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Remarks:

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

(54) **A plate heat exchanger**

(57) A plate heat exchanger comprising separate flow paths for two flows of fluid said paths having different pressure drops at equal mass flows may according to the invention be designed economically by stacking pairs

of two plates (4, 5) provided with pressed patterns, at least one of the plates (4) in a pair (4, 5) being provided with at least two different press depths (D_1 , D_2), the smaller (D_2) being at least 40% of the greater (D_1).

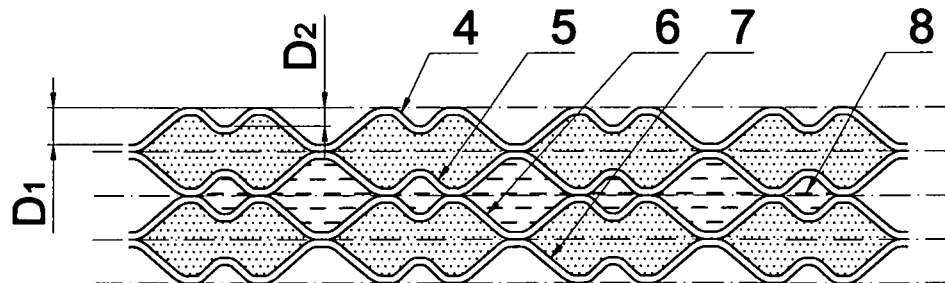


Fig. 9

Description

[0001] The present invention relates to a plate heat exchanger comprising at least two separate flow paths for primary and secondary fluids to exchange heat, the said two flow paths being substantially defined by heat exchanger plates provided with a herring bone pattern of ridges and depressions and offering different pressure drops at equal mass flows of the two fluids.

[0002] Many heat exchangers of the above type are used for heating tap water by means of hot water also used for heating dwelling houses. The inlet temperature of the heating water may be e.g. 75° C, and the outlet temperature thereof may be about 60° C. The inlet temperature of the tap water may be about 10° C and the outlet temperature thereof may be 55° C. This indicates that the mass flow of the heating water must be 2.5 times the mass flow of the tap water. Therefore, it is economical to make the cross section of the flow path for the heating water wider than that of the tap water. E.g. by making the tops of the herring bone pattern flat - and thus wider - while the bottoms are unaltered this may be obtained.

[0003] Although this making the heat exchanger "asymmetric" is an improvement it is still an object to further increase the efficiency of the exchanger - i.e. to increase the heat transmission between the heat exchanging fluids without increasing the weight of the plate heat exchanger.

[0004] The Japanese Patent Application No. 11173771 A published July 2nd, 1999 discloses a plate heat exchanger having different pressure drops in the flow paths in case of equal mass flows.

[0005] This is done by increasing the pitch - i.e. the distance between the contacts of adjacent ridges in the herringbone pattern. This known device is adapted to exchange heat between water and a cooling fluid the water flowing through the flow path having the smaller pressure drop. By making small depressions in parts of plates forming the water channels it is obtained that freezing of water will not cause damage to the plate heat exchanger. However, the areas of contact between plates will thus be relatively great and lost for the heat exchange between the fluids. The small depressions in the channels guiding the water flow will cause corresponding very narrow flow channels in the flow path for the cooling fluid. The areas of contact between adjacent plates are not rigidly interconnected in order to increase the elasticity of the plate heat exchanger, but the mechanical strength of the exchanger will be rather poor making the exchanger unsuitable for high pressure fluids.

[0006] The Japanese Patent Application No. 11281283 A also discloses a heat exchanger in which the pressure drop of two heat exchanging fluids are different in case of equal mass flows. According to the embodiment in Figure 5 of said disclosure the flow paths forming a herring bone pattern comprise channels having greater cross sectional flow area provided with two small secondary depressions in the channels of greater cross

section. This involves that the flow path having a total relatively high pressure drop will consist of parts causing very different pressure drops. This is an uneconomical way of using the material in the exchanger for exchanging heat. Also - as the pitch will increase with increasing numbers of the secondary depressions - the mechanical strength of the exchanger will decrease due to the smaller numbers of contact points at which the plates could be rigidly connected.

[0007] The object of the present invention is to design an "asymmetric" plate heat exchanger in which the material of the plates is used in a more economic way and thus in which the efficiency is improved while maintaining a high mechanical strength of the exchanger

[0008] According to the present invention this is obtained thereby that the depressions in at least some pairs of plates defining the flow path having the lower pressure drop at least partly are alternatively of two different press depths measured from the plan defined by the tops of the ridges of the herring bone pattern of the heat exchanger plate, the smaller being located between two tops of the herring bone pattern and being at least 40 % of the greater, and thereby that the tops of the ridges engaging the tops of a neighboring plate to define a flow channel having high pressure drop substantially contact each other along points defined by crossing lines.

[0009] The invention will be described in more detail with reference to the accompanying drawings in which:

Fig. 1 is a plan view of plate in one known type of a plate heat exchanger.

Fig. 2 schematically shows the crossing patterns of two plates according to Fig. 1 placed on each other - after that one of them has been turned in its plan.

Fig. 3 is a section along the line **A-A** in Fig. 1.

Fig. 4 is a section along the line **B-B** in Fig. 2 in a stack of four plates according to Fig. 1.

Fig. 5 is a section corresponding to Fig. 4, but through a known "asymmetric" plate heat exchanger.

Fig. 6 is a section corresponding to those of Figs. 4 and 5, but through a plate heat exchanger according to the Japanese Patent Application No. 11173771 A

Fig. 7 is a section corresponding to Fig. 6, but through a plate heat exchanger according to the Japanese Patent application No. 11281283 A.

Fig. 8 shows a section corresponding to those shown in Figs. 4-7 through two neighbouring plates of a heat exchanger according to the present invention - the plates being drawn apart.

Fig. 9 is a section through four plates in heat ex-

changer according to the present invention.

Figs. 10-12 show alternative embodiments of the invention.

[0010] Figure 1 is a plan view of a plate 1 of a known and widely used plate heat exchanger provided with a herring bone pattern of ridges 2 and depressions 3. In the exchanger a stack of plates of this type is formed after turning each other plate in the stack in its plane. Figure 2 illustrates how the ridges and depressions then will cross each other.

[0011] Fig. 3 - which is a section along the line A-A in Fig. 1 - illustrates the pitch P and the press depth D both values being of importance for characterising the plate heat exchanger.

[0012] Fig. 4 is a section along the line B-B of Fig. 2 through four plates in a heat exchanger according to the Figures 1-3. The two flows of heat exchanging fluids limited by the plates are shown by different hatching. It will be understood that the two flow paths are offering equal pressure drops at equal mass flows.

[0013] By increasing the pitch P and making the tops 2 of the ridges flat the flow path of one of the fluids will obtain a greater cross section than the flow path of the other fluid.

[0014] However, as shown in Fig. 5 the contact areas between the heat exchanger plates will be much larger. These areas cannot be used for heat exchange between the two flows of fluids.

[0015] Fig. 6 shows a prior art plate heat exchanger according to the Japanese Patent Application No. 11173771 which shows a plate heat exchanger of the "asymmetric" type in which the pairs of plates limiting the flow path having the greater cross sectional area are provided with depressions of less depths D_2 than the press depths D_1 of tops of the ridges of the herring bone pattern. This has been done in order to make the plate heat exchanger more resistant against damage caused by ice formations. The plan contact areas between the plates and not used for heat exchange are still existing in this embodiment.

[0016] Another proposal for manufacturing an "asymmetric" plate heat exchanger has been described in the Japanese Patent Application No. 11281283 A. Here the contact areas between the plates of the exchanger has been established by replacing the plan contact areas by areas containing small depressions. This has been shown in Fig. 7 and it will be understood that the flow path having the greater pressure drop will consist of channels of large cross section and at least the double number of much smaller cross sections. This design is detrimental to the heat transfer in the narrow channels because of the much lower flow rate than in the flow channels having wider cross sections.

[0017] Fig. 8 shows a section corresponding to the sections shown in Figs. 4-7 through two heat exchanger plates according to the present invention. A primary press

depth press depth - i. e. the distance between the plan defined by the tops of the ridges and the lowest plan defined by bottoms of ridges - has been indicated as D_1 . A secondary press depth defined as the distance between the plan of the tops of the ridges of the herring bone pattern and a plan of the bottom of minor depressions has been designated by D_2 . The pitch of the herringbone pattern has been indicated by P.

[0018] The herring bone patterns of the two plates 4 and 5 shown in Fig. 8 are mirror images of each other and thus two tools are used for the pressing of the plates. Also each other of the plates should be turned 180 degrees in its plan relative the adjacent plates in the stack in order to obtain the crossing herring bone patterns. Figure 9 is a section through four plates 4, 5, 6 and 7 of the types shown in Fig. 8 and corresponding to the sections C-C shown in Figs. 4-7. The three channels formed for the flows exchanging heat are shown by two different hatchings. It will be understood from Fig. 9 that the resistance for the flow limited by the plates 5 and 6 is higher than the resistance for the flow limited by the plates 4 and 5 or 6 and 7. However, the contact areas between the plates are kept at a minimum, but the number of contacts at which the plates are interconnected by soldering is substantial and will give mechanical strength to the heat exchanger. It is essential to maintain a substantial mass flow of fluid through the cross sections designed by 8 in Fig. 9. The mass flow through the area 8 is nearly proportional to its cross sectional area and this is in turn mainly dependant on the magnitude of the press depth D_2 . A small press depth D_2 - e.g. as shown in Fig. 7 - will make the areas 8 small and may almost block passage of fluid. A small secondary press depth will have nearly the same effect as the large contact areas between the ridges of the herring bone pattern shown in Fig. 5.

[0019] It has been found that the secondary press depth D_2 should be at least 40 percent of the press depth D_1 - preferably about 50 percent thereof

[0020] Figure 10 is a section corresponding to that of Figure 9, but in which only the plate 4 in a pair of plates 4, 5 has two different press depths. The other plate in the pair - designated by 5 - is of conventional shape having only one press depth. The two plates 4, 5 according to Figure 10 have not patterns which are mirror images of each other and may be designed so that a turning of a plate will not be necessary in order to obtain crossing of the contacting ridges.

[0021] According to the embodiment of Figure 11 the secondary press depth D_2 of the plate 5 is greater than the secondary press depth D_3 of the plate 6.

[0022] Figure 12 shows an embodiment in which the plate 4 has two different secondary press depths. The press depth D_2 is used in one area of the plate and the press depth D_4 in another area of the plate.

[0023] It will be understood that a heat exchanger according to the present invention may comprise other combinations of pairs of plates than those described above. E.g. some pairs may be of the known type shown in Figure

4 providing equal pressure drops in the flow channels for the heat exchanging media — in case of equal mass flows.

Claims

1. A plate heat exchanger comprising at least two separate flow paths for primary and secondary fluids to exchange heat, the said two flow paths being substantially defined by heat exchanger plates (4-7) provided with a herring bone pattern of ridges and depressions (2, 3) and offering different pressure drops at equal mass flows of the two fluids,
characterised in that the depressions in at least some pairs of plates defining the flow path having the lower pressure drop at least partly are alternatively of two different press depths (D_1 , D_2) measured from the plan defined by the tops of the ridges of the herring bone pattern of the heat exchanger plate, the smaller (D_2) being located between two tops of the herring bone pattern and being at least 40 % of the greater (D_1), and thereby that the tops of the ridges engaging the tops of a neighboring plate to define a flow channel having high pressure drop substantially contact each other along points defined by crossing lines. 5 10 15 20 25
2. A plate heat exchanger according to claim 1, **characterised in, that** the smaller press depths (D_2) are about 50% of the greater press depths (D_1). 30
3. A plate heat exchanger according to one of the claims 1 and 2 comprising a pair of plates in which only one of the plates has two different press depths. (Fig. 10). 35
4. A plate heat exchanger according to any of the preceding claims comprising a pair of plates in which the two plates have different secondary press depths. (Fig. 11). 40
5. A plate heat exchanger according to any of the preceding claims comprising a pair of plates in which one plate has two different secondary press depths. (Fig. 12). 45

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

1. A plate heat exchanger comprising at least two separate flow paths for primary and secondary fluids to exchange heat, the said two flow paths being substantially defined by permanently interconnected heat exchanger plates (4-7) provided with a herring bone pattern of ridges and depressions (2, 3) and offering different pressure drops at equal mass flows of the two fluids, 50 55

characterised in that the depressions in at least some pairs of plates defining the flow path having the lower pressure drop at least partly are alternatively of two different press depths (D_1 , D_2) measured from the plan defined by the tops of the ridges of the herring bone pattern of the heat exchanger plate, the smaller (D_2) being located between two tops of the herring bone pattern and being at least 40 % of the greater (D_1), and thereby that the tops of the ridges engaging the tops of a neighboring plate to define a flow channel having high pressure drop substantially contact each other along points defined by crossing lines.

2. A plate heat exchanger according to claim 1, **characterised in, that** the smaller press depths (D_2) are about 50% of the greater press depths (D_1).

3. A plate heat exchanger according to one of the claims 1 and 2 comprising a pair of plates in which only one of the plates has two different press depths. (Fig. 10).

4. A plate heat exchanger according to any of the preceding claims comprising a pair of plates in which the two plates have different secondary press depths. (Fig. 11).

5. A plate heat exchanger according to any of the preceding claims comprising a pair of plates in which one plate has two different secondary press depths. (Fig. 12).

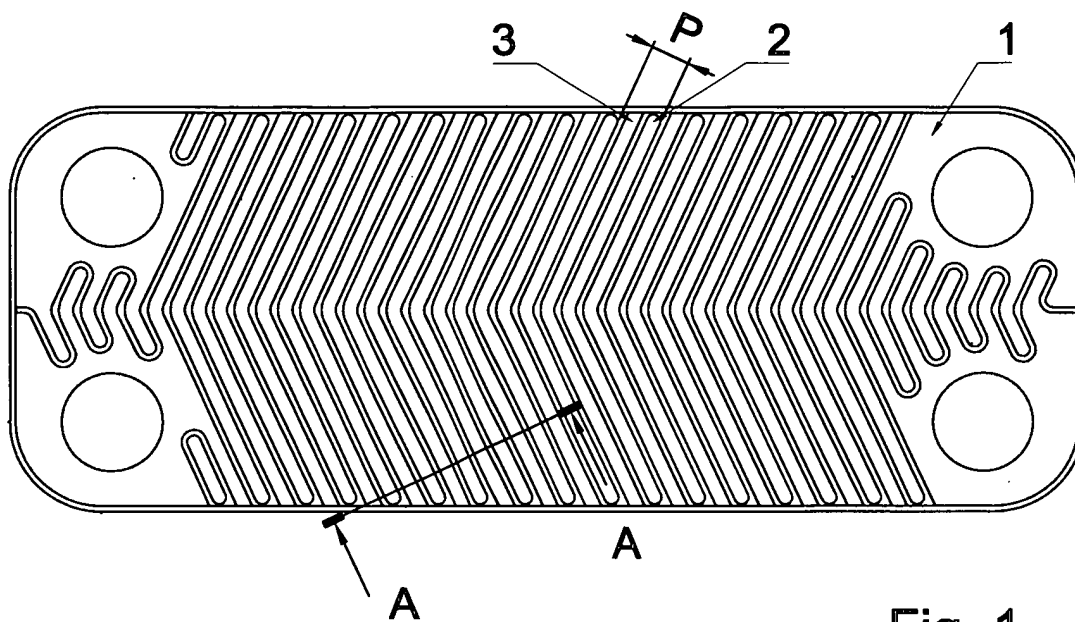


Fig. 1

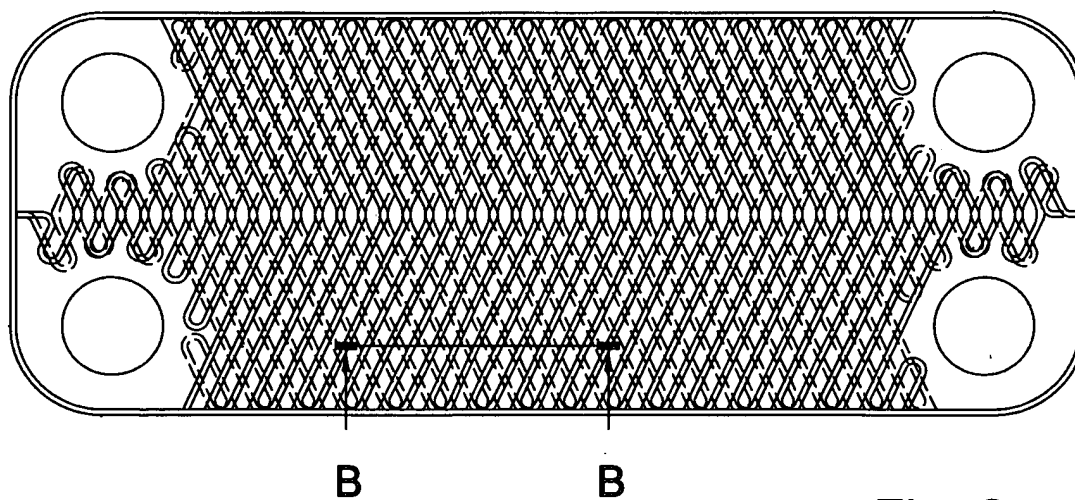


Fig. 2

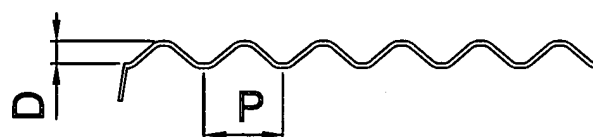


Fig. 3

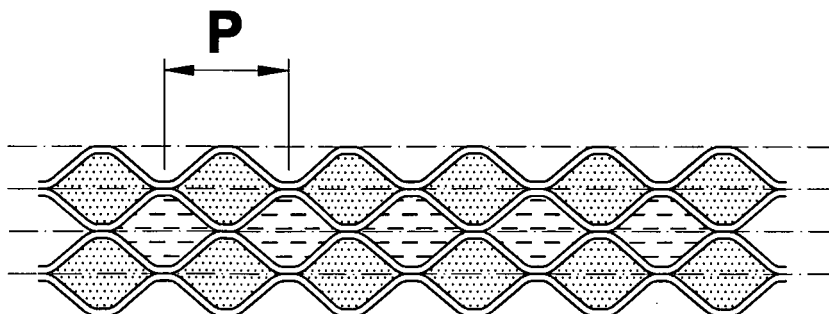


Fig. 4

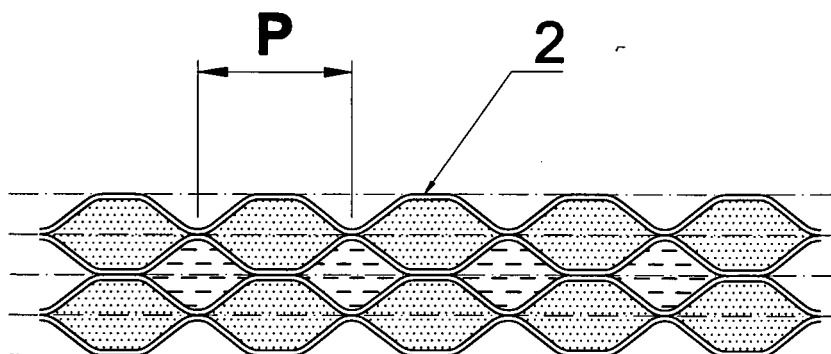


Fig. 5

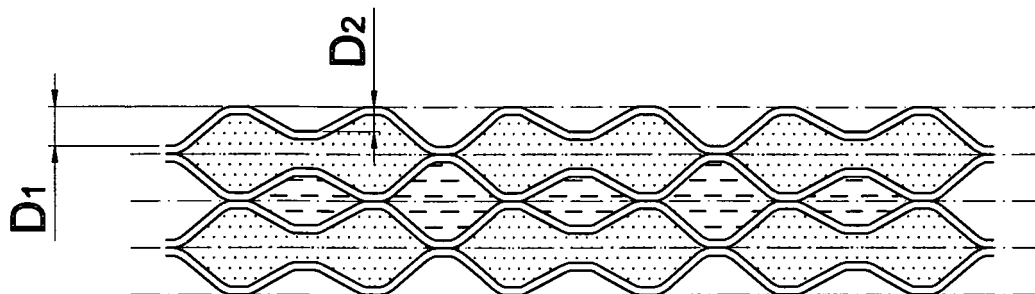


Fig. 6

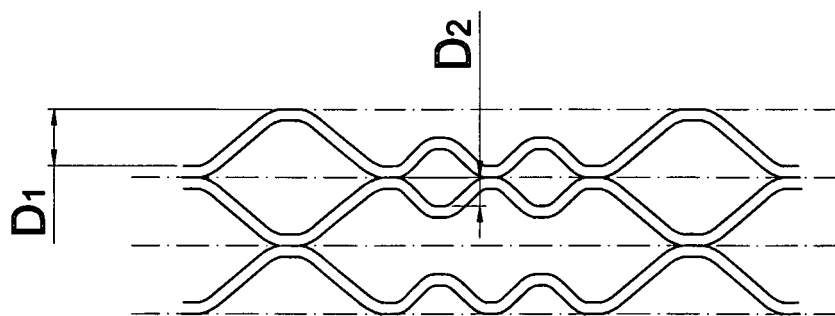


Fig. 7

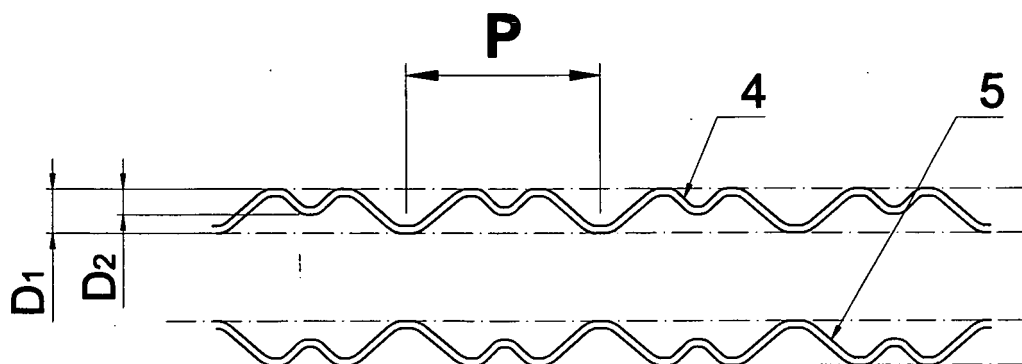


Fig. 8

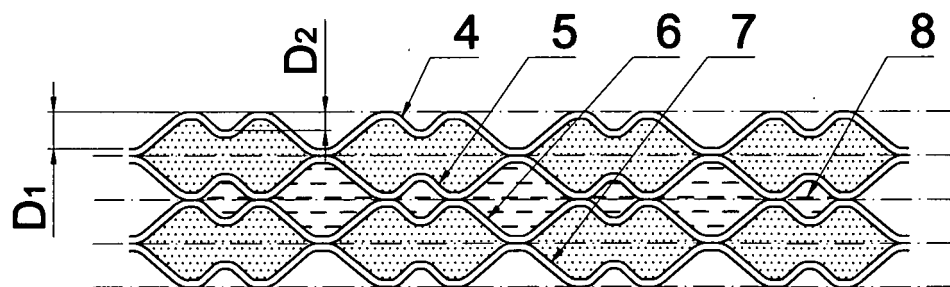


Fig. 9

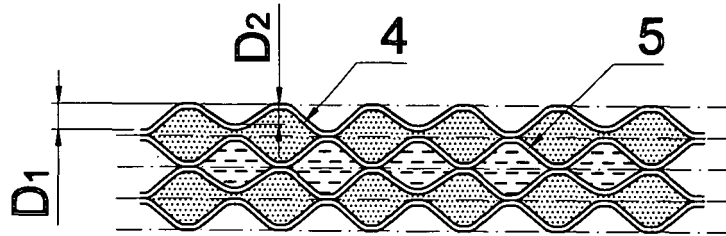


Fig. 10

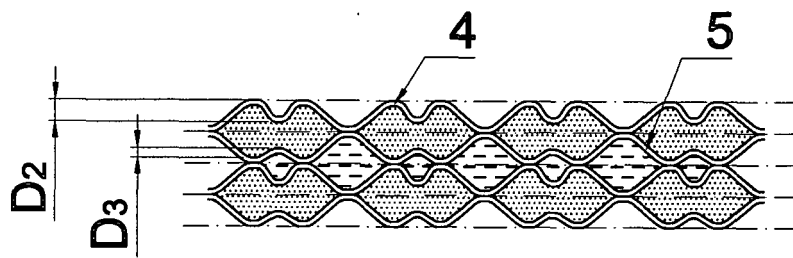


Fig. 11

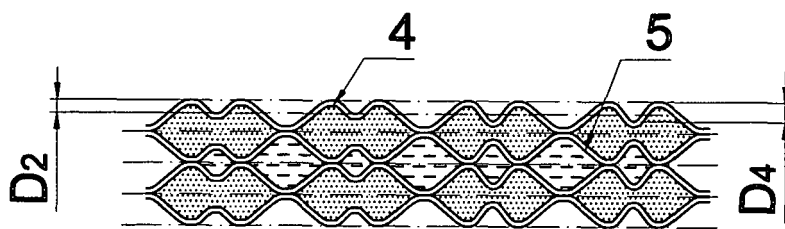


Fig. 12



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EUROPEAN SEARCH REPORT

Application Number
EP 04 02 0494

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)
D,X	PATENT ABSTRACTS OF JAPAN vol. 1999, no. 12, 29 October 1999 (1999-10-29) -& JP 11 173771 A (DAIKIN IND LTD), 2 July 1999 (1999-07-02) * abstract; figures *	1,4	F28D9/00 F28F3/04
X	AT 393 162 B (BROECKL GERHARD ING; FISCHER HELMUT ING) 26 August 1991 (1991-08-26) * figure 6 *	1	
A	PATENT ABSTRACTS OF JAPAN vol. 2002, no. 08, 5 August 2002 (2002-08-05) -& JP 2002 107074 A (SANYO ELECTRIC CO LTD), 10 April 2002 (2002-04-10) * abstract; figure 8 *	1	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			F28D F28F
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 28 January 2005	Examiner Mootz, F
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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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 04 02 0494

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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28-01-2005

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