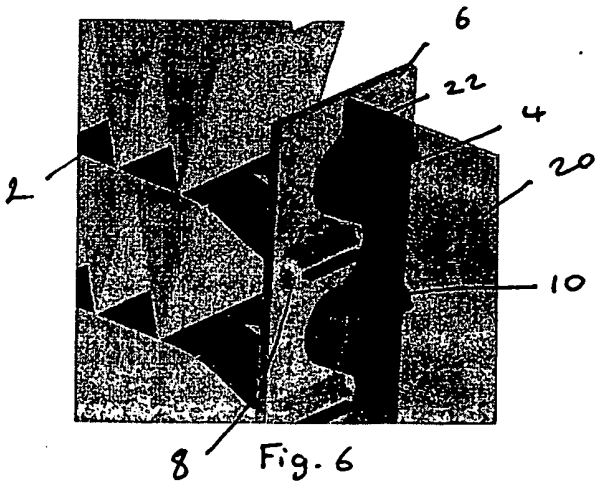


Fig. 6

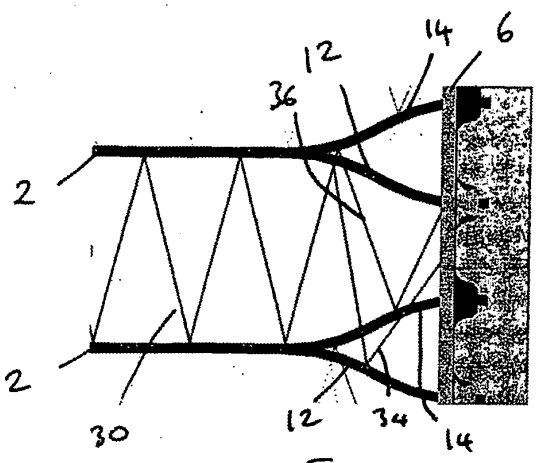


Fig. 7

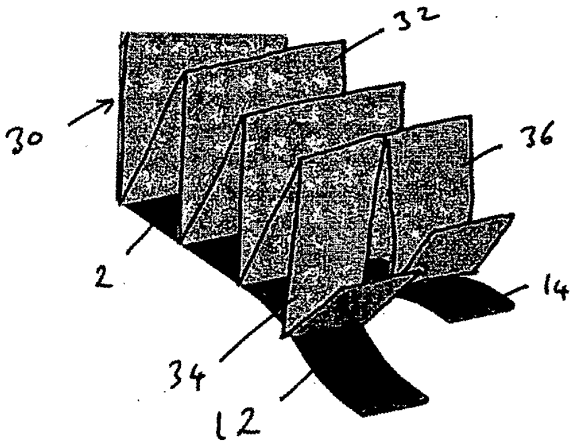


Fig. 8

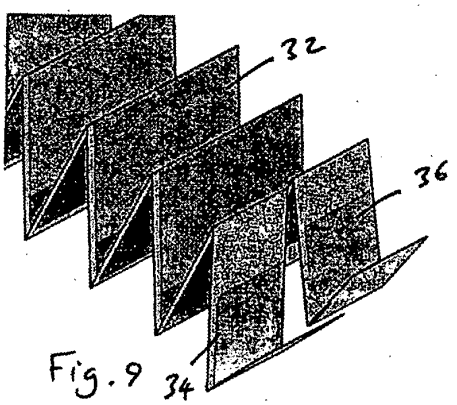


Fig. 9

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- NL 1014832 C1 **[0003]**