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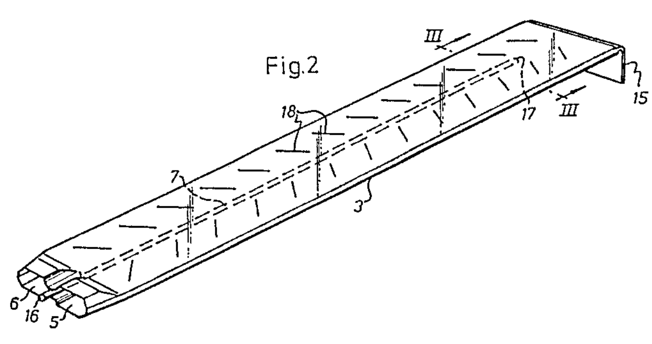
(54) **Method of making a heat exchanger.**

(57) A heat exchanger is operated by a first medium and a second medium and comprises a tank (8) having an inlet chamber (9) and an outlet chamber (10) and containing said first medium, as well as a heat transfer pile (2) with tubes (3) for circulating said first medium, said tubes (3) having a U channel with an inlet (5) for connection to said inlet chamber (9) and an outlet (6) for connection to said outlet chamber (10), said heat transfer pile having fin units (4) arranged alternately with said tubes (3) and adapted to guide said second medium past said tubes. Each tube is formed by bending a strip and joining together its longitudinal edges; the bent strip is flattened and cut into tube blanks; the cut tube blanks are closed at the one end portion; and a partition is provided in the longitudinal direction of each tube blank to form said tube, the inner end of said partition being provided at a distance from the closed end portion of the tube blank to form the said U channel.

Fig.2



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Description

METHOD OF MAKING A HEAT EXCHANGER

The invention relates to a method in the manufacture of a heat exchanger according to the preamble of claim 1.

A heat exchanger comprising a plastics tank and metal tubes as well as a method of making such a heat exchanger are disclosed by EP 0,000,189, according to which round tubes bent into U shape are connected with a tank having an inlet and an outlet chamber separated from each other such that a U-shaped flow is imparted to the cooling or heating medium within the heat exchanger. Furthermore, it is previously known to provide a heat exchanger with flat tubes between two tanks, thereby to provide a larger heat transfer surface and to reduce the heat exchanger dimensions without detracting from its heat transfer capacity. In addition, it is already known, inter alia from the above-mentioned EP 0,000,189 to glue metal tubes on a plastics tank, the tank being provided with connecting pieces for gluing the tubes to the tank, the round tubes being flanged before they are mounted or pressed onto the tank, an arrangement which is disadvantageous because the adhesive tends to flow out, thereby jeopardising the tight seal of the tubes against the tank.

The present invention aims at providing a method of making a heat exchanger having a higher temperature efficiency per m^2 of heat exchanger surface, to establish communication between the tank and the heat transfer pile by, for example, gluing a tank made of injection moulded plastics to a heat transfer pile made of aluminium, and to provide a heat exchanger having a better seal between these components, lower weight, smaller dimensions and thus taking up less space.

These objects are achieved, according to the present invention, by a method of making a heat exchanger, said method being characterised by the features stated in claims 1-10.

According to the invention, a heat transfer pile is equipped with flat tubes which, in their longitudinal direction, have a partition extending to a point at a distance from the tube bottom to form a flat flow channel of U shape. The flat tubes give the advantage of a larger heat transfer surface, while simultaneously reducing the size of the heat exchanger for a given heat transfer capacity, an important advantage when such heat exchangers are used as vehicle coolers or heaters.

The invention will now be described in more detail on the basis of a preferred embodiment and with reference to the accompanying drawings.

Fig. 1 is a perspective view of a heat exchanger, in which certain parts of the tank have been removed.

Fig. 2 is a perspective view of a tube comprised by the heat exchanger.

Fig. 3 is a section along line III-III in Fig. 2.

Fig. 4A is a side view of a tank with connecting pieces for connection to the tubes.

Fig. 4B is a section along the line IV-IV in Fig. 4A.

Fig. 5 is a top view of a perforated strip included in the fin unit of the heat exchanger.

Fig. 6 is a section along line VI-VI in Fig. 5.

Fig. 1 illustrates a heat exchanger 1 with a heat transfer pile 2 comprising on the one hand a plurality of tubes 3 for circulating a first medium, such as water, and on the other hand a plurality of fin units 4 which are arranged alternately with the tubes 3 and past which a second medium, such as air, is intended to flow. The heat exchanger 1 can operate both as a heater and as a cooler. The fin units 4 consist of a perforated and folded strip which is described below. Each tube 3 has at one end an inlet 5 and an outlet 6 and is closed at its other end. Each tube 3 has a partition in the form of a rod 7 which is inserted in the tube 3 and has its inner end located at a distance from the closed end of the tube, whereby a U channel for circulation of the water is formed. The water thus enters at the inlet 5, flows through the U channel and is discharged through the outlet 6. A tank 8 having an inlet chamber 9 and an outlet chamber 10 is connected to the open ends of the tubes 3, the tube inlet 5 communicating with the inlet chamber 9 and the tube outlet 6 communicating with the outlet chamber 10. The water flows into the inlet chamber 10 of the tank 8 via an inlet piece 11 and then flows through the U channels of the tubes 3 and into the outlet chamber 10 of the tank 8, from which the water is finally discharged via an outlet piece 12 schematically illustrated in Fig. 1 and mounted on the upper part of the tank 8. In the embodiment illuillustrated, the second medium is air which flows through the fin units 4 in the direction of the arrow A. If the heat exchanger is used as a cooler, the air flow cools the water in the tubes 3, and inversely the air flow is heated by the water when the heat exchanger is used as a heater, for example a car heater. The specific flat shape of the tubes 3 provides a large heat transfer area which, together with the U shaped water flow path, gives an excellent exchange of heat. Finally, the heat exchanger 1 has upper and lower plates 13 to stiffen the heat transfer pile 2. The rear end wall 14 of the heat exchanger 1 consists of tube end portions 15 bent through about 90° when the tubes 3 are closed. The tank 8 constitutes the front end wall.

Fig. 2 illustrates the construction of a tube 3. The tube which preferably is made of aluminium, has a U channel with an inlet 5 and an outlet 6. To form the U-channel, the end of the tube 3 is closed by bending the end portion 15 through about 90°, and the rod 7 is inserted to form a partition within the tube 3. The outer end portion 16 of the rod 7 projects beyond the open tube end, i.e. past the inlet 5 and the outlet 6, while its inner end 17 is located at a distance from the closed tube end 15. At the inlet 5 and the outlet 6, the tube 3 is flanged to provide a larger inlet and outlet area upon connection to the connecting pieces described below. The flanging also serves to reduce the throttling which occurs at the junction between the tubes and the connecting pieces. Moreover, the outer side of the tube 3 has indentations 18 to provide discontinuities within the tube. These discontinuities produce a turbulent water flow and serve as guide means for the rod 7.

Fig. 3 illustrates a section of the tube 3 and clearly shows the flat tube shape. The space of the tube 3 to the right of the rod 7 constitutes the inlet side of the U channel, while the left-hand space constitutes the tube outlet side. The indentations 18 in the upper and lower sides of the tube 3 form internal ridges 19 and serve to produce a turbulent flow. The ridges 19 preferably are slightly oblique and, together with the rod 7, form an arrow-head pattern (see Fig. 2). In an alternative embodiment, the partition may be formed, instead of by the rod 7, by impressing from the flat sides of the tube 3 longitudinal ridges which are sealingly interconnected in a subsequent operation. The ridge portion thus impressed has preferably the same extent in the tube 3 as the rod 7 (see Fig. 2).

Figs. 4A and B show that part of the tank 8 which is to be connected to the inlets 5 and outlets 6 of the tubes 3. First projecting connecting pieces 20 correspond to the inlets 5 of the tubes 3, while second projecting connecting pieces 21 correspond to the outlets 6 of the tubes 3. Between adjacent connecting pieces 20, 21, a recess 23 is provided which is adapted to accommodate the end portion 16 of the rod 7 projecting from the tube 3. Each pair of connecting pieces 20, 21 is surrounded by throughs 22 which are shallower than the recess 23. Each connecting piece has adhesive passages 26, the function of which will be described below. Each pair of connecting pieces 20, 21 and each trough 22 are surrounded by a wall 27 which is considerably thicker than the connecting pieces 20, 21. Upon connection of the tank 8 to the inlets 5 and outlets 6 of the tubes 3 comprised by the heat transfer pile 2, an adhesive, for example glue, is first applied to the troughs 22, whereupon the tank 8 is pressed onto the open flanged ends of the tubes 3, any excess adhesive flowing into the adhesive passages 26 to ensure tight connection. The projecting end portion 16 of the rod 7 (see Fig. 2) is received in the recess 23 which preferably is also filled with adhesive to further stabilise the connection.

Fig. 5 illustrates a strip 28 which preferably is made from aluminium and which, after folding, forms a fin unit 4 for the heat transfer pile 2. The strip 28 has perforations in the form of first slits 29 and second slits 30. The slits 29, 30 are punched from the strip 28 and widened by bending. The first slits 29 are formed such that their openings are facing the openings of the second slits 30, as is best shown in Fig. 6. During manufacture of the fin unit 4, the strip 28 provided with slits 29, 30 is folded, and the fin units 4 are then placed alternately between the tubes 3 in the heat transfer pile 2 of the heat exchanger 1. When the air flows past the fin units 4, the opposing slits 29, 30 will divide and split up the air flow in the heat transfer pile 2 and serve to break up a laminar boundary layer which, on a planar surface, would position itself as an insulation. The divided split-up flow past the fin units 4, which primarily is in the form of a turbulent flow, promotes the heat exchange.

Briefly, the heat exchanger 1 operates as follows. The water to be cooled flows into the tank 8 via the inlet piece 11 and on through the U channels of the tubes 3 and leaves the tank 8 through the outlet piece 12. The air flows in a zigzag-like manner through the heat transfer pile 2 comprising the tubes 3 and the fin units 4, and because of the above-mentioned slits 29, 30 the air is distributed through the entire pile 2 to ensure satisfactory heat exchange. The ridges 19 in the tubes 3 promote turbulent flow of the water passing through the U channels of the tubes 3, whereby the heat exchange is further improved.

The heat exchanger 1 according to the preferred embodiment may be manufactured as follows. First a preplated strip blank is bent to form a tube, the longitudinal edges of the blank being joined together by welding or seaming. Before welding or seaming is effected, continuities are provided in the strip, and after the strip has been bent, these discontinuities will lie on the inner side of the strip. Also a strip band which has not been preplated may be employed, and plating may be effected for instance after bending by passing the strip through a solder bath prior to welding or seaming. After that, the bent strip is flattened and cut into tube blanks which are closed at one end by clenching. During the closing operation, the other end of the tube blank may be preliminarily flanged to fit the connecting pieces on the tank. After that, a partition is provided in the longitudinal direction of each tube blank, the inner end of the partition being arranged at a distance from the closed end portion of the tube blank to form a U-shaped flow channel. Then the closed end portions of the tube blanks are bent through an angle of about 90°, and the tubes 3 are now finished.

The fin units 4 are manufactured in a different and shorter production line. As with the tubes 3, the starting material of the fin units consists of a strip 28 which is punched to provide slits 29, 30 extending longitudinally of the strip 28 and forming lines of first and second slit areas extending transversely of the strip 28. The slits 29, 30 are bent out of the band 28 (i.e. out of the plane of the drawing in Fig. 5), such that the openings of the slits 29 are directed against the openings of the slits 30. After that the slitted strip 28 is folded alternately in one and the other direction along folding lines B and C to form an endless folded fin strip. The length of the slits 29, 30 preferably is somewhat shorter than the width of the fin unit 4 between the tubes 3. The folded fin strip is cut into lengths slightly shorter than the length of the tubes 3.

The tubes 3 and the fin units 4 formed by cutting the endless fin strip are now alternately stacked in a fixture and compressed with a predetermined force, such that the tube ends folded approximately through 90° will overlap one another in the heat transfer pile 2 formed by the stacking, and will form one end wall 14 of the pile 2. When the tubes and the fin units are stacked, it is also possible to provide at the two ends of heat transfer pile 2 two plated sheets of preferably aluminium for stiffening the completed heat transfer pile 2. The heat transfer pile stacked in the fixture is now inserted in a soldering oven, the temperature of which is gradually increased to establish a subpressure so that the plating previously applied to the tubes 3 and the plates 13 will melt and, through capillary action, seep into the narrow pockets between the plates and the fin units, between the tubes and the fin units, and between the tubes and the partitions thereof. In this manner, no oxidation will occur because of the subpressure prevailing in the oven. The heat transfer pile 2 is then removed from the oven and allowed to cool. The open ends of the tube 3 are flanged to obtain a form corresponding to the connecting pieces in the tank. If flanging has been carried out in this manner, a calibrating subsequent flanging is effected. After that, each tube in the heat transfer pile 2 is pressure-tested and then oven-aged for tempering.

Finally, the heat transfer pile 2 is combined with an injection-moulded tank preferably of plastics, adhesive being applied in the troughs 22 around the connecting pieces 20, 21, and the tube ends of the heat transfer pile are inserted into their respective adhesive troughs, the outer end portion 16 of the rods 7 being inserted in corresponding recesses 23. The adhesive is then allowed to set to form a finished heat exchanger.

Claims

1. A method of making a heat exchanger (1) operated by a first medium and a second medium and comprising a tank (8) having an inlet chamber (9) and an outlet chamber (10) and containing said first medium, as well as a heat transfer pile (2) with tubes (3) for circulating said first medium, said tubes (3) having a U channel with an inlet (5) for connection to said inlet chamber (9) and an outlet (6) for connection to said outlet chamber (10), said heat transfer pile (2) having fin units (4) arranged alternately with said tubes (3) and adapted to guide said second medium past said tubes (3), **characterised** in that each tube is formed by bending a strip and joining together its longitudinal edges; that the bent strip is flattened and cut into tube blanks; that the cut tube blanks are closed at the one end portion; and that a partition is provided in the longitudinal direction of each tube blank to form said tube, the inner end of said partition being provided at a distance from the closed end portion of the tube blank to form the said U channel.

2. A method as claimed in claim 1, **characterised** in that the partition is provided by inserting a longitudinal element (7) into the tube blank to be sealingly connected therewith in a subsequent operation.

3. A method as claimed in claim 1, **characterised** in that said partition is provided by compressing two ridges pressed into the tube blank, said ridges being sealingly connected with one another in a subsequent operation.

4. A method as claimed in any one of claims 1-4, **characterised** in that discontinuities (19) are provided in the strip and, after bending of the tube blank, lie on the inner side thereof.

5. A method as claimed in any one of claims 1-4, **characterised** in that the closed end portion of each tube blank is bent through about 90°, such that the bent end portions (15) together form one end wall (14) of the heat exchanger (11).

6. A method as claimed in any one of claims 1-5, **characterised** in that the bent strip is plated with a solder before its longitudinal edges are joined together.

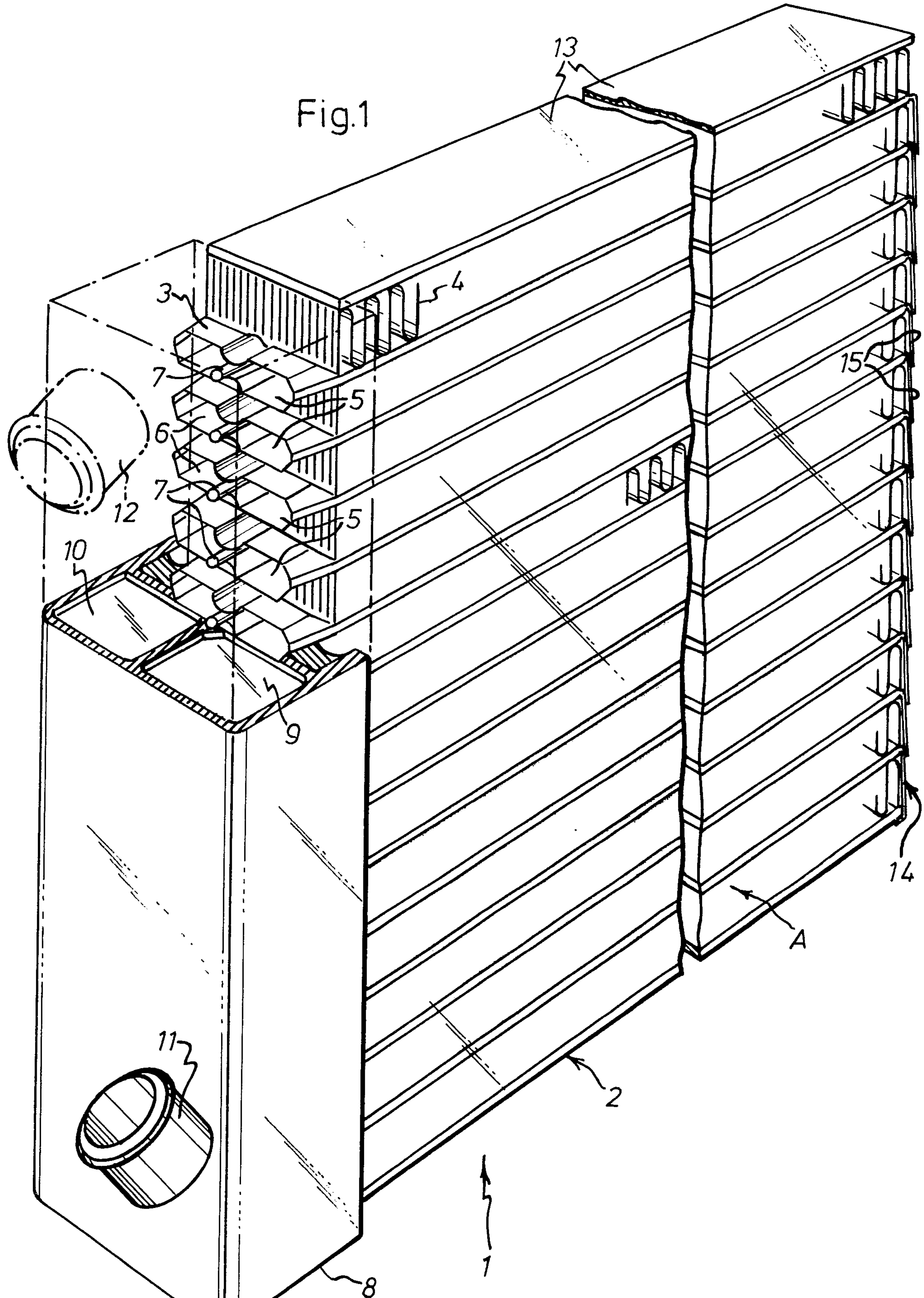
7. A method as claimed in claim 6, **characterised** in that the fin unit (14) and the tubes (3) provided with partitions (7) are stacked to form said heat transfer pile (2) which is then heated for soldering of the fin unit (14) and the tubes (3), during which operation also the partition (7) is soldered in position.

8. A method as claimed in claim 7, **characterised** in that soldering is carried out under a subpressure.

9. A method as claimed in any one of claims 1-8, **characterised** in that the fin unit strip is provided with perforations and is folded in its longitudinal direction to form said fin unit (4).

10. A method as claimed in claim 9, **characterised** in that said perforations are formed by slits extending longitudinally of said strip, that said slits are placed in rows having a width corresponding to the thickness of the finished fin unit, and that at least one edge of said slits is bent out of the plane of the strip.

Fig.1



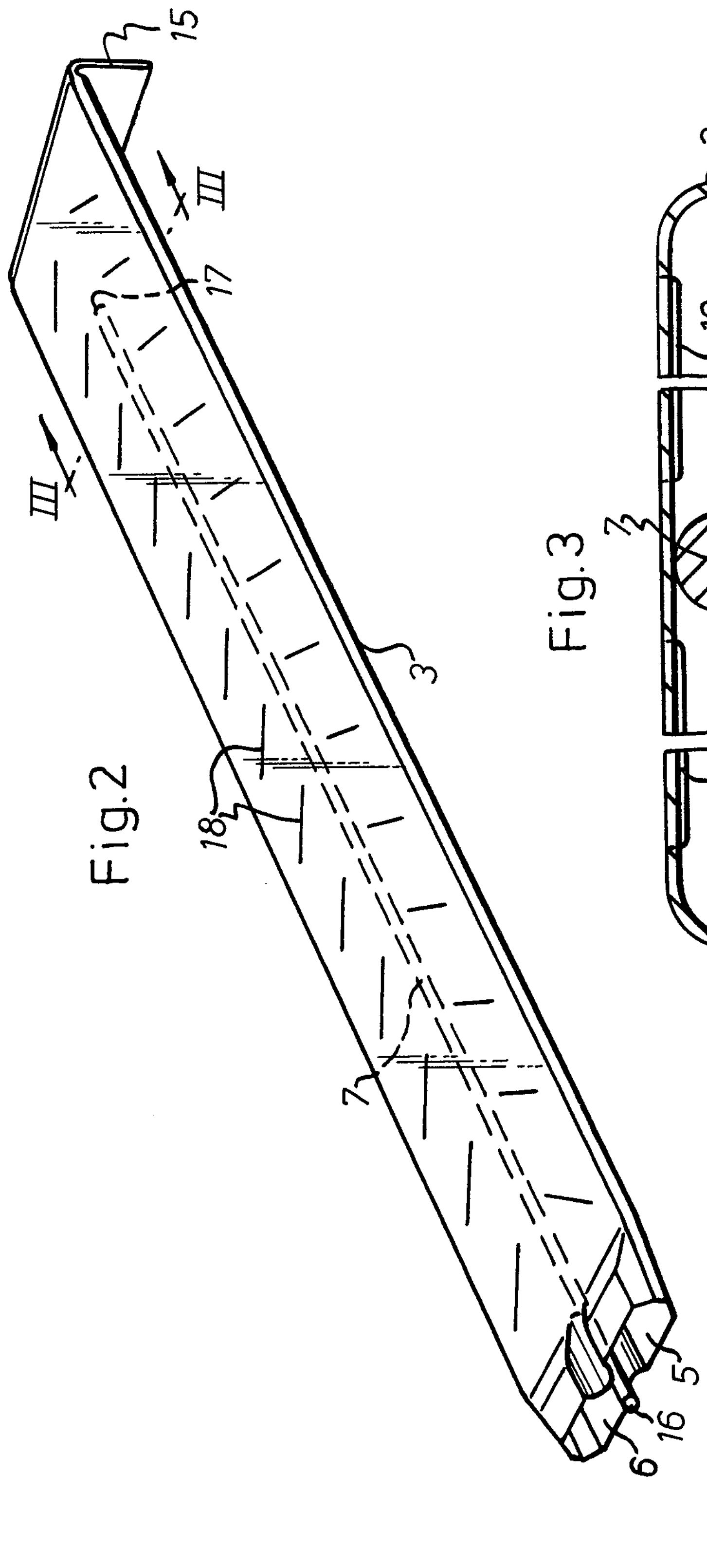


Fig.2

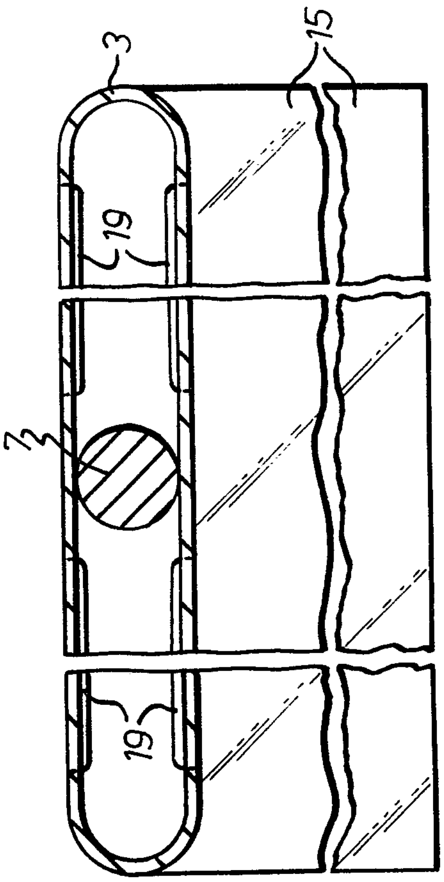


Fig.3

Fig. 4A

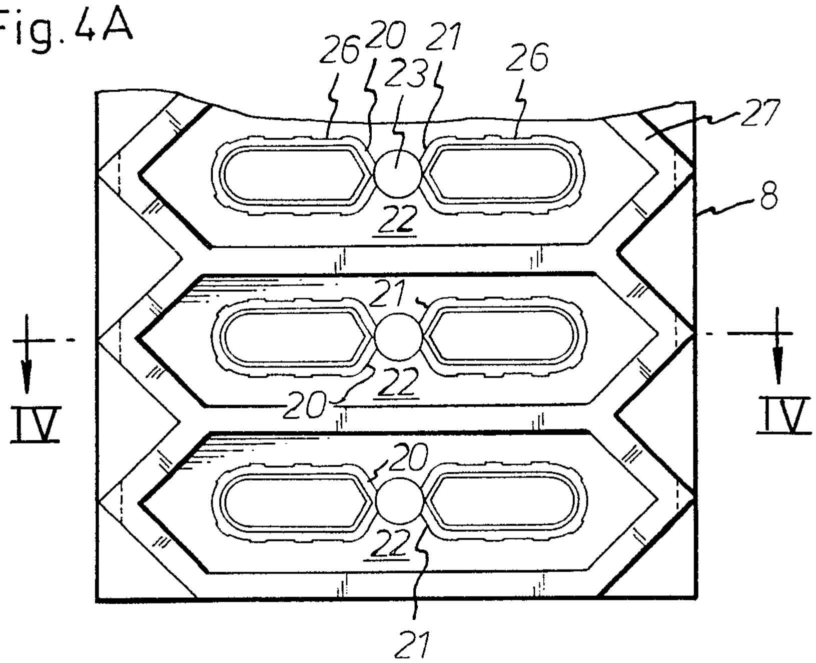


Fig. 4B

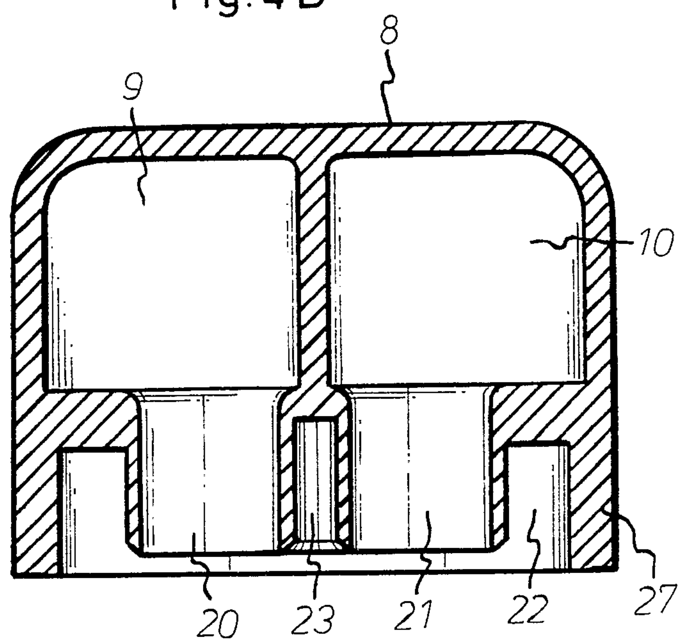


Fig.5

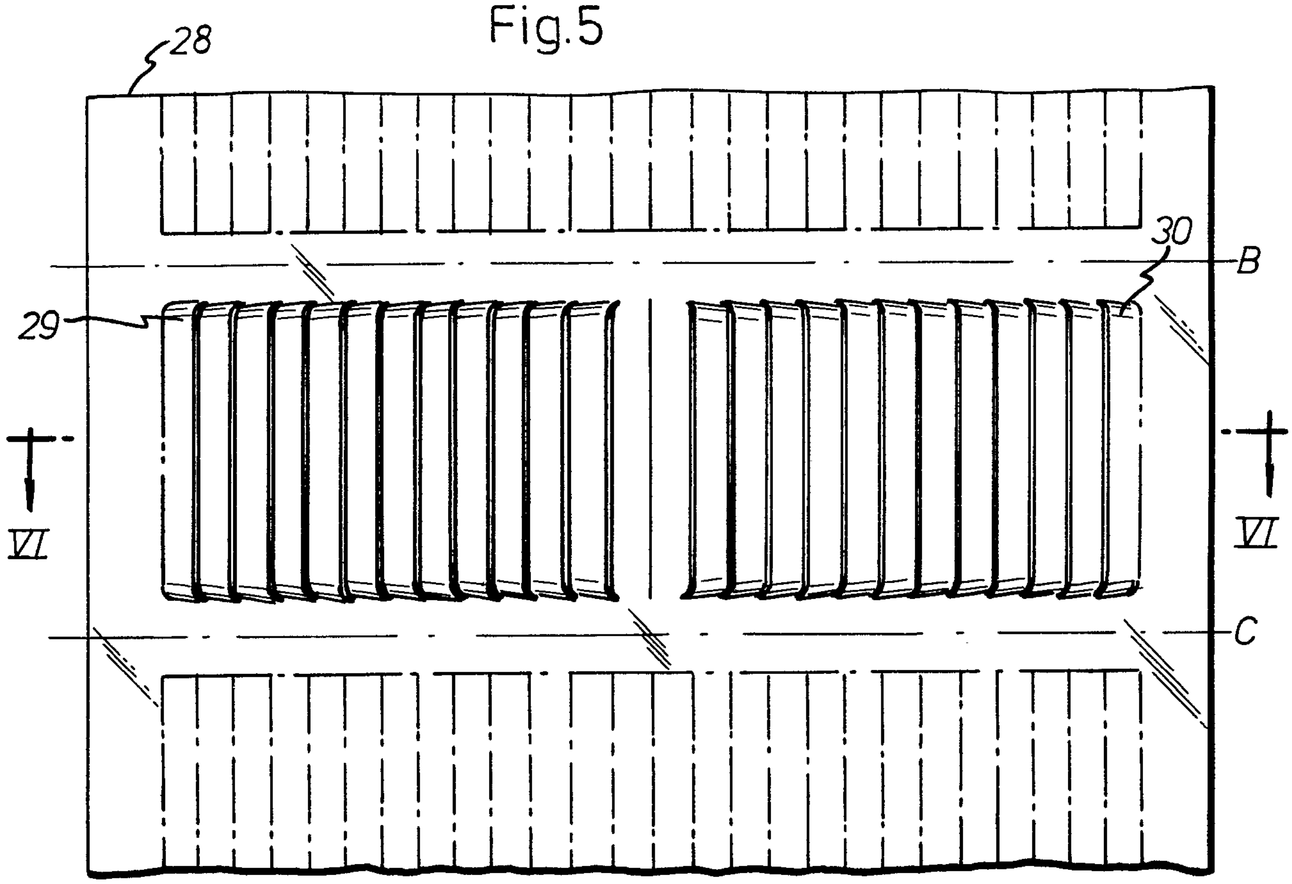


Fig.6

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EUROPEAN SEARCH REPORT

Application number
EP. 89101072.0

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 4)
Y	GB-A-2 116 687 (D. STEEB) 28 September 1983 Whole document ---	1-8	F 28 D 1/04, B 23 P 15/26
Y	GB-A-1 374 982 (ASSOCIATED ENGINEERING LTD) 20 November 1974 Whole document ---	1-8	
Y	CH-A-527 403 (D. STEEB) 13 October 1972 Whole document ---	1-8	
Y	DE-C-527 341 (F.E. KRAUSS) 17 June 1931 Lines 40-43,figs 1-4 ---	1,4	**TECHNICAL FIELDS SEARCHED (Int. Cl.4)**
Y	DE-A-2 855 285 (KLÖCKNER-HUMBOLDT-DEUTZ AG) 3 July 1980 Fig 1; page 4, second paragraph ---	1,2	F 28 D F 28 F B 21 D B 23 P F 01 P
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Y	DE-A-1 501 629 (S.A. DES USINES CHAUSSON) 6 November 1969 Whole document --- .../...	5-8	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
STOCKHOLM	08-03-1989	RIEDEL A.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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D : document cited in the application
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EUROPEAN SEARCH REPORT

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DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int Cl 4)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
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