

(10)



Europäisches Patentamt  
European Patent Office  
Office européen des brevets

(11) Publication number:

**0 035 078  
B1**

(12)

**EUROPEAN PATENT SPECIFICATION**

(45) Date of publication of patent specification: **31.05.89**

(51) Int. Cl.<sup>4</sup>: **F 28 F 1/12, B 21 D 53/08 //**  
**B21C37/26**

(21) Application number: **80300655.0**

(22) Date of filing: **05.03.80**

(54) **Process for manufacturing finned heat-exchangers.**

(43) Date of publication of application: **09.09.81 Bulletin 81/36**

(45) Publication of the grant of the patent: **31.05.89 Bulletin 89/22**

(84) Designated Contracting States:  
**AT BE CH DE FR GB IT LU NL SE**

(58) References cited:  
**FR-A-1 359 712**  
**FR-A-2 354 160**  
**GB-A- 810 876**  
**GB-A-1 132 526**  
**GB-A-1 273 141**  
**GB-A-1 488 443**  
**US-A-3 650 005**  
**US-A-3 712 372**  
**US-A-3 764 774**

(73) Proprietor: **LICENCIA Találmányokat Ertékesítő és Innovációs Külkereskedelmi Vállalat**  
**Bajcsy Zsilinszky ut 16**  
**H-1051 Budapest (HU)**

(72) Inventor: **Gál, Pál**  
**Fadrusz utca, 12**  
**Budapest XI, (HU)**

(74) Representative: **Gold, Tibor Zoltán et al**  
**T.Z.GOLD & COMPANY 9, Staple Inn**  
**London WC1V 7QH (GB)**

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European patent convention).

Courier Press, Leamington Spa, England.

**EP 0 035 078 B1**

## Description

The invention concerns a process for manufacturing finned heat-exchangers. One particular application of the process is the fabrication of radiators of internal combustion engines for road vehicles.

It is well known that the manufacture of heat exchangers is made up of several highly labour-intensive phases. In a characteristic phase of the manufacturing process parts of circular cross-section have to be made and welded or bonded together, but it has proved difficult to obtain high productivity allied with good heat exchange properties and low costs.

It has also been recognised that aluminium would be a desirable material to use owing to its relative cheapness and good thermal conductivity but the fabrication of finned heat exchangers made of aluminium has proved problematic. Thin aluminium plates are difficult to spot weld without causing electrode burns while the use of adhesive resins has proved unsatisfactory in motor car radiators because of the exposure of such resin bonds to the combined effect of relatively high temperatures and mechanical loads, such as vibration as well as the formation of so-called heat dams by the resin material, impeding heat transfer.

Thus, GB—A—1,273,141 discloses a heat exchanger in which pairs of pre-formed metal sheets are roll-bonded together to define liquid flow passages (tubes). Corrugated metallic foil strips are then bonded directly with metal-to-metal contact to the outer walls of the liquid flow passages. The thus finned tube is then secured "back to back" to a like finned tube by epoxy resin adhesive bonding between those adjacent end portion of the strip fins which are remote from the tubes. This disclosure suffers from the already-mentioned disadvantage flowing from the use of adhesives; moreover, closely spaced fins ("microfins") cannot be fabricated in this way since conventional pressure rollers required to effect bonding of the strip fins to the liquid carrying tubes are too large to reach the sites of bonding.

US—A—3,650,005 discloses an improvement in the use of the so-called stop weld technique (itself disclosed in US—A—2,690,002) of fabricating heat exchanger tubes from aluminium sheets, in which, after a pair of sheets carrying a predetermined pattern of stop weld material have been hot-rolled together, the portion which was not bonded together by the effect of the stop weld material is deformed from inside to a tubular form by the use of high-pressure water. This disclosure is essentially limited to the formation of the liquid-carrying tubes and does not address itself at all to the problem of securing fins to such tubes.

Finally, US—A—3,712,372 discloses the fabrication of heat exchangers utilising the stop weld technique in combination with a hydraulic "inflation" technique for deforming the non-bonded

parts of adjacent sheets into tubular form. The tubes are placed in a frame and portions thereof are flattened by special flattening rollers. Thereafter, flat fins are brazed or soldered to these flattened portions. The assembly is then bent into a serpentine form. This disclosure complicates the manufacture of finned heat exchanger tubes by requiring special machinery for flattening selected portions of the tubes and by requiring a separate step of brazing or soldering the roots of fins to the tubes while omitting any teaching of how to secure fin tips to an adjacent tube or tube portion.

The present invention seeks to solve the problems of making finned heat-exchangers in which both ends of the fins are to be secured, of enabling fins of widely varying spacing and geometry to be used and of simplifying manufacturing by combining fabrication with pressure testing.

These problems are to be solved by a process according to the present invention for manufacturing a finned heat-exchanger comprising:

- (i) providing a plurality of pairs of plates;
- (ii) applying a pattern of stop weld material to a first plate of each said pair;
- (iii) superposing a second plate of each said pair on the said first plate and hot-rolling the said plates together to form said pair of plates;
- (iv) expanding the sites of the said pair of plates which are protected by the said stop weld material by the application of fluid pressure to form a plurality of tubular heat exchanger medium flow passages and

(v) securing by means of a cohesive or adhesive bond a plurality of fins at one of their ends to the plates, characterised by

(A) rigidly holding the other end of each fin proximate but unattached to the surface of another plate to which it is to be permanently secured;

(B) filling said flow passages with liquid at a pressure which is of a magnitude both to attain conventional test pressures and also to cause permanent bonding by direct metal-to-metal contact and deformation between said other end of each fin and said surface of said another plate.

In the course of carrying out the process the heat-exchanger elements are assembled and retained in a frame and the tubular passages are expanded by test-pressings or a separately performed pressing and the directly heat-transmitting surfaces are brought into close adhesive connection.

The invention breaks with hitherto known technologies and enables the manufacture of strip finned heat-exchanging elements in a completely novel manner by connecting the strip fins with the cooling tubes or cooling passages by a direct bond.

The invention is described, merely by way of example, with reference to the accompanying drawings, schematically illustrating the invention and wherein:

Figure 1 is a cross-sectional view of a portion of

a heat-exchanger formed from expanded plates formed with tubular passages, with strip fins connected to flat faces of the tubular passages;

Figure 2 is an elevation of the heat-exchanger shown in Figure 1;

Figure 3 is a sectional view of the heat-exchanger provided with strip-like fins in the course of manufacture thereof;

Figure 4 is a plan view of the portion of the heat-exchanger shown in Figure 3;

Figure 5 is a cross-section illustrating thin strip-like fins placed between the cooling passages;

Figure 6 is a part-sectional and part-elevational view of the heat-exchanger fragment shown in Figure 5;

Figure 7 is a cross-section of a portion of a strip-finned heat-exchanger having a narrower or smaller fin spacing;

Figure 8 is a part-sectional, part-elevational view of the heat-exchanger shown in Figure 7, and taken at right-angles thereto;

Figure 9 is a schematic view of a heat-exchanger with offset tubular passages;

Figure 10 is a section of a motor vehicle radiator core having twin chambers and a plurality of flat rows of tubes;

Figure 11 is a sectional view taken along the stepped cross-sectional line A—A of Figure 10;

Figure 12 is a cross-section of the motor vehicle radiator core shown in Figure 11, taken along the line B—B; and

Figure 13 is a perspective view of a condenser or a portion of a water-cooler.

Referring to Figure 1, there is shown a fragmentary heat exchanger wherein the tubular passages 3 are formed from plates which have been welded together and wherein the strip-shaped fins 1 are fixed thereto by securing together a flat side 2a, 2b of the tubular passage 3 and the outer faces 1a, 1b of the strip fins 1.

Figure 2 illustrates by an arrow I the direction of flow of the heating or cooling medium while the arrow designated by II indicates the direction of flow of air.

In forming the tubular passages 3 it is expedient to place one of the welding electrodes 5 which is provided with a water channel and which is therefore water-cooled, inside the full length of the tubular passage 3. The welding electrode 5 then not only serves to weld the fins 1 to the tubular passages 3 but also serves to ensure that the tubular passage does not collapse during the formation and welding of the strip-like fins. When the tubular passage has been equipped with the strip fins, then at the end of that procedure the electrode 5 may be removed. Figure 3 shows the welding seam 4 at the root of the fin 1. This particular solution can only be used for U-shaped tubular passages.

The plan view of Figure 4 does not show the welding electrode itself but shows the trace it leaves on the fin 1. When the pitch or spacing of the fins is greater, then the welding to be employed must have a different geometry to ensure greater metallic contact areas.

The cross-section of Figure 5 shows an embodiment wherein thin strip-fins 1 are connected to the surface of the plate 2 at several locations. The connection between the fins and the plates may according to Figure 6 be effected by ultra-sonic welding or, as shown in Figure 7, where the material of the strip fins is thicker, and the pitch of the fins is smaller, by spot welding. This is also shown in Figure 8.

Figure 9 shows a forced-flow heat-exchanger portion wherein the strip fins 1, the welded sheets 2 and tubular passages 3 are connected in series and in parallel in accordance with the well-known criteria of heat-transfer technology.

The outer faces 1a of the strip fins 1 are welded at locations 4a to plates disposed at the edges of tubular passages and between such passages. In this way, the plurality of fin rows welded to the plate 2 form a finned heat exchanger element. Several completed heat exchanger elements may be assembled together by offsetting one of the rows with the aid of the strip fins and placing it on the adjacent row while the third row is aligned with the first row of such elements. From the point of view of manufacturing technology, it is expedient to form one inlet and one outlet. In this way, each individual heat-exchanging element in effect forms a closed system with only a minimal risk of faults and leaks.

In another expedient embodiment, the heat-exchanger elements to be assembled together are of one piece. The diagram or plan of the individual or tubular passages of the heat exchangers together with their connecting ducts, are continuously applied to the plates 2, with a suitable offset, and then after rolling, expanding and finning, the individual heat-exchangers are bent forwards and backwards and laid upon each other. The heat-exchanger formed in this way is thereafter processed or handled as described above. The figure does not show the inlets and outlets which can be formed in any suitable manner by welding a cylindrical tube into the tubular passages 3. Another expedient solution may lie in welding-in or closing the outlet opening of the tubular passages, and by resistance welding or inductance welding connecting eyes are welded at the appropriate locations of the tubular passages of the sheet 2. These eyes are then suitable for making further connections. This solution is particularly advantageous where the sheet 2 is made from aluminium.

In all these embodiments, after welding the tubular connections, the heat-exchanger held in a frame is subjected to pressure tests. The pressure test is of course a compulsory matter for all heat-exchangers. However, in the heat-exchanger according to the invention, the pressure test is not only a safety and reliability check but at the same time also forms the final or finishing technological phase of the assembly. When the covered and framed tubular elements are subjected to suitable pressure, then the tubular passages inevitably undergo a certain deformation and extension in the direction of the strip fins. This extension is

sufficient to ensure that due to any manufacturing or assembling inaccuracies, any loose heat exchanging elements should be tensioned or come into tight engagement with a frame or with each other. In this way it can be ensured that the flat faces 2a of the tubular passages 3 should tightly engage the outer faces 1a of the strip fins 1 whereby to form a metallic contact therebetween which is suitable for good metallic heat transfer.

Figures 10 to 12 illustrate a heat exchanger in the form of a motor vehicle radiator core. The principle of construction of the strip fins 1 and the tubular passages 3, that is to say the basic characteristic of the heat-exchanger elements, is identical with the heat-exchangers shown in the above-described embodiments, although of course the constructional configuration and the heat flow connections are different. The water chamber of the radiator core in the illustrated embodiment is of the twin-chamber type. A double layer baffle plate 11 separates the hot water chamber 10a from the cooled or cold water chamber 10b. Each individual cooling element 6 is connected by way of a tubular neck 12 to the water chamber 10 whereby to form a double passage 12a and 12b. The water to be cooled flows through passage 12a into the cooling element 6. It then flows through the two tubular passages 3a, turns as it flows through tubular passage 3b flows back through the cooling passages 3c and having cooled down, discharges through the passage 12b into the cooled or cold water chamber 10b.

The mutually superposed cooling elements 6 are connected in parallel in accordance with the foregoing flow scheme.

The motor vehicle radiator described in the preceding paragraphs differs from hitherto known constructions. The new construction has numerous advantages, for instance it is not necessary to solder a large number of pipes to the tube wall. With conventional motor vehicle radiators each tube is associated with two soldering operations for soldering into the tubular wall, while in the present invention one tube wall connection is associated with four tubular passages.

The tube wall 13 is expediently produced by deep-drawing, so that it should be unitary with the sides of the water chamber 13a. In this way a very simple water chamber configuration can be achieved because its one open side may be closed simply by a rimmed cover 14 which bears against the sides 14a of the water chamber 13a and is matched thereto. The cooling elements 5 are superposed in the distribution according to the drawing and are placed in the frame 15a. The connection openings 13c of the tubular wall 13 are aligned with the tube necks 12 onto which on assembly the tube walls 13 are fitted.

The tube wall 13 is fixed to the shoulders 15b of the frame 15a by spot-welding or line-welding. The tube necks 12 are connected in a leakproof manner e.g. by brazing or by another expediently chosen method of welding, to the tube wall 13. In

the case where one utilises plate materials which are so thin that a high quality weld cannot be used at all, then it is expedient to use fusion adhesive bonding. This insulation is of neutral effect on heat transfer because it is in contact with only one side of the water chamber. The cooling at the air-side of the adhesive material disposed between the tube neck 12 and the opening 13c is also ensured because the air stream is at all times in contact with the surface 13b. In the figure arrows I indicate the path of the coolant water while the arrows II indicate the direction of flow of the cooling air.

Figure 13 illustrates a complex industrial condenser or water cooler. The strip fins 1 are disposed on the tubular passages 3 in agreement with the embodiment already shown in Figures 1 and 2 above but its plate 2 has more tubular passages 3. The drawing does not show the end construction of the cooling elements 6 which may at one end be e.g. open with the tubular passages 3 coupled into the tubular wall while at its other element, it may e.g. be flattened and open as for instance is shown in Figures 10, 11, and 12 with regard to the tubular neck 12 of the motor vehicle radiator. In the present illustrated embodiment, there is shown a slit fin 30 wherein before bending and welding a cutter cuts the strip at several places intermittently to produce openings or slits 30a. Another manner of construction is shown by the cut-away strip fin 31. Here, before bending and welding, appropriately sized strips are cut intermittently at several locations from the basic strip, to produce openings 31a. The slit strip-fin 30 and the cut-away strip-fin 31 represent embodiments which for certain heat exchangers can produce a greater air side heat transfer. It is an advantage of this embodiment that the transmission tool can be operated synchronously with the fin forming apparatus so that this part operation does not require a separate working phase. The embodiment shown in Figure 13 makes it possible to manufacture in a particularly simple manner the very large air coolers used in power stations, in the chemical industry etc. because the elements may be made in accordance with the technical requirements in any arbitrary length and width and can be finished to the required size.

## Claims

1. A process for manufacturing a finned heat exchanger, comprising:

- (i) providing a plurality of pairs of plates (2);
- (ii) applying a pattern of stop weld material to a first plate of each said pair;
- (iii) superposing a second plate of each said pair on the said first plate and hot-rolling the said plates together to form said pair of plates (2);
- (iv) expanding the sites of the said pair of plates (2) which are protected by the said stop weld material by the application of fluid pressure to form a plurality of tubular heat exchanger medium flow passages (3, 3a, 3b); and
- (v) securing by means of a cohesive or adhesive

bond a plurality of fins (1; 30) at one of their ends to the plates (2), characterised by

(A) rigidly holding the other end of each fin (1; 30) proximate but unattached to the surface (2a) of another plate (2) to which it is to be permanently secured;

(B) filling said flow passages (3; 3a, 3b) with liquid at a pressure which is of a magnitude both to attain conventional test pressures and also to cause permanent bonding by direct metal-to-metal contact and deformation between said other end of each fin (1; 30) and said surface (2a) of said another plate (2).

2. A process according to claim 1, characterised in that the fins (1; 30) are bent to shape simultaneously with and solely by the said application of liquid pressure to cause permanent deformation.

3. A process according to claim 1 or 2, wherein the heat exchanger is made of aluminium, characterised by securing the said one end of each fin (1; 30) to said plates by a direct weld (4) without the use of any foreign materials.

#### Patentansprüche

1. Verfahren zum Herstellen von mit Rippen versehenen Wärmetauschern mit:

(i) Bereitstellen einer Mehrzahl von Paaren von Platten (2);

(ii) Auftragen eines Musters von schweißhinderndem Material auf eine erste Platte eines jeden Plattenpaares;

(iii) Auflegen einer zweiten Platte jedes Paares auf die jeweilige erste Platte und Verbinden des Plattenpaares (2) durch Warmwalzen;

(iv) Aufweiten der von dem schweißhindernden Material abgeschirmten Stellen der Paare von Platten (2) durch Beaufschlagen mit Flüssigkeitsdruck, um eine Mehrzahl von rohrförmigen Strömungskanälen (3, 3a, 3b) für das Wärmetauschermedium zu bilden; und

(v) Befestigen einer Mehrzahl von Rippen (1; 30) an jeweils einem ihrer Enden an den Platten (2) mittels einer kohäsiven oder adhäsiven Bindung, gekennzeichnet durch

(A) starres Festhalten des anderen Endes einer jeden Rippe (1; 30) in Nähe, jedoch unbefestigt, der Oberfläche (2a) einer weiteren Platte (2), an der die Rippe dauerhaft befestigt werden soll;

(B) Füllen der Strömungskanäle (3; 3a; 3b) mit Flüssigkeit unter so hohem Druck, daß zugleich der herkömmliche Prüfdruck und ebenso eine dauerhafte Verbindung durch direkten intermetallischen Kontakt und Deformation zwischen dem anderen Ende einer jeden Rippe (1; 30) und der Oberfläche (2a) der weiteren Platte (2) gewährleistet ist.

2. Verfahren nach Anspruch 1, dadurch gekenn-

zeichnet, daß die Rippen (1; 30) in ihre Form gleichzeitig mit dem und ausschließlich durch das die dauerhafte Deformation bewirkende Beaufschlagen mit Flüssigkeitsdruck gebogen werden.

3. Verfahren nach Anspruch 1 oder 2, wobei der Wärmetauscher aus Aluminium hergestellt ist, dadurch gekennzeichnet, daß das Befestigen des einen Endes einer jeden Rippe (1; 30) an den Platten durch eine direkte Schweißung (4) ohne jegliches Fremdmaterial erfolgt.

#### Revendications

1. Un procédé de fabrication d'un échangeur de chaleur à ailettes, comprenant les étapes suivantes:

(i) on prépare un pluralité de paires de plaques (2)

(ii) on applique sur une première plaque de chacune desdites paires un matériau empêchant la soudure, selon une disposition prédéterminée,

(iii) on superpose à ladite première plaque une seconde plaque de chacune desdites paires et l'on assemble lesdites plaques par cylindrage à chaud pour former ladite paire de plaques (2),

(iv) on dilate les zones de ladite seconde paire de plaques (2) qui sont protégées par ledit matériau empêchant la soudure en appliquant une pression de fluide, de manière à former une pluralité de passages tubulaires (3, 3a, 3b) pour l'écoulement d'un fluide d'échange thermique,

(v) on fixe à l'aide d'une liaison de cohésion ou adhésive une pluralité d'ailettes (1; 30) par l'une de leurs extrémités sur les plaques (2), caractérisé en ce que:

A. l'on maintient rigidement l'autre extrémité de chaque ailette (1; 30) à proximité de la surface (2a) d'une autre plaque (2) à laquelle elle doit être fixée de manière permanente, sans l'y fixer;

B. on remplit lesdits passages (3, 3a, 3b) d'écoulement avec du liquide à une pression permettant à la fois d'atteindre les pressions d'essai classiques et présentant une valeur telle qu'elle conduise à une liaison permanente par contact direct métal sur métal et déformation entre ladite autre extrémité de chaque ailette (1; 30) et ladite surface (2a) de ladite autre plaque (2).

2. Un procédé selon la revendication 1, caractérisé en ce que les ailettes (1; 30) sont repliées en forme par, et uniquement par, ladite application de la pression de liquide de manière à provoquer une déformation permanente.

3. Un procédé selon la revendication 1 ou 2, dans lequel l'échangeur de chaleur est formé d'aluminium, caractérisé en ce qu'on fixe l'extrémité précitée de chaque ailette (1; 30) auxdites plaques par soudure directe (4) sans utilisation d'aucun matériau étranger.

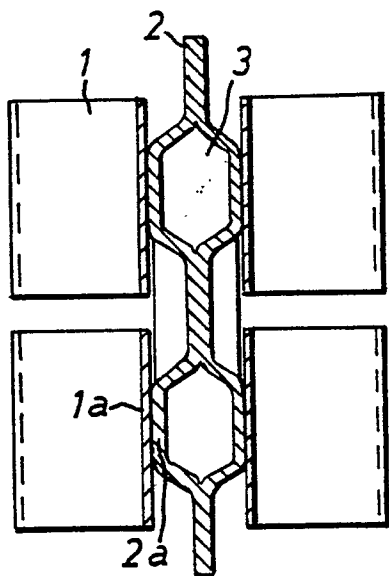


FIG. 1

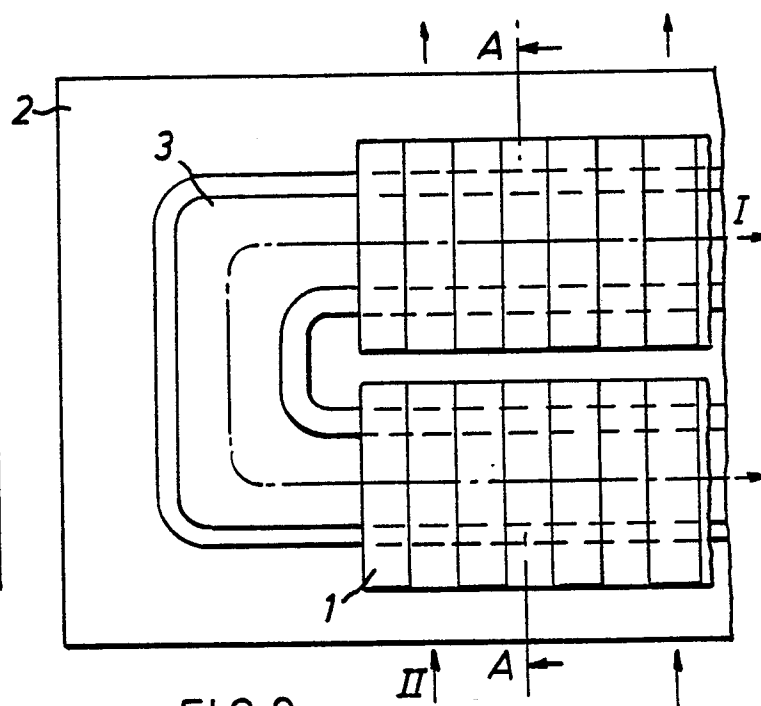


FIG. 2

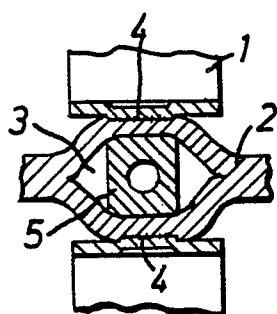


FIG. 3

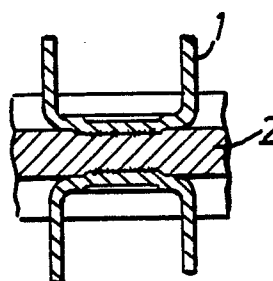


FIG. 5

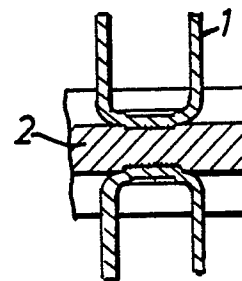


FIG. 7

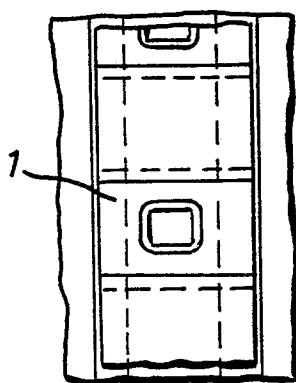


FIG. 4

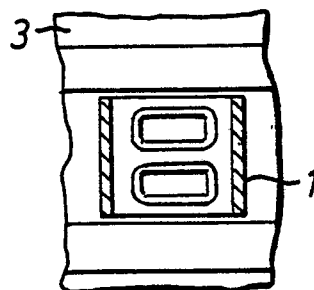


FIG. 6

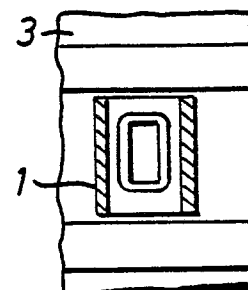


FIG. 8

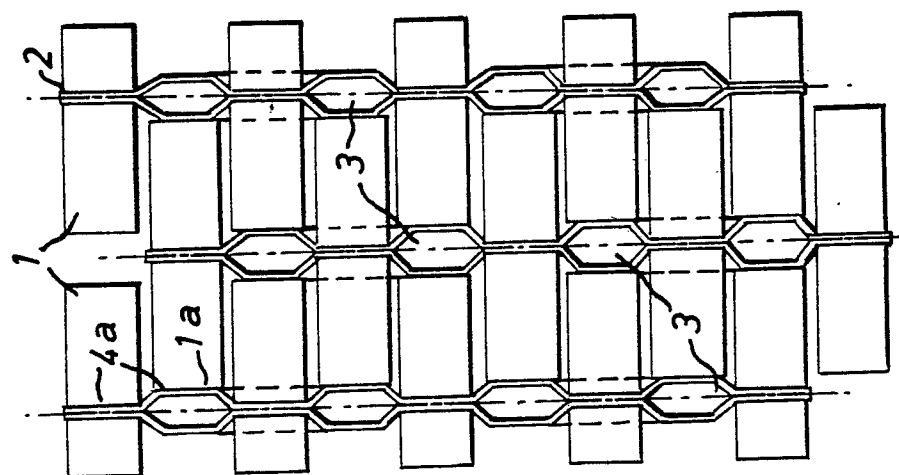


FIG. 9

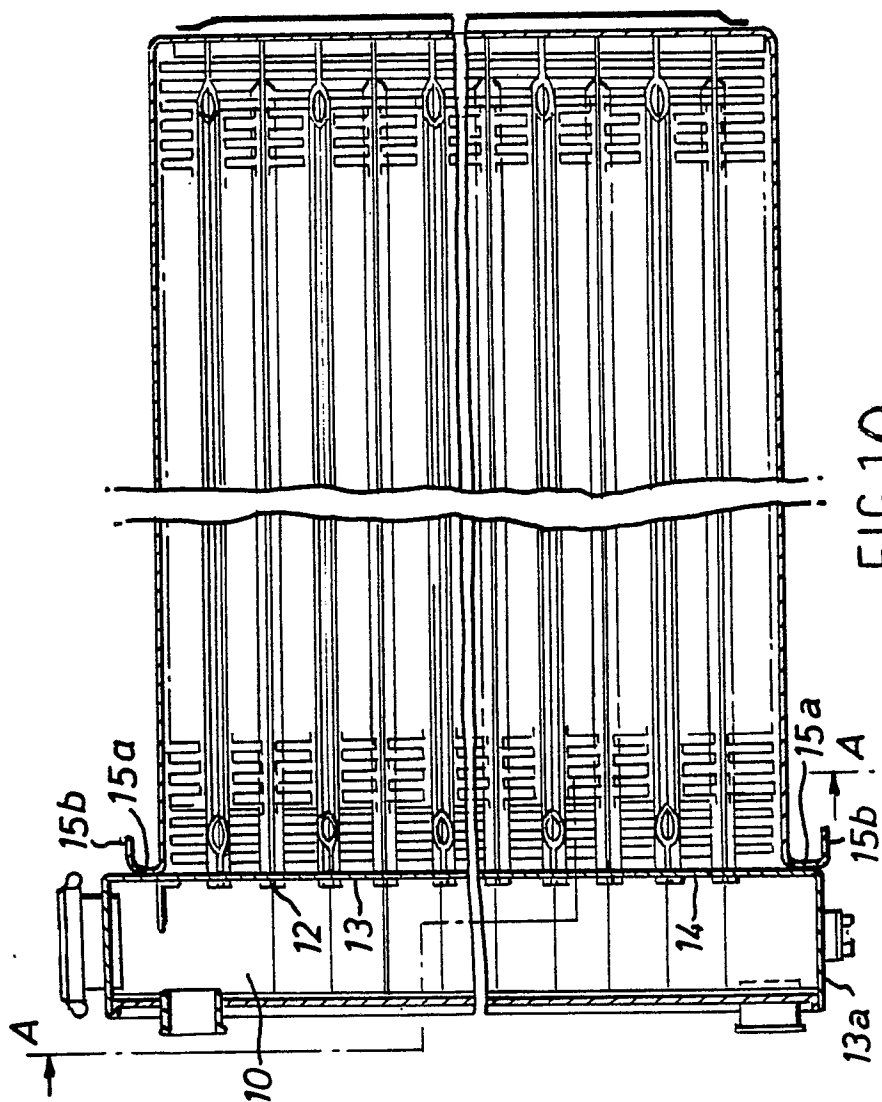


FIG. 10

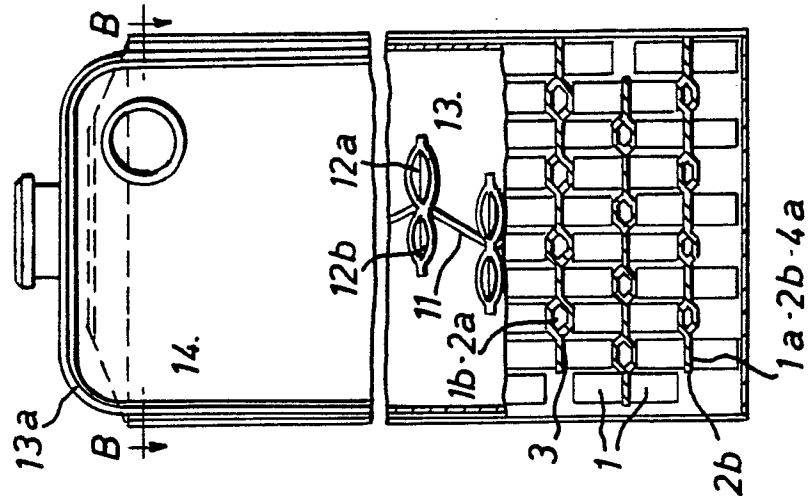


FIG.11

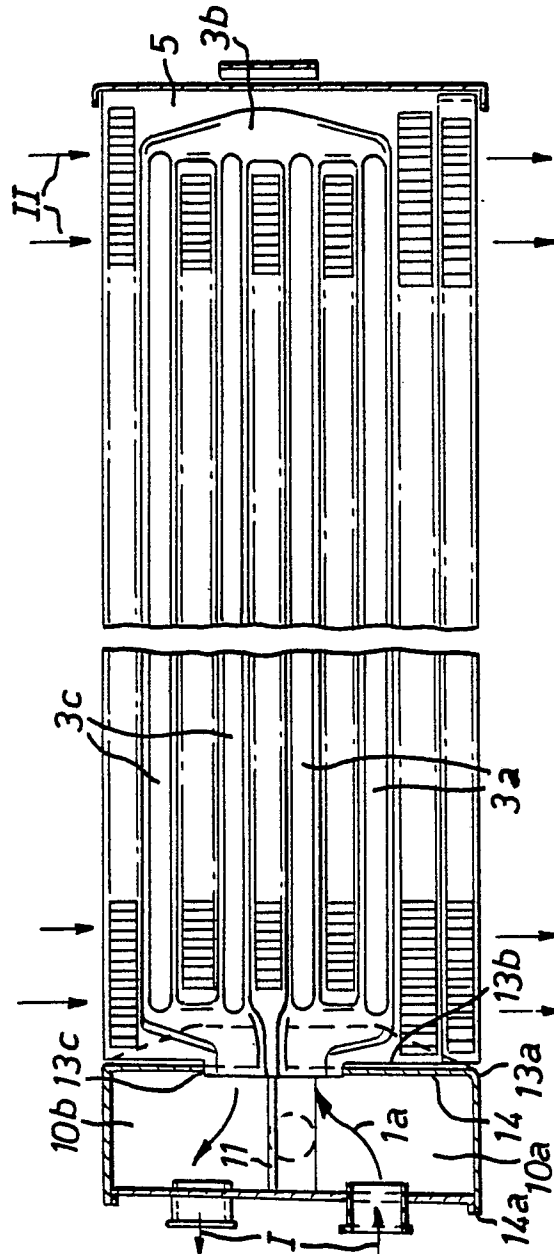


FIG.12

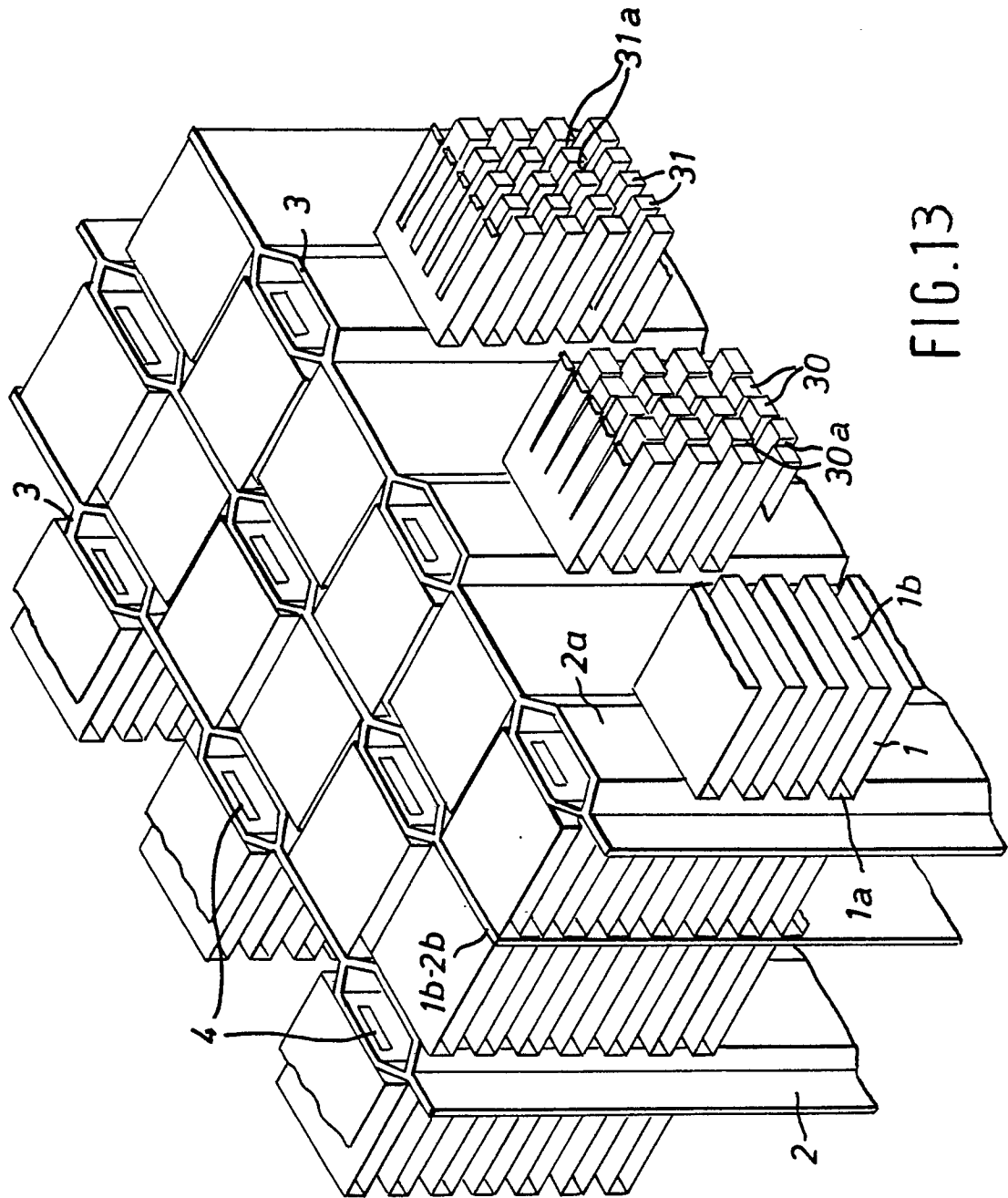


FIG. 13