July 25, 1961 A. HUET 2,993,682

HEAT EXCHANGER TUBES

Filed Feb. 24, 1958 2 Sheets-Sheet 1

Fig. 1

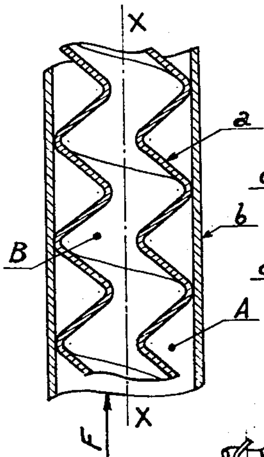


Fig. 2

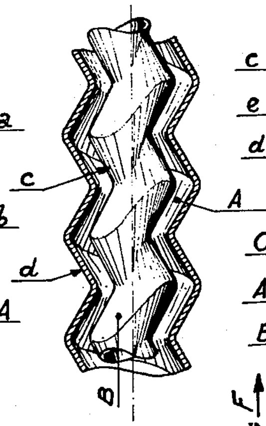


Fig. 3

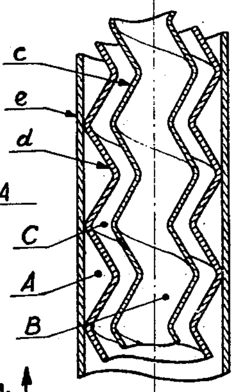


Fig. 4

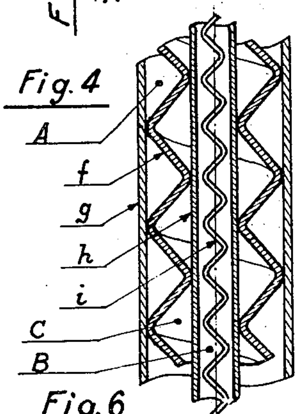


Fig. 5

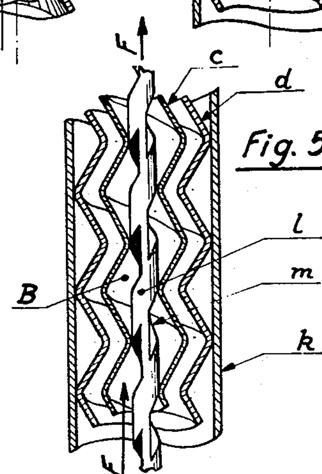


Fig. 6

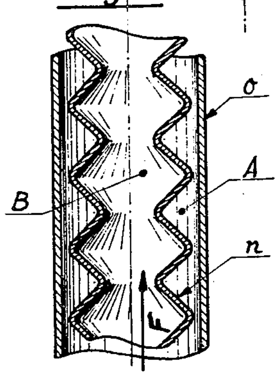


Fig. 7

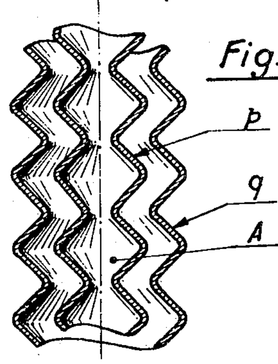
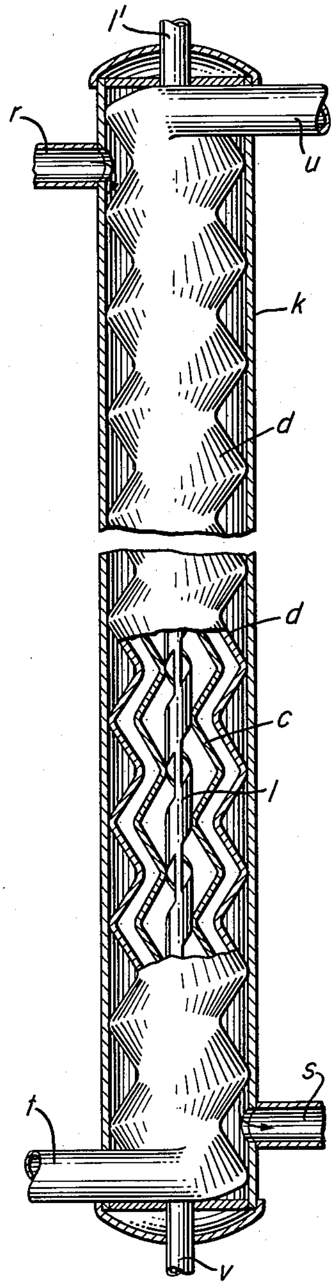


FIG. 8



INVENTOR.
ANDRE HUET
BY Robert E Burns
ATTORNEY

United States Patent Office

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HEAT EXCHANGER TUBES

André Huet, 48 Ave. du President Wilson, Paris, France

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This invention relates to the tubes of heat exchangers, particularly those which are intended to recover heat from the fluid leaving a nuclear reactor. It is particularly concerned with the vaporizer tubes of those thermal installations in which the water is converted into steam.

According to the invention, such vaporizer tubes are designed in such manner as to provide a heat exchange surface which is as large as possible between the fluid leaving the reactor and the water which is intended to be vaporized, while taking up the least possible space. They will be used more especially in the evaporators working with the reactors in which the fluid supplying the heat is molten sodium, and where the entire installation must take up the minimum amount of space.

One feature of these vaporizer tubes consists in that they are of corrugated or helical form so as to impart changes in direction to the fluids both outside and inside the tube. They permit both the increasing of the exchange surface between the two fluids in a given volume and a flushing of the walls by the fluids and the destruction of the adhering films which oppose heat transmission. Moreover, when the tube is helical, the gyratory movement by which the water to be converted into steam is brought to the inside of the tube facilitates the separation of the water and steam, the heavier water being driven by centrifugal force towards the periphery of the tube, while the lighter steam escapes axially of the tube.

With the effect of defining several independent circuits for the fluids, these tubes of corrugated or helical form can be used in combination with one another, or with ordinary cylindrical tubes, these latter having the advantage of being able to exert if necessary an external or internal binding action on the helical tubes which come into contact with them along a helical line of contact.

The invention will be further described with reference to the accompanying drawings where several embodiments are shown by way of example, and wherein—

FIG. 1 is a sectional view of a first embodiment of a helical tube inside a cylindrical tube.

FIG. 2 shows two co-axial helical tubes.

FIG. 3 is a sectional view of the same tubes inside a cylindrical tube.

FIG. 4 is a section of a helical tube between two cylindrical tubes.

FIG. 5 shows two coaxial tubes disposed in the space between two cylindrical tubes.

FIG. 6 is a section showing an embodiment comprising a corrugated tube inside an ordinary cylindrical tube.

FIG. 7 shows a modification with two coaxial corrugated tubes.

FIG. 8 is a side elevational view, partly in section, showing a complete heat exchanger having an internal construction corresponding to that shown in FIG. 5.

In the first embodiment, as shown in FIG. 1, helical vaporizer tube *a* is disposed inside a cylindrical tube *b* which, as will be seen, exerts a binding action on the tube by bearing against the outermost helix of the tube *a*. In this way, two helical spaces are provided for the flow of two fluids A and B. The fluid A, which can be the hot fluid coming from the reactor, is given a gyratory movement in the space between the two tubes *a* and *b*, the effect of which is to ensure the flushing of the external surface of the tube *a*. The fluid B, which is formed by the water to be vaporized, circulates for example in the

direction of the arrow F and will take up a helical movement inside the tube *a*, thereby flushing the internal surface of the latter. In this movement, the water particles, which are the heavier, will be moved towards the periphery, while the lighter steam will be liberted to rise near the axis X—X of the tube *a*, so that the tube *a* not only acts as a vaporizer tube, but also as a separator for the water and steam.

In the modification shown in FIG. 2, the two tubes *c* and *d* are disposed coaxially, the helix of both tubes being of the same pitch. The fluid B circulates inside the tube *c*, while the fluid A circulates between the two tubes *c* and *d*. The two tubes *c* and *d* could be offset axially so as to come into contact along a contact helix, which could cause the fluid A to be compulsorily displaced helically.

The two tubes *c* and *d* can be disposed inside an ordinary cylindrical tube *e* (FIG. 3), which touches the tube *d*. In this way, three circuits are provided for three fluids B, C, A; the fluid C can be an intermediate fluid acting as a separator between the fluid B, which is the water to be vaporized, and the fluid A coming from the reactor, so as to prevent possible radio-active contamination of the water B by the fluid A.

In the embodiment shown in FIG. 4, a helical tube *f* is disposed between two cylindrical tubes *g* and *h* which are, respectively, outside and inside tube *f*, which is thus bound externally and internally along its outermost helix and along its innermost helix. In this way, three circuits are provided for the fluids B, C and A, the fluid B, which is the water to be vaporized circulating in the tube *h* in which can be provided helices *i* for separating the water and the steam.

It is also possible to adopt the arrangement shown in FIG. 5, in which the two coaxial helical tubes *c* and *d* are bound internally and externally by two cylindrical tubes *k* and *l*, the internal tube carrying openings *m* as will be seen in FIG. 5 so as to form only a single space for the circulation of the fluid B inside the tubes *c* and *l*, while the cylindrical tube *l* acts as a separator for the water and steam, the steam which is formed passing through the openings *m* and being discharged in the direction of the arrow F in the upward direction.

The helical tubes which have just been described can be obtained in various ways. For example, by having a part of the wall of an ordinary cylindrical tube spun on a lathe while hot, it is possible to obtain the helical deformation of this wall of the tube. The desired profile for the tube can also be obtained by pressing a previously heated ordinary tube between two helical half dies. It is also possible to screw the tube through a die, by which means the desired helical contour is impressed in the tube.

In FIG. 8, the construction of FIG. 5 has been extended longitudinally in both directions to show inlets and outlets for the fluids supplied. Thus, as seen in FIG. 8, the hot fluid enters through an inlet *r* in the upper portion of outer tube *k* and, after flowing through the space defined between tube *k* and helical tube *d*, leaves through outlet *s*. The fluid to be heated enters the space between the cylindrical tube *l* and the tube *c* through inlet *v* and the steam generated leaves the upper end of the tube *l* through its upper outlet end *l'*. The intermediate fluid which flows in the space between tubes *c* and *d*, enters through an inlet *t* communicating with the lower end of this space and leaves the assembly through the outlet *u* which communicates with the upper end of the space.

The invention is not limited to these helical tubes, but also extends to the use of tubes having corrugated walls, such as those shown in FIGS. 6 and 7. In the example illustrated in FIG. 6, a corrugated tube *n* is disposed inside a cylindrical tube *o*. This latter does not come into contact with the corrugations of the tube *n* so as to leave a free passage for the external fluid A, circulating between the tube *o* and the corrugations of the tube *n*. The tube *n* is traversed by the fluid B in the direction of the arrow F, and the changes in section of the tube cause, in the fluid and at each corrugation, eddy movements or impact between the fluid and the corrugated wall of the tube, ensuring that the wall is flushed and the thermal exchange is improved.

In order that the action can be just as efficient as regards the external fluid A, it is possible to use two coaxial tubes such as *p* and *q*, as shown in FIG. 7, the fluid A circulating in the space between the two tubes. In this case also, ordinary tubes could be provided externally and/or internally of the tubes *p* and *q*, or between the tubes *p* and *q*, in order to provide several independent fluid circuits.

It is obvious that modifications as regards details can be incorporated in the embodiments of this invention without departing from the scope thereof.

What I claim is:

1. A tubular heat exchanger adapted to recover the heat of the fluid leaving a nuclear reactor by transferring it to water and vaporizing said water comprising, in combination, a unit comprised of at least three coaxially-disposed tubes including an outer tube, an inner tube, and an intermediate tube, said outer tube having a cylindrical exterior and being of circular cross-section and adapted to receive the heated fluid leaving the nuclear reaction, said intermediate tube having a helicoidal wall and being disposed interiorly of said outer tube and adapted to receive the water to be vaporized by the heat from said fluid, and said inner tube being disposed interiorly of said intermediate tube and having an outer surface in direct engagement with the innermost helix of said intermediate tube, said inner tube providing a free flow passage therethrough and the surface of said inner tube having a plurality of apertures aligned in at least one longitudinal line, said apertures being disposed in axially-spaced

relationship between the points of contact with the inner helix of said intermediate tube, whereby the vapors formed in the water circulating through said first intermediate tube may pass through said apertures of the inner tube and be led away axially therethrough.

2. A tubular heat exchanger adapted to recover the heat of the fluid leaving a nuclear reactor by transferring it to water and vaporizing said water comprising, in combination, a unit comprised of an outer tube, an inner tube, a first intermediate tube, and a second intermediate tube, said outer tube having a cylindrical exterior and being of circular cross-section and adapted to receive the heated fluid leaving the nuclear reaction, said first intermediate tube having a helicoidal wall and being disposed interiorly of said second intermediate tube and adapted to receive the water to be vaporized by the heat from said fluid, said second intermediate tube having a helicoidal wall and being disposed interiorly of said outer tube and being adapted to receive a heat transfer fluid, and said inner tube being disposed interiorly of said first intermediate tube and having an outer surface in direct engagement with the innermost helix of said first intermediate tube, the surface of said inner tube having a plurality of apertures aligned in at least one longitudinal line, said apertures being disposed in axially-spaced relationship between the points of contact with the inner helix of said first intermediate tube, whereby the vapors formed in the water circulating through said first intermediate tube may pass through said apertures of the inner tube and be led away axially therethrough.

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