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(54) **Plate type heat exchanger, and method of manufacturing it.**

(57) In a plate type heat exchanger having a plurality of substantially parallel spaced apart plates (2), in particular of enamelled steel, spaces for two separate fluid flows are alternately formed between the plates. Adjacent plates (2) are joined at their edges, except for connecting openings, to form a plate pack. On at least two edges, the adjacent plates comprise connecting flanges (5, 6) bent over towards each other and being welded together. At least the connecting flanges (5, 6) of some of the adjacent plates are in flat abutting relationship and are welded together on their outer edges.

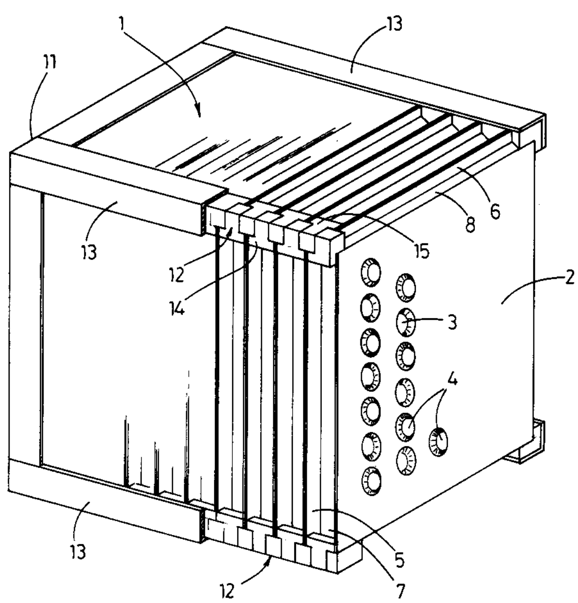

fig.1

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The invention relates to a plate type heat exchanger having a plurality of substantially parallel spaced apart plates in particular of enamelled steel, spaces for two separate fluid flows being alternately formed between the plates, and adjacent plates being joined at their edges, except for connecting openings, to form a plate pack.

In a known embodiment of such plate type heat exchanger, the plates are provided on their edges with packings of silicon rubber keeping the plates space apart and sealing the space between the plates. The disadvantage of this structure is that the packings decay rather quickly, which leads to leakage.

The object of the invention is to provide a plate type heat exchanger of the type mentioned in the preamble, in which this disadvantage is removed in an effective way.

For this purpose, the plate type heat exchanger according to the invention is characterized in that the adjacent plates comprise on at least two edges connecting flanges bent over towards each other and connected by welding, at least the connecting flanges of some of said adjacent plates abut in flat relationship and are welded on their outer edges.

The welded joint between the individual plates creates a very reliable seal which does not suffer from leakages also after a longer period of time. The welding operation, however, is hindered by the enamel layer protecting the plates from the attack of acids and which might be broken by the welding operation leading to weak spots. It has been surprisingly found, however, that when the connecting flanges abutting in flat relationship are welded on their outer edges, the enamel of the plates melts at the inner edges of these flanges and flows into the seam between the flanges to such extent that their is formed a closed protective enamel layer on the inner edges obviating the necessity of a further after-treatment or renewed enamel covering of the whole plate pack. It is not necessary that all plates are interconnected in this manner. It is also possible that groups of plates are welded in another way and are enamelled (again).

The invention is particularly suited for use in plate type heat exchangers working according to the cross-flow principle in which the fluid flows on both sides of each plate are directed substantially perpendicular. The perpendicularly directed edges of the plates are then alternately welded.

A further problem with plate type heat exchangers is the suspension of the plate pack within a frame in such manner that a certain thermal expansion due to temperature variations is admitted.

According to the invention this problem is solved in that plastic block elements are provided at the corners of the plate pack allowing flanges of the frame to engage them to retain the plate pack within the frame.

These plastic block elements create a rigid edge enabling the retainment within the frame but nevertheless admitting a certain warping effect of the plate pack.

Preferably, the plastic block elements also function as sealing elements on the corners of the plates, for which purpose they are preferably provided with grooves with which they may be put onto the plates.

The invention further includes a method of manufacturing a plate type heat exchanger having a plurality of spaced parallel plates, in particular of enamelled steel, wherein adjacent plates are connected, except for connecting openings, on their edges into a plate pack, which is characterized according to the invention in that the edges of the plates are bent over to form connecting flanges, whereafter the plates are connected by welding at the position of the connecting flanges bent over towards each other, at least some of the plates being connected by means of connecting flanges abutting in flat relationship and being welded on their outer edges.

This method allows at least a part of the enamelled plates to be welded together without necessitating a further after-treatment or enamelling treatment of the whole plate pack because, as mentioned before, the enamel starts to flow during the welding operation and forms a layer sealing the seams between the plate flanges. In order to control this flow of the enamel, it is preferred to use the laser welding method in which the temperature and penetration depth of the supplied heat can be controlled very accurately.

In some cases it is possible to first weld small groups, for instance pairs, of plates to each other in a manner other than described and to enamel them again or for the first time, whereafter the groups of plates are assembled by welding the flanges abutting in a flat relationship in order to form the complete plate pack. The outer side of each group of plates or the complete pack can always be enamelled locally or completely by spraying.

The invention will hereafter be elucidated with reference to the drawing showing a number of embodiments of the plate type heat exchanger according to the invention by way of example.

Fig. 1 is a perspective, partially cut-away view of an exemplary embodiment of a section of a heat exchanger according to the invention.

Fig. 2 shows detail II of Fig. 1 with blocking elements demounted.

Fig. 3 is a view corresponding to that of Fig. 2, but showing a modified embodiment.

Fig. 4 is a view corresponding to that of Fig. 2, but showing still another embodiment.

Fig. 5 is a view corresponding to that of Fig. 2, but showing still a further embodiment.

In the drawing there is shown a part of a plate type heat exchanger which is particularly suited for the exchange of heat between two fluids, in particular two gasses. In principle, it is, however, also possible to exchange heat between two liquids or between a liquid and a gas.

The heat exchanger comprises a number of parallel spaced apart plates 2 assembled into a plate pack 1. The plates 2 define between them alternating spaces for two separate fluid flows between which heat should be exchanged. In the case shown, the heat exchanger works according to the cross-flow principle in which a first fluid flow (arrow A) is directed perpendicularly to the adjacent fluid flow (arrow B). The invention is, however, also useful with other principles, such as the counter-flow principle.

In the embodiment shown, the plates 2 are made of steel having a low carbon content ($C < 0.05$ %) covered by two layers of enamel in order to make the heat exchanger resistant to gasses containing aggressive acids and in environments within the heat exchanger having temperatures which are around of below the condensation point of the acid causing the risk of corrosion. The enamel layer offers an excellent protection against most of these acids, and in any case against H_2SO_4,H_2SO_3 and HCL. This makes the heat exchanger particularly suited for desulphurization and nitrogen reduction projects. The plate type heat exchanger is also suitable for use in post-burning installations in refuse incineration. Of course also other uses are conceivable.

The plate 2 may for example have a thickness of 1.5 mm and a dimension of 1.2 x 1.8 meter. In order to maintain the right interspacing between the plates 2 over the entire area there may be pressed concave or convex depressions 3, 4 respectively, preventing the plates 2 from being pressed towards each other when there is a large differential pressure between adjacent flow spaces. In the uses as described the overpressures of the gasses will mostly not exceed circa 50 kPa.

As shown in Fig. 1, but in particular in Fig. 2, each time two edges of adjacent plates 2 are connected by connecting flanges 5, 6 respectively. In this embodiment, the flanges 5 and 6 are of equal construction and extend parallel to the plane of the plates 2, but spaced therefrom. The flanges 5 and 6 are connected to the plates 2 through an inclined wall part 7, 8 respectively.

To connect adjacent plates 2, the connecting flanges 5 or 6 of two opposite edges thereof are positioned in flat abutting relationship and the outer edges thereof are welded so as to form an edge weld 9, 10 respectively. Due to the heat supply during the welding of the connecting flanges 5, 6, the enamel of the enamel layer of both plates 2 flows together on the inner edges of these connecting flanges 5, 6 so that a closed enamel layer is formed over the seam between the connecting flanges 5 or 6 of both adjacent plates 2. In this manner there is created a full protective layer around the flow space for the fluids preventing corrosion of the plates 2, without further after-treatment or enamel covering of the plates 2. A favourable welding method is the laser welding method because the heat supply can there be controlled very well and consequently a controlled flow of the enamel can be obtained.

To arrange the plate pack 1 formed by welding together the individual plates 2, within a frame 11, shown partly in Fig. 1, there are positioned on four edges of the plate pack 1 plastic block elements 12 allowing engagement of corner sections 13 of the frame 11 to confine the plate pack 1 within the frame 11 by clamping it together. In the case shown, the block elements are made up from a plurality of small plastic blocks 14 and 15 having a similar shape, but being mounted alternately in a different manner to the plate pack so as to create the block element 12.

As is shown in Fig. 2 each connecting flange 5, 6 terminates a distance from the adjacent perpendicular edge of the respective plate 2, and also a portion of the wall part 7, 8 is taken away along the same distance. In each small block 14, 15 are arranged two inclined grooves 16 with which the blocks 14, 15 may be slid over the wall portions 7 or 8 of adjacent plates 2 allowing the blocks 14, 15 to partially submerge in the space between adjacent plates 2. In this manner the blocks 14, 15 function as seal element on corner edges of the plate pack 1 and the created block elements 12 form flanges for the plate pack 1 admitting a certain thermal expansion. A material of the blocks 14, 15 suited for these purposes is for instance teflon, which is resistant to acids and high temperatures up to 270 °C. Of course also other plastics may be used depending on the use of the heat exchanger. Another conceivable plastic is polyvinyldifluoride.

The embodiment of the heat exchanger shown in Fig. 1 is particularly suited for the heat exchange between a clean gas flowing horizontally through horizontal flow spaces between the adjacent plates 2 (arrow A) and an aggressive gas flowing vertically through the adjacent spaces according to arrow B. Any condensate of such an aggressive gas will flow along the walls of the plates 2 to the exterior of the plate pack 1 so that no acid remains within the plate pack. To form larger heat exchangers it is possible to connect several plate packs 1 to each other, but on the other hand it is also possible to connect a supply and discharge for the respective gasses to the plate pack 1 as shown.

Fig. 3 shows an alternative of the embodiment of Fig. 2, the difference being that the wall portions 7 and 8 are not bent over 45° as in Fig. 2, but an angle of 90° with respect to the plane of the plates 2. The shape of the blocks 14, 15 is adapted to the shape of the connecting flanges 5, 6 and wall parts 7, 8. This embodiment is suited for the same use as that of Fig. 2, but for higher pressures of the gasses, or for another use in which the load on the plates 2 can be high.

The embodiment of the heat exchanger of Fig. 4 is particularly suited for exchanging heat between two corrosive gasses. For this purpose, the connecting flanges 6 and the wall parts 8 on the upper and lower side of the plates 2 are replaced by a horizontally flanged flange 17, the flanges 17 of adjacent plates 2 being interconnected by means of a buttweld 18. In the production of the plate pack 1 in this embodiment pairs of plates 2 are each time connected to each other through the connecting flanges 17, the butt ends of the flanges 17 are grind and etched on the outer side. Then each pair of plates 2 is again enamelled completely. As next step the pairs of plates 2 are interconnected to the connecting flanges 5 in a manner described above and are assembled into the plate pack 1. During operation, the plate pack 1 is suspended within the frame 11 at an angle of 1 to 2° in order to allow the corrosive condensate of the gas to flow out.

Fig. 5 shows another variant of the embodiment of Fig. 4. The dimensions of the blocks 15 are minimized. The slots 16 are omitted which is made possible by removing the upper edges of the wall parts 7. To protect the weld 9 in aggressive, for example acid, surroundings there is arranged an enamelled cover plate 19 on the pair of abutting flanges 5 with an interposed ceramic paste. The outer end of each block 15 has a downwardly projecting edge 20 lying over the cover plate 19.

The frame, in which the plate pack 1 is suspended, preferably comprises adjusting elements, such as adjustable supports or spacers. By interposing a teflon cord the difference in extension between the frame and the plate pack upon warming up and cooling down can be absorbed.

The invention is not restricted to the embodiments described above and shown in the drawing, which can be varied in different manners within the scope of the invention. It is for instance possible to replace enamel by another material as protecting layer on the plates, which flows at higher temperatures. Also other welding methods besides laser welding can be used.

Claims

1. Plate type heat exchanger having a plurality of substantially parallel spaced apart plates, in particular of enamelled steel, spaces for two separate fluid flows being alternately formed between the plates, and adjacent plates being joined at their edges, except for connecting openings, to form a plate pack, **characterized** in that the adjacent plates comprise on at least two edges connecting flanges bent over towards each other and connected by welding, at least the connecting flanges of some of said adjacent plates abut in flat relationship and are welded on their outer edges.

2. Plate type heat exchanger according to claim 1, wherein only the connecting flanges of adjacent pairs of plates are in flat abutment parallel to the plane of the plates and are welded on their outer edges.

3. Plate type heat exchanger according to claim 2, wherein the plates of said pairs are interconnected by connecting flanges abutting end-to-end and being butt-welded and then enamelled (again).

4. Plate type heat exchanger according to claim 1, wherein all plates are connected by connecting flanges which abut in flat relationship and which are welded on their outer edges.

5. Plate type heat exchanger according to one of the preceding claims, operating according to the cross-flow principle, wherein the fluid flows on both sides of each plate are directed substantially perpendicularly and wherein the perpendicularly directed edges of adjacent plates are alternately welded.

6. Plate type heat exchanger according to one of the preceding claims, wherein plastic block elements are provided at the corners of the plate pack allowing flanges of the frame to engage them to retain the plate pack within the frame.

7. Plate type heat exchanger according to claim 6, wherein a block element is provided on each pair of plates and adjacent block elements are in abutting relationship.

8. Plate type heat exchanger according to claim 7, wherein the block elements are inserted onto the edges of those corner edges of the plates which are left free by the connecting flanges and also function as sealing element.

9. Method of manufacturing a plate type heat exchanger having a plurality of spaced parallel plates, in particular of enamelled steel, wherein adjacent plates are connected, except for connecting openings, on their edges into a plate pack, **characterized** in that the edges of the plates are bent over to form connecting flanges, whereafter the plates are connected by welding at the position of the connecting flanges bent over towards each other, at least some of the plates being connected by means of connecting flanges abutting in flat relationship and being welded on their outer edges.

10. Method according to claim 9, wherein all plates are welded to each other through said flanges abutting in flat relationship.

11. Method according to claim 9, wherein several pairs of plates are butt-welded by means of connecting flanges bent over at right angles and are subsequently enamelled (again) whereafter said pairs of plates are welded together through their connecting flanges abutting in flat relationship.

12. Method according to one of claims 9-11, wherein the welding operation is carried out by laser welding.

13. Method according to one of claims 9-12, wherein the formed plate pack is secured within a frame by means of plastic block elements positioned on the four edges extending perpendicular to the plates of the plate pack, said block elements being clamped between flanges of the frame.

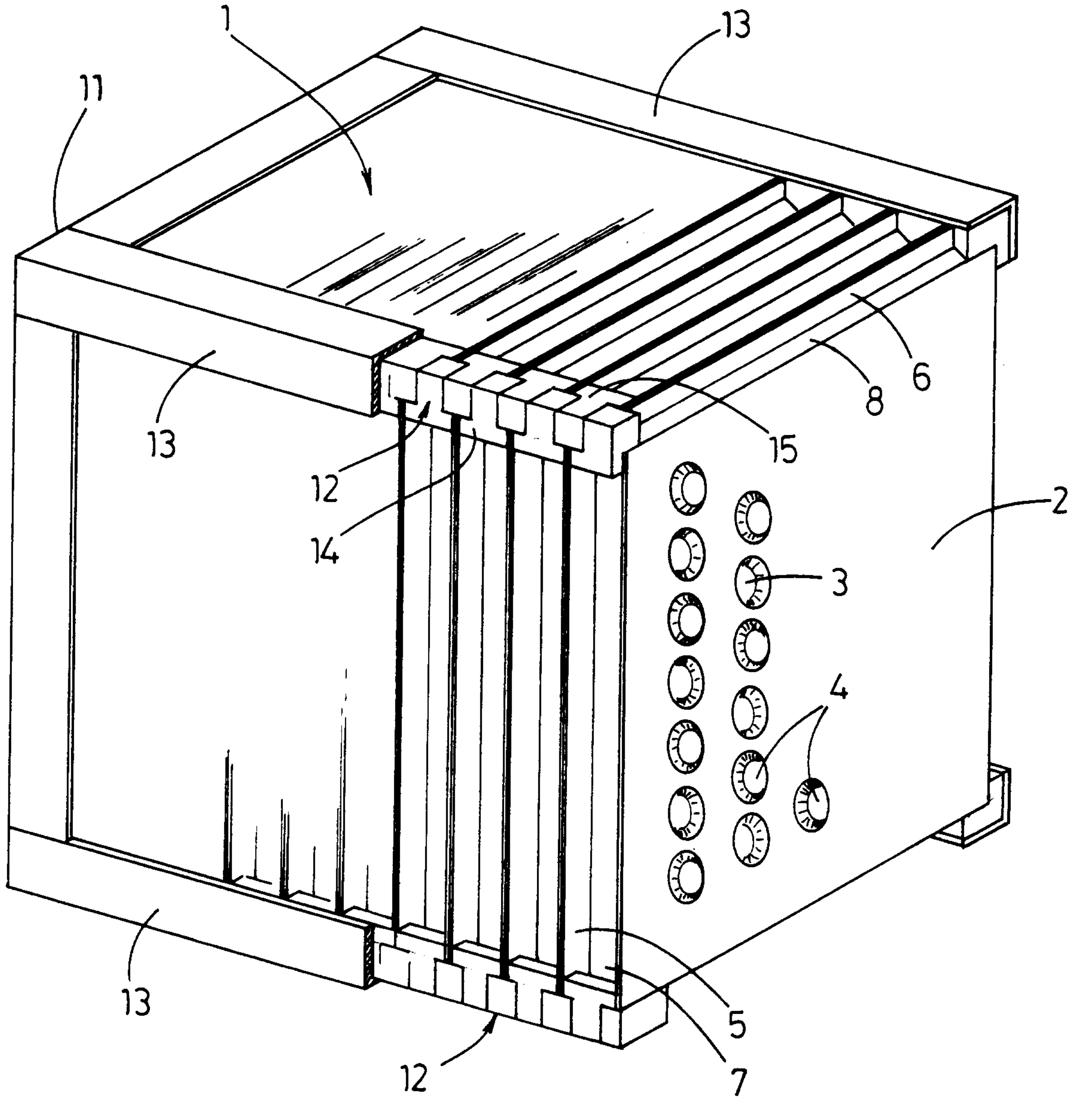

fig.1

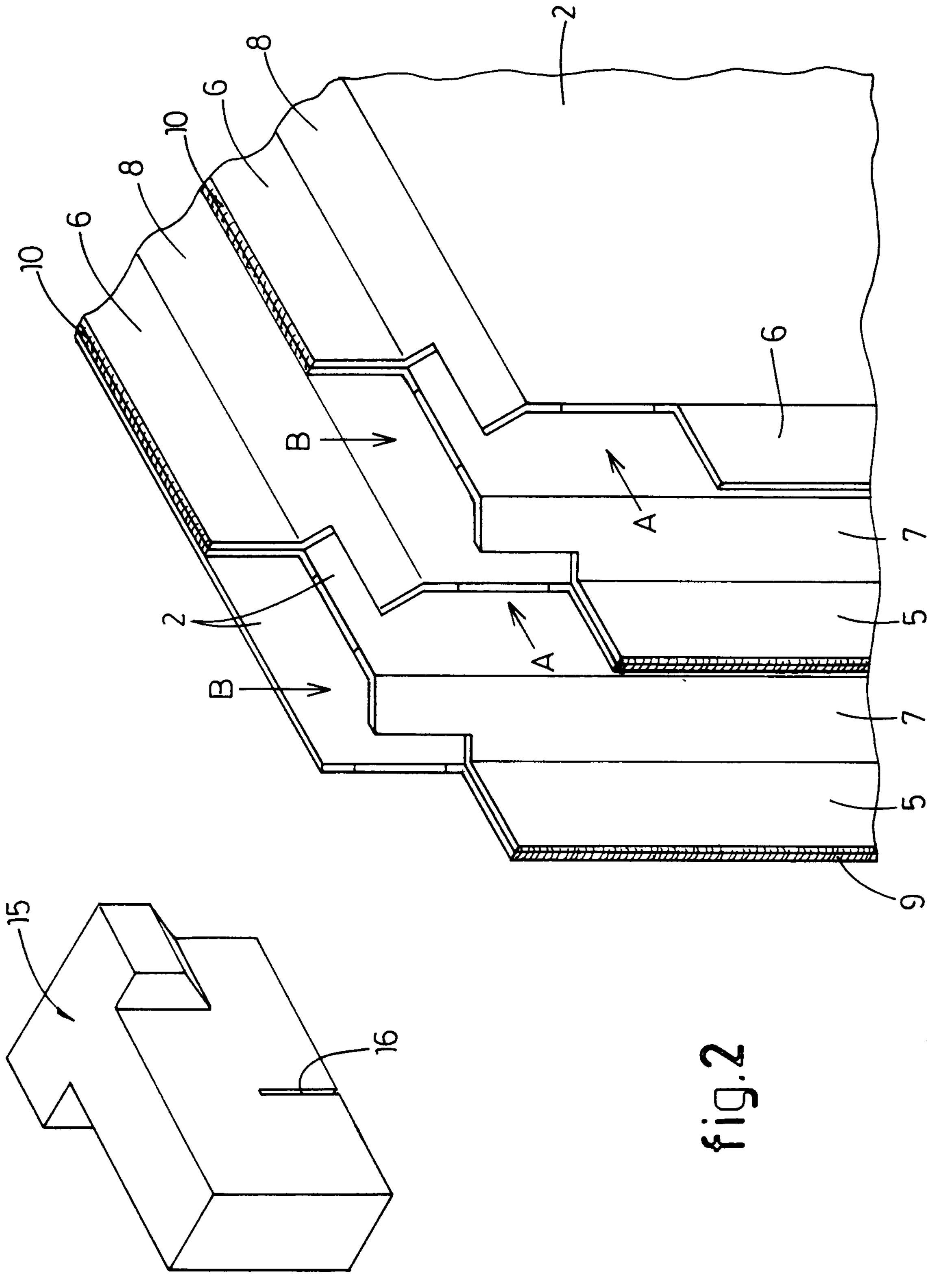

fig.2

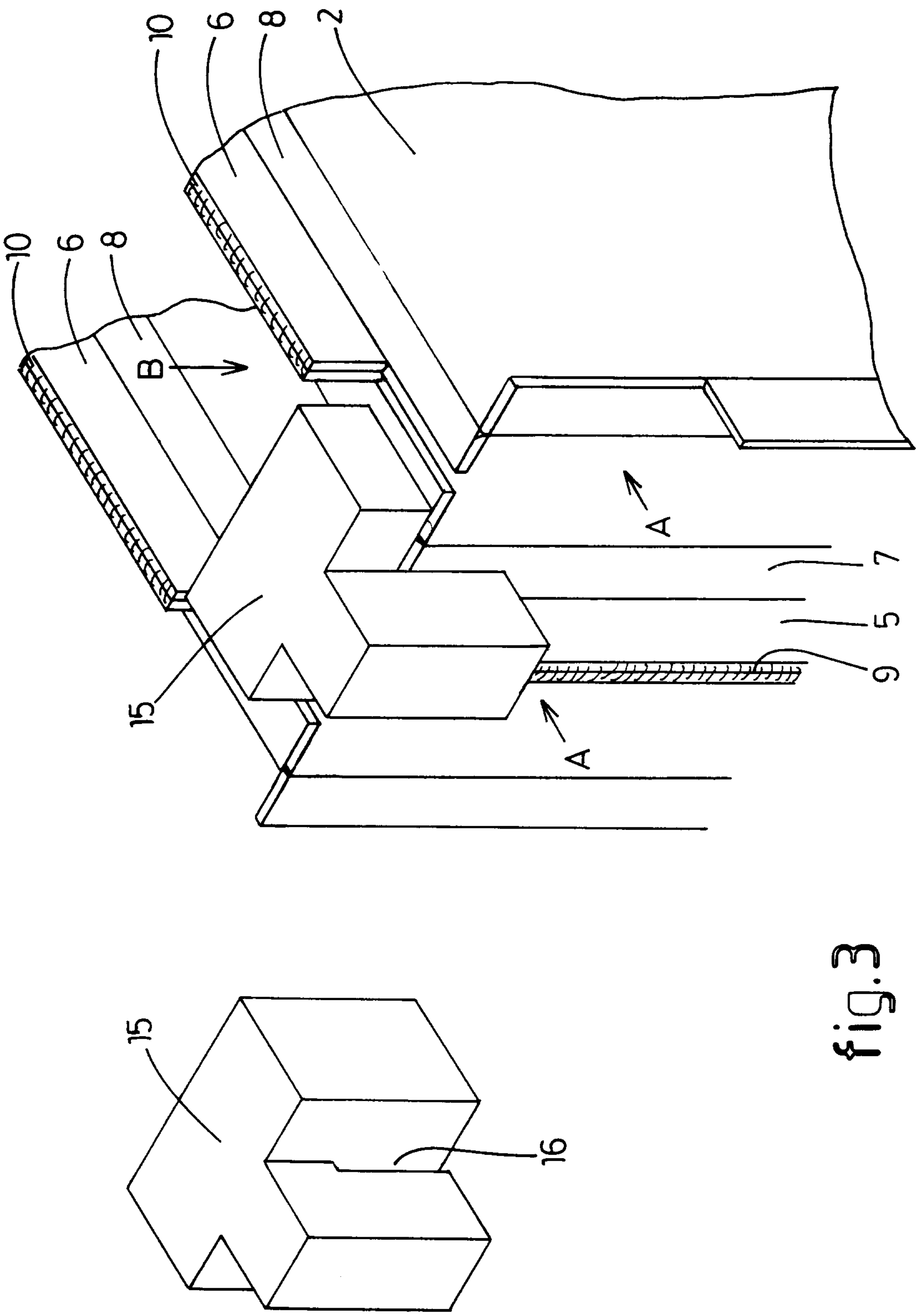

fig.3

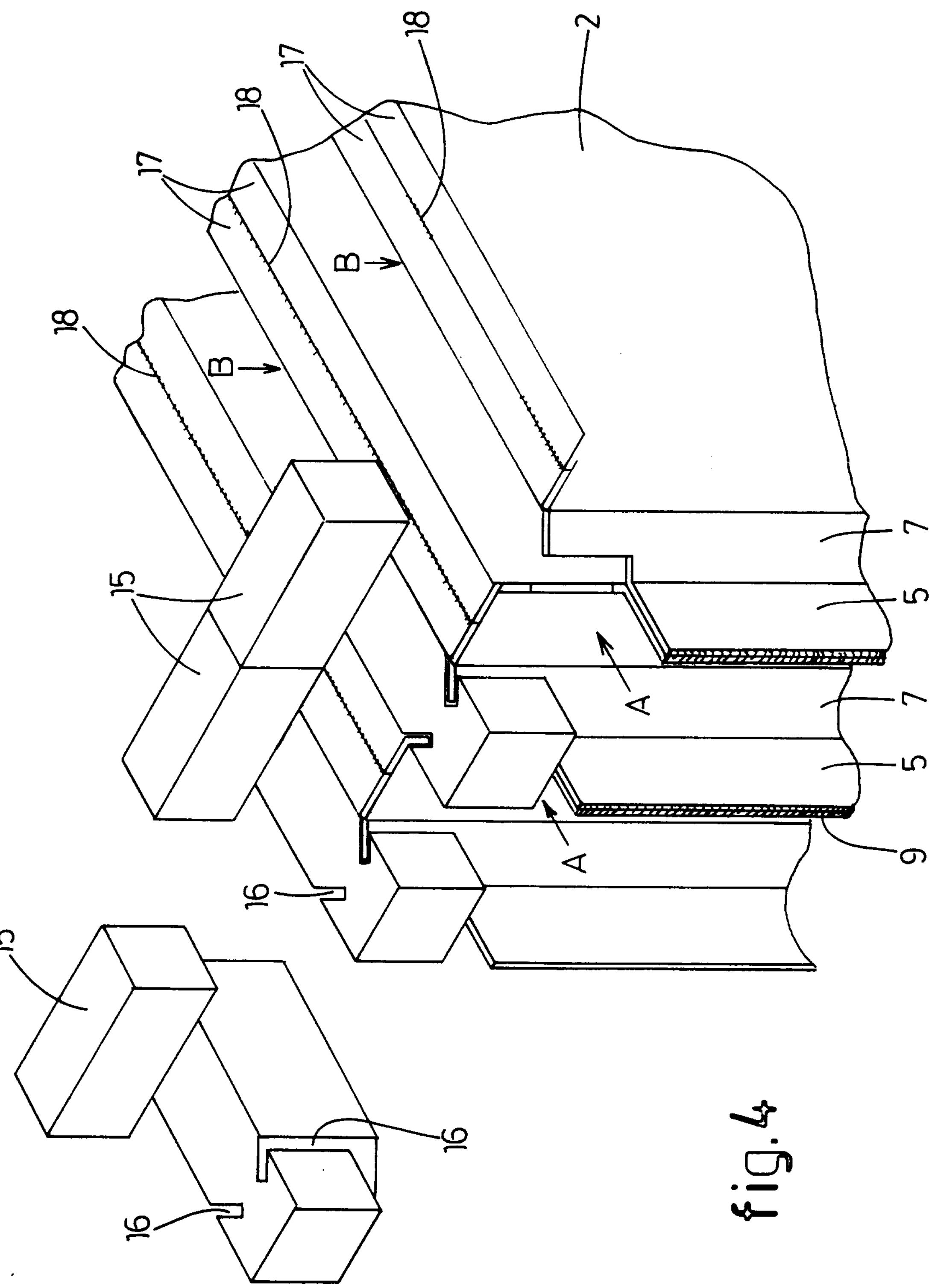

fig. 4

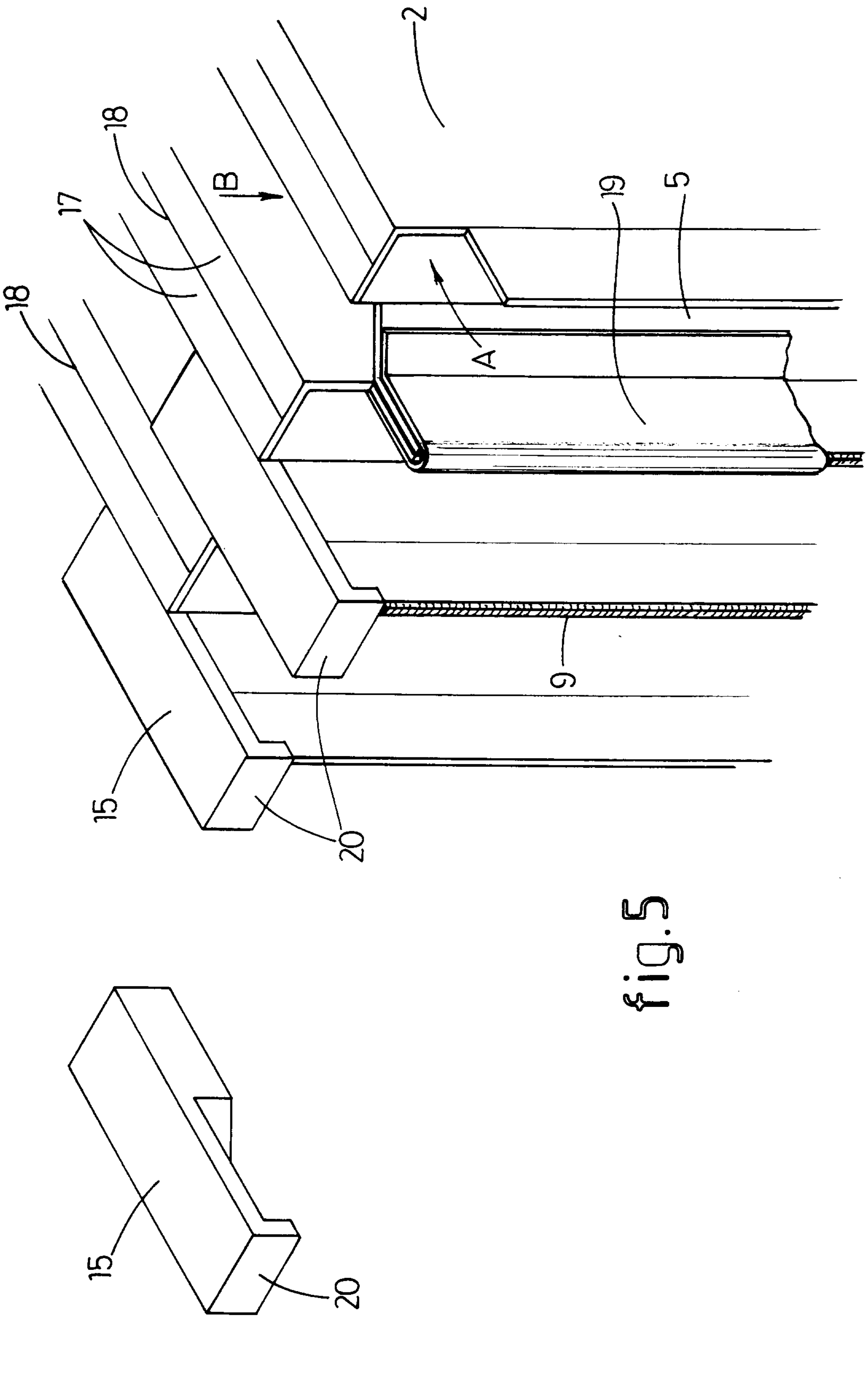

fig.5

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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.5)
X	US-A-3 274 672 (DORÉ) * column 2, line 1 - column 2, line 72; figures 1-4 *	1,2,4,5, 9,10	F28D9/02 F28F3/10
X	US-A-2 959 401 (BURTON) * column 2, line 12 - column 3, line 6; figures 1,2 *	1,2,4,5, 9,10	
X	FR-A-2 318 398 (AKTIEBOLAGET C.MUNTERS) * page 2, line 21 - page 3, line 29 * * page 5, line 1 - page 5, line 26 * * page 6, line 2 - page 6, line 14; figures 1,4,5A *	1,2,4-6, 9,10,13	
A		7,8	
X	DE-A-4 031 436 (BAVARIA ANLAGEBAU GMBH) * column 3, line 4 - column 4, line 31; figures 1-8 *	1,2,4,5, 9,10	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
X	EP-A-0 165 179 (VICARB) * page 5, line 29 - page 6, line 26; figures 1-8 *	1-5,9-11	F28D F28F
Y		6,12	
Y	FR-A-2 317 617 (ALUMINIUM SUISSE SA) * page 6, line 1 - page 6, line 4; figure 7 *	6	
Y	PATENT ABSTRACTS OF JAPAN vol. 6, no. 253 (M-178)11 December 1982 & JP-A-57 149 083 14 September 1982 * abstract *	12	

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	20 JULY 1993	BELTZUNG F.C.

CATEGORY OF CITED DOCUMENTS

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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.5)
A	FR-A-2 392 349 (PFAUDLER-WERKE AG) * page 3, line 19 - page 3, line 24; figure 5 * -----	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)

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