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SERPENTINE-SHAPED HEAT EXCHANGER AND PROCESS FOR ITS MANUFACTURE

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Fig. 1

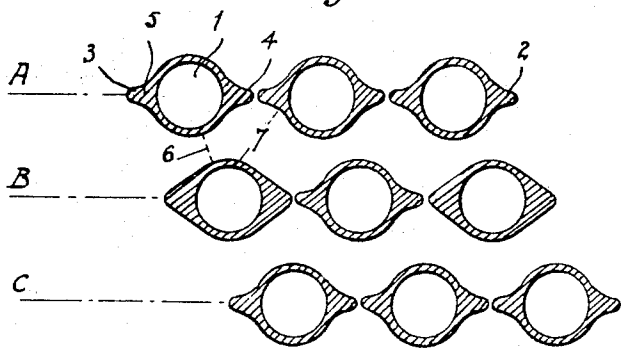
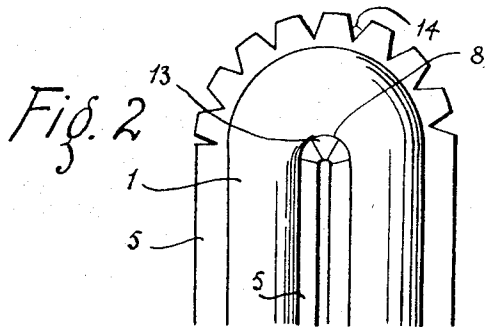


Fig. 3

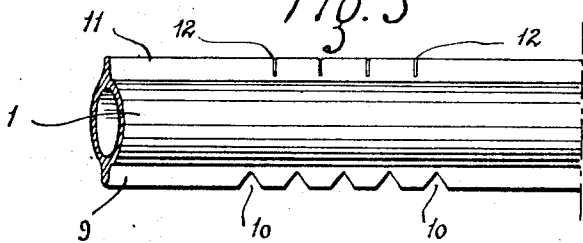
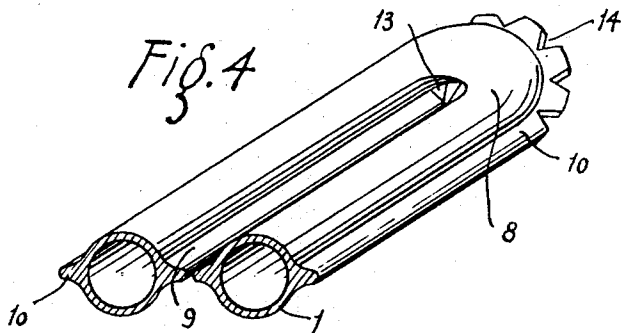


Fig. 4



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**SERPENTINE-SHAPED HEAT EXCHANGER AND
PROCESS FOR ITS MANUFACTURE**

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4 Claims. (Cl. 165—183)

The present invention relates to a serpentine-shaped heat exchanger, that is to say a heat exchanger constituted by pipes bent back to form parallel branches, such as those employed in superheaters, reheaters, economisers, etc.

This heat exchanger is characterised thereby that it is constituted by pipes having longitudinal ribs in the axial plane of the serpentine.

In such pipes, generally of a circular section, the ribs are diametric, constituted by a progressive variation of the thickness from the extremity of one diameter to the other extremity of the same diameter. These ribs may have any desired external form, convex or concave, but are, more generally, of a triangular section. The form of the ribs may differ from one portion to another of the same pipe. The height of the ribs is of the order of the thickness of the pipes and may reach three times the value of this thickness or one-third of the external radius of the pipes.

When such ribbed pipes are arranged side by side, the ribs being contiguous in the same axial plane, the serpentine thus formed displays an assembly of undulated surfaces, capable of expanding freely.

The heat exchanger formed of serpentine pipes with longitudinal ribs ensures a good heat transfer, and opposes to the passage of the external fluid only small pressure losses. Each branch of the pipe is endowed with a great freedom of expansion.

In this exchanger, the coils comprising an assembly of ribbed pipes each are arranged parallel to the tubes proper, aligned or in a lozenge-like arrangement.

In this manner, passages having undulations are created between the parallel surfaces, possibly with nodes and loops, forming a converging-diverging sequence favorable to heat exchange and to the flow of the external fluid. If the tubes are in a lozenge-like arrangement, the median line to the successive nozzles is itself undulated.

To form a coil, the different branches of the pipes are connected by elbow-pieces. These elbow-pieces may be separate and welded to the rectilinear tubular elements forming the branches of the serpentine; however, they may also be constituted by the pipe itself, suitably bent. In all cases, it is advantageous to keep the curvature of the elbow-pieces small and to provide ribs on the elbow-pieces in continuation of the ribs on the straight portion of the pipes.

The bending of the built-up elbow-pieces or of the pipes themselves is effected by cutting small triangles or even the totality of the ribbing from the portion which, after bending, will be the intrados, while the ribs of the portion forming the extrados are provided with slits as narrow as possible. These slits may extend over the whole or a part of the height of the ribs.

In this manner, the bending of the tubes, which can be effected cold or by heating any suitable portion thereof, is facilitated by the cut-out triangles and the slits and the operation can be carried out without any undesirable flattening or folding of the tube. Owing to this, the internal diameter of the curved tube portion will not be reduced. A bend of very small radius of curvature can be obtained, so that the ribs of two parallel branches will be located very close to each other or touch each other or overlap. In this method of bending, even with small radius of

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curvature, the thickness of the tube remains practically unchanged.

The characteristics and advantages of the invention will now be described in greater detail with reference to the accompanying drawings which illustrate an example of embodiment of the heat exchanger according to the invention.

In the drawings:

FIG. 1 is a sectional view of a portion of the exchanger;

FIG. 2 is a plan view corresponding to the FIG. 1;

FIG. 3 shows the preparation of a tubular element intended to form the elbow or bend of this tube;

FIG. 4 is a perspective view of the bent tube portion.

The heat exchanger according to the invention is composed of successive parallel series A, B, C of the tube 1 having longitudinal ribs, i.e. ribs oriented in the direction of two opposite generatrix lines, the ribs of the different tubes of the same series being in the common axial plane 2. Each tube, of circular internal cross-section, displays on its periphery a thickness varying progressively from the extremity 3 of its diameter to the extremity 4 of this same diameter. This variable thickness constitutes the longitudinal ribs 5 of the tube 1. The height of the rib 5 is of the order of three times the value of the thickness of the tube at its narrowest part. It may be of the order of one-third of the tube radius.

The ribbed tube thus constituted can be obtained by any of the known processes, for example by rolling, drawing, forging or even by welding of separate profiles. It differs from the known finned tubes in that the ribs form integral parts of the tube and displays an overall triangular form of progressively varying thickness.

In the example shown (FIG. 1), the successive tube series A, B, C are displaced in relation to each other so that the tubes 1 of two consecutive series are quincuncial. By this arrangement, passages having an undulated median line are created between the series A, B and C, displaying a suite of narrowing and widening portions 6 and 7, which form a converging-diverging sequence.

It is to be noted here that in the exchanger thus constituted, intended for counter-current flow of the fluids: a cold fluid circulating in the tubes 1 and a heating fluid circulating in the undulated passages 6-7, the frontal impact of the heating fluid on the tubes is avoided, while increasing the heat-transmitting surface by means of the ribs. Similarly, turbulences at the rear of the tubes are also avoided which could produce a loss of energy and reduce heat transfer. In this manner, thermal exchange is improved while pressure losses are reduced.

The improvement of heat transfer, owing to a more uniform distribution over the surface of each tube, allows avoiding internal stresses within the tube, which is an appreciable advantage in heat exchangers operating at high pressures and elevated temperatures.

To form a serpentine, the tubes 1 of a given series are interconnected by the elbow-pieces 8 (FIG. 2). These elbow-pieces can be made separately and joined to the straight branches of the tubes 1 or, and preferably, they can be produced by suitably bending the tube itself. Advantageously, these elbow-parts are provided with ribs in continuation of the ribs 5 of the straight tube portions.

To effect the bending of the ribbed tube, the elbow element or the tube itself are prepared as shown in FIG. 3.

An appropriate number of suitably spaced triangles 10 is cut from the rib 9 intended to form the intrados of the bend, by milling or other means. Slits 12, as narrow as possible, are sawn in the rib 11 of the extrados. These slits 12 may occupy a more or less great portion of the height of the rib.

The portion of the tube 1 thus prepared is subjected

to the bending operation, either cold or after heating of the appropriate portion of the tube and/or of the ribs. This can be carried out in a single operation or in two stages. In the second case, a curvature of relatively great radius is produced at first, followed by a compression of the two branches parallel to each other so as to reduce the bending radius.

These operations are carried out in a manner such that, after bending, the ribs 9 of the two parallel branches are located very close to each other (FIG. 4) or are in contact if necessary or possibly overlap each other. After bending, on the intrados, at 13, the edges of the recesses 10 have come nearer to each other, restoring the continuity of the internal rib. On the extrados, the slits 12 have formed more or less pronounced flarings 14.

According to this process, with preparation of the recesses 10 and the slits 12, the presence of the ribs of the intrados or of the extrados does not impede the bending operation. The latter prevent a flattening or folding of the tube 1, so that it retains its internal cross-section in its bent portion.

Preferably, the slits 12 are displaced in relation to the triangular recesses 10.

It will be noted that the weakening of the rib 9 of the intrados by the triangular cuts 10, or possibly even the suppression of the ribs in the bending zone, will displace towards the intrados the mean deformation axis of the tube during bending, i.e. the axis along which the tube will undergo the deformations due to the compression of the intrados side and to the traction from the extrados side. However, the thinning of the extrados wall is practically impossible owing to the ribs remaining on the extrados.

Of course, this bending operation can be effected on a separate tube section as well as on the tube itself, said section then being joined to the straight branches of the ribbed tube by forging, welding, etc.

Although the preceding description primarily concerned the embodiment of a serpentine-shaped exchanger with straight branches having bends at their extremities, it is

to be understood that the invention also applied to a tubular exchanger with helical ribs.

In all cases, the various serpentine assemblies may be made up of tubes of different diameters. These assemblies may also comprise ribs of different shapes, depending on the intended form of embodiment and application.

I claim:

1. Heat exchanger consisting of a serpentine-shaped tube having parallel coplanar straight portions interconnected by elbow-shaped portions, wherein the straight and elbow-shaped portions have two diametrically opposed longitudinal ribs located within the axial plane of the serpentine, the original straight ribs having thin transverse slits on the extrados-forming portions of the elbows and triangular notches on the intrados-forming portions of the elbows, the rib portions adjacent to the notches coming in mutual contact by bending of the tube so as to form a continuous circular rib on the inner side of the elbows.

2. Heat exchanger as recited in claim 1, wherein said contact occurs between the sides of the triangular notches.

3. Heat exchanger as recited in claim 1, wherein said contact is produced by an overlap of the rib portion located on opposite sides of each triangular notch.

4. Heat exchanger according to claim 1, in which said tube has a selected wall thickness and in which said longitudinal ribs located within the axial plane of the serpentine each comprise an outermost edge and a base and increase progressively in thickness from said outermost edge toward said base thereof, said longitudinal ribs having a dimension outwardly from said tube equal to about three times the wall thickness of the tube.

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