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(54) A heat exchanger manifold and method of forming a heat exchanger manifold

(57) The invention relates to a method of forming a heat exchanger manifold from a single sheet of base material. The method comprises forming a longitudinal locating groove (21; 121) in the central portion (20; 120) of the heat exchanger base material (12; 112) and forming tube insertion slots (36; 136) therein. The tube insertion slots (36; 136) have extruded walls (38; 138) which create locating channels (40; 140) between corresponding walls (38; 138) of adjacent tube insertion slots (36; 136).

A series of protrusions (24; 124) are provided along opposed edges of the first and second partitioning wall portions (14; 114) to form ridged edges (22; 122) thereon, the series of protrusions (24; 124) being positioned along the ridged edges (22; 122) to correspond with portions of the longitudinal locating groove (21; 121) and the series of channels (40; 140) of the central portion (20; 120). When the walls of the base material are folded to form the heat exchanger, the protrusions (24; 124) of the ridged edges (22; 122) are located in the groove (21; 121) of the channels (40; 140) between the series of tube insertion slots (36; 136) and are securely brazed thereto.

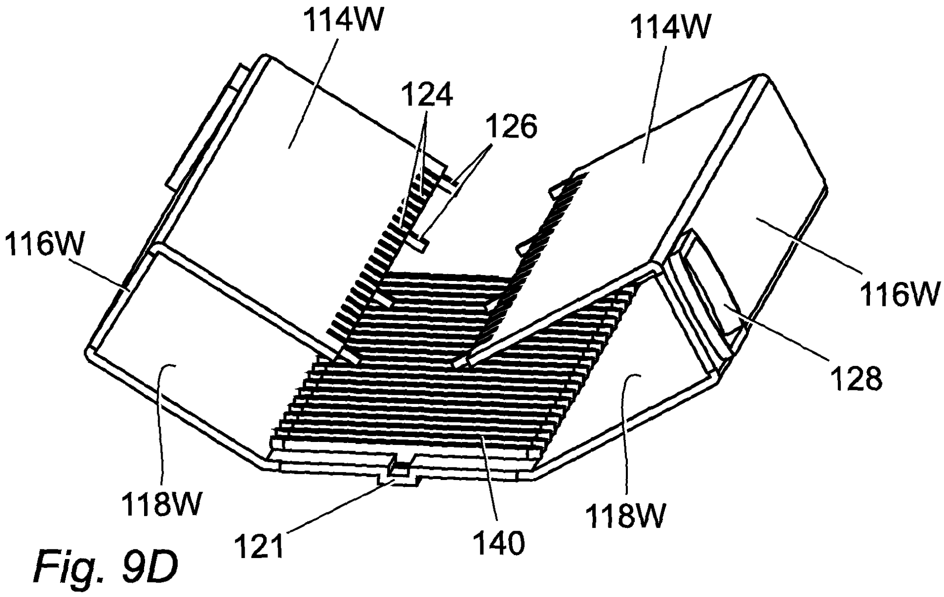

Fig. 9D

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Description

[0001] The invention relates to a method of forming a heat exchanger manifold, particularly, but not exclusively, a method of extruding features on a sheet of base material and folding the sheet of base material into a manifold for a Heating Ventilation and Conditioning (HVAC) system.

[0002] It is desirable for heat exchanger manifolds to have two longitudinal chambers; an inlet chamber for the flow of fluid into the manifold and an outlet chamber for the flow of fluid out of the manifold.

[0003] It is know to form such dual chamber manifolds by a bending a single sheet of material as described in United States Patent Publication No. 2004/0182558 for example; however, it can be difficult to reliably braze heat exchanger tubes to the resulting geometrical arrangement of such manifolds.

[0004] According to the present invention, there is provided a method of forming a heat exchanger manifold from a sheet of base material, the method comprising:

providing the sheet of base material with first and second partitioning wall portions, first and second upper wall portions, first and second side wall portions and a central portion;
forming a longitudinal locating groove in the central portion of the base material;
forming a series of tube insertion slots across the longitudinal locating groove of the central portion, each tube insertion slot having extruded walls which create locating channels between corresponding walls of adjacent tube insertion slots;
forming a series of protrusions along opposed edges of the first and second partitioning wall portions to form ridged edges thereon, the series of protrusions being positioned along the ridged edges to correspond with portions of the longitudinal locating groove and series of channels of the central portion;
folding the ridged edges of the first and second partitioning wall portions toward the central portion in order to form first and second partition walls;
folding the first and second upper wall portions, and first and second partition walls toward the central portion to form first and second upper walls;
folding the first and second side wall portions, the first and second upper walls, and the first and second partition walls toward the central portion to form first and second side walls;
folding the first and second side walls, first and second upper walls, and first and second partition walls towards the central portion;
locating the protrusions of the ridged edges in the longitudinal locating groove of the channels between the series of tube insertion slots; and
brazing the protrusions of the ridged edges to the walls of the channels in the longitudinal groove.

[0005] According to the present invention there is also provided a heat exchanger manifold formed from a sheet of base material, the heat exchanger manifold comprising:

folded first and second partition walls;
folded first and second upper walls;
folded first and second side walls;
a central base portion having a longitudinal locating groove;
a series of tube insertion slots across the longitudinal locating groove the central base portion, each tube insertion slot having extruded walls which create locating channels between corresponding walls of adjacent tube insertion slots;
a series of protrusions along opposed edges of the first and second partitioning wall portions which form ridged edges thereon, the series of protrusions being positioned along the ridged edges to correspond with portions of the longitudinal locating groove and series of channels of the central base portion;

wherein the protrusions of the ridged edges are located in the groove of the channels between the series of tube insertion slots and are brazed thereto.

[0006] Further features and advantages of the invention will become apparent from the attached claims as well as the following description and drawings.

[0007] Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

- Fig. 1A is a plan view of the heat exchanger manifold of the present invention, in a first embodiment, prior to being folded in accordance with the method of the present invention;
- Fig. 1B is a cross sectional view of a portion of the heat exchanger viewed in the direction indicated A-A in Fig. 1A, showing the raised heat exchanger tube insertion slot profile;
- Fig. 1C is a more detailed view of the manifold central portion shown in Fig. 1A;
- Fig. 1D is a more detailed view of a mounting hole portion indicated as B in Fig. 1C;
- Fig. 2A is a cross-sectional view of the heat exchanger manifold of Fig. 1A from above after is has been folded into its final configuration;
- Fig. 2B is a partial cross sectional view showing a longitudinal groove in the base of the folded manifold;
- Fig. 2C is a side view of the folded manifold of Fig. 2A;
- Fig. 2D is a further view of the bottom of the folded manifold;
- Fig. 2E is a view of the opposite side of the manifold to Fig. 2C, showing fluid flow tube apertures provided therethrough;
- Fig. 2F is a bottom view of the manifold of Fig. 2A;
- Fig. 2G is a cross sectional view of a portion of the

heat exchanger viewed in the direction indicated B-B in Fig. 2C;

- Fig. 3 is a perspective view of the open end of the first embodiment of the manifold, where heat exchanger tubes are inserted into tube insertion slots of the manifold;
- Fig. 4 is a schematic cross section of the manifold of Fig. 3;
- Fig. 5 is a perspective underside view of the external surface of the manifold;
- Fig. 6 is a further perspective view of an open end of the manifold where heat exchanger tubes are inserted into the tube insertion slots of the manifold;
- Fig. 7 is a cross sectional view of the manifold, where a fluid flow connection tube is inserted through the outer and inner walls of the manifold; and
- Fig. 8 is a further cross sectional view of the arrangement in Fig. 8 taken further along the longitudinal axis of the manifold.
- Fig. 9A is a perspective view of a second embodiment of the manifold, in its initial unfolded configuration. ;
- Fig. 9B shows the manifold of Fig. 3A after a first folding step;
- Fig. 9C shows the manifold after a second folding step;
- Fig. 9D shows the manifold after a third folding step; and
- Fig. 9E shows the manifold in its final folded configuration after a fourth folding step.

[0008] With particular reference to Fig. 1A, in its initial unfolded configuration, the heat exchanger manifold comprises a sheet of base material 12 that is easily manipulated into the finished article and is suitably strong to withstand the environments it will be subjected to in use. An example of a suitable material is a sheet of aluminium alloy.

[0009] The sheet 12 is divided into first and second partition wall portions 14, first and second upper manifold wall portions 16, first and second side wall portions 18 and central portion 20. Division of the sheet may be assisted by the provision of discontinuities, such as score lines, formed in the surface of the sheet 12.

[0010] Opposed edges 22 have a series of short protrusions 24 and elongated protrusions 26 formed thereon. The protrusions 24 and 26 combine to form ridged edges 22.

[0011] First and second partition wall portions 14 are each provided with fluid flow tube apertures 28 stamped therethrough. Side wall portion 18 is also provided with a corresponding fluid flow tube aperture 30 as well as tube aperture 32. Strengthening ribs 34 (see Fig 2E) are provided in the remaining space between the apertures 30 and 32 on side wall portion 18 and along the entire length of the opposing side wall portion 18. The apertures 28 and 32 are formed to allow a fluid flow tube F to be inserted therein as described in more detail subsequently.

[0012] Central portion 20 of the sheet 12 is formed with a series of tube insertion slots 36. As seen in Figs. 3 to 8, the tube insertion slots have a pair of opposed ledges 38 which protrude from the base sheet 12 to form the slot 36 therebetween, in which heat exchanger tubes T may be received. As well as defining the slot 36, the opposed ledges 38 also define locating channels 40 (Fig. 1 B) on the base sheet material 12 between the ledges. As seen in Fig. 6, 7 and 8, in this first embodiment, the series of tube insertion slots 36 do not span across the entire width of the central portion 20; to the contrary, side lips 42 are provided along either edge of the central portion 20 between either edge of the slots 36 and the adjacent side wall portions 18. A longitudinal locating groove 21 is also provided along central portion 20.

[0013] With reference to Fig. 1D, the longitudinal locating groove 21 has regularly spaced mounting holes 44 which are of a shape and size which corresponds with the combined shape and size of the regularly spaced elongated protrusions 26 of the ridged edges 22.

[0014] With the exception of strengthening ridges 34 and the locating groove 21, all of the above features are formed by stamping through the sheet of base material 12 with a stamping tool. Furthermore, certain features may also be formed by an extrusion process; for example, the apertures 28 and 32 may have extruded collars 28C, 32C to facilitate a fluid tight connection with the fluid flow tubes F. The strengthening ridges 34 and locating groove 21 are formed by partially extruding portions of the base sheet in order to form indentations in the material wall without cutting there through.

[0015] Once the features previously described have been stamped on the base sheet of material 12, the partition wall portions 14, upper manifold wall portions 16 and the side wall portions 18 are sequentially folded toward the central portion 20 in order to form the manifold 10 shown in Figs. 2 - 8 (this folding sequence is best described subsequently in relation to a second embodiment of the invention, although substantially the same sequence applies to this first embodiment).

[0016] It can be seen from the previous description and the drawings that the interior of the manifold 10 is divided by the partition walls 14W into a first longitudinal chamber 46 and a second longitudinal chamber 48 (one being for fluid flow into the manifold and the other being fro fluid flow out of the manifold). In the folded manifold 10, aperture 30 in side wall 18W and the pair of apertures 28 in the partition walls 14W align with one another to provide a passage through which a fluid flow tube F may pass through chamber 46 and directly into chamber 48.

[0017] When folding the walls of the sheet 12 together, as the partition walls 14W approach their final position their faces begin to abut against one another and the series of short protrusions 24 rest within the locating groove 21 of the corresponding series of channels 40 between the opposed ledges 38. Furthermore, the elongated protrusions 26 of each ridged edge 22 pass into the mounting holes 44. In this regard, as seen in Fig. 4, the elongated protrusions 26 may also be provided with an angled point in order to facilitate insertion into the mounting holes 44.

[0018] In this folded configuration, the web of the partition walls 14W between the short protrusions 24 abut against the thin edge of each ledge 38 and the outer edge of each protrusion 24 abuts against the trough of the inner walls of the locating channels 40 and groove 21. When the manifold 10 is to be incorporated into a heat exchanger, heat exchanger tubes T are inserted into each of the slots 36 until their respective ends abut against the lower edge of the partition walls 14W spanning the tube insertion slots 36. Each heat exchanger tube T has its own partition web along its internal bore (evidenced by seam 50) such that the portion of tube T on one side of seam 50 is in isolated fluid communication with chamber 48 and the portion on the other side of seam 50 is in isolated fluid communication with chamber 46.

[0019] The previously described arrangement has a geometry which provides superior brazing properties as follows:

- The upper and lower ledges 38 of the slots 36 provide a flat surface which can be brazed to the outer wall of each tube T. When brazing it is desirable to, at least partially, cover the seam 50 of tubes T. Since tubes T are typically inserted into the manifold either way around (i.e. with the seam on one side or the other), there could otherwise be a risk that this requirement is not fulfilled; however, the presence of the upper and lower ledge ensures this.

[0020] The series of short protrusions 24 sit snugly in the groove 21 within the series of channels 40 and allow brazing along all sides thereof.

[0021] The side lips 42 along the edge of the slots 36 allow the side walls 18 to be bent up from the plane of the base sheet 12 until they are very close to the tubes T. Indeed, the tubes T may be brazed directly to the side walls 18W to improve the overall structural rigidity of the manifold.

[0022] The separating web along the seam 50 of the tube T can be brazed to the edges of the partition walls 14W to provide a structural bond as well as a fluid tight seal therebetween.

[0023] A second embodiment of the invention is shown in Figs. 9A to 9E. The second embodiment of the invention is substantially similar to the first and has substantially the same advantages, with the exception of the apertures 128 which are, in this second embodiment, oval shaped and provided on the upper manifold wall 116W rather than through the side manifold walls 118W.

[0024] The sequence of folding the sheet of base material 112 to form the manifold 110 of the second embodiment will now be described, although it will be appreciated that this sequence is equally applicable to the manifold of the first embodiment.

[0025] Starting from the planar sheet of base material 112 having the stamped features provided thereon, in a first folding step, the first and second partition wall portions 114 are folded toward the central portion 120 at approximately 90 degrees from the plane of the sheet of material to form partition walls 114W.

[0026] In a second folding step, the first and second upper manifold wall portions 116, along with the previously folded partition walls 114W, are folded toward the central portion 120 at approximately 90 degrees from the plane of the sheet of material to form first and second upper manifold walls 116W and hence the partially closed box depicted in Fig. 9C.

[0027] In a third folding step, the first and second side wall portions 118, along with the previously folded partition walls 114W and previously folded first and second upper manifold walls 116W, are folded toward the central portion 120 as depicted in Fig. 9D. In this third and final folding step, as the ridged edges 22 of the partition walls 114W approach the central portion 120, the short protrusions 124 are meshed into the groove 121 in the channels 140 between the opposed ledges 136. At the same time, the elongated protrusions 126 of each opposed ridged edge 22 are jointly inserted into the mounting holes 44 to secure the manifold 10 in its final closed configuration depicted by Fig. 9E.

[0028] In use, the manifolds of the present invention provide first and second inlet / outlet chambers which have a series of single heat exchanger tube insertion slots for both chambers and which provide optimum brazing properties. The invention also improves the heat distribution, reduce the part count and complexity of the manifold over previous arrangements and minimises the likelihood of fluid leaks.

[0029] Modifications and improvement may be made to the foregoing, without departing from the scope of the invention.

Claims

1. A method of forming a heat exchanger manifold from a sheet of base material, the method comprising:

   providing the sheet of base material (12; 112) with first and second partitioning wall portions (14; 114), first and second upper wall portions (16; 116), first and second side wall portions (18; 118) and a central portion (20; 120);

   forming a longitudinal locating groove (21; 121) in the central portion (20; 120) of the base material (12; 112);

   forming a series of tube insertion slots (36; 136) across the longitudinal locating groove of the base material (12; 112), each tube insertion slot having extruded walls (38; 138) which create locating channels (40; 140) between corresponding walls (38; 138) of adjacent tube insertion

slots (36; 136);
forming a series of protrusions (24; 124) along opposed edges of the first and second partitioning wall portions (14; 114) to form ridged edges (22; 122) thereon, the series of protrusions (24; 124) being positioned along the ridged edges (22; 122) to correspond with portions of the longitudinal locating groove (21; 121) and series of channels (40; 140) of the central portion (20; 120);
folding the ridged edges (22; 122) of the first and second partitioning wall portions (14; 114) toward the central portion (20; 120) in order to form first and second partition walls (14W; 114W);
folding the first and second upper wall portions (16; 116), and first and second partition walls (14W; 114W) toward the central portion (20; 120) to form first and second upper walls (16W; 116W);
folding the first and second side wall portions (18;118), the first and second upper walls (16W; 116W), and the first and second partition walls (14W; 114W) toward the central portion (20; 120) to form first and second side walls (18W; 118W);
folding the first and second side walls (18W; 118W), first and second upper walls (16W; 116W), and first and second partition walls (14W; 114W) towards the central portion (20; 120);
locating the protrusions (24; 124) of the ridged edges (22; 122) in the longitudinal locating groove (21; 121) of the channels (40; 140) between the series of tube insertion slots (36; 136); and
brazing the protrusions (24; 124) of the ridged edges (22; 122) to the walls of the channels (40; 140) in the longitudinal groove (21; 121).

2. A method of forming a heat exchanger manifold according to claim 1, further comprising providing each tube insertion slot (36; 136) with a pair of opposed extruded walls (38; 138).

3. A method of forming a heat exchanger manifold according to claim 2, further comprising:

inserting a series of heat exchanger tubes (T), into the tube insertion slots (36; 136), the heat exchanger tubes (T) having a web member which divides their internal bore into a first and second fluid flow chamber;
brazing the web member to edges of the partitioning walls (14W; 114W) between the protrusions (24; 124); and
brazing opposite external faces of the heat exchanger tubes (T) to the pair of opposed extruded walls (38; 138).

4. A method of forming a heat exchanger manifold according to any preceding claim, further comprising:

forming a series of elongated protrusions (26; 126) along the ridged edges (22; 122);
forming a series of mounting holes (44; 144) in the longitudinal groove (21; 121), and
locating the elongated protrusions (26; 126) of each ridged edge (22; 122) in the mounting holes (44; 144).

5. A heat exchanger manifold formed from a sheet of base material, the heat exchanger manifold comprising:

folded first and second partition walls (14W; 114W);
folded first and second upper walls (16W; 116W);
folded first and second side walls (18W; 118W);
a central base portion (20; 120) having a longitudinal locating groove (21; 121);
a series of tube insertion slots (36; 136) in the central base portion (20; 120), each tube insertion slot having extruded walls (38; 138) which create locating channels (40; 140) between corresponding walls (38; 138) of adjacent tube insertion slots (36; 136);
a series of protrusions (24; 124) along opposed edges of the first and second partitioning wall portions (14; 114) which form ridged edges (22; 122) thereon, the series of protrusions (24; 124) being positioned along the ridged edges (22; 122) to correspond with portions of the longitudinal locating groove (21; 121) and series of channels (40; 140) of the central base portion (20; 120);

wherein the protrusions (24; 124) of the ridged edges (22; 122) are located in the groove (21; 121) of the channels (40; 140) between the series of tube insertion slots (36; 136) and are brazed thereto.

6. A heat exchanger manifold according to claim 5, wherein each tube insertion slot (36; 136) comprises a pair of opposed extruded walls (38; 138).

7. A heat exchanger manifold according to claim 6, wherein a series of heat exchanger tubes (T) are located in the tube insertion slots (36; 136), the heat exchanger tubes (T) having a web member which divides their internal bore into a first and second fluid flow chamber; and wherein the web member is brazed to edges of the partitioning walls (14W; 114W) between the protrusions (24; 124) and opposite external faces of the heat exchanger tubes (T) are brazed to the pair of opposed extruded walls (38; 138).

8. A heat exchanger manifold according to any of claims 5 to 7, further comprising a series of elongated protrusions (26; 126) along the ridged edges (22; 122) the series of elongated protrusion being located within a series of corresponding mounting holes (44; 144) in the longitudinal groove (21; 121).

9. A heat exchanger manifold according to claims 5 to 8, wherein the series of tube insertion slots (36; 136) only span across a portion of the central base portion (20; 120) width thereby providing side lips (42; 142) along opposite longitudinal edges of the central portion (20; 120).

10. A heat exchanger manifold according to either of claims 8 or 9,
wherein the elongated protrusions (26; 126) comprise angled ends in order to facilitate insertion into the mounting holes 44.

11. A heat exchanger manifold according to claims 5 to 10, wherein the walls (14W; 18W; 116W) of the heat exchanger are provided with fluid flow apertures (28; 128, 30, 32) formed therethrough.

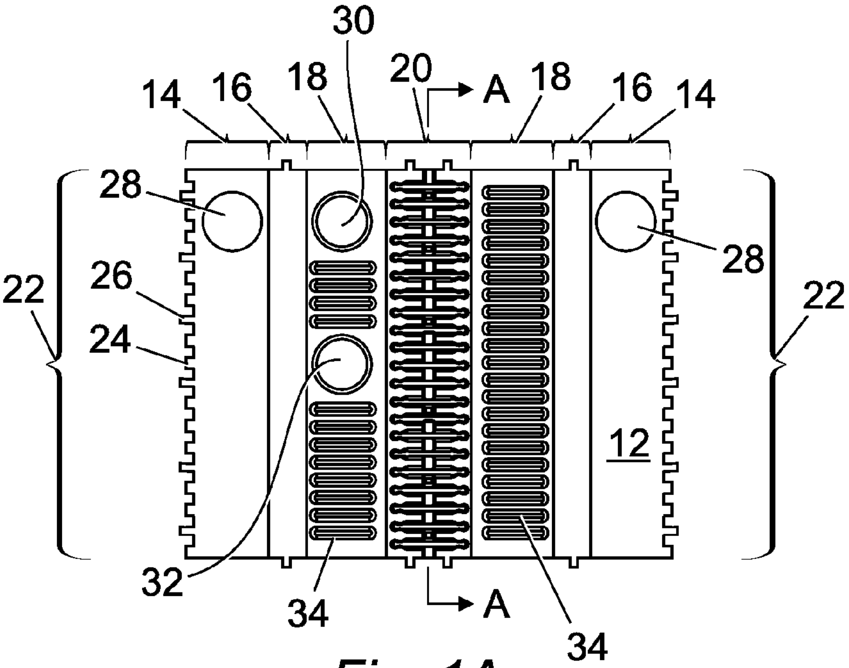


Fig. 1A

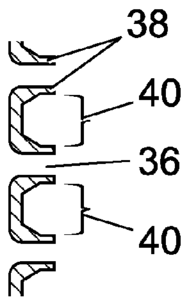


Fig. 1B

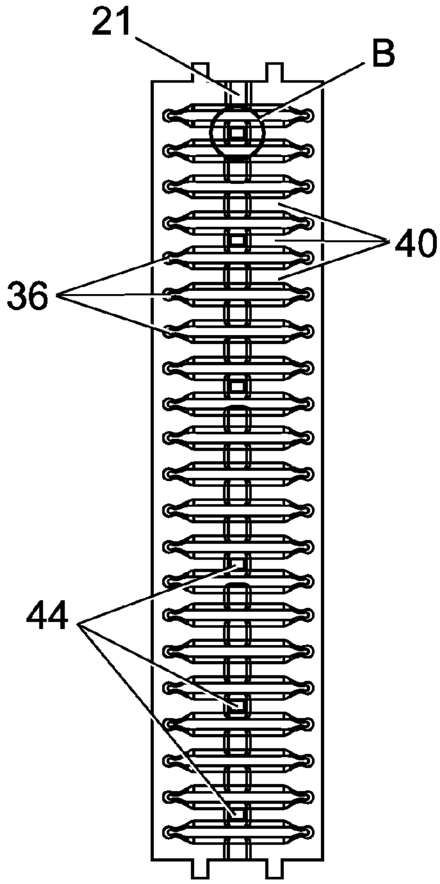


Fig. 1C

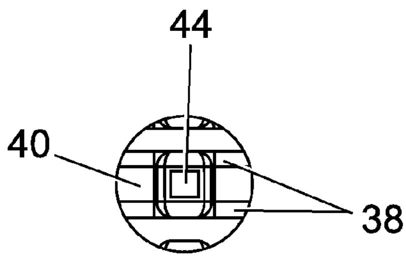


Fig. 1D

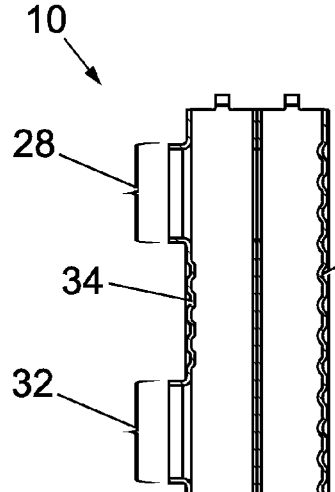


Fig. 2A

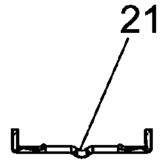


Fig. 2B

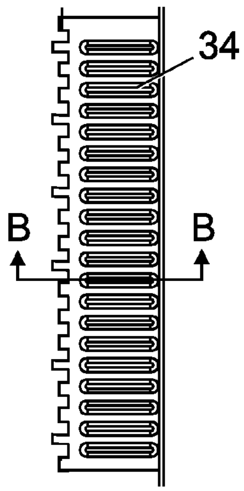


Fig. 2C

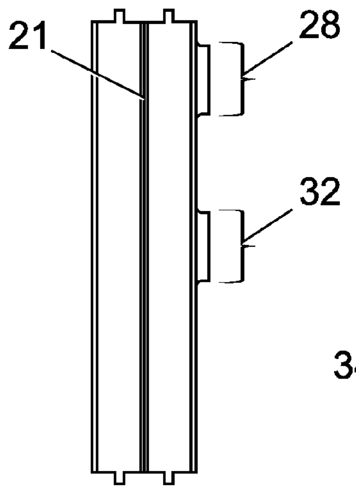


Fig. 2D

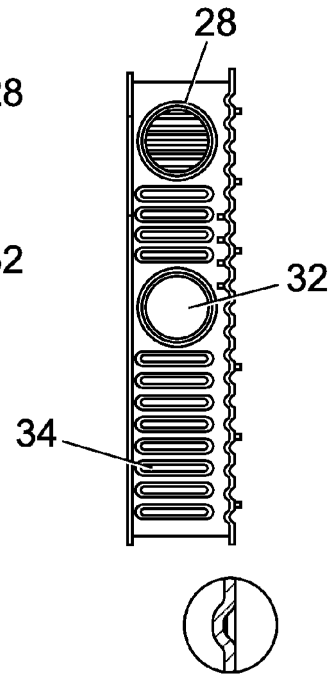


Fig. 2E

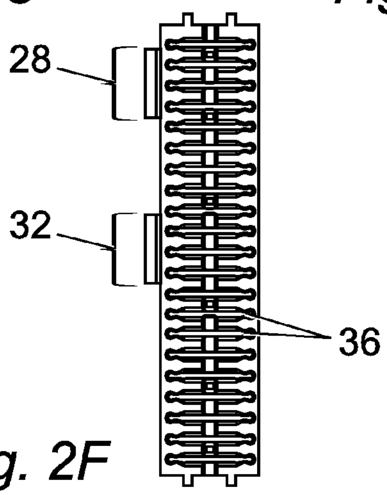


Fig. 2F

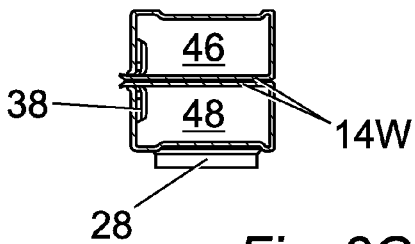


Fig. 2G

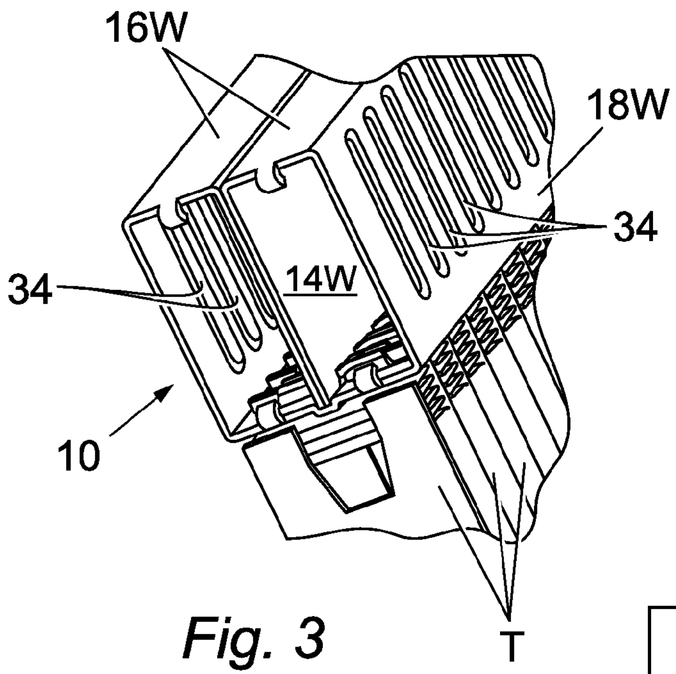


Fig. 3

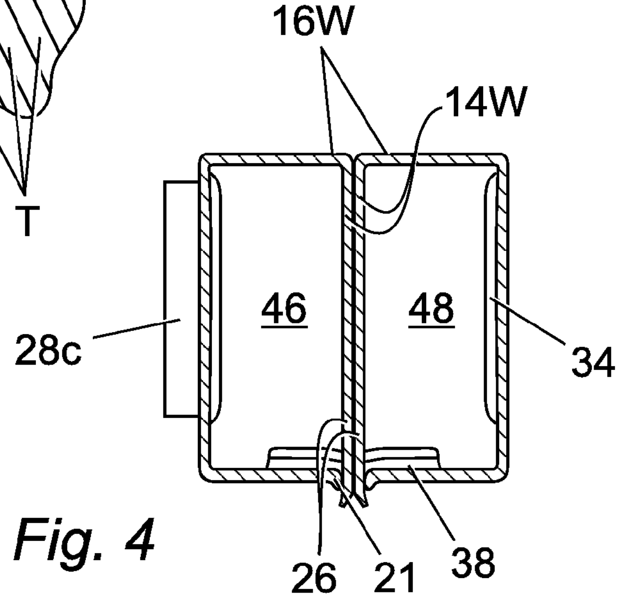


Fig. 4

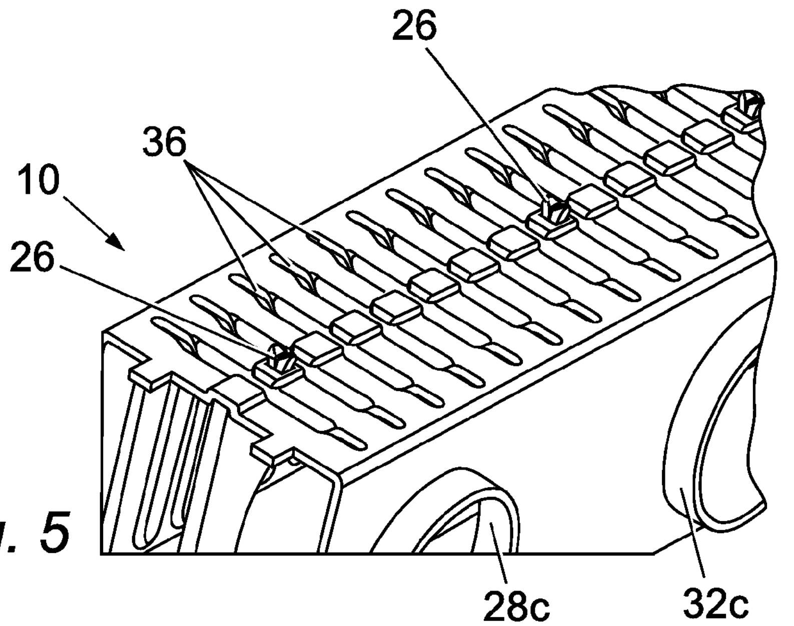
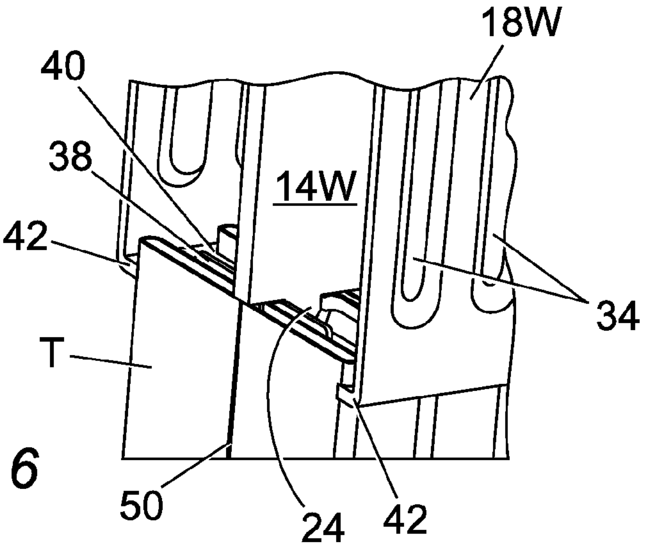


Fig. 5



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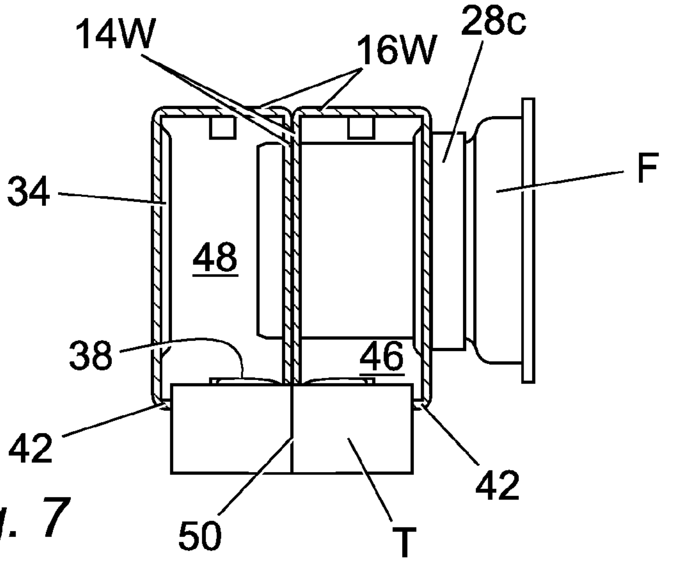

Fig. 7

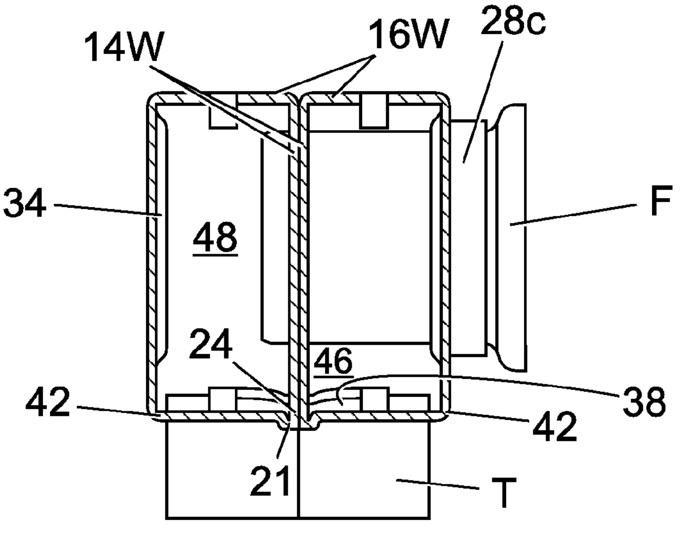

Fig. 8

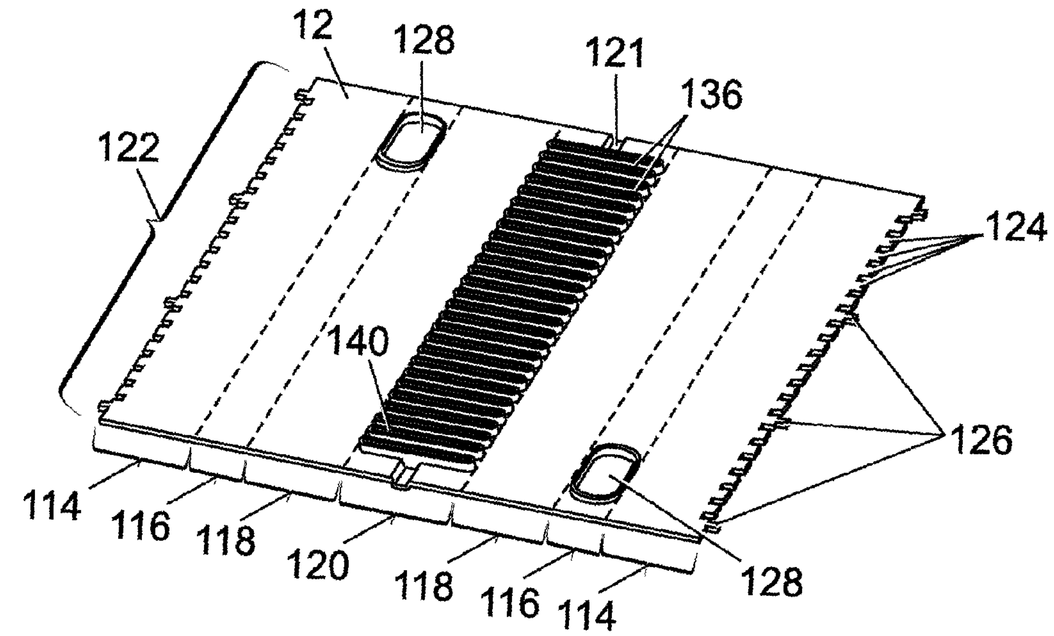
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Fig. 9A

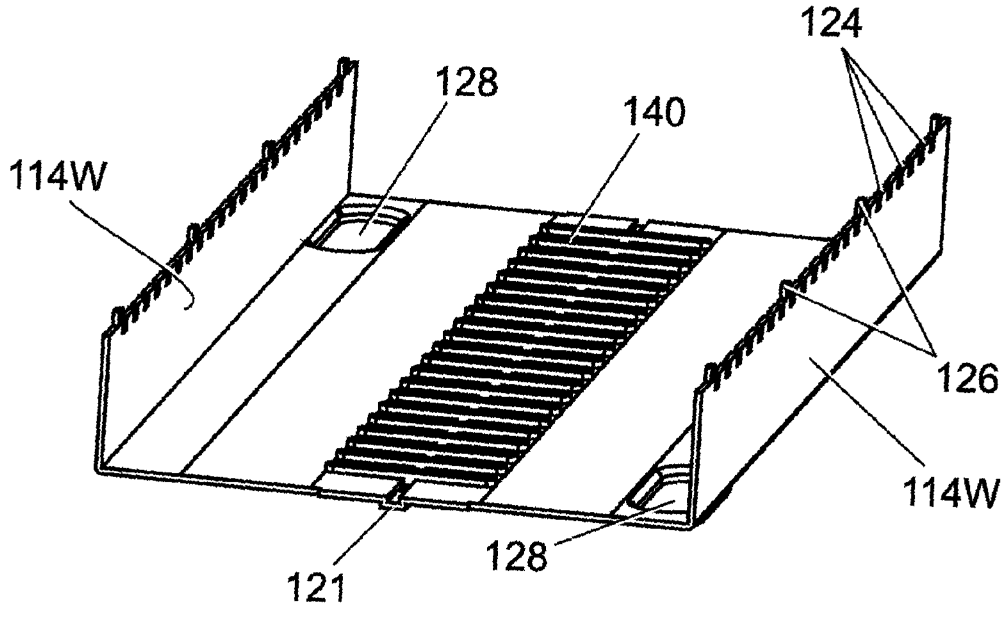
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Fig. 9B

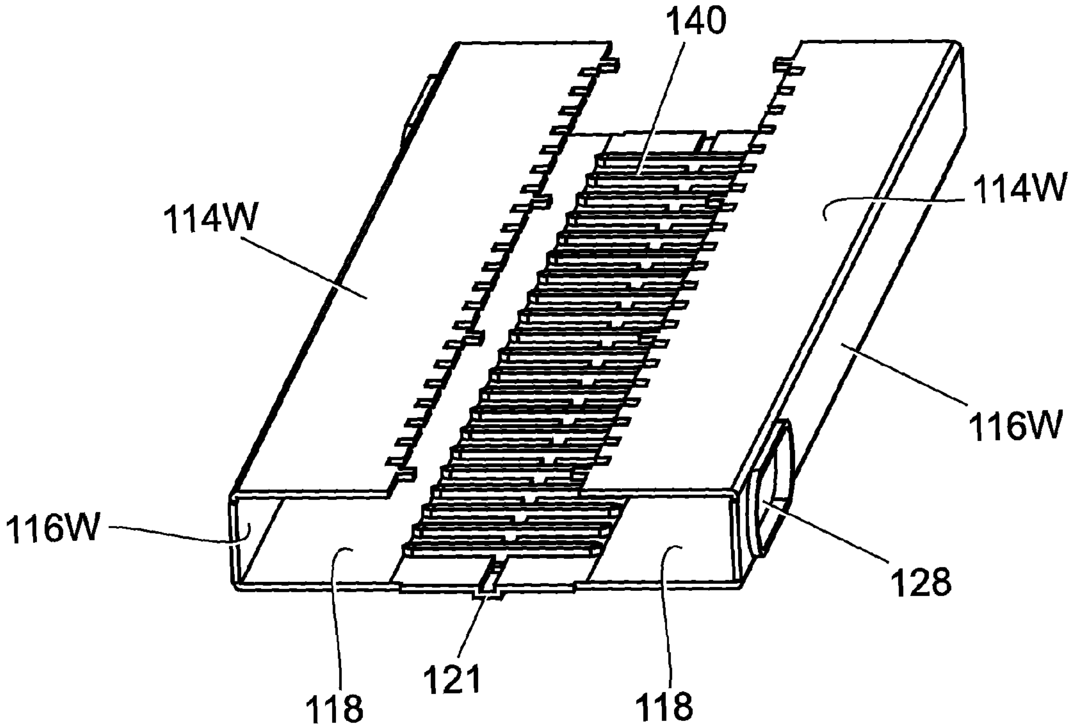
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Fig. 9C

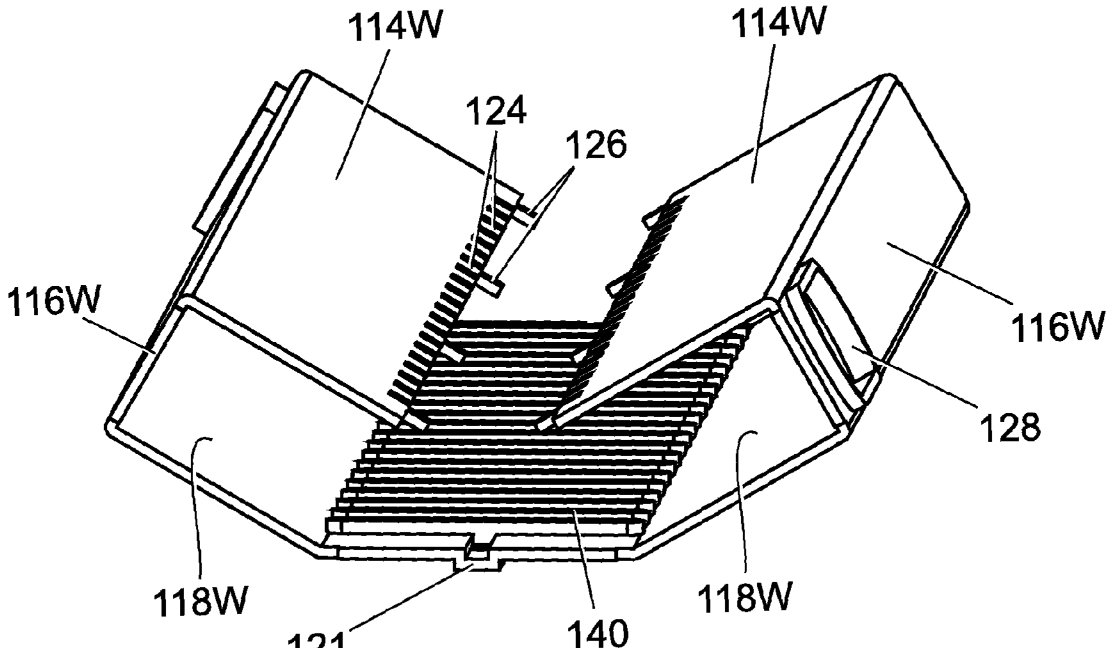
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Fig. 9D

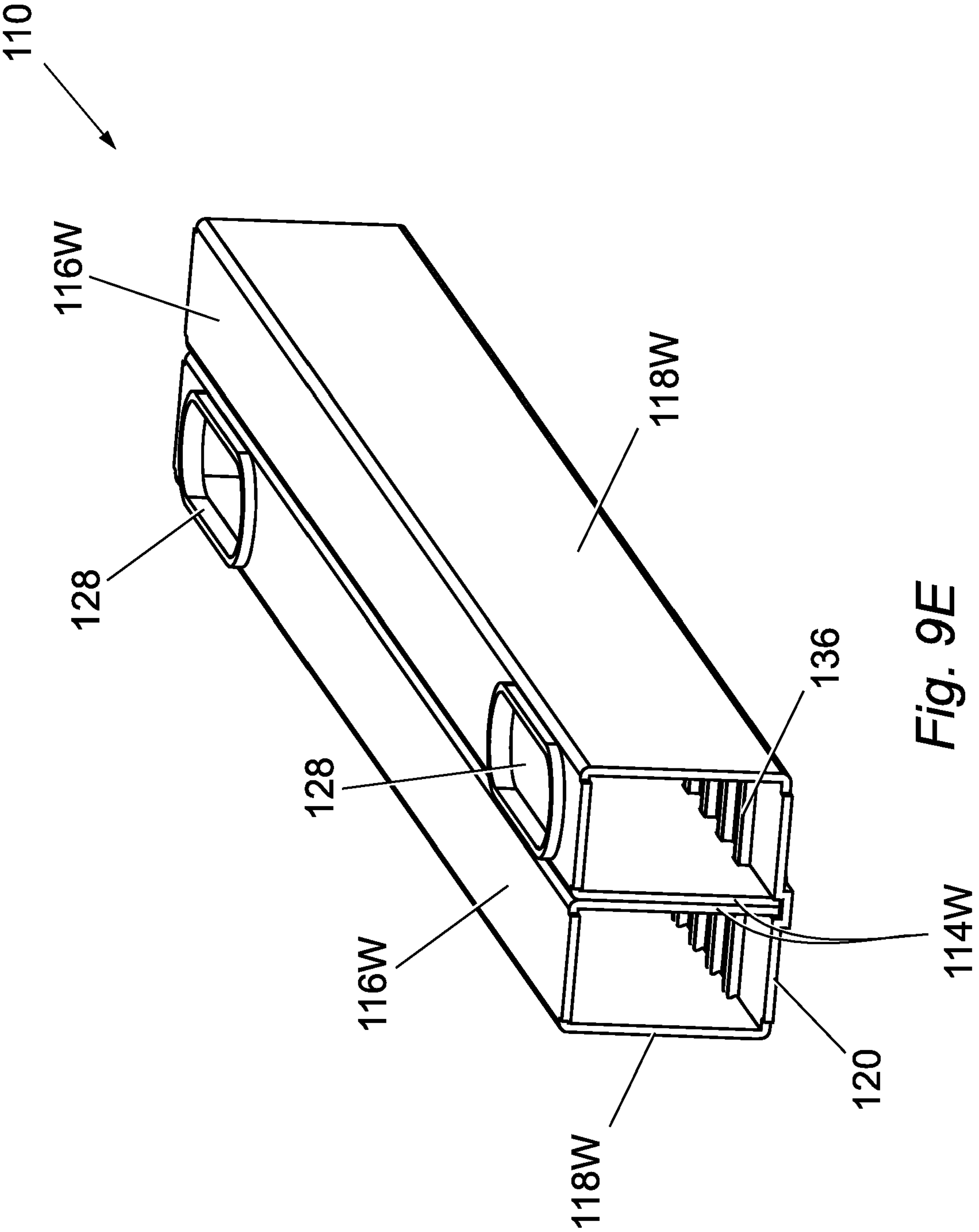

Fig. 9E

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EP 08 15 2405

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Place of search	Date of completion of the search	Examiner
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