The present invention relates to heat exchangers, and particularly apparatus for generating steam comprising economizing sections or water re-heaters, evaporators and, possibly, superheaters for the transformation of water into steam by means of a hot fluid circulating externally of the tubes which constitute these different devices.

It is known to use for apparatus of this kind tubes coiled serpentine fashion. Moreover, it is also known to use in heat exchangers tubes with small transverse fins, throats or grooves which result in an augmented surface for the heat exchange between the tubes and the external fluid. Finally, it has also been suggested to use in the formation of serpentine tubes in such heat exchangers different pitches of helix, according to the nature of the device which they constitute. Thus, comparatively flat pitches are used for the economizing section, whereas for the evaporators pitches of far greater steepness are used so that the tube axis approaches the vertical.

When small transverse fins or grooves, for example of helical shape, are applied to these tubes, the throats produced between the small fins or grooves provided on the tube must not be inclined too much relative to the general direction of the hot fluid circulating externally of the tubes, because otherwise eddies and load losses will be produced which are detrimental to the functioning of the apparatus.

The invention provides, for tubes which are coiled serpentine fashion at a comparatively flat pitch, as for example in the case of the economizing sections (the serpentine axis being arranged so that the serpentine axis runs parallel with the general circulation of the external fluid, for example vertically from top to bottom) that comparatively flat pitches be chosen for the helical circuits or grooves so that the throats provided between the fins or grooves are directed slightly obliquely relative to the general flow direction from top to bottom of the external fluid which circulates in the economizing section.

In the case of evaporators, on the other hand, where the tubes have to be greatly inclined, these tubes are coiled serpentine fashion at a much steeper pitch and the fins or grooves provided on the outer tube surface are coiled helically likewise at a much steeper pitch so that, in the case of an external fluid flowing down vertically and meeting the evaporator tubes, the direction of the groove or throat will only be slightly inclined relatively to the direction of the external fluid.

In the case of superheaters which constitutes an intermediate case, i.e., when the tubes employed are coiled serpentine fashion at a medium pitch, the grooves or fins provided on these tubes likewise have a medium pitch.

In all cases, speaking generally, the general direction of the fluid circulating externally of the tubes should be at a small angle relatively to the direction of the grooves or throats provided on the tubes. Where the general direction of the external fluid flowing into the apparatus is vertical, for example, it may happen that, in certain apparatus, helical grooves or throats provided on tubes which themselves are coiled helically are still inclined rather greatly relative to this direction. In such a case the invention provides, inside the apparatus and in the path of the external fluid, guide surfaces or deflection devices which will cause the hot fluid to be directed in the desired sense relative to the direction of the grooves of the tubular apparatus located downstream of said deflection devices.

These deflection devices may also impart to the fluid a gyroatory movement and advance it towards the evaporator tubes, which are coiled helically, in a direction approaching that of the grooves or throats provided on these tubes.

A feature of the invention is that it provides controlled orientation of gases in the direction of heat exchanger devices in such manner as to ensure optimum efficiency of heat exchange by means of grooved tubes.

The tubes employed here may be ordinary tubes, circular-section tubes, or lenticular-section tubes which may have differently curved surfaces, or tubes of any other shape.

When evaporators are employed which are made with a plurality of co-axial serpentine systems coiled in cylindrical or barrel shape of different diameter, between which the heating fluid passes, it may occur that the surface of some of these barrels constituted by a wall of grooved tubes, the direction favorable to the flow of the external fluid is the reverse of that which is indicated for the other surface of the adjacent barrel. In such a case the deflecting devices, provided in the space between two tube barrels, will be arranged in such a way that they regulate the rotation of the external fluid in one sense towards one of the barrel faces, and in the other sense towards the other wall of the adjacent barrel, which lies opposite.

Moreover, these deflection devices and guide surfaces may serve as stays for the tubes of the apparatus.

The following description, given with reference to the drawings which illustrate examples, will help to understand how the invention can be put into practical effect.

FIG. 1 is a diagrammatic elevation view of a heat exchanger to which the device forming the object of this invention is applied.

FIG. 2 is a diagrammatic fragmentary view on an enlarged scale of an evaporator as shown in FIG. 1.

FIG. 3 is a perspective view of a deflection device arranged between the barrels of the evaporator of FIG. 2.

The invention will now be described in its application to an apparatus for producing steam which comprises, internally of an envelope a through which passes a hot fluid in the direction of an arrow F, devices for producing steam constituted by tubes in which water circulates that is to be transformed into steam. These devices comprise basically, in the lower section, a reheating device b, an evaporator c in which the water is converted into steam, and finally sometimes a superheater d which superheats the steam produced.

These devices are formed by tubes coiled serpentine fashion. These tubes may be of circular or lenticular cross-section, possibly having unequally curved surfaces, or of any other shape.

In the case of the economizing device, the coil pitch of the tubes b is comparatively flat, as has been shown diagrammatically for a single tube in FIG. 1. On the other hand, in the evaporator c where steam is formed, the tube c must approach the vertical and the coil pitch is far steeper, as has been shown diagrammatically for a single tube c. Finally, in the case of the superheater d, the coil pitch of the tubes is of medium character, in between the two previously mentioned cases.

Each of the devices b, c, d, etc. is of course formed by a plurality of helical coiled tubes constituting a cylinder or barrel. It is possible to provide inside the envelope a a plurality of co-axial barrels or cylinders formed by helically coiled tubes, so as to fill the space of the duct a as completely as possible. FIG. 2, for example, shows on an enlarged scale the evaporator c of FIG. 1, formed by three co-axial barrels I, II, III sharing the common
3 axis X—X of the envelope a and arranged in such a way that in the case of each barrel I, II, III, the tubes c, which are of lenticular cross-section, are practically in contact with one another so as to form a continuous wall all along the barrels I, II, III. The hot fluid F passes through the spaces between these barrels. According to the invention, all the tubes h, c, d employed here are provided with small fins, extending either transversely or helically, which have a height of the order of millimeters and leave between them transverse or helical throats on the tube surface. These small fins may be substituted by transverse or helical grooves, provided on the outer tube surface.

In the case of an economizing device such as b where the coil pitch is flat, it is possible to employ small transverse fins which will extend in a direction approaching the vertical, as has been illustrated by short lines on the tube b in FIG. 1. In the case of the evaporator tubes c, the helical fins or grooves have a comparatively steep pitch which may approximate the vertical, and in FIG. 1 has been illustrated the general direction of these fins or grooves provided on the helically coiled tube c. The inclination of these fins or grooves may be such as to be parallel with the general direction of the axis of the helically coiled tube. The ultimate instance in which the tube is no longer coiled helically, will merely be that of a tube with longitudinal fins.

In the case of the superheater d, the pitch chosen for the fins or grooves is intermediate, as has been shown diagrammatically by short transverse lines in FIG. 1.

The exchanger a being traversed by a hot fluid circulating in the direction of the arrow F, as has been said before, the general direction of the fluid F should, according to the invention, form a comparatively small angle of the order of a few degrees (for example 10°) with the direction of the fins or grooves provided on the tubes. Since the coil pitch of the tubes b in the case of the economizing device b is very flat, the closely spaced helical fins are conveniently inclined in the desired manner relatively to the direction of the fluid F, or it would even be possible to employ fins extending merely perpendicularly to the tube axis.

In the case of the evaporator, the problem is more complicated, because the orientation of the helical fins or grooves cannot be the same on that half of the tube which faces the X—X axis as on that which faces away from the X—X axis. At any rate, in order that the angle formed by this groove direction with the direction of the fluid F should be of the order of 10°, as has been mentioned above, the invention provides that deflection devices be used which are mounted in the path of the fluid F in such a way that the flow of the fluid where it leaves these deflection devices is directed in the desired manner relatively to the tube surfaces which it must pass. For this purpose there are provided between the tube barrels I, II, III of the evaporator shown in FIG. 2, guide surfaces such as illustrated diagrammatically in FIG. 3, which may be inverted surfaces such as e, by means of which the current of the fluid F, originally directed from top to bottom, is diverted so as to emerge in the direction of arrows G and thereafter directed in such a way as to form with the grooves f of the outer tubes g, and the grooves h of the inner tube i, the desired angle of approximately 10°.

These guide surfaces or deflection devices e may be distributed over the entire height of the evaporator and it is possible to use for their formation, or as supports, the stays which serve to space apart the tubes of the barrels I, II, III. Said surfaces e may also be arranged in such a way that a gyrotopical flow effect is attained for the fluid F around the axis X—X in the apparatus so that here, too, this fluid is directed in the desired sense in accordance with the direction in which the grooves on the tubes extend.

The deflection device E, shown diagrammatically in FIG. 3, is constituted by two inverse surfaces e1, e2 between which is arranged a deviation which ensures the formation, downstream of the device, of a volume of external fluid in which the static pressure is increased, thus impairing the speed of the fluid, so that a sort of fluid baffle is created by which the fluid F is deflected when meeting with a particular baffle.

It is contemplated to use deflection devices in certain cases even for slowing down the rotation if the latter becomes excessive and follows the fins or throats provided on the tubes too closely.

It will be noted that in FIG. 3 the grooves f are cooled to the right for the tubel g of the barrel I. Conversely, on the tubel of the barrel II the grooves h are oriented to the left. Thus, on the inner surface (facing the axis X—X) of the barrel I as well as on the whole outer surface (facing away from the axis X—X) of the barrel II, the general direction of the external fluid G as it leaves the deflection device E remains more or less the same.

It is also possible, however, that for the formation of the barrels I, II, III tubes are used on which all grooves run in the same direction. In this case deflection devices such as e which are arranged in the spaces between the barrels I, II, III would be bifurcated so as to convey a part of the external fluid in one direction on one of the surfaces of the outer barrel, and in a sufficiently different direction towards the surface opposite thereto of the inner barrel.

Obviously, modifications of detail may be applied to the practical realizations of this invention, without thereby departing from its scope.

I claim:

1. A heat exchanger for exchanging heat between two fluids having a temperature differential comprising, a tubular casing through which a first fluid flows in operation in a given general direction, a plurality of helical tubes arranged in concentric layers internally of said casing and through which a second fluid flows internally thereof in operation, each of said tubes having convolutions of varying pitch, each tube having an intermediate section in which the pitch of the convolutions is greater than two opposite end sections of said tube, a first one of said end sections having convolutions in which the pitch thereof is less than the pitch of the convolutions of the other end section, each of said tubes having axially spaced thereon means defining peripheral surfaces for increasing the heat transfer surfaces thereon, and the last-mentioned means being disposed obliquely on each of said tubes making an angle no greater than 10° with said direction of flow of said first fluid flowing through said casing.

2. A heat exchanger for exchanging heat between two fluids having a temperature differential comprising, a tubular casing through which a first fluid flows in operation, in a given general direction, a plurality of helical tubes arranged in concentric layers internally of said casing and through which a second fluid flows internally thereof in operation, each of said tubes having convolutions of varying pitch, each tube having an intermediate evaporator section in which the pitch of the convolutions is greater than two opposite end sections of said tube, a first one of said end sections comprising an economizer and having convolutions in which the pitch thereof is less than the pitch of the convolutions of the other end section, said other section comprising a superheater section in each tube, each of said tubes having axially spaced thereon means defining peripheral surfaces for increasing the heat transfer surfaces thereon, and the last-mentioned means being disposed obliquely on each of said tubes making an angle no greater than 10° with said direction of flow of said first fluid flowing through said casing.

3. A heat exchanger for exchanging heat between two fluids having a temperature differential comprising, a tubular casing through which a first fluid flows in operation, in a given general direction, a plurality of heli-
cal tubes arranged in concentric layers internally of said casing and through which a second fluid flows internally thereof in operation, each of said tubes having convolutions of varying pitch, each tube having an intermediate section in which the pitch of the convolutions is greater than two opposite end sections of said tube, a first one of said end sections having convolutions in which the pitch thereof is less than the pitch of the convolutions of the other end section, each of said tubes having axially spaced therein means defining peripheral surfaces for increasing the heat transfer surfaces thereof, the last-mentioned means being disposed obliquely on each of said tubes making an angle no greater than 10° with said direction of flow of said first fluid flowing through said casing and said other end section of each of said tubes being disposed upstream of said intermediate and first sections relative to said first fluid.

4. A heat exchanger for exchanging heat between two fluids having a temperature differential comprising, a tubular casing through which a first fluid flows in operation in a given general direction, a plurality of helical tubes arranged in concentric layers internally of said casing and through which a second fluid flows internally thereof in operation, each of said tubes having convolutions of varying pitch, each tube having an intermediate section in which the pitch of the convolutions is greater than two opposite end sections of said tube, a first one of said end sections having convolutions in which the pitch thereof is less than the pitch of the convolutions of the other end section, each of said tubes having guide means defining peripheral surfaces for guiding the flow of said first fluid and increasing the heat transfer surfaces thereof, and the last-mentioned means comprising distance-pieces disposed obliquely on said tubes intermediate adjacent layers of tubes and making an angle no greater than 10° with said direction of flow of said first fluid flowing through said casing.

5. A heat exchanger, according to claim 4, in which said guide means are configured to define convergent, divergent fluid-flow guide means.

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