

Jan. 23, 1968

E. HENRY BIABAUD
PALTE TYPE HEAT-EXCHANGERS HAVING
CORRUGATED, ZIG-ZAG SHEET MEMBERS

3,364,992

Filed Dec. 22, 1965

4 Sheets-Sheet 1

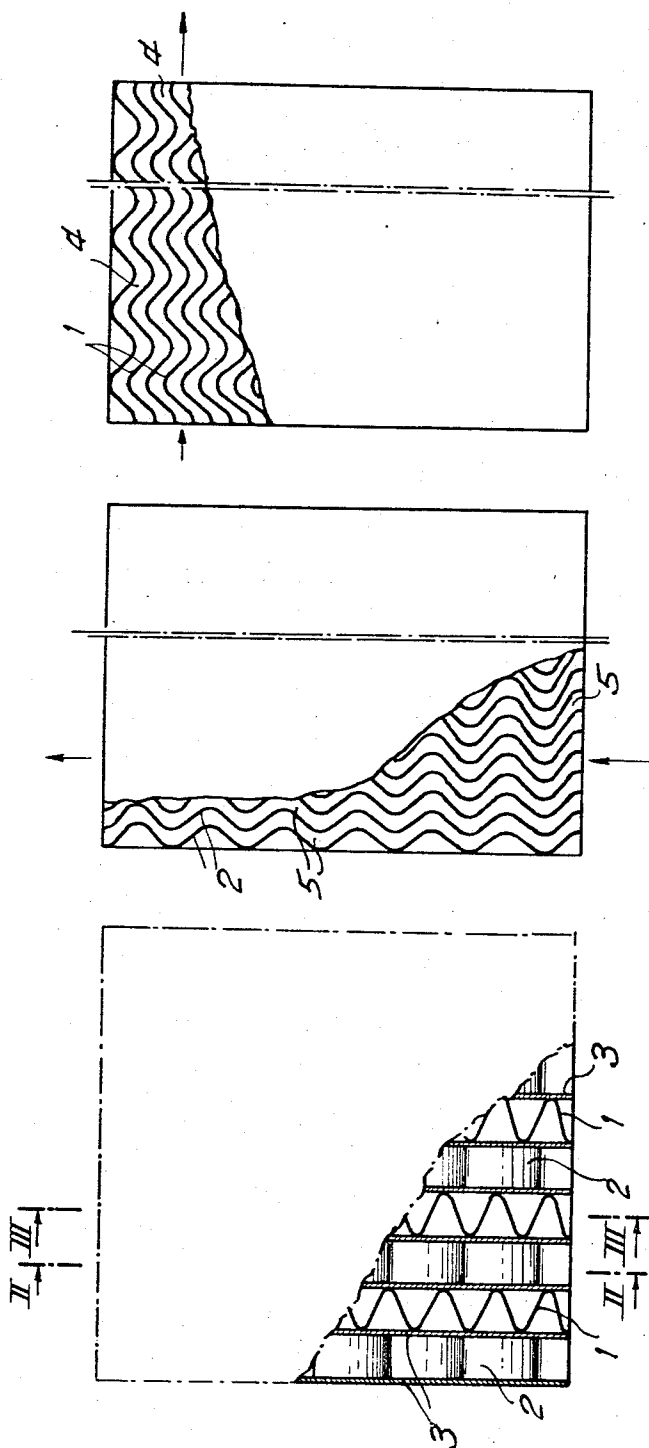


Fig. 1

Fig. 2

Fig. 3

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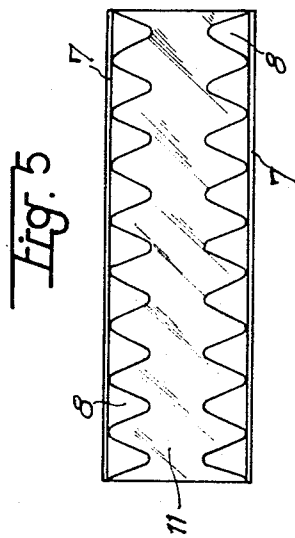


Fig. 7

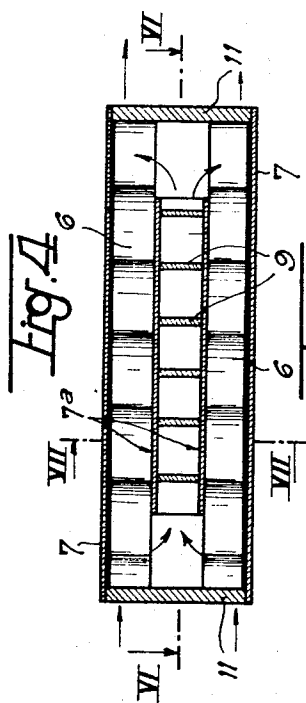
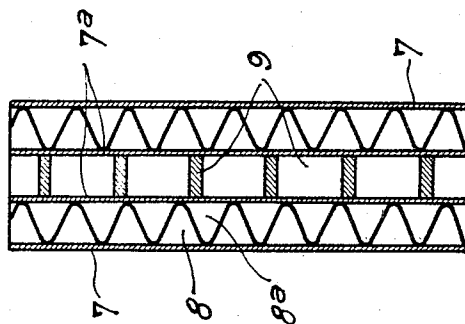
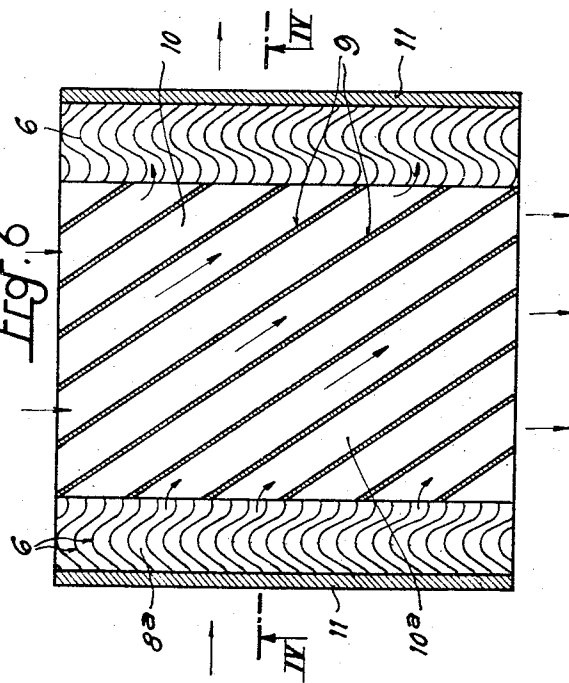


Fig. 6



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Fig. 10

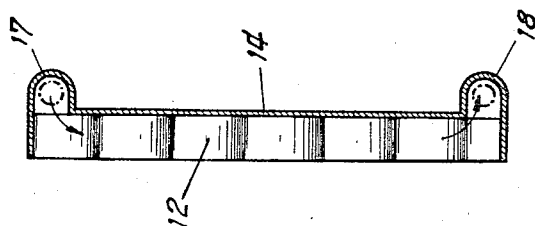


Fig. 9

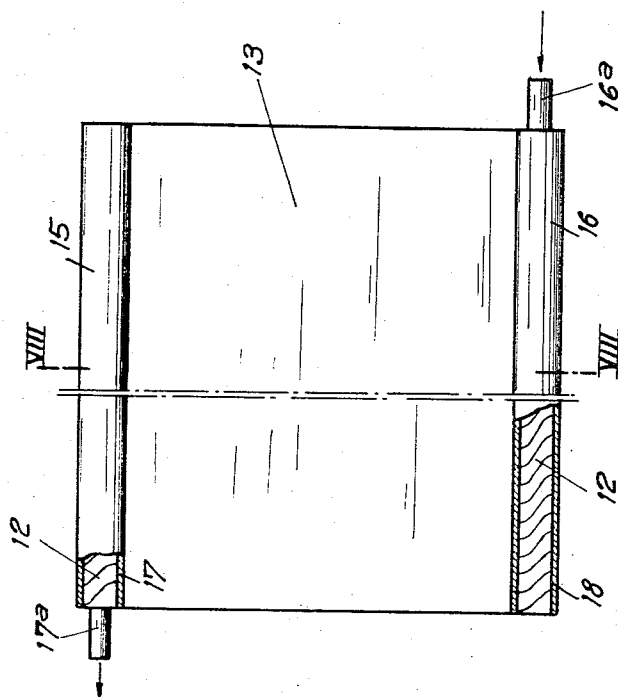
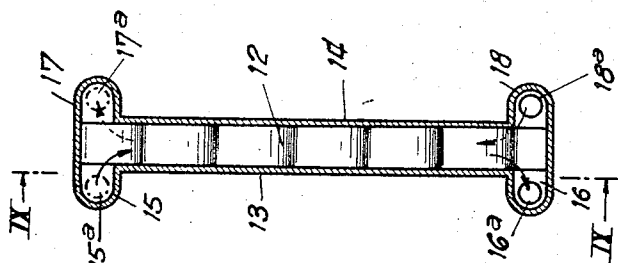


Fig. 8



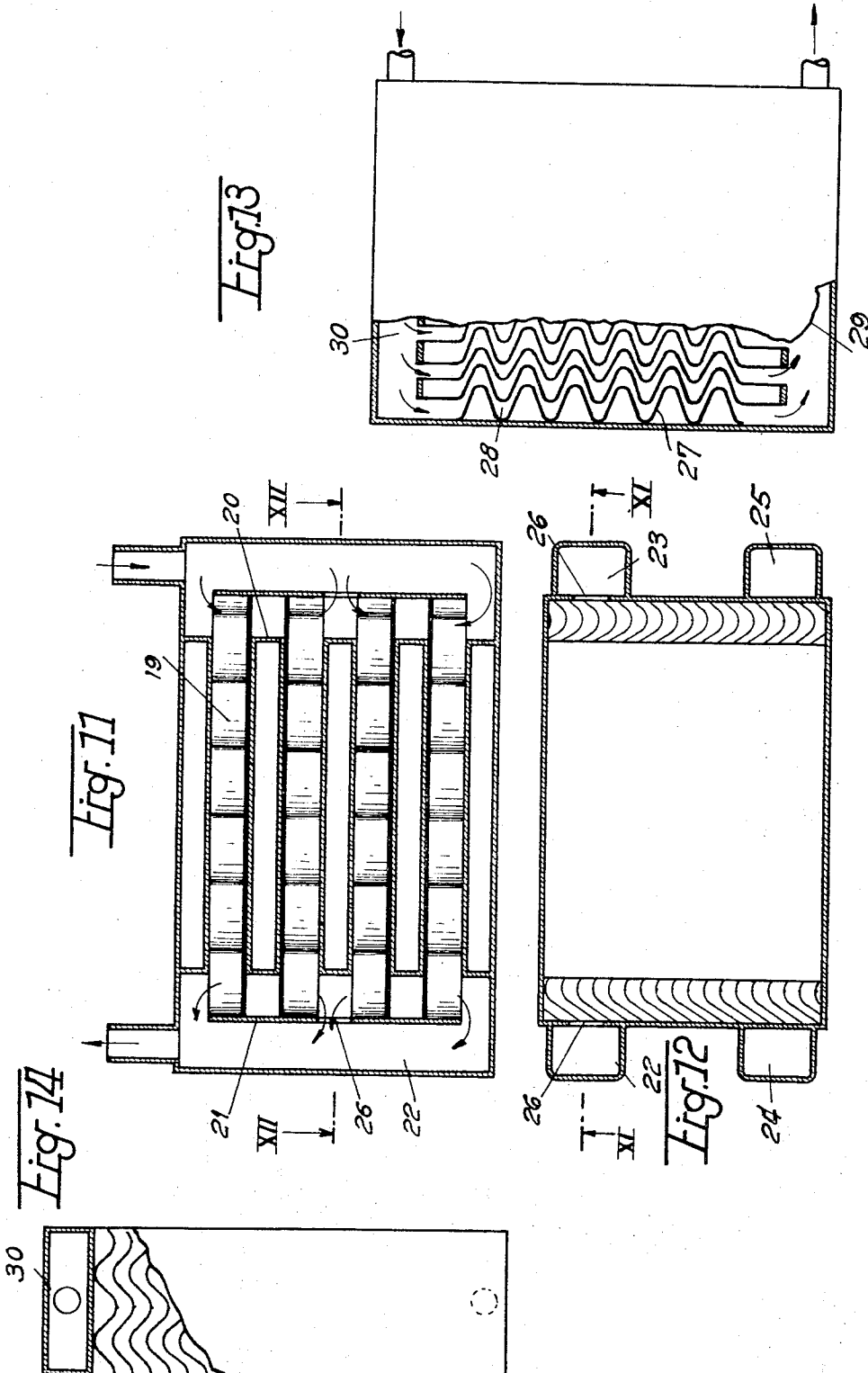
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PLATE TYPE HEAT-EXCHANGERS HAVING CORRUGATED, ZIG-ZAG SHEET MEMBERS

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Filed Dec. 22, 1965, Ser. No. 515,702

Claims priority, application France, Dec. 31, 1964, 3,171 3 Claims. (Cl. 165—166)

ABSTRACT OF THE DISCLOSURE

A heat exchanger has an assembly of two planar plates and a sheet member therebetween having corrugations with zig-zag peaks and valleys in the planes of and secured to the plates to define two sets of zig-zagging passages separated by such sheet member for heat transfer through the latter between fluids flowing in the respective passage sets. Preferably, two assemblies, as aforesaid, are arranged in spaced parallel relation with partitions between their facing plates defining conduits extending obliquely to general directions of the passages to supply and exhaust one fluid at opposed ends of the inner sets of passages, while the other sets of passages carry another fluid.

This invention relates to heat-exchangers.

Certain heat-exchangers include, for reasons of weight and bulk, a large number of very fine passages; this is the case particularly with heat-exchangers for use in small gas turbines. Usually these passages are formed by stacking sheets of very thin metal, alternately plane and folded in the manner of an accordion, and welded to one another.

Such heat-exchangers are submitted during use, to very high stresses owing to temperature differences which exist between the different parts of the structure; these stresses may even result in the destruction of the heat-exchanger. Moreover, it is impossible, without recourse to very thick sheet metal, to use the folds as primary heat-exchange surfaces, that is to say to cause the passage from one side to the other of the folds, the two fluids between which it is desired to exchange heat. These exchangers are necessarily secondary surface heat-exchangers, a common fluid passing between the two sides of the folds.

The present invention has for its object, a heat-exchanger which overcomes the disadvantages outlined above.

According to the present invention there is provided in a heat-exchanger, a corrugated chevron structure defining at least one heat-exchange surface.

A chevron structure of corrugated form is formed from a plane or lightly-ribbed sheet, which is folded and of which the folds are corrugated. The walls of the folds are constituted by cylindrical surfaces of which the generating lines are orientated in two different directions, and are separated from one another by corrugated passages of which the general direction is perpendicular to the two directions of the generating lines. The fold lines are all contained in two parallel planes or "faces" of the structure. The perpendicular direction to the general direction of the corrugated passages and parallel to the faces constitutes the length or the breadth of the base plate and it will be termed hereinafter, for simplification, the longitudinal direction of the structure, whilst in practice it may be orientated to the breadth of the structure. The chevron structures which are also corrugated are described particularly in French Patent No. 1,106,780 of June 10, 1954.

In a first embodiment, the heat-exchanger has secondary surfaces and comprises a series of corrugated chevron

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structures separated from one another by sheets situated in the planes of the faces of the structures, the latter being orientated alternately in two perpendicular directions to one another, means for causing a first fluid to pass in the passages of the structures orientated according to a first direction and means for causing a second fluid to pass in passages of the other structures.

In a second embodiment, the heat-exchanger has primary surfaces and comprises at least one chevron structure on at least one of the faces of which a sheet is secured, and means for causing two fluids to pass through the structure.

The heat-exchanger need include only one structure and a single plate, the passages formed between the structure and the plate being connected to two headers, whilst the external passages are open. One embodiment of this kind is suitable for the exchange of heat between a liquid and a gas, for example a central heating radiator.

The exchanger may also include a partition structure disposed between two plates, each group of passages formed between the structure and one of the plates being connected to two headers.

The exchanger with primary surfaces may include several chevron structures in parallel. These may, for example, be separated from one another by boxes, the headers of each structure being in communication, at one of their ends with the general or main header. In a modification, two chevron structures may be assembled, by being joined together in the direction perpendicular to the faces but nested one within the other in such a manner that an interrupted duct is formed between the two structures.

In one particular embodiment, the exchanger includes two partition structures which are disposed each between two plates and are placed with respect to one another, with the interior walls separated by oblique partitions which define the passages in communication with the interior ducts of the structure by openings provided in the interior plates.

Various embodiments of heat-exchangers according to the invention will now be described, by way of example, with reference to the accompanying diagrammatic drawings, in which:

FIGURE 1 shows a fragmentary elevation of a first embodiment;

FIGURE 2 is a fragmentary section on line II—II of FIGURE 1;

FIGURE 3 is a fragmentary section on the line III—III of FIGURE 1;

FIGURE 4 is a section on line IV—IV of FIGURE 6 of a second embodiment;

FIGURE 5 is an end view of the second embodiment;

FIGURE 6 is a section on line VI—VI of FIGURE 4; FIGURE 7 is a section on the line VII—VII of FIGURE 4;

FIGURE 8 is a cross-section of the third embodiment; FIGURE 9 is a view, partly in section, one line IX—IX of FIGURE 8;

FIGURE 10 is a view similar to FIGURE 8 of a modification;

FIGURE 11 is a section on line XI—XI of FIGURE 12 of a fifth embodiment;

FIGURE 12 is a sectional view on line XII—XII of FIGURE 11;

FIGURE 13 is a view in elevation with parts broken away and partly in section of a sixth embodiment; and

FIGURE 14 is an end view, likewise with parts broken away and partly in section.

The heat-exchanger shown in FIGURES 1 to 3 is of the type with secondary surfaces and arranged for cross-flow.

It is formed by a series of corrugated chevron structures 1 and 2 separated from one another by plates 3 situated

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in planes of the faces of the structures, the assembly being secured together by welding. Corrugated passages 4 or 5, communicating with headers (not shown), are thus formed between two successive folds of a structure 1 or 2 and the adjacent plates 3. The structures 1 and 2 which are alternate, are orientated in two perpendicular directions in such a manner that the passages 4 and 5 are likewise orientated in two perpendicular directions. The passages 4 are used for the passage of a fluid (hot gas for example) and the passages 5 for the passage of another fluid (cold air for example) as indicated by the arrows in FIGURES 2 and 3.

The embodiment of FIGURES 4 to 7 is of the primary surface type and operates on the counter-flow principle. It is formed by two partitioned structures with corrugations 6 which have the same orientation and are each interposed between two plates 7 and 7a; passages of substantially triangular section 8 and 8a are thus formed between each of the structures and the plates 7 and 7a (see FIGURE 7). The plate 7 has a size at least equal to that of the structure whilst the plate 7a has a size somewhat smaller. The two structures are disposed one upon the other, with the plates 7a opposite one another, whilst being separated by oblique partitions 9 defining ducts 10 and 10a of which at the most only one end discharges to the exterior of the exchanger, this end being the entry for the ducts 10 and the exit for the ducts 10a; they are assembled together by means of connecting pieces 11 which are disposed between the edges of the perpendicular structures at their folds and conform to one another in such a manner as to block the ends of the passages 8a (FIGURE 5). Owing to the smaller size of the plates 7a, the passages 8a of the two structures are in communication at one of their ends with the ducts 10, and at their other ends with the ducts 10a.

The passages 8 are interposed in the circuit of one of the fluids, for example the hot gas. For their part, the ducts 10 and 10a are interposed in the circuit of the other fluid, for example cold air. Under these conditions, this air passes through the ducts 10 then enters the passages 8a, traverses the passages 8a in counter-flow to the gas which circulates in the passages 8 and finally is discharged to the exterior of the heat-exchanger through the ducts 10a.

This heat-exchanger effectively resists differences in pressure which may exist between the passages 8 and 8a. It is possible to assemble any number of elements or structures, by simple superposition.

It is possible to construct on the same principle heat-exchangers suitable, in particular, when one of the fluids is a liquid.

It is thus, that the heat-exchanger shown in FIGURES 8 and 9 includes a structure with corrugated partitions 12 disposed between two plates 13 and 14 slightly larger than the structure and welded to the latter. The passages situated on one side of the structure communicate through two headers 15 and 16 disposed in an extension of the plate 13, with inlet ducts and outlet ducts 15a and 16a; similarly, the passages situated on the other side of the structure communicate with two headers 17 and 18 with inlet ducts and outlet ducts 17a and 18a. This exchanger is suitable for heat-exchange between two liquids and by causing one to enter through the duct 15a and the other through the duct 18a the liquids circulate in counter-flow.

The embodiment of FIGURE 10 is simpler, in that only the plate 14 and the headers 17 and 18 have been provided. This embodiment is suitable for a process of heat-exchange between a liquid and a gas. The liquid enters through the header 17 and leaves through the header 18; for its part, the gas circulates naturally between the folds of the structure 12 and the heat is transferred by radiation and natural convection.

The embodiment of FIGURES 11 and 12 shows an exchanger including several corrugated partition structures 19 disposed in parallel. These structures are superimposed whilst being separated from one another by boxes 20 of

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somewhat smaller size; the ends of the passages thus formed are blocked by plates 21. The spaces formed between the boxes 20 and the plates 21 constitutes the headers. Moreover, four general headers 22, 23, 24, 25 are disposed between the ends of the assembly. The plates 21 have openings 26 providing communication with the headers 22 and 23; these openings are provided in front of one of the two boxes 20. The plates 21 likewise include openings opposite the headers 24 and 25, but these are disposed in quincunx relationship with the opening 26.

In the embodiment of FIGURES 13 and 14 corrugated chevron structures 27 are assembled together with a predetermined spacing in the direction perpendicular to the faces, whilst being partially nested in one another, in such a manner that their folds face one another, thus forming a series of interrupted ducts 28. Every other one of the ducts 28 communicates with two headers 29 and 30; the other ducts allow circulation of a second fluid along the direction of the corrugated passages.

The exchangers according to the invention are totally insensitive, in the longitudinal direction and in the general direction of the corrugated passages, to expansions and contractions caused by temperature variations; they have, however certain degree of flexibility. The mechanical strength is thus superior to that of present day heat-exchangers with secondary surfaces. On the other hand, its developed surface is very large so that its bulk is reduced. Finally its sides, parallel to the directions of the generating lines, are very strong, which allows the construction of primary surface heat-exchangers with extremely thin sheets, and are therefore light.

It will be clear that the invention should not be considered to be limited to the embodiments described and shown but it covers, on the contrary, all modifications.

I claim:

1. A heat exchanger comprising at least two assemblies each assembly having two spaced parallel planar plates, and between said plates, a sheet member having corrugations with parallel, zig-zag peaks and valleys respectively lying in common planes and along which said sheet member is secured to said planar plates to define with the latter two sets of zig-zagging passages which sets are separated from each other by said sheet member, said assemblies being in spaced parallel relationship so that one of said plates from each one of said assemblies faces and is parallel to one of the plates of the other of said assemblies, a series of parallel spaced apart portions extending between said facing plates and obliquely with respect to the general directions of said passages, said portions defining with said facing plates first and second sets of conduits, the conduits of said first and second sets respectively communicating with the opposite end portions of the one set of passages in each of said assemblies defined between said one plate and the respective corrugated sheet member, so that a first fluid can be introduced to, and exhausted from said one set of passages in each assembly by way of said first and second sets of conduits, respectively, the other of said sets of passages in each assembly having openings at the opposite ends thereof for respectively receiving and exhausting a second fluid to flow therethrough counter-current to the first fluid and in heat exchange relation thereto through the corrugated sheet member between said sets of passages.

2. A heat exchanger according to claim 1, in which said assemblies are quadrilateral and have first and second pairs of opposed sides, said conduits of the first and second sets respectively opening at the opposed sides of said first pair, and said openings of said other sets of passages in said assemblies being at the opposed sides of said second pair, whereby to facilitate connections to said conduits and to said openings of the other sets of passages.

3. A heat exchanger according to claim 2, in which said facing plates of the assemblies have smaller dimensions in said general directions of the passages than the

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corresponding dimensions of said corrugated sheet members so as to provide for said communicating of said conduits with the opposite end portions of said one set of passages in each assembly, and connecting pieces extend between said corrugated sheet members at said second pair of opposed sides. 5

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