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54 **Heat exchanger modules and method of manufacturing.**

57 A new method of manufacturing of heat exchangers, and more particularly a method of producing completely integrated heat exchanging modules of variable size and capacity, and heat exchangers provided by such method is disclosed. The method comprises steps of providing a hollow shape (2) comprising a tube (21) with one or more voids, longitudinally extending fins (22) projecting from the tube surface, partial removal of fins and bending of the tube in areas free of fins providing a meander-like loop for heat exchanging medium and a multiplicity of convection chambers (24). The heat exchanging module (2) is also provided with apertures (25,26) constituting inlets and outlets for transverse circulation of heat exchanging media.

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Heat exchanger modules and method
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The present invention relates to a new method for manufacturing of heat exchangers, and more particularly to a method of producing complete integrated heat exchanger units (modules) of variable size and capacity, and also to heat exchangers produced by such method.

There are many different known types/designs of heat exchangers seeking to improve the heat transmission parameters by providing larger heat transmitting surfaces.

Drawbacks in common for all known, disclosed designs of heat exchangers or radiators is that their parts (components) are joined by means of welded, soldered, brazed, glued, threaded or pressed joints. These mechanical ways of assembling heat exchangers are rather expensive due to the extensive use of labour and equipment.

German laid open patent application AS 2 046 770 discloses a classical heat radiator comprising two manifold pipes and several parallel running circulation tubes between these manifold pipes attached metallic sheets in order to increase the heat rejection. The metallic sheets (covers) are designed as a shutter providing a possibility of influencing the direction of the circulating air current through the radiator. The connection between the pipes and the shutter is ensured by means of screws, clamps etc., which means high production and assembling costs.

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German utility model No. 1.714.347 discloses a heat exchanger comprising a meander-like bent pipe provided with coextruded single webs partly removed in the U-bend area in order to facilitate manufacturing of the heat exchangers. The disclosed heat exchanger is limited to the shown embodiment and does not provide possibility of forming circulation channels between the parallel running tube parts. Furthermore, there is no possibility for an easy way of connecting the web parts together and/or to cover the U-bends.

US Patent No. 2.578.305 relates to a heat exchanger tube for exposure to gases that flow transversely of its longitudinal axis. The tube is provided with symmetrically disposed longitudinally extending fins projecting from the tube surface in planes at either side of the axis and formed in the edge portions thereof in contact with the tube. Furthermore, the fins are provided with slots that form with the tube surface passages converging in the direction of the flow toward the space between the fins.

The disclosed tube design and configuration of fins will not give a possibility of bending the tube in a meander-like path and form integrated circulation chambers. Furthermore, there is no flexibility in the design with regard to the possibility of bending the tube in other directions than parallel to the fin's projection.

Finally, German Patent No. 831263 discloses a heat exchanger comprising a bundle of pipes provided with longitudinally extending fins welded to the pipe surface and forming vertical channels of variable cross-sections.

The object of the present invention is to provide an improved method for manufacturing of heat exchangers resulting in integrated, one-piece, jointless heat exchanging modules having a multiplicity of channels for external circulation of the

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heat exchanging medium, e.g. air, outside the tubes constituting a circulation loop for the heating medium.

Another object of the invention is to provide a method of manufacturing heat exchangers ensuring flexibility with regard to the possibility of bending the circulation tube in desired angles in relation to the fin's projection and furthermore, that the U-bend parts of the circulation tube are completely withdrawn (hidden) behind the front panel of the heat exchangers formed by attached fins.

Still another object of the invention is to provide compact, jointless heat exchanger modules having longitudinally extending channels formed by fins attached to the circulation tubes and transversal apertures in the fins, ensuring an optimal heat rejection performance.

The invention will be best understood by consideration of the following description of several embodiments when read in conjunction with the attached drawings, Figs. 1-10, where

Fig. 1 is a perspective view of a heat exchanger according to the present invention shown partly in an open, transverse section illustrating a preferred embodiment (design) of the tube and the coextruded fins,

Figs. 2-3 are perspective views in section through two preferred embodiments of the extruded hollow shapes for heat exchangers,

Figs. 4-5 illustrate schematically steps of the manufacturing method according to the present invention, where

Figs. 4 and 4a show a partial removal of fins from the tube on the extruded hollow shape, here by means of a circular saw, and

Figs. 5, 5a and 5b illustrate the subsequent bending operation and the resulting heat exchanging module (5b),

Figs. 6, 6a and 6b illustrate schematically the superior heat exchanging performance of the heat exchanging module provided in accordance with the present invention,

Fig. 7 shows in a cross-section another embodiment of the applied extruded hollow shape,

Fig. 8 is a perspective view of still another embodiment of the hollow shape,

Fig. 9 shows in a perspective view a compact heat exchanging module comprising units displaced and connected in a 90° angle to each other, and

Fig. 10 is a cross-sectional view of the hollow shape applied in the heat exchanging module from Fig. 9.

Fig. 1 shows in a perspective view a radiator manufactured in accordance with the present invention. A hollow, extruded shape (2) comprising a tube (21) provided with integrated, longitudinally extending fins (22) is bent several times and constitutes a meander-like loop for circulating heating medium. The attached fins are removed in the bending area in a special way in order to facilitate formation of the U-bend parts (23) and, after the bending operation is completed, to achieve a rectangular, compact radiator where the meander

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tube is completely withdrawn and shielded behind a front cover formed by the remaining butt-to-butt arranged fins (22). Furthermore, after the bending operation the special design of the applied hollow shapes with substantially parallel running projecting fins results in formation of a circulation chambers (24) in the longitudinal direction, and by perforating the fins and providing alternatively inlet (25) and outlet (26) apertures a secondary transversal current for heat exchanging medium, e.g. air, is also provided. A side cover plate (30) can optionally be applied to complete the radiator, and the tube (21) is also provided with a connection flange (31).

Fig. 2 shows in more details an enlarged hollow shape (extrusion) (2) from Fig. 1, comprising a tube (21) and the attached fins (22,22'), defining a longitudinally running circulation chamber (24), connected to the tube by a short bridging part (23) running perpendicular to one of the tube's radial planes. The inlet (25) and outlet (26) apertures can be seen on the fins, and even the bridging parts (23) can be provided with additional apertures (28) to improve the circulation of the heat exchanging medium in the vertical direction.

Fig. 3 shows still another embodiment of the applied hollow shape (2) forming not only one, but in this case three separate, longitudinally running chambers (24,24',24") between the fins (22,22'). The bridging part (23) is provided with several apertures (28) ensuring circulation between the adjacent chambers (24) in a ready assembled exchanger.

Fig. 4 illustrates schematically the first step of the manufacturing method according to the present invention - removing of fins (22) from the tube (21) on the extruded, hollow shape (2). A twin circular saw (30) is used in two sequential steps to separate the fins longitudinally from the central

tube part, first a cut over a distance "a" and then a new cut in the transversal direction to remove the fins over a distance "b". The width of the part notched out is such that after bending of the tube by 180° the U-bend disappears behind the remaining fins. The cutting operations are carried out at regular intervals until the required number of U-bend locations are cleared of the fins. Any suitable kind of cutting/punching tool can be used for these operations.

Fig. 4a is a cross-sectional view taken along line I-I on Fig. 4, and (21), (22) and (30) denominate the tube, the fins and the saw respectively.

Fig. 5 shows the hollow shape (2) ready cut to the required length during a bending operation to provide a compact heat exchanging module (1) of rectangular shape with completely withdrawn (hidden) U-bends (23), as shown in Fig. 5b, behind the fins (22) forming a continuous, integrated cover plate of the radiator.

Fig. 5a is a cross-sectional view taken along line I-I on Fig. 5 illustrating a temporary displacement of the fins in order to facilitate the bending operation. As shown in the figure, one of the fins (22') is displaced or swivelled approximately by a wall thickness so that the fins can temporarily overlap. Once the bending operation is completed, the displaced part is moved back into its original position. This special combination of hollow shape design and this type of bending allows that the removed part of the fins is just wide enough for the U-bend (21) to disappear behind the remaining fins forming circulation chambers and at the same time a perfect alignment between the two adjacent fins is achieved.

Fig. 6 is a schematical view of the heat exchanger according to the invention with horizontally arranged circulation

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chambers and inlet apertures (25) and outlet apertures (26) ensuring transversal air circulation in the vertical direction.

Fig. 6a is a cross-sectional view of the heat exchanger taken along line I-I in Fig. 6, showing horizontally arranged chambers (24) and the inlet (25) and the outlet (26) apertures in the fins (22). The transversal current of the heat exchanging medium, in this case air, is submitted to the chambers (24) surrounding the tube (21) ensuring a vertical circulation, improving substantially the heat exchanging performance of the radiator.

Fig. 6b illustrates graphically how a continuous supply of "cold" air at each chamber level in the vertical direction improves the heat transfer, expressed here in W/m^2K , as a result of a larger temperature difference at each of the inlet apertures (25).

Fig. 7 shows in a cross-section another possible embodiment of the hollow shape (2) applied in the heat exchanging modules, comprising a double tube (21,21') with a multiplicity of chambers (24), formed between the fins (22) running perpendicular to the bridging part (23) between the tubes.

Fig. 8 illustrates still another variant of the hollow shape (2), where the tube (21) is provided with a double cavity (partition wall between two voids). As shown on the figure, the outer shape of the tube can also be flat oval, elliptical or of any other suitable shape without departing from the scope of the invention. The fins (22) running perpendicular to the bridging part (23) form several circulation chambers (24).

The embodiments of the hollow shape shown in Figs. 7 and 8 are particularly useful when different cooling/heating loops

for different media and/or heat exchanging media in the chambers are applied.

Fig. 9 illustrates a typical and advantageous application of the heat exchanging modules (1) according to the invention for providing of compact heat exchangers for automotive purposes of desired size/capacity. Fig. 10 shows more clearly in a cross-sectional view the hollow shape (2) applied in the module shown in Fig. 9 with a special configuration of fins (22) surrounding the tube (21) which allows bending of the shape in different directions (x,y) assuring formation of a multiplicity of circulation chambers (24) between a pair of adjacent fins (see Fig. 9). This module comprises units displaced and connected in a 90° angle in relation to each other by bending of the tube (21,21') in different directions.

The present invention is not limited to the disclosed, and in connection with the accompanying drawings described embodiments and/or applications of the heat exchanging modules and can be used e.g. for manufacturing of electrically heated radiators by embedding a resistant wire into the meander folded tube. Such application will result in a substantial reduction of production and material costs.

Claims

1. Method of manufacturing of integrated jointless heat exchangers, particularly heat exchanger modules for heat exchangers of variable size and capacity, characterized in that the method comprises steps of
 - providing a hollow section (2) comprising a tube (21) having one or more voids (cavities) and provided with longitudinally extending fins (22) projecting from the tube surface,
 - removing of parts of the said longitudinally extending fins from the tube surface,
 - bending of the tube (21) in areas free for fins (3) providing a meander-like circulation loop, and
 - forming convection chambers (24) running substantially parallel to the straight parts (23) of the tube (2).
2. Method according to claim 1, characterized in that during the meander-like bending one of the adjacent fins is displaced or distorted in relation to its longitudinal axis approximately by the wall thickness of the fins, so that the fins will temporarily interlap enabling bending, and subsequently the displaced fin is moved back after termination of the bending process so that the U-bend is completely covered by the fins, constituting a heat exchanging module (1) which is rectangular in its outer dimensions and has no projecting parts.
3. Method according to claim 1 or 2, characterized in that the fins (22) are subsequently perforated with a number of transversal apertures (25,26) constituting a system of transverse channels.

4. Heat exchanging module according to claim 1,
c h a r a c t e r i z e d i n t h a t
the whole module is an integrated, one-piece, jointless hollow shape (2) comprising a meander-like, bent tube (21) having one or more voids creating a circulation path for the heat exchanging medium, where the tube (21) is provided with integrated, longitudinally extending fins (22) projecting from the tube's surface and forming a multiplicity of chambers (24) running substantially parallel to and between the straight parts of the meander tube.
5. Heat exchanging module according to claim 4,
c h a r a c t e r i z e d i n t h a t
the longitudinally extending fins (22) run perpendicular to one of the tube's radial planes.
6. Heat exchanging module according to claim 4,
c h a r a c t e r i z e d i n t h a t
the longitudinally extending fins are also provided with apertures (25,26) resulting in formation of transverse circulation channels.
7. Heat exchanging module according to claim 4,
c h a r a c t e r i z e d i n t h a t
the chambers (24) formed by bending of the tube (2) by means of the integrated fins (22) constitute on at least one heat exchanging surface of the heat exchanger a rectangular cover (shield) for the meander tube (21).
8. Heat exchanging unit according to one or more preceding claims,
c h a r a c t e r i z e d i n t h a t
a multiplicity of integrated and substantially parallel chambers (24) is formed on one or both sides of the meander tube (21).

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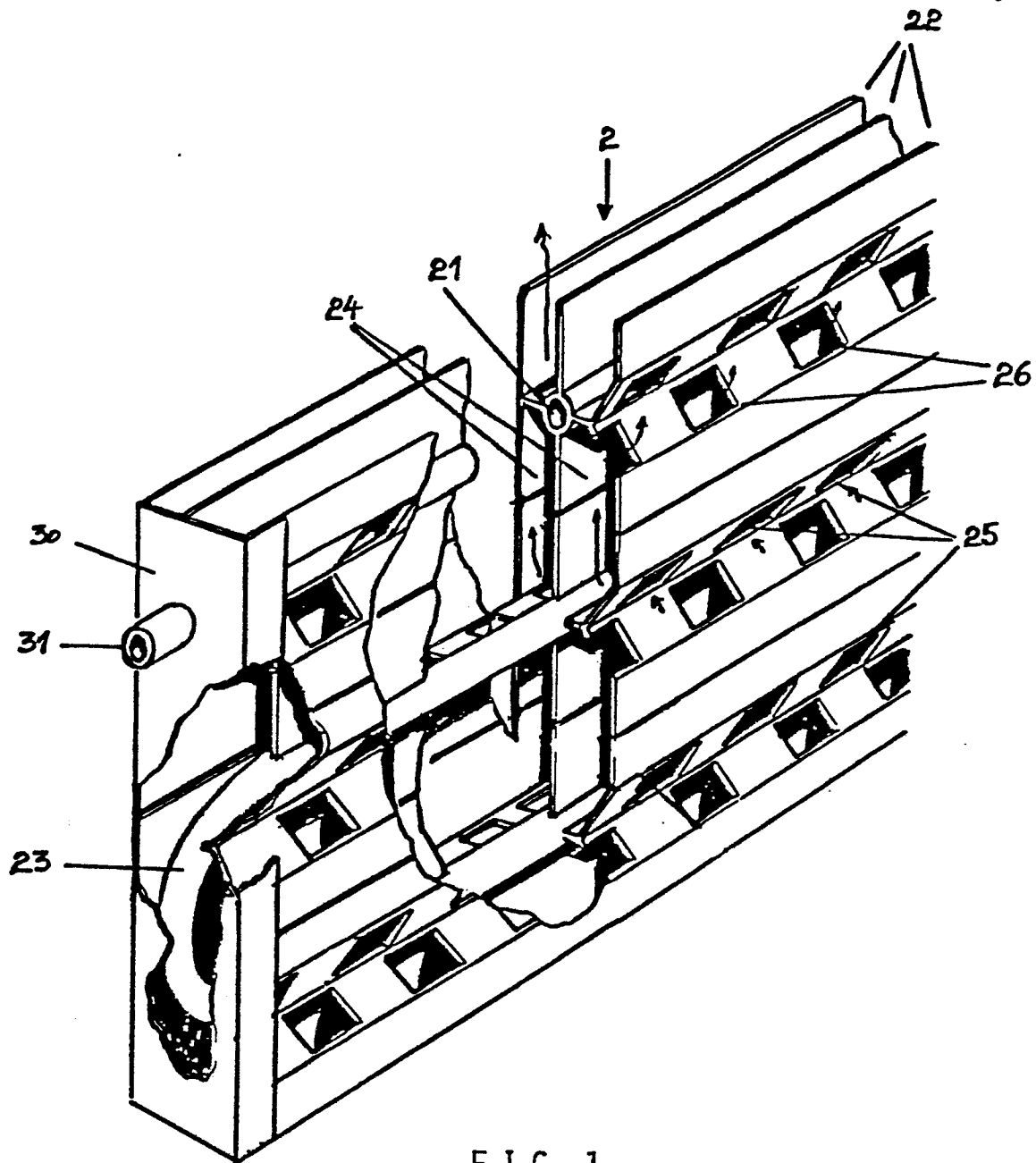


FIG. 1

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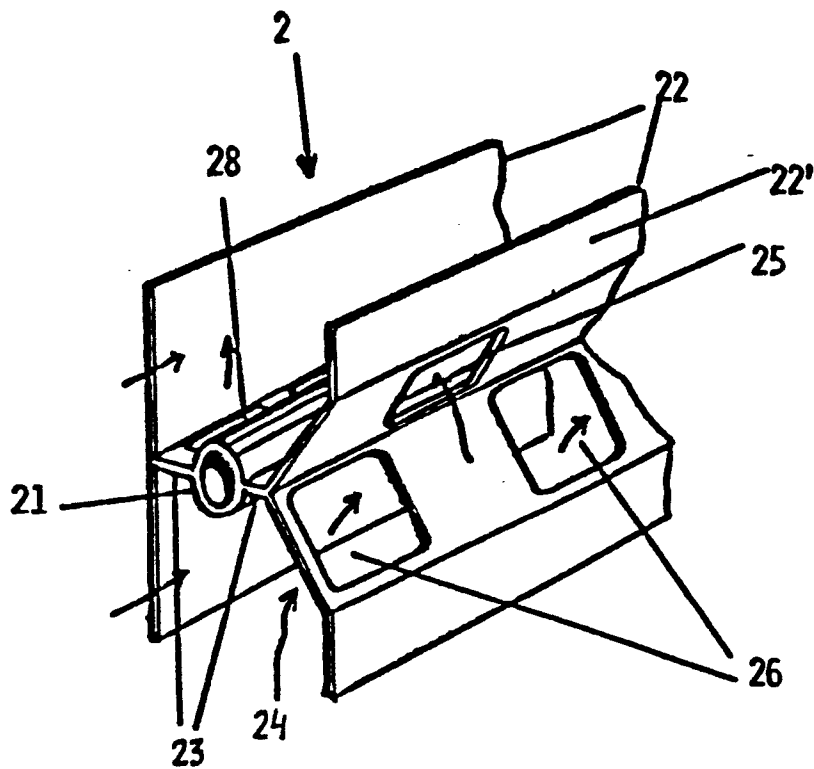


FIG. 2

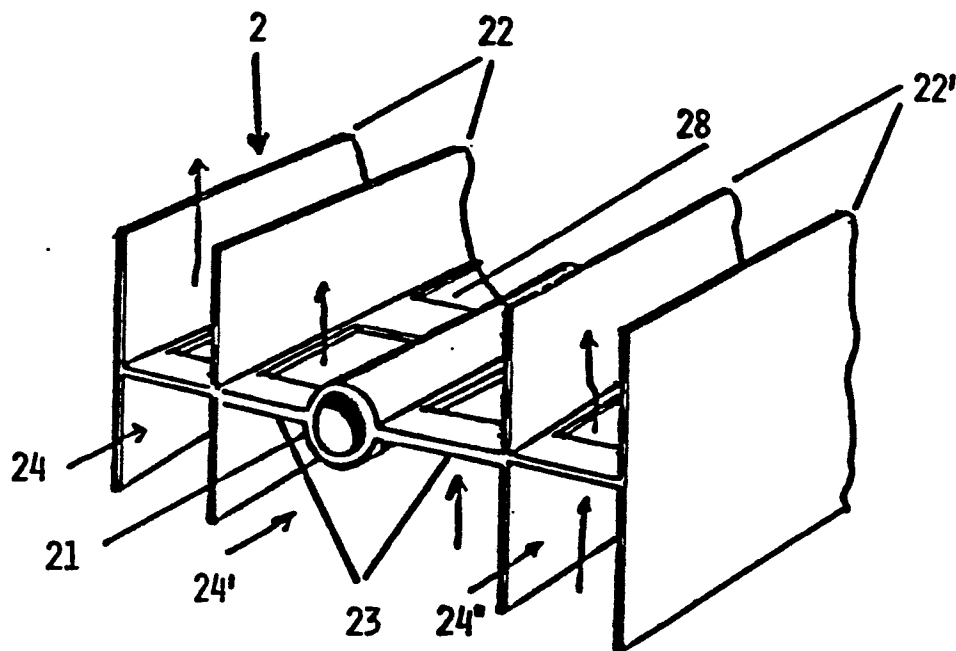


FIG. 3

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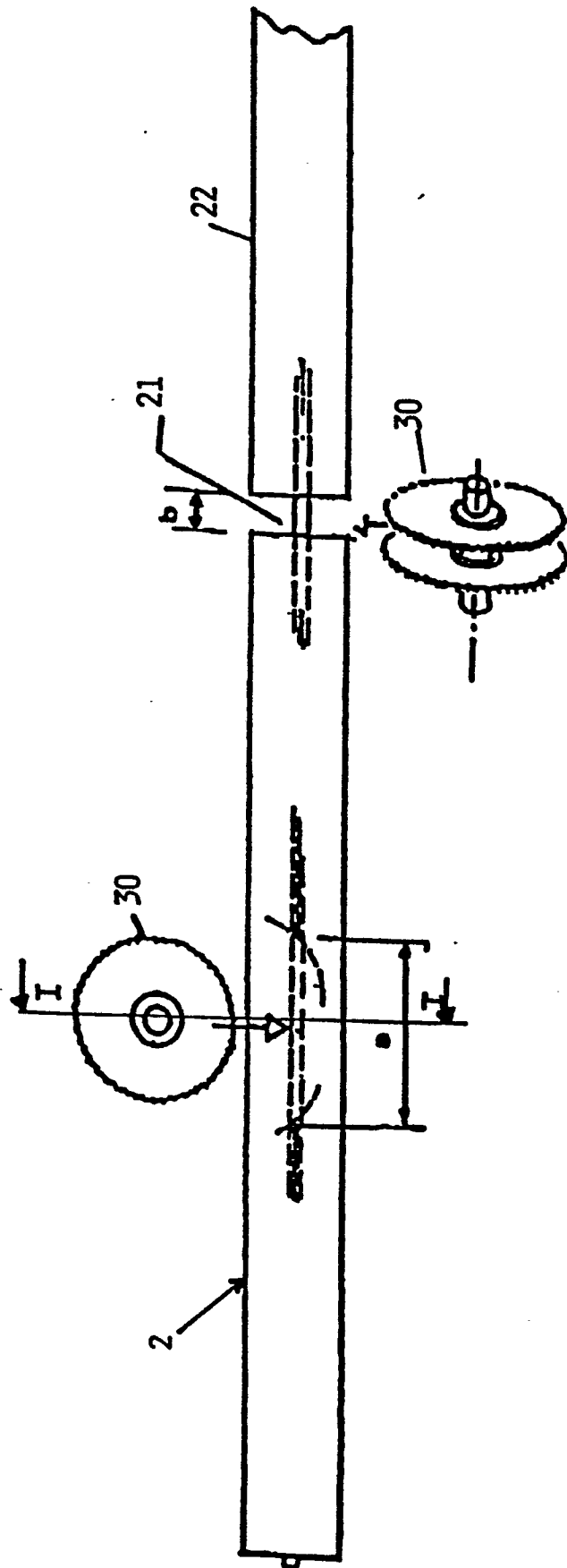


FIG. 4

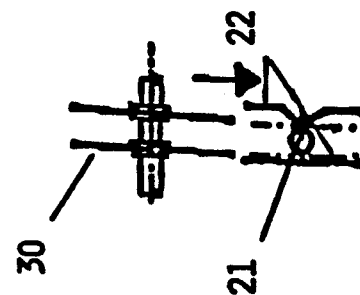


FIG. 4A

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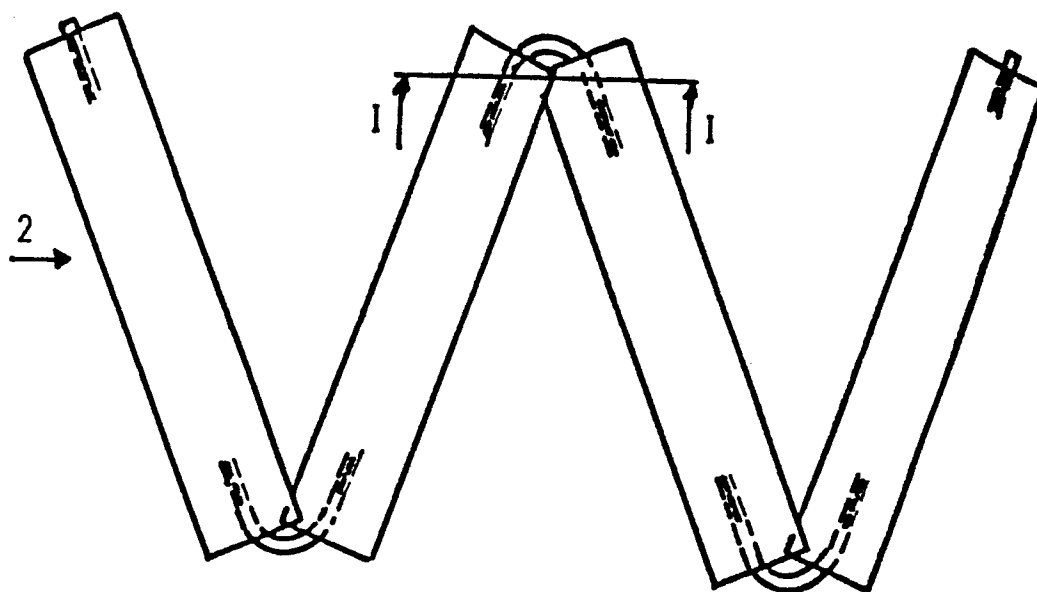


FIG. 5

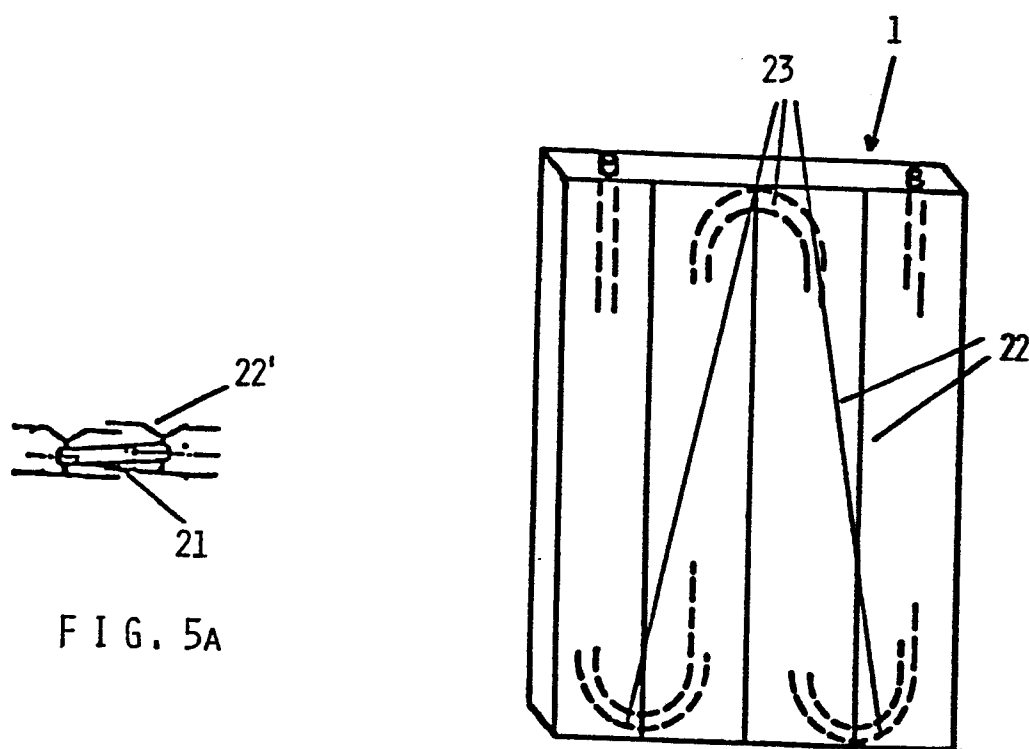


FIG. 5A

FIG. 5B

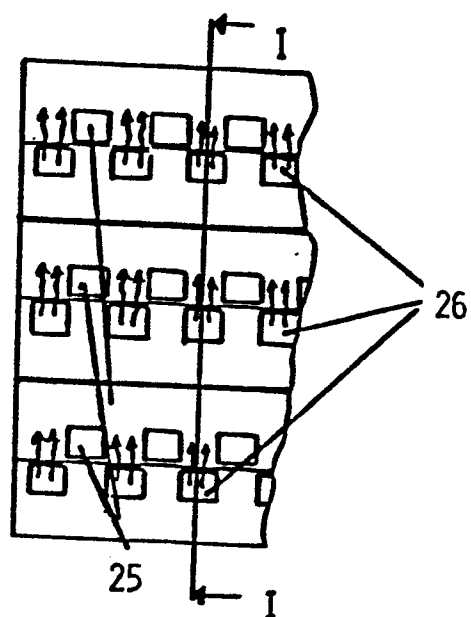


FIG. 6

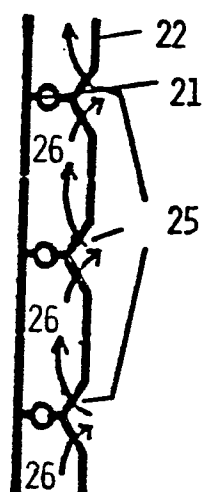


FIG. 6A

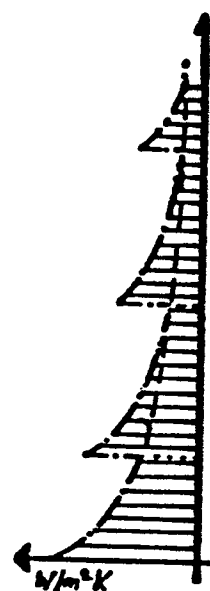


FIG. 6B

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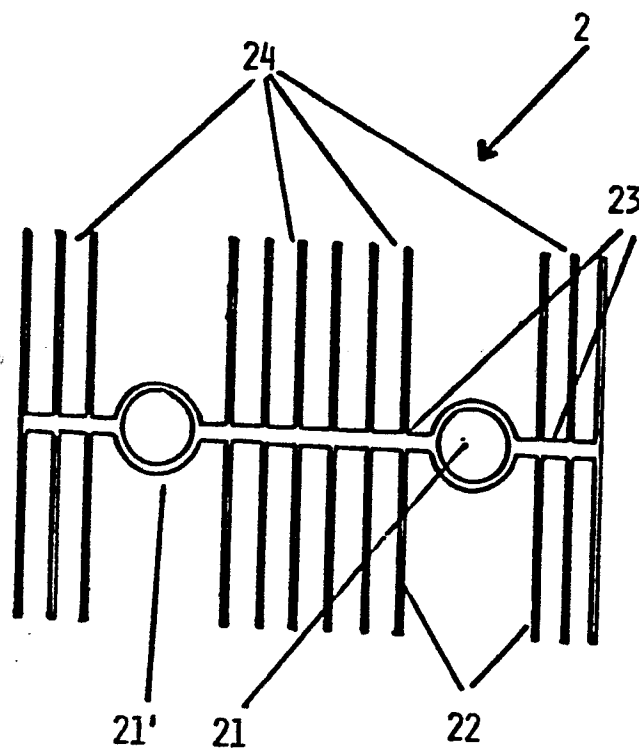


FIG. 7

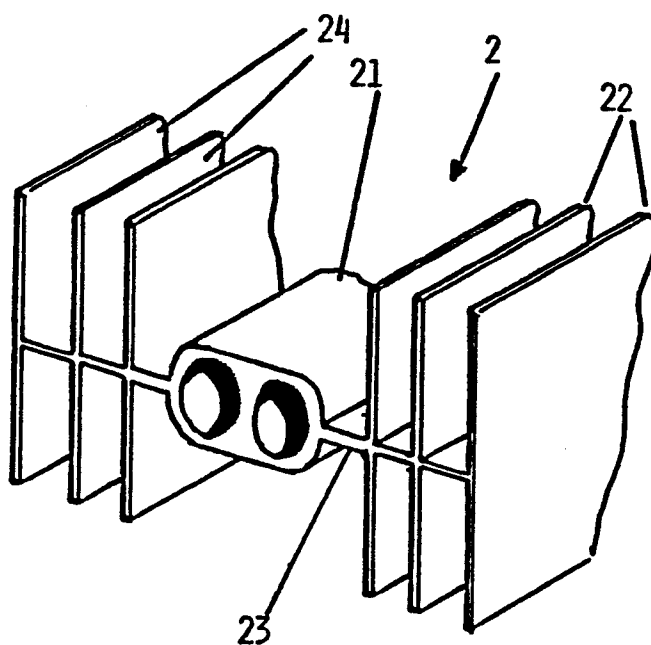


FIG. 8

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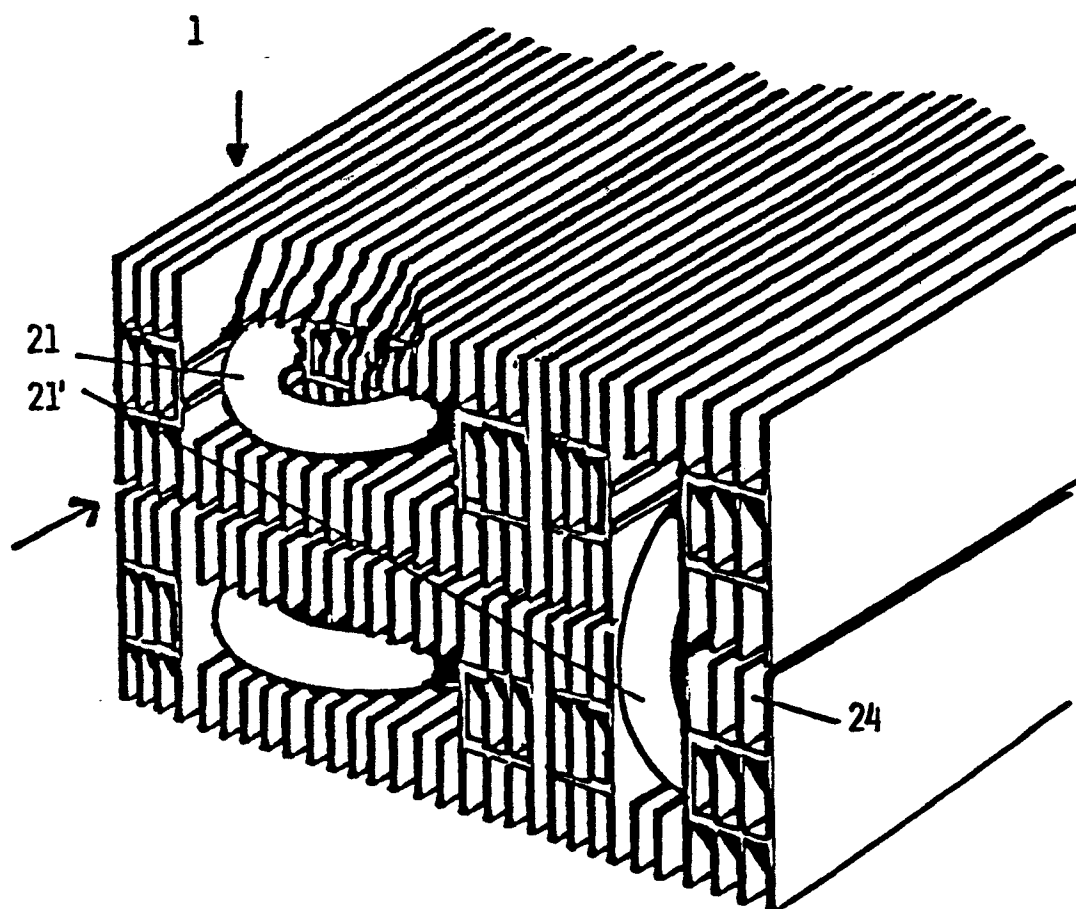


FIG. 9

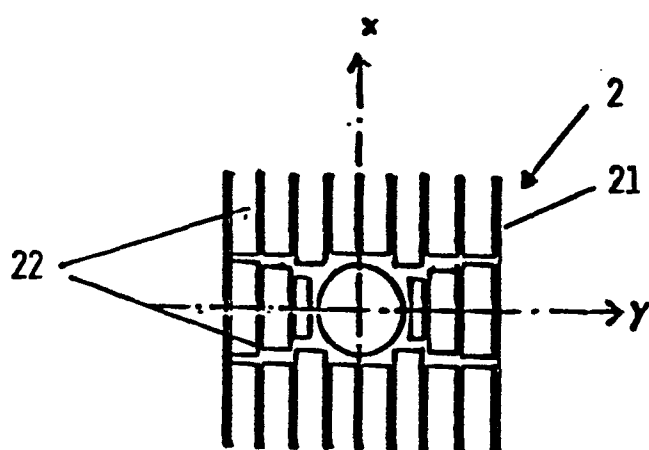


FIG. 10