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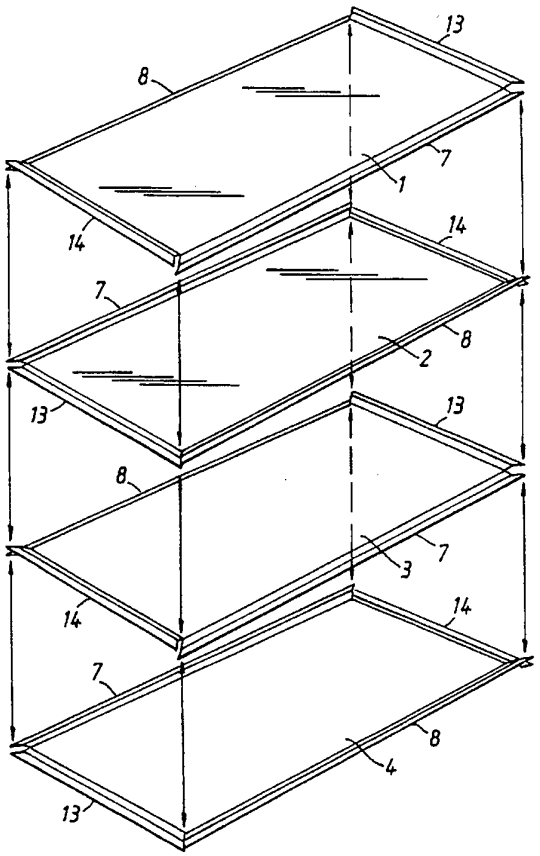
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(57) Abstract

The invention relates to a cross-flow heat exchanger with a number of parallel plates which constitute partitions between channels for the two heat-exchange media. The plates are essentially of the same construction, and comprise a preferably rectangular surface (5) provided with slits (6) in the corner portions and with edge portions (7, 8; 13, 14) bent into L-shape, the outermost edge portion being co-planar with the surface (5). The slits (6) extend at an angle to the edge portions (7, 8; 13, 14) of the plate. Two opposite edge portions (7, 8) are bent in the same direction in relation to said surface (5), while the two remaining edges are bent in the opposite direction. By turning every second plate upside down, the plates (1-4) may be stacked in such a way that alternate channels (20, 21) are formed when the outermost edge portions (11, 12) are joined to the respective adjacent edge portions. Sealing strips (19) are inserted into the corner slits (6).



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RIBBED HEAT EXCHANGER

The present invention relates to a lamellate heat exchanger.

Such heat exchangers are used in many different contexts. One characteristic feature of a lamellate heat exchanger is that flat plates are disposed to form channels through which two heat exchange media flow on different sides of the plates.

The present invention is not restricted to any particular field of use and can be applied with both small heat exchangers and with relatively large heat exchangers of the kind used in heating plants to effect an exchange of heat between flue gases and some other medium. The plates of such heat exchangers may, for instance, measure 4,000 x 1,000 millimeters in size, and the total plate surface area may be 4,000 square metres, for instance.

Conventional heat exchangers of the present kind which effect an exchange of heat with flue gases are constructed by welding the upper edges and lower edges of mutually parallel plates to beams or bars, so as to hold the plates in place. Side pieces are also welded to the structure, such as to obtain a tight or impervious join between the plates that form mutually adjacent channels. The plates are embossed with a large number of bosses or protuberances over the whole of the plate area, with said bosses lying against adjacent plates so that the plates will be spaced from one from the other.

The plates are normally made of stainless steel and in order to be able to weld the plates together, it is necessary for the plates to have a smallest thickness of 1 millimeter. A smaller plate thickness would reduce the cost of materials and also increase the heat transfer capacity of the structure.

Heat exchangers of this kind are expensive to manufacture, partly because of the time taken to weld the structure and

partly because of material costs.

Swedish Patent Specification... (Patent Application No. 9202638-4) describes a heat exchanger which is much cheaper to manufacture than known heat exchangers of this kind and also provides better transfer of heat between the two heat exchange media than said known heat exchangers.

The present heat exchanger can be used for all purposes, among them the purposes mentioned in the aforesaid patent specification.

The aforesaid patent specification teaches a lamellate heat exchanger which includes a number of mutually parallel plates which define channels through which the two heat-exchange media pass and wherein each plate, with the exception of the outermost plates, form limitations between two mutually adjacent channels. According to this patent specification, each alternate plate has upwardly folded opposing first edges, and each other alternate plate has the two remaining, second edges folded up. The upwardly folded parts of each plate are intended to abut an adjacent plate. U-shaped strips are fitted over each upwardly folded part such that the inner surfaces of the two legs of each U-shaped strip will lie against the mutually distal surfaces of two adjacent plates. This results in the formation of mutually parallel channels where each alternate channel extends in one direction and each other alternate channel extends in a direction perpendicular to the first-mentioned channels. According to the aforesaid patent specification, each U-shaped strip is sealed against the upwardly folded part concerned and adjacent plates with an elastic glue.

The fact that the plates and strips are glued together enables much thinner plate to be used than in conventional heat exchangers in which the plates are welded. However, a glued construction presents a problem in some environments and at

some temperature ranges.

This problem is solved by the present invention, which enables thin plate or metal sheet to be used despite the fact that the heat exchanger is a welded construction.

Accordingly, the present invention relates to a lamellate heat exchanger which includes a number of mutually parallel plates which define channels for the two media between which an exchange of heat shall take place, wherein each plate, with the exception of the outermost plates, forms a limitation between two mutually adjacent channels, and which is characterized in that each plate has the same or essentially the same construction; in that each plate includes a flat, preferably rectangular, surface which is slotted at each corner, said slot extending from said corner and defining an angle with the side edges of the plates; in that two opposing first sides of the plate are bent to a generally L-shape in cross-section, wherein the plane of the outer portion of said L-shaped part is essentially parallel with the plane of the surface of said plate; in that the remaining two opposing second sides of the plate are bent to the same configuration as the first sides of said plate but in an opposite direction relative to the surface of said plate; in that plates are placed one upon the other with each alternate plate turned in one direction and each other alternate plate turned upside down; in that each plate is fastened on one side thereof to an adjacent plate by means of the outer parts of the L-shaped portion of the first mutually opposing sides of said plates and in that each plate is fastened on its other side to an adjacent plate by means of the outer parts of the L-shaped portion of the second opposing sides of said plates, whereby first channels are formed which extend in one direction and whereby intermediate, second channels are formed which extend in a direction perpendicular to said one direction; and in that an insertion plate whose width exceeds the length of said slot and whose length corresponds to or exceeds the height of

the pack formed by the mutually superimposed and mutually fastened plates is inserted into the slot in each of the corners of the pack; and in that the insertion plates inserted into said corners are sealingly connected to the slots such as to separate the first and the second channels at said corners.

The invention will now be described in more detail partially with reference to an exemplifying embodiment thereof and also with reference to the accompanying drawings, in which

- Figure 1 is an exploded view of two metal plates forming part of a heat exchanger, said plates being shown in an exploded view to facilitate an understanding of their construction;
- Figure 2 illustrates a metal plate of an inventive heat exchanger from above;
- Figure 3 is a sectional view taken on the line B-B in Figure 2;
- Figure 4 is a sectional view taken on the line A-A in Figure 2;
- Figure 5 is an exploded view of part of a heat exchanger, said view being shown to facilitate an understanding of the construction of the heat exchanger and includes more metal plates than the Figure 1 illustration;
- Figure 6 illustrates one corner region of a plate;
- Figure 7 is a perspective view of one corner region of a heat exchanger;
- Figure 8 illustrates a heat exchanger in one direction of flow of a first medium;
- Figure 9 illustrates the heat exchanger of Figure 8 from beneath, i.e. in the direction of flow of a second medium;
- Figure 10 illustrates a detail for fastening two plates together; and
- Figure 11 illustrates a spacer means.

Part of a lamellate heat exchanger constructed in accordance with the invention is shown in Figure 2 and in Figure 5. Only

two plates 1, 2 are shown in Figure 2 for the sake of clarity. The entire lamellate heat exchanger includes a plurality of mutually parallel plates which define channels for the two heat-exchange media. Each plate, with the exception of the outermost plates in a plate pack, forms a limitation between two mutually adjacent channels in the heat exchanger.

According to the invention, each plate 1, 2 has the same or essentially the same construction. As shown in Figures 1 and 2, each plate 1, 2 has a flat, preferably rectangular surface 5. As will be seen from Figure 2, there is provided in each corner of each plate a slot 6 which extends from said corner and defines an angle with the side edges of the plate. Two mutually opposing first sides 7, 8 of the plate 1, 2 are folded or bent to form an essentially L-shaped part 9, 10 in cross-section, wherein the plane of the outer portion 11, 12 of said L-shaped part is generally parallel with the plane of the plate surface 5. The remaining two opposing second sides 13, 14 of the plate 1, 2 are bent to a similar configuration, but in the opposite direction in relation to the plate surface. The lines along which said sides are bent are illustrated in broken lines in Figure 2. Figure 3 is a sectional view taken on the line B-B in Figure 2 and Figure 4 is a sectional view taken on the line A-A in Figure 2.

After having provided a flat plate with the slots 6 in each corner of the plate, and after having bent the sides of the plate, and after having bent the sides of the plate to the shapes shown in Figures 3 and 4, the plates will have the form shown in perspective in Figure 1.

The plates 1, 2 shown in Figure 1 are mutually the same, but turned in different directions.

According to the invention, the heat exchanger is constructed by placing plates one upon the other, with each alternate plate being turned in one direction and each other alternate

plate being turned upside down as illustrated in Figure 1, and as shown more clearly in Figure 5, which shows four plates 1-4. Figure 5 can be said to be an exploded view of part of the heat exchanger.

Each plate is fastened on one side to an adjacent plate by means of the outer parts 11, 12 of the L-shaped part 9, 10 of the first mutually opposing sides 7, 8 of the plate. This is illustrated in Figure 1, where the double-headed arrows show how the plates are brought together so that the outer parts 11, 12 of the L-shaped parts on the first opposing sides will abut one another and are fastened together. This results in the formation of a first channel between the plates 1 and 2.

Similarly, each plate is fastened on its other side to an adjacent plate by means of the outer parts 17, 18 of the L-shaped part 15, 16 of the second opposing sides 13, 14 of said plates. This is illustrated in Figure 5 between the plates 2 and 3, where the double-headed arrows show how the plates 2 and 3 are brought together at the sides 13 and 14 and then fastened to one another. This results in the formation of a second channel between the plates 2 and 3, this channel extending in a direction which is perpendicular to the direction in which the first channel extends.

When the plates 3 and 4 are brought together along the sides 7 and 8, there is formed a further first channel. In this way, viz bringing together further plates, any number of plates can be combined to form a plate pack in which the plates form channels of which each alternate channel extends in one direction with intermediate channels that extend perpendicular to said each alternate channel.

As before mentioned, each corner of such a plate pack will include a slot. According to the invention, an insert plate 19 whose width exceeds the length of the slot 6 and whose length corresponds to or exceeds the height of the pack formed

by the mutually superimposed and mutually fastened plates is inserted into the slots of respective corners of the pack. Figure 6 illustrates a plate 1 which is the uppermost plate of a plate pack and which is shown in Figure 6 from above in the normal direction of the plate 1. The insert plate 19 is shown on the left of the Figure 1 before being inserted into the slots 6 of the superimposed plates, and shows the insert plate 19 inserted into the slots on the right of the Figure. Figure 6 shows the insert plate 19 distanced from the slot for the sake of clarity. Figure 7 is a schematic, perspective view of one such insert plate 19 inserted into the slots at one corner of a plate pack.

According to the invention, the insert plates 19 inserted into the corners connect sealingly with the slots 6, so as to separate the first and the second channels in the corners of the pack. A seal is thus fitted between the plates 1-4 and the inserted plates 19.

According to a preferred embodiment, a suitable sealing compound, such as silicone, is used to this end, or a suitable glue. According to another preferred embodiment, however, the inserted plates 19 are welded to the edges of the slots.

The plates 19 are preferably designed to project beyond the corners, as illustrated in Figures 6 and 7, and as also illustrated in Figures 8 and 9. The outwardly projecting part of the plates 19 can be readily fastened to a casing or the like which extends around the heat exchanger, wherein channels which convey gases or liquids with which an exchange of heat is to be effected are connected to the casing. The casing is not shown in the drawings, since it forms no part of the present invention. The casing may be a simple box provided with connecting ports for the heat-exchanging media, although it will be understood that the casing may have any one of a number of different designs. The heat exchanger can also be used without a casing, by connecting the ends of respective

first and second channels of the heat exchanger to channels in which the heat exchanging media are intended to flow.

Figure 8 is a side view of an inventive heat exchanger corresponding to a view from the left in Figure 5. Figure 9 shows the heat exchanger of Figure 8 from above. These Figures thus show first channels 20 which extend perpendicularly to second channels 21.

According to one preferred embodiment, the bent plates 1-4 are made of a stainless metal sheet having a thickness of less than 1 millimeter, preferably a thickness of about 0.5 millimeter. A thinner plate thickness will increase the heat transfer capacity and reduce both material costs and weight.

The plates that are inserted into the corners, however, will preferably have a thickness of about 1 to 2 millimeters. This will facilitate welding of the plates to the edges of slots 6.

According to one preferred embodiment, at least the longer of the first, 7; 8, and the second, 8; 7, of the opposing sides of the plates 1-4, i.e. the longer sides of the plates 1, 2 in Figure 1, are joined together by a continuous weld, preferably by seam-welding, along the full length of said sides.

An inventive heat exchanger is preferably constructed by first welding plates together in pairs, i.e. welding pairs of plates together along their long sides, as illustrated in Figure 1. These pairs of plates are then joined together, by fastening the other sides, i.e. the shorter sides, together. Referring to Figure 5, the first plates 1 and 2 and the plates 3 and 4 are first welded together along their respective long sides 7, 8. The short sides 13, 14 of the plates 2 and 3 are then joined together.

The short sides 13, 14 may also be welded together, although this may be difficult because the space between the plates may be confined when the channels 21 are narrow. In this case, the short sides are secured to one another in some other way, for instance by spot-welding. The joins can be made tight with the aid of a suitable sealing agent.

According to another preferred method of fastening together at least the shorter of the aforesaid first, 13, and second, 14, opposing sides of the plates there is used to this end a U-shaped strip 22 which is fitted over the outer parts 17, 18 of the L-shaped part of two mutually adjacent plates and spot-welded to said outer part of the L-shaped parts, as illustrated in Figure 10. The length of the strips 22 corresponds to the length of said second sides.

According to a further preferred embodiment, spacer means are disposed uniformly over the surfaces of respective plates 1-4, so as to space the plates apart. These spacer means may have any suitable configuration, although a preferred configuration is shown in Figure 11. In this case, the spacer means 23 is a sheet-metal element that has been bent to a U-shape with flanges 24, 25 which extend outwardly from the U. This spacer means may, for instance, be fastened to the plate 2 by spot-welding at the arrow 26. The number of spacer means may vary in accordance with the surface area of the plates 1-4, the pressure differences between the first and the second channels respectively, and so on.

With regard to the cost of manufacturing the inventive heat exchanger, it has been found that the working costs entailed by the manufacture of an inventive heat exchanger is roughly half the working cost entailed by a conventionally manufactured heat exchanger, despite welding the plates together. Welding results in a highly compact and impervious construction and in a highly mechanically stable heat exchanger.

The inventive heat exchanger illustrated schematically in the drawings includes only a few plates. It will be understood, however, that a heat exchanger will normally include hundreds of plates. Naturally, the number of plates and the surface areas of said plates can vary from case to case. Furthermore, the channels may have the same or different widths. The width is given by the length of the slots 6 and by the extent to which the long sides 7, 8 and the short sides 13, 14 have been bent-up. The inventive heat exchanger is dimensioned in a conventional manner in these respects.

It will be evident from the aforegoing that the present invention solves the problems recited in the introduction and provides a heat exchanger which is more effective and less expensive than conventional heat exchangers.

The present invention is therefore not restricted to the aforedescribed and illustrated exemplifying embodiments thereof, since modifications and variations can be made within the scope of the following Claims.

CLAIMS

1. A lamellate heat exchanger comprising a plurality of mutually parallel plates which define channels for passage of the two media with which a heat exchange is to be effected, where each plate, with the exception of the outermost plates, forms a limitation between two mutually adjacent channels, **characterized** in that each plate has the same or essentially the same construction; in that each plate includes a flat, preferably rectangular surface (5) in which a slot (6) has been formed in each corner, said slot (6) extending from said corner and defining an angle with the side edges (7, 8; 13, 14) of the plate; in that two mutually opposing first sides (7, 8) of the plate (1-4) are bent to form a generally L-shaped part (9, 10) in cross-section, wherein the plane of the outer part (11, 12) of said L-shaped part is generally parallel with the plane of the surface (5) of the plate (1-4); in that the remaining two opposing second sides (13, 14) of the plate (1-4) are bent in a similar fashion but in the opposite direction in relation to the plate surface (5); in that plates (1-4) are placed one upon the other with each alternate plate (1-3) turned in one direction and each other alternate plate (2, 4) turned upside down; in that each plate (1-4) is fastened on one side to an adjacent plate by means of the outer parts (11, 12) of the L-shaped part of the first (7, 8) opposing sides of respective plates; and that each plate is fastened on its other side to an adjacent plate by means of the outer parts (17, 18) of the L-shaped part of the second opposing sides (13, 14) of respective plates, thereby to form first channels (20) which extend in one direction and intermediate thereof second channels (21) which extend perpendicularly thereto; and that an insertion plate (19) having a width which extends the length of said slot (6) and a length which corresponds to or exceeds the height of the pack formed by the superimposed and mutually fastened plates (1-4) is inserted into the slot (6) in each corner of the pack; and in that the insertion plates (19) inserted into said corners connect sealingly with the slots (6) so as to separate

the first channels (20) from the second channels (21) at the corners of the pack.

2. A heat exchanger according to Claim 1, **characterized** in that the bent plates (1-4) are made of a stainless sheet-metal material with a thickness smaller than 1 millimeter, preferably with a thickness of about 0.5 millimeter.

3. A heat exchanger according to Claim 1, **characterized** in that the insert plates (19) inserted into the corners of the pack are welded to the edges of the slots (6).

4. A heat exchanger according to Claim 3, **characterized** in that the insert plates (19) have a thickness of about 1 to 2 millimeters.

5. A heat exchanger according to Claim 1 or 2, **characterized** in that the insert plates (19) are glued to the edges of the slots (6) in the corners of the plate pack.

6. A heat exchanger according to Claim 1, 2, 3, 4 or 5, **characterized** in that at least the longer of said first and said second opposing sides (7, 8) of the plates are joined together by a continuous weld, preferably by a seam weld.

7. A heat exchanger according to Claim 1, 2, 3, 4 or 5, **characterized** in that at least the shorter of the first and second opposing sides (13, 14) of respective plates are joined together by means of a U-shaped strip (22) fitted over the outer part of the L-shaped part (13, 14) of two mutually adjacent plates, said strip (22) being spot-welded to said outer part of the L-shaped parts.

8. A heat exchanger according to any one of the preceding Claims, **characterized** by spacer means (23) disposed uniformly over the surface of the plates (1-4) so as to maintain the plates in mutually spaced relationship.

Fig. 1

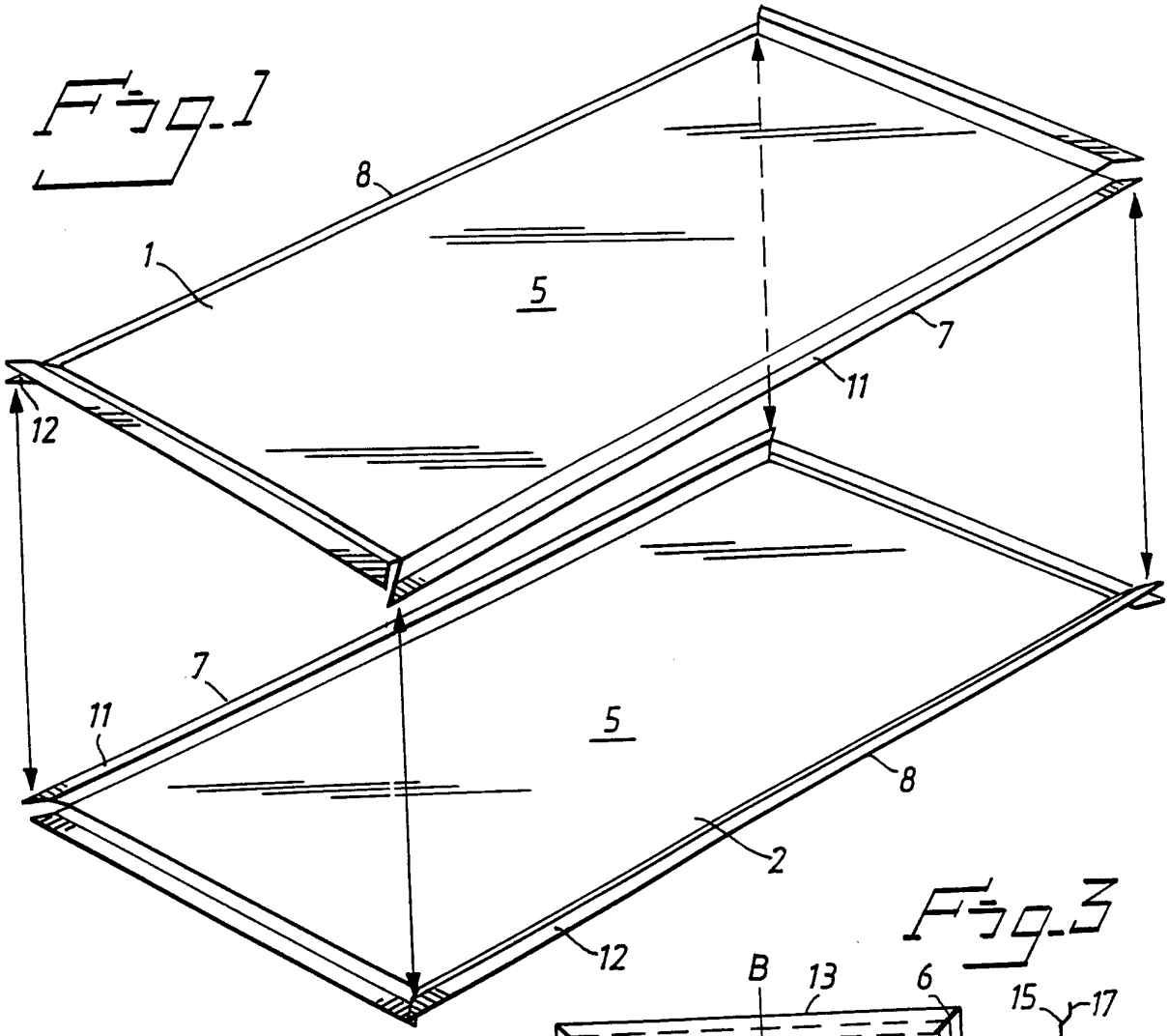


Fig. 3

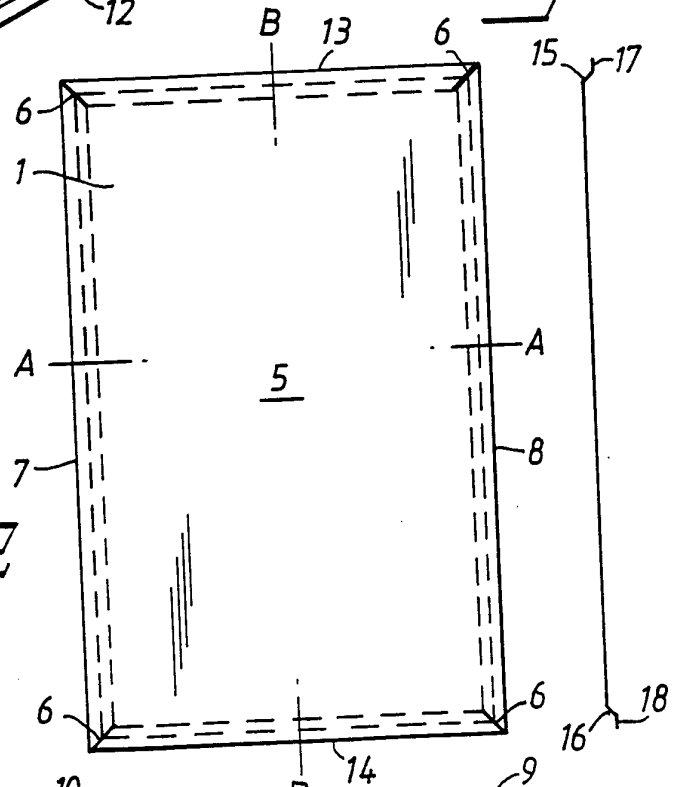


Fig. 2

Fig. 4

Fig. 5

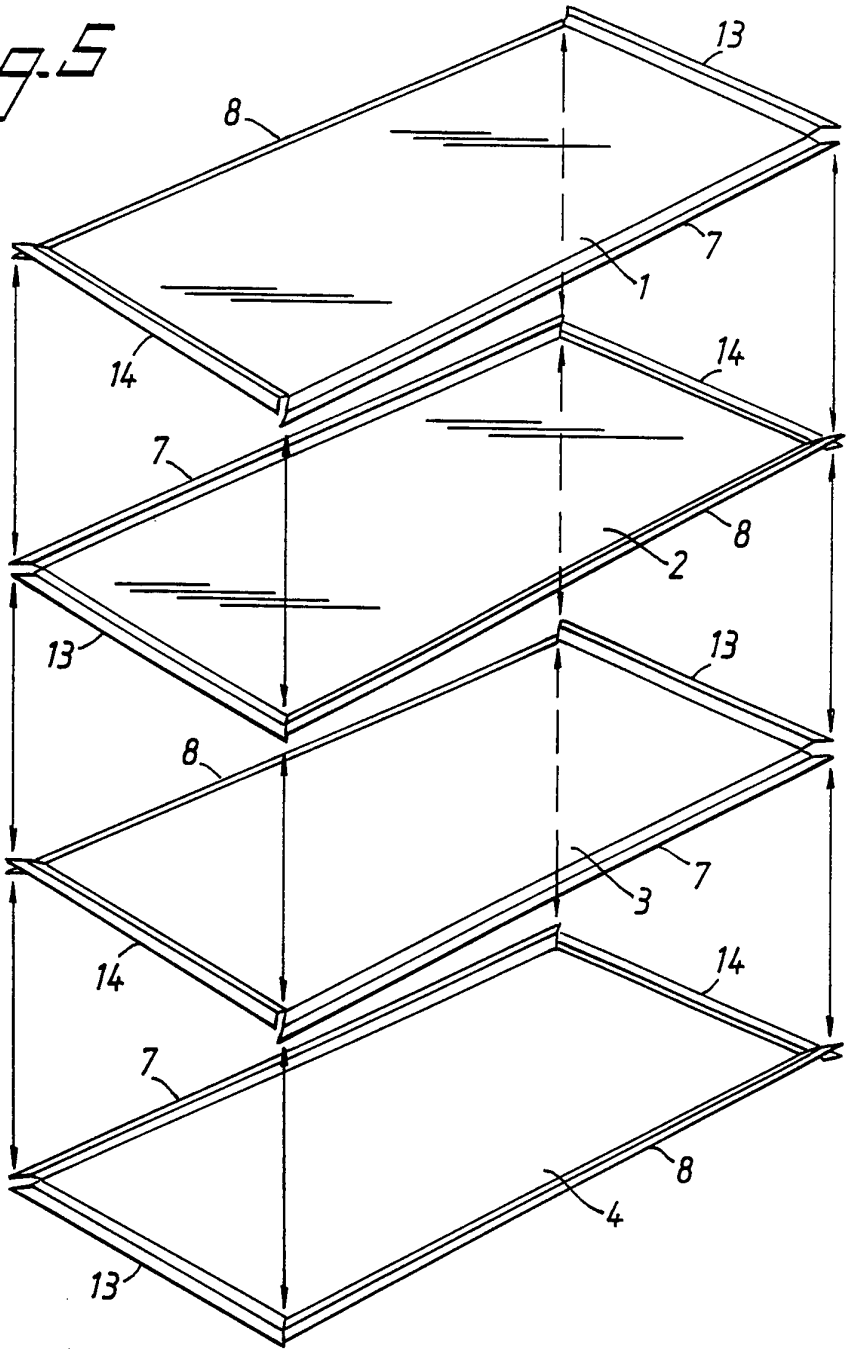


Fig. 6

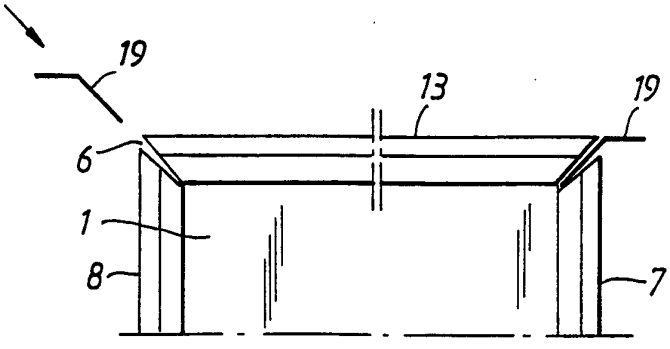


Fig. 7

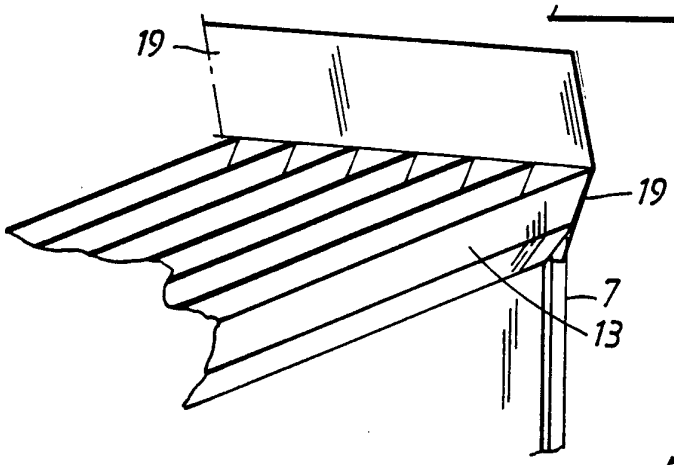


Fig. 8

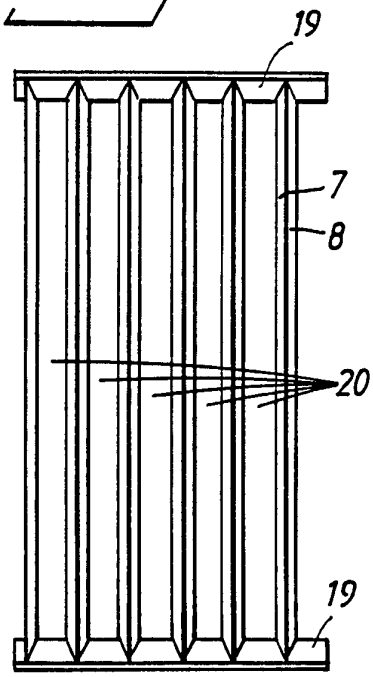


Fig. 9

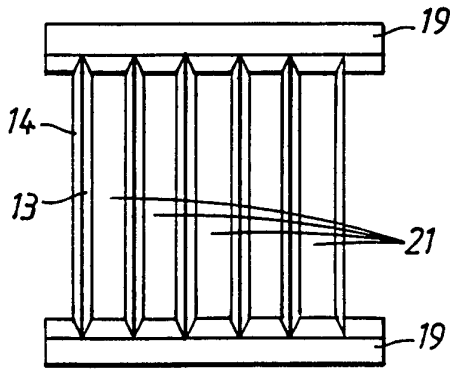


Fig. 10

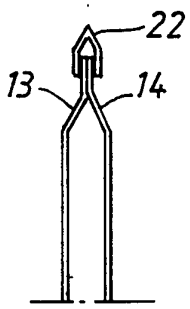
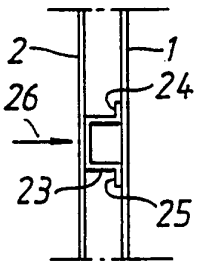


Fig. 11



INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 94/00934

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: F28F 3/08 // F28F 3/10
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: F28D, F28F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

31/12/94

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PCT/SE 94/00934

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