

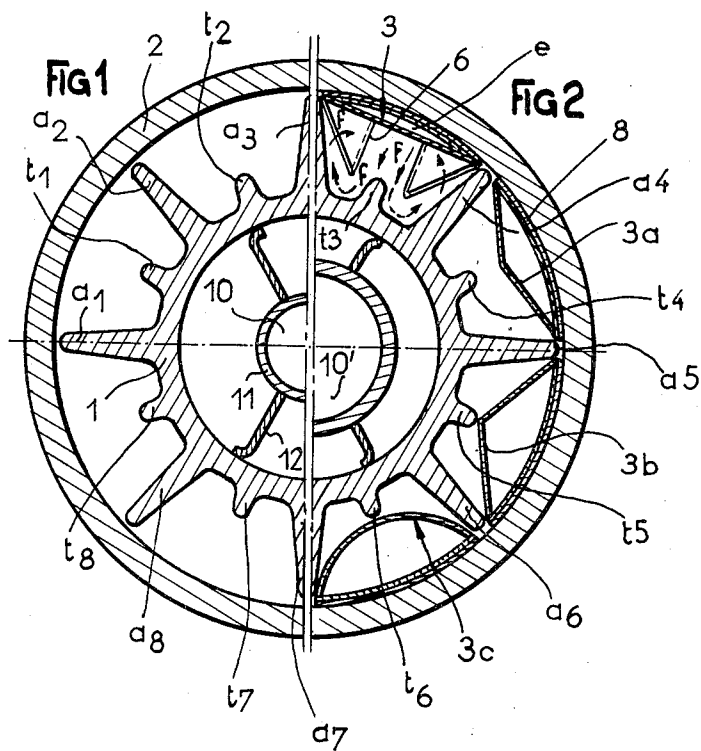
May 29, 1962

P. LEGRAND
HEAT EXCHANGER

3,036,818

Filed Jan. 29, 1959

3 Sheets-Sheet 1



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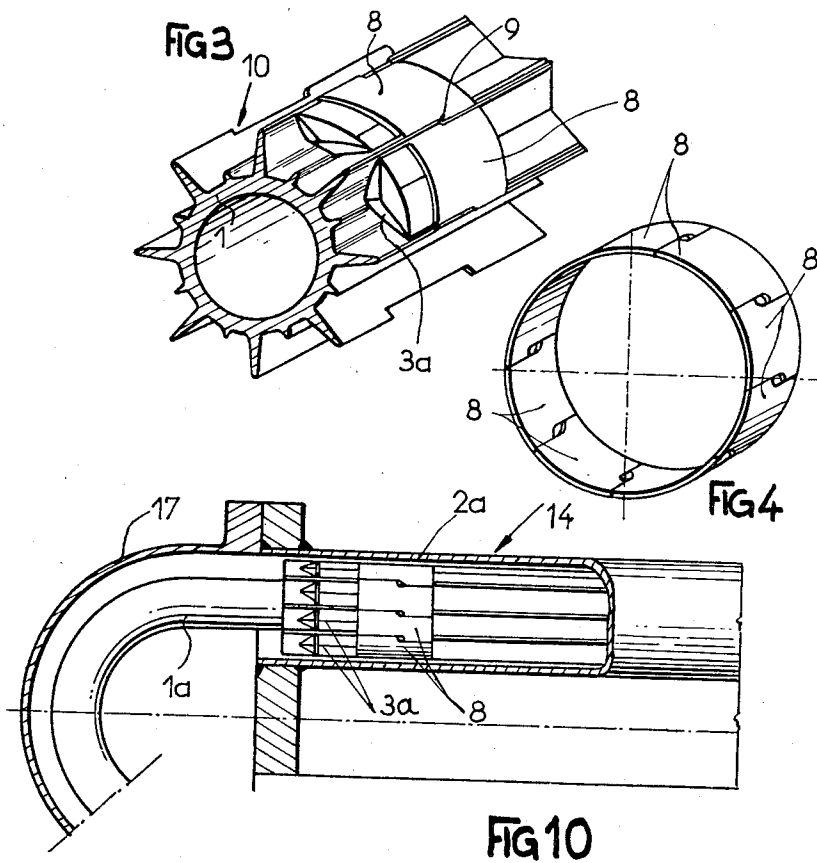
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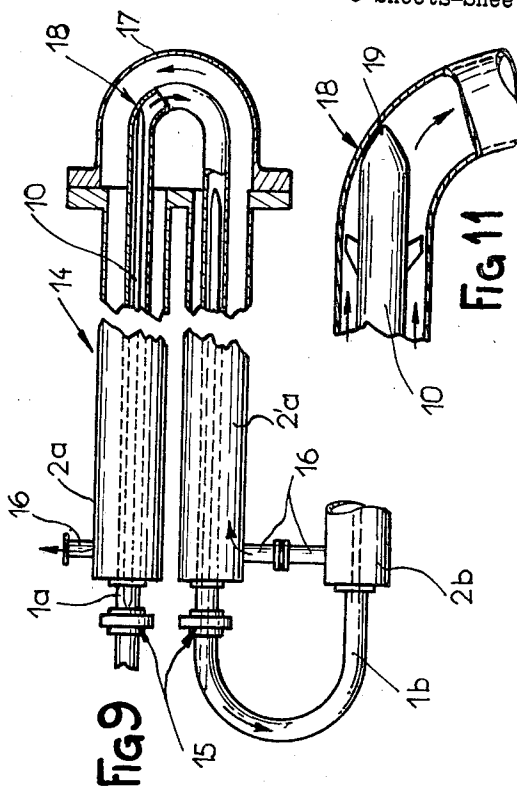
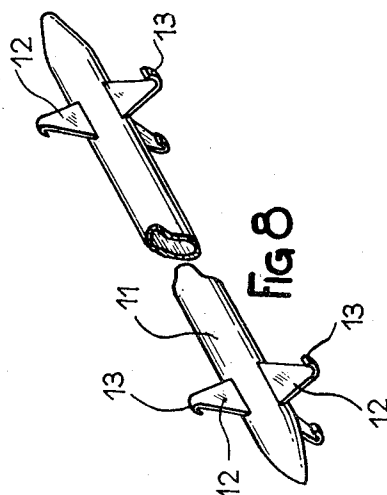
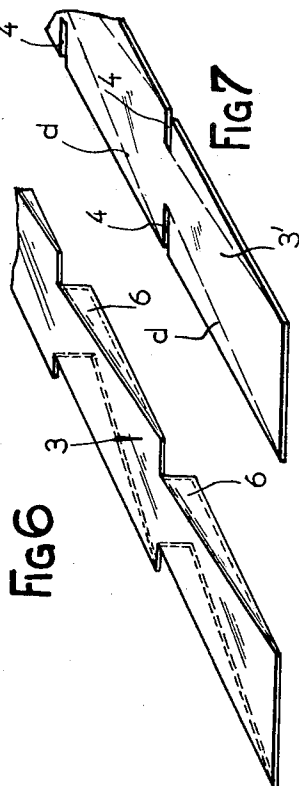
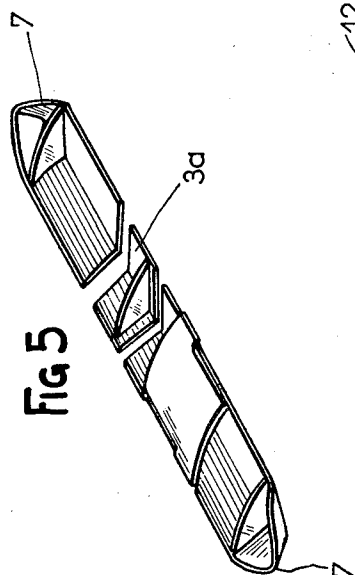
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HEAT EXCHANGER

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6 Claims. (Cl. 257-246)

The present invention is concerned essentially with the construction of tubular elements of heat exchangers or like devices.

It relates more particularly to a specific type of heat exchanger comprising at least a main central element and a concentric tube which form therebetween an intermediate annular space for the circulation of a heat exchange fluid. The main central element may consist either of a solid heating member, or if desired of another tube in which another fluid is caused to circulate, the two fluids circulating in this case either in the same direction or in opposite directions. As a rule, heat exchangers of this type are provided with longitudinal radial fins carried for example by the outer surface of the inner tube or member and extending from this tube or element to the inner wall of the outer tube in order to increase the transmission of heat from one fluid to another.

It is known that the characteristics of heat exchangers of this general type, that is, the length and diameter of the tubes, the number, height and thickness of the fins, etc. should be determined in each case as a function of the characteristics of the two fluids, notably their output or rate of flow, viscosity, specific heat, temperature, pressure drops, permissible soil content, etc. in order to obtain the optimum rate of heat exchange, which is normally based on the use of a minimum exchange surface according to the conditions contemplated.

Under these conditions, it is necessary to provide different types of inner and outer tubular elements for each installation, and this is obviously inconsistent with requirements such as low manufacturing cost, mass production and assembly, and also facility and simplicity of repair and replacement of these elements.

On the other hand, when it is desired to maintain the cross-sectional area available for the circulation of the outer fluid to a relatively reduced value, it is frequently necessary to multiply the number of fins disposed between the two tubular members, thus dividing the annular space into an equal number of "cells" of substantially triangular cross-section, the centre of gravity of these cells being nearer to the outer tube than to the inner tube. As a consequence, the fluid velocity along these fins, and consequently the coefficient of heat exchange, decreases in the direction from the vertex to the base of the fins. Thus, the efficiency of these fins is reduced considerably as their efficient heat-exchange surface may represent only 0.5 or even 0.2 of their actual area, particularly when these fins are thin and their thickness is of the order of 1 millimeter.

Now it is the essential object of this invention to avoid the drawbacks set forth hereinabove and this invention is remarkable notably in that it consists in providing, on the central member and/or the outer tube, longitudinal radial fins dividing the section of the aforesaid annular space into a number of compartments, and mounting between said fins longitudinal intermediate parts adapted to modify the cross-sectional passage area available in said compartments for the circulation of fluid therein according to the desired heat exchange conditions.

This solution is particularly advantageous for it permits of forming the central member by means of a tube carrying a relatively small number (for example 6 to 8) of large, thick fins, instead of a great number (for example

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24 to 36) of thin fins. Thus, an aggregate efficient exchange surface of the same order may be obtained as with a greater number of thin fins, due to the more rational section or contour of these fins which may have a thickness of about 3 millimeters at the tip and about 5 millimeters at the base, with rounded fillets along their junction with the body of the corresponding tube. Therefore, by using these thicker fins it is possible to compensate the major portion (with a very good coefficient of efficiency, of the order of 0.6 to 0.8) of the number of fins thus lost.

According to another feature of this invention the central member consists of a tube with, if desired, a series of axial members adapted to be threaded into this tube and permitting the adjustment of the cross-sectional area available in said central tube for the inner fluid according to the desired heat exchange conditions.

By using at the same time intermediate parts disposed in the annular space between the tubes and the aforesaid axial members, it is possible for example to obtain, from only four basic types of internal members and four basic types of external members made from two predetermined coaxial tube diameters twenty-five different combinations, including those cases wherein the sections are left bare, thus making a total of 25 pairs of different passage sections for the two fluids.

The considerable advantage arising from this arrangement will be readily understood by anybody conversant with the art, for it makes it possible to provide a standard supply of parts for the essential component elements, that is: a single internal tube formed with integral outer fins, and a single external tube, the resulting tubular element being adapted to provide the best coefficient of heat transmission for any desired fluid by simply adding or removing intermediate parts and axial parts of adequate cross-sectional area and contour.

This invention is also concerned with tubular elements of a heat exchanger, of the type comprising at least one central member and a concentric tube forming therebetween an intermediate annular space for the circulation of a heat exchange fluid, said tubular element being arranged according to the method broadly set forth hereinabove and being remarkable notably in that it comprises radial longitudinal fins dividing the aforesaid annular space into a number of compartments, intermediate separate longitudinal parts being adapted to be mounted between said fins in order to adapt at will the passage area and contour available in said compartments for the fluid circulating therethrough, according to the specific heat exchange conditions contemplated.

Other features and advantages of this invention will appear as the following description proceeds with reference to the attached drawings forming part of this specification and illustrating diagrammatically by way of example a few forms of embodiment of the invention. In the drawings:

FIGURES 1 and 2 illustrate in half cross-sections two different forms of embodiment of tubular elements arranged in accordance with the teaching of this invention;

FIGURE 3 illustrates in isometric view the inner tube of the element shown in FIGS. 1 and 2 with intermediate parts according to this invention disposed between the fins;

FIGURE 4 illustrates diagrammatically in perspective the annular arrangement of members constituting stay members for wedging or positioning the intermediate parts of the tubular heat exchanger of FIGS. 1 and 2;

FIGURE 5 shows diagrammatically in perspective an intermediate part of the same tubular element;

FIGURE 6 is a diagrammatic perspective view showing a modified form of embodiment of an intermediate part;

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FIGURE 7 illustrates diagrammatically the manner in which the intermediate part of FIG. 6 is made from sheet material or the like;

FIGURE 8 is a perspective view showing an axial part mounted in the central tube of the tubular element of FIGS. 1 to 3;

FIGURE 9 is a diagrammatic elevational view of the composite tubular element of this invention;

FIGURE 10 is a fragmentary longitudinal section showing on a larger scale one portion of the composite tubular element of FIG. 9 and

FIGURE 11 is a diagrammatic longitudinal section showing on a larger scale a detail of the assembly of FIG. 9.

In the example shown in FIG. 1 of the drawings a tubular element for heat exchanger comprises according to this invention a main central member for example in the form of a tube 1 provided with a plurality of external longitudinal radial fins $a_1, a_2, a_3 \dots a_8$ and another concentric tube 2 forming between the former and its inner wall an annular space divided by these fins into a corresponding number of compartments or cells in which one of the exchange fluids is circulated, the other fluid circulating inside the central tube 1.

According to this invention, intermediate or interference parts adapted to reduce the cross-sectional area available for the circulation of the first fluid between the registering walls of tubes 1 and 2 are mounted in each cell or compartment in order to adapt this passage area to the specific heat-exchange conditions contemplated. The reference numeral 3 (FIGS. 2 and 6) designates a first form of embodiment of this intermediate part, which is obtained for example from strip sheet material such as 3' (FIG. 7) in which marginal slots 4 have been punched or otherwise formed, the marginal portions extending between adjacent slots being bent about a line such as d in order to form a plurality of lugs 6 as shown in FIG. 6. This part, positioned as shown in FIG. 2 between two fins such as a_3, a_4 of the inner tube 1, masks one portion e of the corresponding cell and imparts to the fluid circulating through this cell a double vortex motion as shown by the arrow f . This double vortex motion is caused by the successive throttlings of the fluid stream by the pairs of registering lugs 6 of part 3, this throttling action deflecting cyclically the filaments of this fluid stream against projections or ribs $t_1, t_2, t_3 \dots t_8$ formed on the tube 1 intermediate the fins thereof.

According to a modified form of embodiment, an intermediate part consists of a dihedral-shaped member 3_a positioned like the preceding one between two adjacent fins of the tube 1 and formed with rounded or pointed ends 7. A part such as 3_a may be fastened in position for example by using stay members like the members 8 consisting for example of simple bent metal plates disposed side by side at the outer periphery of each cell in order to constitute a ring-like assembly as shown in FIG. 4. The edges of these plates are formed preferably with notches or indentations 9 fitting into each other. Moreover, the edges of these plates fit in notches 10 formed in the tips of the tube fins with a view to secure the intermediate parts 3_a against axial or longitudinal movement, said parts are maintained against transverse movement by the tube 2 on the inner wall of which said metal plates are applied. If desired, two rings consisting of stay-forming plates 8 may be provided substantially at either end of the tubular element.

FIGURE 2 illustrates diagrammatically in section at 3_b and 3_c two other forms of embodiment of these intermediate parts. Part 3_b is of dihedral configuration like part 3_a , its vertex also registering radially with a projection or rib t_5 formed between the fins a_5, a_6 in the relevant cell or compartment.

Of course, any other types and shapes of interchangeable intermediate members may be provided so that the cross-sectional area of the cells formed in the annular

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space may be adapted to the specific heat-exchange conditions contemplated.

Moreover, in combination with the aforesaid intermediate parts, a central or axial part such as 10 or 10' may be provided within the central tube 1; this central or axial part 10 or 10' may consist (FIGS. 1, 2 and 8) of a central core 11 for example of tubular configuration, closed at either ends and formed with substantially radial fixation lugs 12 having bent ends 13 for supporting in a flexible manner said central part inside the tube 1.

A set of these parts 10, or 10' having different shapes and sizes may be provided in order to adapt the cross-sectional area of the inner passage of tube 1 to the specific conditions of flow or characteristics of the inner fluid which are contemplated.

A heat exchanger tubular element of the type described hereinabove may be used in composite form as illustrated by way example at 14 in FIGS. 9 and 10. In this composite element the inner tube 1 is of coil or like form and constitutes a plurality of straight sections of which the different hairpin shaped portions $1_a, 1_b$ are interconnected at 15. The outer tube consists on the other hand of successive sections $2_a, 2'_a, 2_b \dots$ communicating with one another through intermediate pipes 16. In FIG. 9, the direction in which the fluid circulates in this composite element is indicated by arrows.

The tubular members of this element can be easily assembled and disassembled due to the provision of separate return bends 17 connecting two outer tube sections such as $2_a, 2'_a$. The central or axial parts such as 10 or 10' are engaged before interconnecting inner tube sections $1_a, 1_b$ by threading them directly into these tubes, the longitudinal positioning and fixation of these axial parts 10 being obtained by simply causing their ends to abut against the connecting return bends 18 of the inner tube as shown diagrammatically in FIG. 11.

In order to avoid deteriorating the inner tubes where this abutment takes place these axial parts 10 may be formed with round and suitably shaped ends as shown at 19 in FIG. 9.

Of course, any shapes and types of intermediate parts and stay members outside those illustrated may be provided; besides, a plurality of interchangeable intermediate parts adaptable between the two tubes of the heat exchange element may be provided, if desired.

Moreover, the relative arrangement of parts illustrated in the case of coaxial tubes may be extended if desired to exchangers of the type comprising for example a solid central member surrounded by only one concentric tube and providing an annular space for the passage of a single heat exchange fluid. Finally, the radial fins forming as many compartments or cells in the annular intermediate space may be formed on the outer tube, if desired.

Of course, the invention should not be construed as being limited to the few forms of embodiment shown and described herein, as many modifications may be brought thereto without departing from the spirit and scope of the invention as set forth in the appended claims.

What I claim is:

1. A tubular element of a heat exchanger comprising an internal tubular member, longitudinal radially extending fins on the outer wall of said member, notch means formed on the tips of said fins, a coaxial outer tube surrounding said internal tubular member and defining an annular space with said internal tubular member, separate longitudinal compartments being formed by said fins in said annular space for the circulation of an outer fluid, removable longitudinal insertion parts of strip sheet material extending parallel to the axis of said tubular members and located within each of said separate longitudinal compartments to modify the cross-sectional passage area thereof and stay forming parts disposed between said fins to hold said insertion parts in said longitudinal compartments.

2. A tubular element as claimed in claim 1 wherein said

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stay forming parts consist of plate means having rectilinear edges to fit between the tips of said fins so as to be inserted in said notch means.

3. A tubular element as claimed in claim 2 wherein each of said plate means is formed along its rectilinear edges with indentations adapted to fit with conjugate indentations of adjacent plate means.

4. A tubular element as claimed in claim 1 wherein every one of said removable longitudinal insertion parts consists of a tube having in cross-section substantially the form of a curvilinear triangle, one vertex of said triangle being turned towards the axis of said internal tubular member, the base of said triangle opposite to said vertex being located along the inner wall of said outer tube.

5. A tubular element as claimed in claim 4 wherein said tube is provided with pointed ends.

6. A tubular element as claimed in claim 1 wherein every one of said removable longitudinal insertion parts

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consist of a plate inserted longitudinally between the fins limiting the relevant compartment, said plate comprising a series of lugs formed on its edges by bending the latters.

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