(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 214 784**
B1

(12) # EUROPEAN PATENT SPECIFICATION

(45) Date of publication of patent specification: **17.01.90**

(51) Int. Cl.^{5}: **F 28 F 1/36,** B 21 C 37/26

(21) Application number: **86306379.8**

(22) Date of filing: **18.08.86**

(54) **Finned heat transfer device and method for making same.**

(30) Priority: **21.08.85 US 767801**

(43) Date of publication of application:
18.03.87 Bulletin 87/12

(45) Publication of the grant of the patent:
17.01.90 Bulletin 90/03

(84) Designated Contracting States:
DE FR GB IT SE

(56) References cited:
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Description

The present invention relates to an improved heat transfer fin for a finned heat transfer device, and to an improved process and apparatus for making and applying the same to a tube.

In refrigeration and air conditioning applications it is common to utilize a refrigerant-carrying tube as the means by which heat is removed from a chamber or areas to be cooled, and to flow air across the refrigerant-carrying tube to assist in transferring heat to or from the tube wall as imparted by the heat of vaporization or condensation of the refrigerant within the tube. In the applications just mentioned, the refrigerant carrying tubes usually constitute either a condenser or an evaporator.

The refrigerant has a significantly greater ability to transfer heat to the tube in which it is carried than does the air which flows across its exterior. As a result, it is an accepted practice in the refrigeration art to substantially increase the surface area provided on the outside, or airside, of the tube. Most often, the increased surface area is provided in the form of some sort of extended cooling surface or fin extending from the tube outer surface. Many types of finned tubing are commercially available for use in refrigerant-to-air heat exchangers (both evaporators and condensers). One type of extended surface fin is that known as a "spine fin", as disclosed in my prior U.S. Patent 2,983,300. The spine fin has a disadvantage in that it is mechanically weak and has a low resistance to bending and compressive forces. Therefore, to permit its practical utilization the spine fins are spaced very closely on the refrigerant tube. Other types of extended surface fins are disclosed for example in U.S. Patent No. 4,143,710, issued to LaPorte et al; these latter fins are complex geometric shapes, which are difficult to fabricate and have a higher degree of waste material in relation the heat transfer capacity provided.

These prior art fins have been used successfully for many years to increase the surface area of the air side of refrigerant carrying tubes in home refrigerators and air conditioning units, where the operating temperature of the air flowing across the air side of the tube is above the freezing point of water. However, they have not been so successful in environments where the air temperatures are below freezing, primarily for two reasons:

(1) because the moisture in the freezing air condenses out and forms a "frost bridge" between the closely spaced spine fins or portions of the geometric fins, which materially inhibits the air flow across and between the fins, and which in turn reduces the heat transfer capability; and

(2) if the fins are spaced far enough apart to prevent this frost bridging, the resulting structure is mechanically weak.

DE—C—1,108,716 discloses the use of a mounting flange in continuous close contact with the tube and fins formed integrally with the mounting flange and extending radially outward from the mounting flange.

The present invention provides a new form of fin structure which facilitates a solution to the dual problems of frost bridging and insufficient mechanical strength.

Preferred forms of fin structure according to the invention greatly reduce frost bridging and will function in an environment where the convection air forced across the fins is below the freezing point of water, while at the same time maintaining sufficient mechanical strength to permit pragmatic utilization.

It is also an object of the present invention to provide a method of manufacturing a chain of looped fins in which the looped fin stock is applied to refrigerant-carrying tube stock immediately after its formation, so as to minimize the number of steps required in the manufacturing process.

According to a first aspect of the present invention there is provided a finned heat transfer device providing heat transfer to and from a tube for containing a heat transfer fluid and comprising an integrally formed chain of heat conductive fins wound helically under tension round the tube, said chain comprising continuous mounting flange means in continuous snug contact with the tube and fins formed integrally with the mounting flange means and extending radially outward therefrom characterized in that the continuous mounting flange means comprises two axially-spaced parallel helically extending flanges both of which are in continuous contact with the tube and in that each fin comprises two leg members formed integrally with the two flanges respectively and a bridge member interconnecting and formed integrally with the two leg members respectively, said leg members and said mounting flanges being provided in preselected dimensions in relation to each other to substantially reduce frost bridging between adjacent fins.

According to a second aspect of the present invention there is provided a method of making a finned heat transfer device providing heat transfer to and from a tube for containing a heat transfer fluid comprising the steps of forming an elongate strip of thermally conductive material into an integrally formed chain of heat conductive fins with continuous mounting flange means, and winding the formed strip helically about a tube with the flange means thereof in continuous snug contact with the tube, characterized by transversely lancing said strip and forming it into an intermediate configuration having a pair of imperforate opposed side mounting flange portion interconnected by a lanced web portion stretch preforming said intermediate configuration to reform the same into a subsequent configuration comprising an integrally formed chain of a plurality of looped fins between said mounting flanges, each of said fins comprising leg members extending outwardly from each of said mounting flanges and a bridge section connecting said leg members at the distal end of said leg members, said leg members and said mounting flanges being provided in preselected dimensions in relation to each other to substantially reduce frost bridging between adjacent fins; and helically winding said chain under tension onto the exterior surface of a tube with the fins extending longitudinally of the tube.

According to a third aspect of the present invention there is provided apparatus for making a finned heat transfer device, comprising, in combination means for feeding an elongate strip of thermally conductive material, means for forming the strip into an integrally formed chain of heat conductive fins with continuous mounting flange means, and winding the formed strip helically about a tube with the flange means thereof in continuous snug contact with the tube, characterised by means for transversely lancing said strip into an intermediate configuration (Figure 6) having a pair of imperforate opposed side mounting portions interconnected by a lanced web portion and means for stretching and reforming said intermediate configuration into a subsequent configuration comprising an integrally formed chain of a plurality of looped fins, said chain having a respective mounting flange formed from each of said imperforate opposed side portions, and each of said fins comprising two vertical leg members extending outwardly from a respective one of said mounting flanges and a bridge portion connecting said leg members to one another at the distal end of said leg member, said leg members and said mounting flanges being provided in preselected dimensions in relation to each other to substantially reduce frost bridging between adjacent fins.

It is preferred that the fins are wound on the tube at a pitch from substantially 1 to 2 per cm.

Particular preferred embodiments of the invention will now be described, by way of example, with reference to the accompanying diagrammatic drawings, wherein:

FIGURE 1 is a schematic perspective view of a first embodiment of apparatus of the invention for fabricating a looped fin structure and mounting it on a cylindrical tube, and also illustrates the corresponding method of the invention;

FIGURE 2 is a perspective view to a larger scale and showing the stage at which the looped fin structure is mounted on the tube;

FIGURE 2A is a cross section on the line 2A—2A in Figure 2;

FIGURE 2B is an end elevation of the assembled structure of Figure 2;

FIGURE 3A is a cross section through the looped fin structure of Figures 1 and 2, while Figures 3B through 3D are similar cross sections illustrating alternative structures of the invention;

FIGURE 4 is a plan view of lancing cutting work station A of Figure 1, at which thin metal strip stock is lanced and changed to channel form;

FIGURE 5 is a side elevation of the work station A;

FIGURE 6 is a perspective view of the lanced and channel-formed thin metal strip after it emerges from work station A;

FIGURE 7 is a plan view of combined stretch forming and U-shape forming work station B of Figure 1;

FIGURES 7C, 7D and 7E are cross sections on the lines C—C, D—D and E—E of Figure 7 to show the progressive pre-forming of the lanced stock in the work station B;

FIGURE 8 is a side elevation of the work station B;

FIGURE 9 is a perspective view of the "looped fin" strip after it emerges from work station B;

FIGURE 10 is a perspective view of an alternative apparatus for forming the U-shape corresponding to station B of Figure 1, or station F of Figure 11, or station J of Figure 12;

FIGURE 11 is a perspective view of an alternative apparatus of the invention, and also illustrates a corresponding alternative method of the invention;

FIGURE 12 is a perspective view of a further alternative apparatus of the invention, and also illustrates a further alternative method of the invention;

FIGURE 13 is a perspective view of the flat lanced thin metal strip that emerges from station E of the apparatus of Figure 11, or station H of the apparatus of Figure 12;

FIGURE 14a shows the preferred angular relation (angle α) between a line through the lance roll centers and another line through the form roll centers;

FIGURE 14b shows the possible range of size of the angle α;

FIGURE 15 shows a transverse cross section of a loop fin of the invention and the manner in which if moisture is retained it is retained therein; and

FIGURE 16 shows a similar cross section of a prior art fin structure and the manner in which moisture is retained therein.

Description of the Preferred Embodiments

Referring particularly to Figure 1; the looped fin chain 3 of the present invention is fabricated in a unitary process employing apparatus that combines several work stations which cooperate to produce and apply the formed looped fin chain 3 immediately to a tube 4. In this embodiment a coil 1 of thin sheet metal 2 (fin stock), for example, aluminum of the 3003 or 1100 alloy type, is disposed horizontally around a series of work stations A through D arranged generally vertically over a table 15 and within the core of the coil 1, all of which rotate in the direction shown by arrow 16 around the tube 4, which is fed vertically longitudinally along its own axis at approximately the center of the coil 1 in the direction shown by arrow 5. An apparatus of this kind is described in U.S. Patent No. 3,134,166 issued to Venables.

The stock 2 is drawn from the coil 1 by its engagement between two lance cutter rolls 6 and

7 which comprise work station A and which cooperate in their rotation to pull the fin stock 2 therethrough. The equipment and processes for producing a series of slits through a moving thin metal strip are generally known, and in this embodiment the cutter rolls 6 and 7 are both equipped with radial cutting teeth 18 which intermesh as the fin stock 2 is fed therebetween, as is shown in more detail in Figure 5. The lance cutter 7 is equipped with flanges of selected vertical dimension and constitutes a "female" cutter, while the lance cutter 6 engages in the space between the flanges and constitutes a "male" cutter. The width of the fin stock 2 is greater than that of the lance cutters 6 and 7, so that it is formed into a shallow lanced generally channel shaped form shown in Figure 6, with the unlanced portions 8 and 9 of the fin stock extending perpendicularly to the lanced central portion, which has a series of closely spaced transverse fin preforms 10 formed therein by a series of parallel transverse slits produced by the intermeshing teeth 18.

The lanced and channeled fin stock is then drawn between matched cooperating forming rolls 12 and 13 of selected dimension located at work station B, which stretch preform and final-U-form the fin preforms 10 to the required "looped fin" configuration. As discussed in more detail below, stretch preforming enables the lanced channel to be formed into the required deep U-form in a single processing step. This may be compared, for example, with the process described in U.S. Patent No. 4,224,984, issued to Sharp K. K., in which multiple forming steps are required to produce its shaped heat transfer fin.

The center line through the axes of the form rolls 12 and 13 of work station B is oriented at preselected angle α in relation to the center line through the axes of lance cutters 6 and 7 of work station A, with the result that the lanced channel 2 is placed in tension as it is pulled around the male forming roll 12 before being pulled through the interface of the two forming rolls. By placing work station B at this preselected angle in relation to work station A, and by operating the form rolls 12 and 13 of work station B at a slightly higher peripheral speed than the lance cutters 6 and 7 of station A, tension is applied to the unlanced mounting flange tips 8 and 9 between the stations A and B, and this tension urges the mounting flange tips to move toward each other in a direction to be disposed parallel to the corresponding peripheral face of form roll 12. This causes the stock to stretch and begin, prior to the point of its tangential contact with form roll 12, to form into a general U-shape which is finalized between the form rolls 12 and 13. The stretch preforming function and U-forming sequence is discussed in more detail below and is shown in Figures 7 to 9, and particularly in the progressive Figures 7C, 7D and 7E.

As the U-shaped fin stock emerges from work station B the product is now in its final configuration as shown in Figure 9, namely an integrally formed chain of looped fins separated by slits, each of which fins comprises a pair of generally vertical leg members 10a and 10b connected by a bridge portion 10c, and having relatively short mounting flanges 8 and 9 substantially parallel to the bridge portion 10c extending perpendicularly from each vertical leg member. The integral chain is then fed around guide roll 11 at work station C, preparatory to being helically wound under tension around the tube 4 at work station D in an inverted fashion, the base flanges 8 and 9 of the looped fins being applied in contact with the outer periphery 4a of the tube 4, the looped fins being disposed generally longitudinally of the length of the tube, and the bridge portions 10c of the looped fins being disposed generally circumferentially and outwardly in relation to the tube periphery 4a. As the chain 3 is wound on the tube the fins separate from one another with a progressively increasing circumferential spacing as the radial distance increases from surface 4a of the tube. The chain is wound so that the immediately adjacent portions of base flanges 8 and 9 of successive turns butt as closely as possible tightly against one another, so as to minimize the space between them. The tension applied to the chain 3 as it is wound around the tube assures adequate contact between the base flanges of the looped fin stock and the outer periphery of the tube stock which promotes mechanical contact providing a good heat transfer relationship between the looped fin and the tube. Guide roll 11 is disposed with its rotation axis at a selected angle β which permits the looped fin structure to approach the tube stock at the selected helix angle θ. For example, the angle θ is 19° when wrapping at a pitch of 1 looped fin per centimetre (2 1/2 looped fins per inch).

Referring now to Figures 2 and 3, in order to provide the most resistance to frost bridging, the looped fin chain 3 is made to preselected dimensions and is helically wound around the refrigerant tube 4 at a preselected pitch or distance between adjacent rows, so that the fins are spaced far enough apart in all three directions, namely radially from the mounting flange tips 8 and 9 to the bridge portion 10c, circumferentially between the generally parallel vertical members 10a and 10b and longitudinally between successive helical wraps (spaces 14 in Figures 2 and 2A). For example, when 0.018 cm (0.007 inch) thick aluminum strip 2 of 2.5 cm (1 inch) width is used for the fin stock, the lancing of such stock with slits 11 that are 2 cm (0.80 inch) long and spaced 0.076 cm (0.030 inch) apart results in unlanced mounting flange tips 8 and 9 each of 0.25 cm (0.100 inch) width. The resultant fins are very narrow, and this close spacing of the slits results in an increase in available air-contacting area of about 20% to 25%, because the height of the vertical edges thus generated when the fins are formed is added to the area of the top and bottom of the initial strip. This may be contrasted with prior art methods in which metal is removed during the forming process with consequent loss of available air-contacting area. In this example, when such a lanced channel is stretch preformed and worked into the final looped fin chain configuration 3, the bridge portion 10c will be approximately 0.5 cm (0.200 inch) wide, while the vertical members 10a and 10b will each be approximately 0.75 cm (0.300 inch) in length. In this example, the resultant element is to be used for a domestic refrigerator or air conditioner and the diameter of the tube 4 employed is 0.94 cm (0.375 inch), the fins being wound at a pitch of 2 per cm (5 per inch). In another example employed with the same size tube 4, but with the fins wound at a pitch of 3 per cm (8 per inch), the length of each flange 8 and 9 is 0.16 cm (0.0625 inch), the length of each leg member is 0.95 cm (0.375 inch), while the bridge member reduces to 0.32 cm (0.125 inch). The distance from the exterior surface 4a of the tube to the outermost part of the bridge member 10c can be characterized as about equal to the tube diameter. The distance 14 (Figures 2 and 2A) between the helical rows is generally controlled by the width to which the mounting flange tips 8 and 9 have been formed, the pitch of the rotation of fin stock 2 and the rate of longitudinal feed of the tube stock 4 being arranged so that the tips 8 and 9 of adjacent turns are contiguous to each other; the distance 14 between adjacent helical rows will therefore be nominally double the length of each connecting flange, namely 0.5 cm (0.200 inch) and 0.32 cm (0.125 inch) in these examples. These dimensions, which are exemplary only, have been found effective to prevent frost bridging with a refrigerant tube, while providing sufficient mechanical strength to permit pragmatic industrial use. Alternative materials for the fin stock are copper and steel.

In commercial practice a refrigerator or air conditioner heat exchanger assembly will comprise a predetermined length of the pipe 4 having a corresponding length of the chain 3 mounted thereon while straight and then bent to the required shape. The tensioned chain is fastened to the pipe at least at its two ends by any suitable means, such as mechanical clamps, welding, or a suitable glue or cement. The chain can also be retained under tension on the tube by fastening the butting mounting flanges 8 and 9 to one another by any of these means so as to prevent relative longitudinal movement between them, at least at the two ends of the chain, and perhaps also at intermediate points.

It is found that the lancing of the strip produces a small stretch of the unlanced side portions 8 and 9, but to an extent of less than about 0.5% of the strip length. A much greater extension is produced during the stretch forming between the form rolls 12 and 13, and the amount of tension that is required usually is such as to produce an extension of about 1% to 2.5% in length of the flanges 8 and 9, usually in the range 2% to 2.5%.

Another extension is produced by the wrapping tension of the order of 1% to 1.5% in length. The total extension produced by the process must of course be within the yield limit of the material, and for a hard aluminum (or alloy) this will be about 4%, while for softer aluminum (or alloy) this will be of the order of 5% to 6%. The extension produced by the lancing is due to the spreading action of the cutting blades, irrespective of their speed, and appropriate forming and wrapping tensions may be maintained by adjusting the respective drive to feed out the required smaller length of lanced fin stock than would be required in the absence of tension, or by utilizing tension sensing devices controlling variable speed mechanisms between the lance cutter drive, the forming roll drive, and the tube rotating drive.

It is preferred that the fin leg members 10a and 10b be essentially parallel to each other as shown in Figure 3A to provide optimum distance between fin members to minimize frost bridging. The bridge portion 10c is optimum when it is essentially flat and substantially parallel to the mounting flange tips 8 and 9, again as shown in Figure 3A, but variations to this optimum configuration can be tolerated with only slight degradation in performance, as measured by resistance to frost bridging promotion and resistance to deformation during fabrication and application. For example, a slight radius 10r at the intersections of portions 10a and 10b with portion 10c, as shown in Figure 3A, will have only a slight effect in reducing resistance to frost bridging. Extending that radius to one half the distance between portions 10a and 10b to form an arch shaped bridge section 10s, as shown in Figure 3B, will also permit only slightly increased frost bridging. Fin members in which the portions 10a, 10b and 10c merge smoothly with one another to constitute a general semi-circle (not shown) would also be effective in preventing frost bridging. When the looped fins each comprise geometric shapes such as shown in Figures 3C and 3D, of a dimension approaching that of fin pitch spacing 14, the propensity to form frost bridging begins to increase. In addition, geometric shapes such as shown in Figures 3C and 3D offer less resistance to deformation. Decreasing the length of cross portion 10c as shown in Figures 3C and 15 decreases the resistance to frost bridging, and when cross portion 10c is reduced to zero to form an inverted V-shape as shown in Figure 16, which is the structure disclosed in U.S. Patent No. 4,184,544, issued to Ullmer, the resulting vertex tips provide a nucleating site or focal point which promotes frost formation, which in turn accelerates frost bridging, and shapes with such highly reduced bridge portions 10c are accordingly not effective in minimizing frost bridging. Decreasing the length of portion 10c, for example as shown in Figure 3C by utilizing angular leg portions 10d, and as shown Figure 3D by inclining the leg portions 10a and 10b toward one another, results in shapes which have a greater tendency to hold defrost water by surface energy within the shortened dimension. The water is held in the form of a meniscus 17, which shields the fin legs and bridge portion and thereby reduces the effective fin surface area available for effective heat transfer as shown by the cross-hatched area of Figures 15 and 16. In practice the dimension of the bridge 10c, or the equivalent dimension between the leg portions is correlated with the fin pitch, or the number of turns per unit length of tube. For refrigerator and air conditioning applications the practical maximum is about 3 turns per cm (about 8 turns per inch). Thus, with the particular examples described, it is preferred that the approximate minimum dimension of portion 10c to prevent such water meniscus retention and frost bridging should not be reduced below 0.32 cm (0.125 inch). Such dimensions, of course, are exemplary only.

Stretch preforming as employed in this invention is a novel process whereby the lanced channel produced from the strip 2 is progressively formed into an approximate U-shape in a single forming step as the lanced channel progresses around the circumference of male roll 12 in its approach to the tangent contact point with female roll 13. Stretch preforming is accomplished in this embodiment by providing the two rolls with complementary shoulders 12s and 13s between which the flange tips 8 and 9 pass and are gripped thereby, and by operating the work station B form rolls 12 and 13 at approximately 1% to 2.5% higher peripheral speed than the rate at which the lanced channel is fed out of the lance cutters 6 and 7 at work station A. This tension acts to progressively bend the lanced center strips 10 into a sufficiently preformed U-shape appropriate for entering the intermesh of form rolls 12 and 13 where the final U-shape is produced at their point of tangency. A distance C D (Figure 8) between the centers of the form rolls 12 and 13 is selected which provides sufficient contact friction of the rolls to mounting flange tips 8 and 9 to provide sufficient tension in preforming the U-shape, but which allows adequate slippage to prevent exceeding the elastic limit of the selected fin material.

An alternative method of providing adequate frictional drive without exceeding the elastic limit of the selected fin material involves spring loading the bearing support of either roll 12 or 13 to provide a floating or variable center distance C D, such spring loading accommodating minor variations in the thickness of the fin stock 2 and the imperforate unlanced mounting flange tips 8 and 9. A second alternative to accomplish the same result can be the provision of a slip clutch in the drive shaft of the drive to the form rolls 12 and 13. Other methods generally known in the art could also be employed to provide the needed tension and, if needed, slippage of the generally U-shaped fin stock as it passes through form rolls 12 and 13.

Figure 10 shows an alternative arrangement of forming rolls for employment at station B to provide final U-forming after stretch preforming, in which the single female form roll 13 is replaced by two angular rolls 13a, 13b, which respectively engage the side portions 10a and 10b, and back up roll 13c which engages cross portion 10c and maintains it flat.

Reference to Figures 7 and 14a shows that, when the angle α is approximately 90°, stretch preforming of the lanced channel is accomplished through an arc γ of the circumference of the forming roll 12, the preforming being substantially completed at cross section E—E, before the actual intermesh between the rolls. Where α is approximately 90°, the stretch preforming is accomplished through an arc γ of approximately 85° when proper tension is maintained. The stretch preforming of the lanced channel commences at a leading angle ω (Figure 14a) prior to intersection of the lanced channel with a line 20 through the axis of forming roll 12 at cross section C—C, which line 20 is parallel to a line 19 through the axes of lance cutters 6 and 7. By the time the lanced channel has progressed around male form roll 12 to point C—C, the imperforate unlanced mounting flange tips 8 and 9 are already upwardly disposed, as shown in Figure 7C. As the lanced channel continues to be pulled around the forming roll 12 the flange tips 8 and 9 move continuously toward one another, as illustrated by sections D—D and E—E, so that final forming of the lanced channel may be accomplished by a single pass through the intermesh of rolls 12 and 13. In the preferred arrangement, as shown in Figure 14a, when angle α is approximately 90°, stretch preforming occurs throughout an arc of γ of between 80° and 90°, preferably approximately 85°, and the corresponding leading angle ω is between 20° and 30°, with a preferred value of approximately 25°. Figure 14b shows that angle α may range from a minimum 60° to a maximum of at least 180° when the two lines are parallel so as to accommodate work stations in other arrangements besides that described above.

Alternative machinery arrangements for different methods of making the looped fin chain 3 of the present invention are disclosed in Figures 11 and 12. In the apparatus of Figure 11 both the rotational and the directional motions are provided to the refrigerant tubing 4. In this apparatus and with this method there are only two work stations, E and F, before the looped fin 3 is helically applied to the tubing 4. This provides more working or maintenance space between work stations. The required helix approach angle θ with respect to the tubing 4, determined by the rotational and longitudinal feed rate of tube 4, is provided by appropriate angular placement of the stations E and F with respect to the plane of travel of the tubing 4. It would also be possible to maintain all axes of rotation in parallel orientation by adding an idler roll oriented to the helix angle such as the idler roll 11 of station C in the apparatus of Figure 1.

Another alternative apparatus and method of making the loop fin of the present invention is shown in Figure 12. In this embodiment, a lance station H performs only the lancing function and all final loop fin forming is performed at a forming station J. Lance station H is similar to that described earlier in relation to Figures 4 and 5 except that the flanges have been removed from "female" lance cutter 7. Since the width of the fin stock 2 is greater than the width of the lance cutters 6 and 7, it emerges from lance station H as a flat center lanced strip with fin preforms 10a, the imperforate unlanced portions 8a and 9a extending on each side of the slits 11, as shown in Figure 13.

An idler roll 20 at station I is located in such a manner as to guide the flat center lanced stock and cause it to approach form roll 12 at the required approach angle α prior to contact therewith. As the stock contacts form roll 12 it is stretch preformed around an arc γ of the roll until stretch preforming is complete prior to the intermesh between the two rolls, where any remaining final U-forming is accomplished, and the stock emerges in the loop fin configuration 3 as shown in Figure 9.

In the apparatus of Figure 12 it will be seen that the employment of an idler roll 20 allows parallel alignment of the lance and form stations. Idler roll 20 aids in the critical step of stretch preforming in the process depicted in Figure 12 by providing an adequate angle of approach α. As with the apparatus of Figure 1, the tension on imperforate unlanced portions 8a and 9a is provided by operating the cooperating forming rolls 12 and 13 or work station J at a slightly higher peripheral speed than the cooperating lance cutters 6 and 7 of work station H. For example, sufficient stretch preforming occurs if work station J is operated at a peripheral speed approximately 1% greater than work station H. Work station J functions and operates essentially the same as work station B of Figure 1 to provide the final looped fin configuration 3. After exiting from work station J the looped fin chain 3 is wound onto the tubing 4 at work station K, with the helix angle controlled by the longitudinal speed of the tube 4 along the line of arrow 5 and the rate of rotation of tube 4 as it travels in that direction.

Claims

1. A finned heat transfer device providing heat transfer to and from a tube (4) for containing a heat transfer fluid and comprising an integrally formed chain (3) of heat conductive fins wound helically under tension round the tube, said chain comprising continuous mounting flange means in continuous snug contact with the tube and fins formed integrally with the mounting flange means and extending radially outward therefrom characterized in that the continuous mounting flange means comprises two axially-spaced parallel helically extending flanges (8, 9) both of which are in continuous contact with the tube and in that each fin comprises two leg members (10a, 10b) formed integrally with the two flanges (8, 9) respectively and a bridge member (10c) interconnecting and formed integrally with the two leg members (10a, 10b) respectively, said leg members (10a, 10b) and said mounting flanges (8,9) being provided in preselected dimensions in relation to each other to substantially reduce frost bridging between adjacent fins.

2. A heat transfer device as claimed in claim 1, characterized in that said fins are wound on the tube at a pitch from substantially 1 to 2 per cm.

3. A heat transfer device a claimed in claim 1 or claim 2 characterized in that the chain is wound upon the tube in sufficient tension to produce an elongation of about 1% to 1.5% in length of the mounting flanges (8, 9).

4. A heat transfer device as claimed in any one of claims 1 to 3, characterized in that the chain (3) is stretch formed by stretching a transversely lanced strip (Figure 13) as it is passed between mating form rollers (12, 13) which convert the lanced portion of the strip in a single pass to a general U-shape comprising said leg members (10a, 10b) and said bridge member (10c).

5. A heat transfer device as claimed in claim 4, characterized in that the chain is stretch formed with the application of tension such as to produce an elongation of about 1% to 2,5% in length of the mounting flanges.

6. A heat transfer device as claimed in any one of claims 1 to 5, characterized in that said leg members (10a, 10b) are substantially perpendicular to said tube (4).

7. A heat transfer device as claimed in any one of claims 1 to 6, characterized in that the chain (3) of fins is made of aluminum.

8. A heat transfer device as claimed in any one of claims 1 to 7, characterized in that said bridge member (10c) is substantially straight and substantially parallel to the outer surface (4a) of said tube (4).

9. A heat transfer device as claimed in any one of claims 1 to 7, characterized in that said bridge member (10c) is radiused at the points of intersection (10r, Figure 3A) between said leg members (10a, 10b) and said bridge member (10c).

10. A heat transfer device as claimed in any one of claims 1 to 7, characterized in that said bridge member (10c) is connected to the said leg members (10a, 10b) by intermediate portions (10d) to comprise a substantially arched shape (Figure 3B).

11. A heat transfer device as claimed in any one of claims 1 to 7, characterized in that the said bridge member (10s) is smoothly merged with said leg members (10c, 10b) in a generally semicircled fashion.

12. A heat transfer device as claimed in any one of claims 1 to 11, characterized in that the distance between the two leg members (10a, 10b) of a fin is substantially the same as the distance between the helical rows of said fins wrapped on said tube (4).

13. A heat transfer device as claimed in any one of claims 1 to 11, characterized in that the distance from the exterior surface (4a) of the tube (4) to the outermost part of the bridge member (10c) is about equal to the diameter of the tube (4).

14. A method of making a finned heat transfer

device providing heat transfer to and from a tube (4) for containing a heat transfer fluid comprising the steps of forming an elongate strip (2) of thermally conductive material into an integrally formed chain of heat conductive fins with continuous mounting flange means, and winding the formed strip helically about a tube with the flange means thereof in continuous snug contact with the tube, characterized by transversely lancing (11) said strip and forming it into an intermediate configuration having a pair of imperforate opposed side mounting flange portion (8, 9) interconnected by a lanced web portion (10) stretch preforming said intermediate configuration to reform the same into a said mounting flanges, each of said fins comprising leg members (10a, 10b) extending outwardly from each of said mounting flanges and a bridge section (10c) connecting said leg members at the distal end of said leg members, said leg members (10a, 10b) and said mounting flanges (8, 9) being provided in preselected dimensions in relation to each other to substantially reduce frost bridging between adjacent fins; and helically winding said chain (3) under tension onto the exterior surface of a tube (4) with the fins (10) extending longitudinally of the tube (4).

15. A method as claimed in claim 14, characterized in that said fins are wound on the tube at a pitch from substantially 1 to 2 per cm.

16. A method according to claim 13 or claim 14, characterized in that the chain is wound upon the tube in sufficient tension to produce an elongation of about 1% to 1.5% in length of the mounting flanges (8, 9).

17. A method according to any one of claims 14 to 17, characterized in that the chain is stretch formed with the application of tension such as to produce an elongation of about 1% to 2.5% in length of the mounting flanges.

18. A method according to any one of claims 14 to 15, characterized in that said intermediate configuration comprises a shallow generally channeled cross section.

19. A method according to any one of claims 14 to 18, characterized in that said lanced web portion is reformed from said intermediate configuration to said subsequent configuration by stretch preforming comprising pulling said strip around a male forming roll adapted to initially contact the center of said lanced web portion, whereby tension on the imperforate side mounting flange portions and the pressure of the forming roll the center of said web portion gradually reforms said web portion to conform to said male forming roll.

20. A method according to claim 19, characterized in that said stretch preforming occurs as the center of said lanced web portion contacts said male forming roll through an arc between 80° and 90°.

21. A method according to claim 20, characterized in that said arc is 85°.

22. A method according to any one of claims 19 to 21, characterized in that said male forming roll comprises a central forming section and a shoulder on each side of said central forming section, and said strip is pulled around said male forming roll by being gripped between said shoulders and complementary shoulders on a female forming roll.

23. A method as claimed in any one of claims 14 to 22, characterized in that said leg members (10a, 10b) are substantially perpendicular to said tube (4).

24. A method as claimed in any one of claims 14 to 22, characterized in that the chain (3) of fins is made of aluminum.

25. A method as claimed in any one of claims 14 to 23, characterized in that said bridge member (10c) is substantially straight and substantially parallel to the outer surface (4a) of said tube (4).

26. A method as claimed in any one of claims 14 to 23, characterized in that said bridge member (10c) is radiused at the points of intersection (10r, Figure 3A) between said leg members (10a, 10b) and said bridge member (10c).

27. A method as claimed in any one of claims 14 to 23, characterized in that said bridge member (10c) is connected to the said leg members (10a, 10b) by intermediate portions (10d) to comprise a substantially arched shape (Figure 3B).

28. A method as claimed in any one of claims 14 to 23, characterized in that said bridge member (10s) is smoothly merged with said leg members (10c, 10b) in a generally semi-circled fashion.

29. A method as claimed in any one of claims 14 to 28, characterized in that the distance between the two leg members (10a, 10b) of a fin is substantially the same as the distance between the helical rows of said fins wrapped on said tube (4).

30. A method as claimed in any one of claims 14 to 28, characterized in that the distance from the exterior surface (4a) of the tube (4) to the outermost part of the bridge member (10c) is about equal to the diameter of the tube (4).

31. Apparatus for making a finned heat transfer device, comprising, in combination means (1, 6, 7) for feeding an elongate strip of thermally conductive material, means for forming the strip into an integrally formed chain of heat conductive fins with continuous mounting flange means, and winding the formed strip helically about a tube with the flange means thereof in continuous snug contact with the tube, characterized by means (6, 7) for transversely lancing (11) said strip into an intermediate configuration (Figure 6) having a pair of imperforate opposed side mounting portions (8, 9) interconnected by a lanced web portion (10), and means (12, 13) for stretching and reforming said intermediate configuration into a subsequent configuration comprising an integrally formed chain (3) of a plurality of looped fins, said chain having a respective mounting flange (8, 9) formed from each of said imperforate opposed side portions, and each of said fins comprising two vertical leg members (10a, 10b) extending outwardly from a respective one of said mounting flanges and a bridge portion (10c)

connecting said leg members to one another at the distal end of said leg member, said leg members (10a, 10b) and said mounting flanges (8, 9) being provided in preselected dimensions in relation to each other to substantially reduce frost bridging between adjacent fins.

32. Apparatus as claimed in claim 31, characterized in that said fins are wound on the tube at a pitch from substantially 1 to 2 per cm.

33. The apparatus of claim 31 or claim 32, characterized in that said means for supplying said elongate strip comprise coil holding means (15) from which the strip is fed to said means for transversely lancing and forming said ribbon into said intermediate configuration.

34. The apparatus of claim 33, characterized in the said means (6, 7) for transversely lancing said strip (2) into said intermediate configuration comprise a pair of opposing lance cutter means (6, 7) disposed to receive said strip therebetween.

35. The apparatus of claim 34, characterized in that one (7) of said lance cutters is provided with forming means comprising vertical flanges at the ends of its cutting surface to simultaneously form the strip to produce a strip of intermediate configuration having a shallow generally channeled cross section.

36. The apparatus of claim 35, characterized in that the said means (12, 13) for stretching and reforming said strip of generally channeled intermediate configuration into a strip of said subsequent configuration comprise a pair of form rolls (12, 13) disposed at a preselected angle (α) to said lance cutter means (6, 7) to receive said strip of intermediate configuration therebetween and stretch and reform it into said strip of subsequent configuration.

37. Apparatus as claimed in any one of claims 31 to 36, characterized in that the chain is wound upon the tube in sufficient tension to produce an elongation of about 1% to 1.5% in length of the mounting flanges (8, 9).

38. Apparatus as claimed in any one of claims 31 to 37, characterized in that the chain is stretch formed with the application of tension such as to produce an elongation of about 1% to 2.5% in length of the mounting flanges.

Patentansprüche

1. Gerippte Wärmeübertragungsvorrichtung, die eine Wärmeübertragung zu und von einem Rohr (4), das ein Wärmeübertragungsfluid beinhaltet, vorsieht, und die eine einteilig ausgebildete Kette (3) mit wärmeleitenden Rippen, die schraubenartig unter Spannung um das Rohr gewunden sind, umfaßt, wobei die Kette eine durchgehende Befestigungsflanscheinrichtung aufweist, die durchgehend im engen Kontakt mit dem Rohr ist, und die Rippen einteilig mit der Befestigungsflanscheinrichtung ausgebildet sind und von ihm radial nach außen ragen, dadurch gekennzeichnet, daß die durchgehende Befestigungsflanscheinrichtung zwei axial beabstandete, parallele, sich schraubenartig erstreckende Flansche (8, 9) beinhaltet, die beide durchgehend Kontakt mit dem Rohr haben, und daß jede Rippe zwei Fußelemente (10a, 10b) aufweist, die jeweils einteilig mit den zwei Flanschen (8, 9) ausgebildet sind, und daß ein Brückenelement (10c) jeweils die zwei Fußelemente (10a, 10b) miteinander verbindet, und einteilig mit ihnen ausgebildet ist, wobei die Fußelemente (10a, 10b) und die Befestigungsflansche (8, 9) mit einem vorgewählten Abstandsverhältnis zueinander versehen sind, um eine Kältebrückenbildung zwischen den benachbarten Rippen im wesentlichen zu verringern.

2. Wärmeübertragungsvorrichtung nach Anspruch 1, dadurch gekennzeichnet, daß die Rippen mit einer Teilung von im wesentlichen 1 bis 2 pro cm um das Rohr gewickelt sind.

3. Wärmerübertragungsvorrichtung nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die Kette um das Rohr mit genügend Spannung gewunden ist, um eine Längung der Befestigungsflansche (8, 9) von ungefähr 1% bis 1.5% zu erzeugen.

4. Wärmeübertragungsvorrichtung nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß die Kette (3) durch Strecken eines quergeschlitzten Streifens streckgeformt ist (Fig. 13), nachdem er an ineinandergreifenden Formwalzen (12, 13) vorbeigeführt wurde, die die geschlitzten Bereiche des Streifens in einem einzigen Durchgang in eine allgemeine U-Form umwandelt, die die Fußelemente (10a, 10b) und das Brückenelement (10c) umfaßt.

5. Wärmeübertragungsvorrichtung nach Anspruch 4, dadurch gekennzeichnet, daß die Kette durch Aufbringen einer Zugspannung streckgeformt ist, um eine Längung der Befestigungsflansche von ungefähr 1% bis 2.5% zu erzeugen.

6. Wärmeübertragungsvorrichtung nach einem der Ansprüche 1 bis 5, dadurch gekennzeichet, daß die Fußelemente (10a, 10b) im wesentlichen rechtwinklig zu dem Rohr (4) sind.

7. Wärmeübertragungsvorrichtung nach einem der Ansprüche 1 bis 6, dadurch gekennzeichnet, daß die Kette (3) der Rippen aus Aluminium gefertigt ist.

8. Wärmeübertragungsvorrichtung nach einem der Ansprüche 1 bis 7, dadurch gekennzeichnet, daß das Brückenelement (10c) im wesentlichen gerade und im wesentlichen parallel zu der Außenfläche (4a) des Rohres (4) verläuft.

9. Wärmeübertragungsvorrichtung nach einem der Ansprüche 1 bis 7, dadurch gekennzeichnet, daß das Brückenelement (10c) an den Verbindungspunkten (10r, Fig. 3A) zwischen den Fußelementen (10a, 10b) und dem Brückenelement (10c) mit einem Radius versehen ist.

10. Wärmeübertragunsvorrichtung nach einem der Ansprüche 1 bis 7, dadurch gekennzeichnet, daß das Brückenelement (10c) mit den Fußelementen (10a, 10b) über Verbindungsbereiche (10d) verbunden ist, um eine im wesentlichen gebogene Form (Fig. 3B) aufzuweisen.

11. Wärmeübertragungsvorrichtung nach

einem der Ansprüche 1 bis 7, dadurch gekennzeichnet, daß das Brückenelement (10s) sanft in die Fußelemente (10c, 10b) in eine im allgemeinen halbkreisartige äußere Form übergeht.

12. Wärmeübertragungsvorrichtung nach einem der Ansprüche 1 bis 11, dadurch gekennzeichnet, daß der Abstand zwischen den zwei Fußelementen (10a, 10b) einer Rippe im wesentlichen gleich dem Abstand zwischen den schraubenförmigen Reihen der Rippen ist, die um das Rohr (4) gewunden sind.

13. Wärmeübertragungsvorrichtung nach einem der Ansprüche 1 bis 11, dadurch gekennzeichnet, daß der Abstand von der Außenfläche (4a) des Rohres (4) zu dem äußersten Teil des Brückenelementes (10c) ungefähr dem Durchmesser des Rohres (4) entspricht.

14. Verfahren für die Herstellung einer gerippten Wärmeübertragungsvorrichtung, die eine Wärmeübertragung zu und von einem Rohr (4) zum Aufnehmen eines Wärmeübertragungsfluides vorsieht, mit den Schritten, einen gelängten Streifen (2) aus einem Material mit einer thermischen Leitfähigkeit in einer einteilig geformte Kette aus wärmeleitenden Rippen mit einer durchgehenden Befestigungsflanscheinrichtung auszubilden und die geformten Streifen schraubenförmig mit seiner Flanscheinrichtung um ein Rohr in einem kontinuierlichen engen Kontakt mit dem Rohr zu winden, dadurch gekennzeichnet, daß der Streifen quer geschlitzt (11) und in eine Zwischenkonfiguration geformt wird, die ein paar durchlöcherte, sich gegenüberliegende Befestigungsflanschbereiche (8, 9) aufweist, die miteinander über einen geschlitzten Bandbereich (10) verbunden sind, worauf durch Streckung der Zwischenkonfiguration die Befestigungsflansche ungeformt werden, sodaß jede der Rippen mit den Fußelementen (10a, 10b) nach außen von jedem der Befestigungflansche wegragen und ein Brückenabschnitt (10c) die Fußelemente an den entfernten Enden der Fußelemente miteinander verbindet, die Fußelemente (10a, 10b) und die Befestigungsflansche (8, 9) mit einem vorgewählten Abstandsverhältnis zueinander versehen sind, um eine Kältebrückenbildung zwischen den benachbarten Rippen im wesentlichen zu verringern; und die Kette (3) unter Spannung schraubenförmig auf die Außenfläche eines Rohres (4) aufgewickelt wird, wobei sich die Rippen (10) entlang dem Rohr (4) erstrecken.

15. Verfahren nach Anspruch 14, dadurch gekennzeichnet, daß die Rippen, mit einer Teilung von im wesentlichen 1 bis 2 pro cm um das Rohr gewickelt sind.

16. Verfahren nach Anspruch 13 oder 14, dadurch gekennzeichnet, daß die Kette mit ausreichender Zugspannung um das Rohr gewunden ist, um eine Längung der Befestigungsflansche (8, 9) von ungefähr 1% bis 1.5% zu erhalten.

17. Verfahre nach einem der Ansprüche 14 bis 16, dadurch gekennzeichnet, daß die Kette durch Aufbringen einer Zugspannung streckgeformt ist, sodaß eine Längung der Befestigungsflansche von ungefähr 1% bis 2.5% erzeugt wird.

18. Verfahren nach einem der Ansprüche 14 bis 15, dadurch gekennzeichnet, daß die Zwischenkonfiguration einen flachen, im allgemeinen kanalförmigen Querschnitt aufweist.

19. Verfahren nach einem der Anprüche 14 bis 18, dadurch gekennzeichnet, daß der geschlitzte Bandbereich von der Zwischenkonfiguration zu der nachfolgenden Konfiguration durch Streckung umgeformt wird, wobei das Band um eine patritzenartige Formwalze gezogen wird, die angepaßt ist, anfängliche mit der Mitte des geschlitzten Bandbereiches in Kontakt zu treten, wobei eine auf die geschlitzten Seitenbefestigungsflanschbereiche aufgebrachte Spannung und der Druck der Formwalze, der auf die Mitte des Bandbereiches wirkt, diesen Bandbereich allmählich umformen, um ihn an die patritzenartige Formwalze anzupassen.

20. Verfahren nach Anspruch 19, dadurch gekennzeichnet, daß das Strecken auftritt, wenn die Mitte des geschlitzten Bandbereiches mit der patritzenartigen Formwalze über einen Winkel zwischen 80° und 90° in Kontakt steht.

21. Verfahren nach Anspruch 20, dadurch gekennzeichnet, daß der Winkel 85° beträgt.

22. Verfahren nach einem der Ansprüche 19 bis 20, dadurch gekennzeichnet, daß die patritzenartige Formwalze einen mittleren Formabschnitt und eine Schulter auf jeder Seite des mittleren Formabschnittes aufweist und der Streifen um die patritzenartige Formwalze gezogen ist, in dem er zwischen den Schultern und den komplementären Schultern, einer matritzenartigen Formwalze gegriffen wird.

23. Verfahren nach einem der Ansprüche 14 bis 21, dadurch gekennzeichnet, daß die Fußelemente (10a, 10b) im wesentlichen senkrecht auf dem Rohr (4) angeordnet sind.

24. Verfahren nach einem der Ansprüche 14 bis 22, dadurch gekennzeichnet, daß die Kette (3) der Rippen aus Aluminium hergestellt ist.

25. Verfahren nach einem der Ansprüche 14 bis 23, dadurch gekennzeichnet, daß das Brückenelement (10c) im wesentlichen gerade und im wesentlichen parallel zu der Außenfläche (4a) des Rohres (4) angeordnet ist.

26. Verfahren nach einem der Ansprüche 14 bis 23, dadurch gekennzeichnet, daß das Brückenelement (10c) an den Verbindungspunkten (10r, Fig. 3A) zwischen den Fußelementen (10a, 10b) und dem Brückenelement (10c) mit einem Radius versehen ist.

27. Verfahren nach einem der Ansprüche 14 bis 23, dadurch gekennzeichnet, daß das Brückenelement (10c) mit den Fußelementen (10a, 10b) durch dazwischenliegende Bereiche (10d) verbunden ist, um eine im wesentlichen bogenförmige Form anzunehmen (Fig. 3B).

28. Verfahren nach einem der Ansprüche 14 bis 23, dadurch gekennzeichnet, daß das Brückenelement (10s) sanft in die Fußelemente (10c, 10b) in eine im wesentlichen halbkreisförmige Form übergeht.

29. Verfahren nach einem der Ansprüche 14 bis 28, dadurch gekennzeichnet, daß der Abstand

zwischen den zwei Fußelementen (10a, 10b) der Rippen im wesentlichen der selbe wie der Abstand zwischen den schraubenförmigen Reihen der Rippen, die um das Rohr (4) gewunden sind, ist.

30. Verfahren nach einem der Ansprüche 14 bis 28, dadurch gekennzeichnet, daß der Abstand von der äußeren Oberfläche (4a) des Rohres (4) zu dem äußersten Teil des Brückenelementes (10c) etwa dem Durchmesser des Rohres (4) entspricht.

31. Vorrichtung zur Herstellung einer gerippten Wärmeübertragungsvorrichtung, umfassend in Kombination eine Einrichtung (1, 6, 7) zum Einspeisen eines länglichen Streifens aus thermisch leitfähigem Material, eine Einrichtung zum Formen des Streifens zu einer einteilig ausgebildeten Kette mit wärmeleitenden Rippen und einer durchgehenden Befestigungsflanscheinrichtung, wobei der geformte Streifen mit seiner Flanscheinrichtung schraubenförmig um ein Rohr mit durchgehendem engen Kontakt mit dem Rohr gewunden wird, gekennzeichnet, durch eine Einrichtung (6, 7) zum Querschlitzen (11) des Streifes in eine Zwischenkonfiguration (Fig. 6), die ein paar gelochte, sich gegenüberliegende Befestigungsbereiche (8, 9) aufweist, die miteinander über einen geschlitzten Bandbereich (10) verbunden sind, vorgesehen ist, und eine Einrichtung (12, 13) zum Strecken und Umformen der Zwischenkonfiguration in eine nachfolgende Konfiguration mit einer Vielzahl bügelartiger Rippen, die einförmig mit der Kette (3) ausgebildet sind, wobei die Kette jeweils auf jeder Seite der gelochten, sich gegenüberliegenden Seitenbereiche einen Befestigungsflansch (8, 9) und jede der Rippen zwei senkrechte Fußelemente (10a, 10b) aufweist, die sich von jeweils einem der Befestigungsflansche nach außen erstrecken, und einen Brückenbereich (10c) der die Fußelemente miteinander an den entfernten Enden der Fußelemente verbindet, wobei die Fußelemente (10a, 10b) und die Befestigungsflansche (8, 9) mit einem vorgewählten Abstandsverhältnis zueinander versehen sind, um Kältebrückenbildung zwischen den benachbarten Rippen zu verringern.

32. Vorrichtung nach Anspruch 31, dadurch gekennzeichnet, daß die Rippen mit einer Teilung von im wesentlichen 1 bis 2 pro cm um das Rohr gewickelt sind.

33. Vorrichtung nach Anspruch 31 oder 32, dadurch gekennzeichnet, daß die Einrichtung zum Einspeisen des länglichen Streifens eine Spulenhalterungseinrichtung (15) umfaßt, von der der Streifen der Einrichtung zugeführt wird, die das Band durch Querschlitzen und Formen in die Zwischenkonfiguration bringt.

34. Vorrichtung nach Anspruch 33, dadurch gekennzeichnet, daß die Einrichtung (6, 7) zum Querschlitzen des Streifens (2) in die Zwischenkonfiguration ein paar sich gegenüberliegende Schlitzschneideeinrichtungen (6, 7) aufweist, die so angeordnet sind, um den Streifen dazwischen aufzunehmen.

35. Vorrichtung nach Anspruch 35, dadurch gekennzeichnet, daß einer (7) der Schlitzschneider mit einer Formeinrichtung versehen ist, die an den Enden ihrer Schneideoberfläche vertikale Flansche aufweist, um den Streifen gleichzeitig zu formen, um eine Zwischenkonfiguration herzustellen, die einen flachen, im allgemeinen kanalförmigen Querschnitt aufweist.

36. Vorrichtung nach Anspruch 35, dadurch gekennzeichnet, daß die Einrichtung (12, 13) zum Strecken und Umformen des Streifens von einer im allgemeinen kanalförmigen Zwischenkonfiguration in einen Streifen der darauffolgenden Konfiguration ein Paar Formwalzen (12, 13) umfaßt, die in einem vorgewählten Winkel (α) zu der Schlitzschneideeinrichtung (6, 7) angeordnet ist, um den Streifen mit der Zwischenkonfiguration dazwischen zu empfangen und zu strecken und ihn in den Streifen der nachfolgenden Konfiguration umzuformen.

37. Vorrichtung nach einem der Ansprüche 31 bis 36, dadurch gekennzeichnet, daß die Kette mit ausreichender Zugspannung um das Rohr gewunden ist, um eine Längung der Befestigungsflansche (8, 9) von ungefähr 1% bis 1.5% zu erzeugen.

38. Vorrichtung nach einem der Ansprüche 31 bis 37, dadurch gekennzeichnet, daß die Kette durch Aufbringen einer Zugspannung um eine Längung der Befestigungsflansche von ungefähr 1% bis 2.5% herzustellen, streckgeformt ist.

Revendications

1. Un dispositif de transmission de chaleur à ailettes assurant une transmission de chaleur vers et à partir d'un tube (4) contenant un fluide de transmission de chaleur, et comprenant une chaîne (3), formée unitairement, d'ailettes conductrices de chaleur enroulée en hélice sous tension autour du tube, ladite chaîne comprenant des rebords de montage continus en contact étroit continu avec le tube, et les ailettes étant formées unitairement avec les rebords de montage en s'étendant radialement vers l'extérieur à partir de ceux-ci, caractérisé en ce que les rebords de montage continus comprennent deux rebords (8, 9) parallèles, axialement espacés, s'étendant en hélice et qui sont tous deux en contact continu avec le tube, et en ce que chaque ailette comprend deux branches (10a, 10b) formées unitairement avec les deux rebords respectifs (8, 9) et une âme d,'interconnexion (10c), formée unitairement avec les deux branches (10a, 10b), lesdites branches (10a, 10b) et lesdits rebords de montage (8, 9) étant réalisés avec des dimensions présélectionnées les uns par rapport aux autres pour réduire sensiblement un pontage par du givre entre ailettes adjacentes.

2. Un dispositif de transmission de chaleur tel que revendiqué dans la revendication 1, caractérisé en ce que lesdites ailettes sont enroulées sur le tube avec un pas correspondant sensiblement à 1 à 2 ailettes par cm.

3. Un dispositif de transmission de chaleur tel que revendiqué dans la revendication 1 ou la revendication 2, caractérisé en ce que la chaîne

est enroulée sur le tube avec une tension suffisante pour produire un allongement d'environ 1% à 1,5% de longueur des rebords de montage (8 9).

4. Un dispositif de transmission de chaleur tel que revendiqué dans une quelconque des revendications 1 à 3, caractérisé en ce que la chaîne (3) est formée par allongement en soumettant à allongement une bande perforée transversalement (figure 13) à mesure qu'elle passe entre des rouleaux de formage correspondants (12, 13) qui transforment, en un seul passage, la partie perforée de la bande en une forme générale de U comprenant lesdites branchnes (10a, 10b) et ladite âme (10c).

5. Un dispositif de transmission de chaleur tel que revendiqué dans la revendication 4, caractérisé en ce que la chaîne est formée par allongement avec application de tension de manière à produire un allongement d'environ 1% à 2,5% de longueur des rebords de montage.

6. Un dispositif de transmission de chaleur tel que revendiqué dans une quelconque des revendications 1 à 5, caractérisé en ce que lesdites branches (10a, 10b) sont sensiblement perpendiculaires audit tube (4).

7. Un dispositif de transmission de chaleur tel que revendidqué dans une quelconque des revendications 1 à 6, caractérisé en ce que la chaîne (3) d'ailettes est réalisée en aluminium.

8. Un dispositif de transmission de chaleur tel que revendiqué dans une quelconque des revendications 1 à 7, caractérisé en ce que ladite âme (10c) est sensiblement droite et sensiblement parallèle à la surface extérieure (4a) dudit tube (4).

9. Un dispositif de transmission de chaleur tel que revendiqué dans une quelconque des revendications 1 à 7, caractérisé en ce que ladite âme (10c) est arrondie aux points d'intersection (10r, figure 3A) entre lesdites branches (10a, 10b) et ladite âme (10c).

10. Un dispositif de transmission de chaleur tel que revendiqué dans une quelconque des revendications 1 à 7, caractérisé en ce que ladite âme (10c) est reliée auxdites branches (10a, 10b) par des parties intermédiaires (10d) de façon à former un profil sensiblement en forme d'arche (figure 3B).

11. Un dispositif de transmission de chaleur tel que revendiqué dans une quelconque des revendications 1 à 7, caractérisé en ce que ladite âme (10s) se raccorode progressivement auxdites branches (10a, 10b) selon un profil dans l'ensemble en demi-cercle.

12. Un dispositif de transmission de chaleur tel que revendiqué dans une quelconque des revendications 1 à 11, caractérisé en ce que la distance entre les deux branches (10a, 10b) d'une ailette est sensiblement la même que la distance entre les rangées hélicoïdales desdites ailettes enroulées sur ledit tube (4).

13. Un dispositif de transmission de chaleur tel que revendiqué dans une quelconque des revendications 1 à 11, caractérisé en ce que la distance entre la surface extérieure (4a) du tube (4) et la partie la plus extérieure de l'âme (10c) est à peu près égale au diamètre du tube (4).

14. Un procédé de fabrication d'un dispositif ailete de transmission de chaleur assurant une transmission de chaleur vers et à partir d'un tube (4) contenant un fluide de transmission de chaleur, comprenant les étapes consistant à former une bande allongée (2) de matière thermiquement conductrice en une chaîne, formée unitairement d'ailettes conductrices de chaleur, avec des rebords continus de montage, et à enrouler la bande formée en hélice autour d'un tube, ces rebords étant en contact étroit et continu avec le tube, caractérisé en ce qu'on perfore transversalement (11) ladite bande et on assure son formage en une configuration intermédiaire comportant une paire de rebords latéraux de montage (8, 9) non perforés, placés dans des positions opposées et reliés entre eux par une âme perforée (10), on préforme par allongement ladite configuration intermédiaire pour la reprofiler sous forme d'une configuration suivante comprenant une chaîne formée unitairement avec des ailettes en boucles entre lesdits rebords de montage, desdits ailettes comprenant des branches (10a, 10b) s'étendant vers l'extérieur à partir de chacun desdits rebords de montage et une âme (10c) reliant lesdites branches à l'extrémité distale desdites branches, lesdites branches (10a, 10b) et lesdits rebords de montage (8, 9) étant réalisés dans des dimensions présélectionnées en relation mutuelle afin de réduire sensiblement la formation de givre entre ailettes adjacentes; et à enrouler en hélice ladite chaîne sous tension sur la surface extérieure d'un tube (4), les ailettes (10) s'étendant dans la direction longitudinale du tube (4).

15. Un procédé tel que revendiqué dans la revendication 14, caractérisé en ce que lesdites ailettes sont enroulées sur le tube avec un pas correspondant sensiblementà 1 à 2 ailettes par cm.

16. Un procédé selon la revendication 13 ou la revendication 14, caractérisé en ce que la chaîne est enroulée sur le tube avec une tension suffisante pour produire un allongement d'environ 1% à 1,5% en longueur des rebords de montage (8, 9).

17. Un procédé selon une quelconque des revendications 14 à 17, caractérisé en ce que la chaîne est formée par allongement avec application de tension de manière à produire un allongement d'environ 1% à 2,5% en longueur des rebords de montage.

18. Un procédé selon une quelconque des revendications 14 à 15, caractérisé en ce que ladite configuration intermédiaire comprend une section droite en forme de canal généralement peu profond.

19. Un procédé selon une quelconque des revendications 14 à 18, caractérisé en ce que ladite partie d'âme perforée est reformée de ladite configuration intermédiaire dans ladite configuration suivante par un préformage par allongement consistant à tirer ladite bande autour d'un, rouleau de formage mâle adapté pour entrer initiale-

ment en contact avec le centre de ladite partie d'âme perforée, de façon qu'une tension exercée sur les rebords de montage situés sur le côte non perforé et la pression exercée par le rouleau de formage sur le centre de la partie d'âme reforment graduellement ladite partie d'âme de façon qu'elle épouse le profil dudit rouleau de formage mâle.

20. Un procédé selon de revendication 19, carctérisé en ce que ledit préformage par allongement est produit au centre de ladite partie d'âme perforée en contact avec ledit rouleau de formage mâle sur un arc compris entre 80° et 90°.

21. Un procédé selon la revendication 20, caractérisé en ce que ledit arc est de 85°.

22. Un procédé selon une quelconque des revendications 19 à 21, caractérisé en ce que ledit rouleau de formation mâle comprend une section centrale de formage et un épaulement situé de chaque côte de ladite section centrale de formage, et ladite bande est tirée autour dudit rouleau de formage mâle en éntant saisie entre lesdits épaulements et des épaulements complémentaires prévus sur un rouleau de formage femelle.

23. Un procéde te que revendiqué dans une quelconque des revendications 14 à 22, caractérisé en ce que lesdites âmes (10a, 10b sont sensiblement perpendiculaires audit tube (4).

24. Un procédé tel que revendiqué dans une quelconque des revendications 14 à 22, caractérisé en ce que la chaîne (3) d'ailettes est réalisée en aluminium.

25. Un procédé tel que revendiqué dans une quelconque des revendications 14 à 23, caractérisé en ce que ladite âme (10c) est sensiblement droite et sensiblement parallèle à la surface extérieure (4a) dudit tube (4).

26. Un procédé tel que revendiqué dans une quelconque des revendications 14 à 23, caractérisé en ce que ladite âme (10c) est arrondie aux points d'intersection (10r, figure 3A) entre lesdites branches (10a, 10b) et ladite âme (10c).

27. Un procédé tel que revendiqué dans une quelconque des revendications 14 à 23, caractérisé en ce que ladite âme (10c) est reliée auxdites branches (10a, 10b) par des parties intermédiaires (10d) de façon à créer un profil sensiblement en forme d'arche (Figure 3B).

28. Un procédé tel que revendiqué dans une quelconque des revendications 14 à 23, caractérisé en ce que ladite âme (10s) se raccorde progressivement auxdites branches (10a, 10b) selon un profil dans l'ensemble en demi-cercle (Figure 3B).

29. Un procédé tel que revendiqué dans une quelconque des revendications 14 à 28, caractérisé en ce que la distance entre les deux branches (10a, 10b) d'une ailette est sensiblement la même que la distance entre les rangées hélicoïdales desdites ailettes enroulées sur ledit tube (4).

30. Un procédé tel que revendiqué dans une quelconque des revendications 14 à 28, caractérisé en ce que la distance entre la surface extérieure (4a) du tube (4) et la partie la plus extérieure de l'ailette (10c) est à peu près égale au diamètre du tube (4).

31. Machine de fabrication d'un dispositif aileté de transmission de chaleur, comprenant, en combinaison, des moyens (1, 6, 7) pour assurer l'avancement d'une bande allongée de matière thermiquement conductrice afin de former la bande en une chaîne, formée unitairement, d'ailettes conductrices de chaleur, avec des rebords se montage continus, et pour enrouler la bande formée en hélice autour d'un tube, avec ces rebords en contact étroit et continu avec le tube, caractérisé par des moyens (6, 7) pour perforer transversalement (11) ladite bande selon une configuration intermédiaire (figure 6) comportant une paire de parties latérales de montage (8, 9) non perforées, opposées et reliées entre elles par une partie d'âme perforée (10), et des moyens (12, 13) pour allonger et reformer ladite configuration intermédiaire en une configuration suivantes comprenant un chaîne (3), formée unitairement, d'une pluralité d'ailettes en boucles, ladite chaîne comportant un rebord de montage respectif (8, 9) formé à partir de chacune desdites parties latérales opposées et non perforées, et chacune desdites ailettes comprenant deux branches verticales (10a, 10b), s'étendant vers l'extérieur à partir d'un rebord de montage respectif et une partie d'âme (10c) reliant lesdites branches l'une avec l'autre à l'extrémité distale desdites branches, lesdites branches (10a, 10b) et lesdits rebords de montage (8, 9) étant réalisés dans des dimensions présélectionées en relation mutuelle pour réduir sensiblement la formation de givre entre ailettes adjacente.

32. Machine telle que revendiquée dans la revendication 31, caractérisé en ce que lesdites ailettes sont enroulées sur le tube avec un pas correspondant sensiblement à 1 à 2 ailettes par cm.

33. La machine selon la revendication 31 ou revendication 32, caractérisé en ce que ledit moyen pour assurer l'avancement de ladite bande allongée comprend un moyen de maintien de bobine (15) à partir duquel la bande est transférée jusqu'au dit moyen de perforation transversale et de formage de ladite bande selon ladite configuration intermédiaire.

34. La machine selon la revendication 33, caractérisé en ce que lesdits moyens (6, 7) pour perforer transversalement ladite bande (2) sous la forme de ladite configuration intermédiaire comprennent deux moyens opposé de découpage de perforations (6, 7) qui sont disposés de façon à recevoir ladite bande entre eux.

35. La machine selon la revendication 34, caractérisé en ce qu'un (7) desdits moyens de découpage de perforations est pourvu de moyens de formage comprennant des rebords verticaux placés aux extrémités de sa surface de coupe pour former simultanément la bande de façon à produire une bande de configuration intermédiaire ayant une section droite en forme de canal généralement peu profond.

36. La machine selon la revendication 35,

caractérisé en ce que lesdits moyens (12, 13) pour allonger et reformer ladite bande de configuration intermédiaire en forme de canal dans l'ensemble sous la forme d'une bande de ladite configuration suivante comprennent deux rouleaux de formage (12, 13) qui sont disposés selon un angle présélectionné (α) par rapport auxdits moyens de découpage de perforations (6, 7) de façon à recevoir ladite bande de configuration intermédiaire entre eux et à l'allonger et la reformer sous la forme de ladite bande de configuration suivante.

37. Machine telle que revendiquée dans une quelconque des revendications 31 à 36, caractérisé en ce que la chaîne est enroulée sur le tube avec une tension suffisante pour produire un allongement d'environ 1% à 1,5% en longeur des rebords de montage (8, 9).

38. Machine telle que revendiquée dans une quelconque des revendications 31 à 37, caractérisé en ce que la chaîne est formée par allongement avec application de tension de façon à produire un allongement d'environ 1% à 2,5% en longueur des rebords de montage.

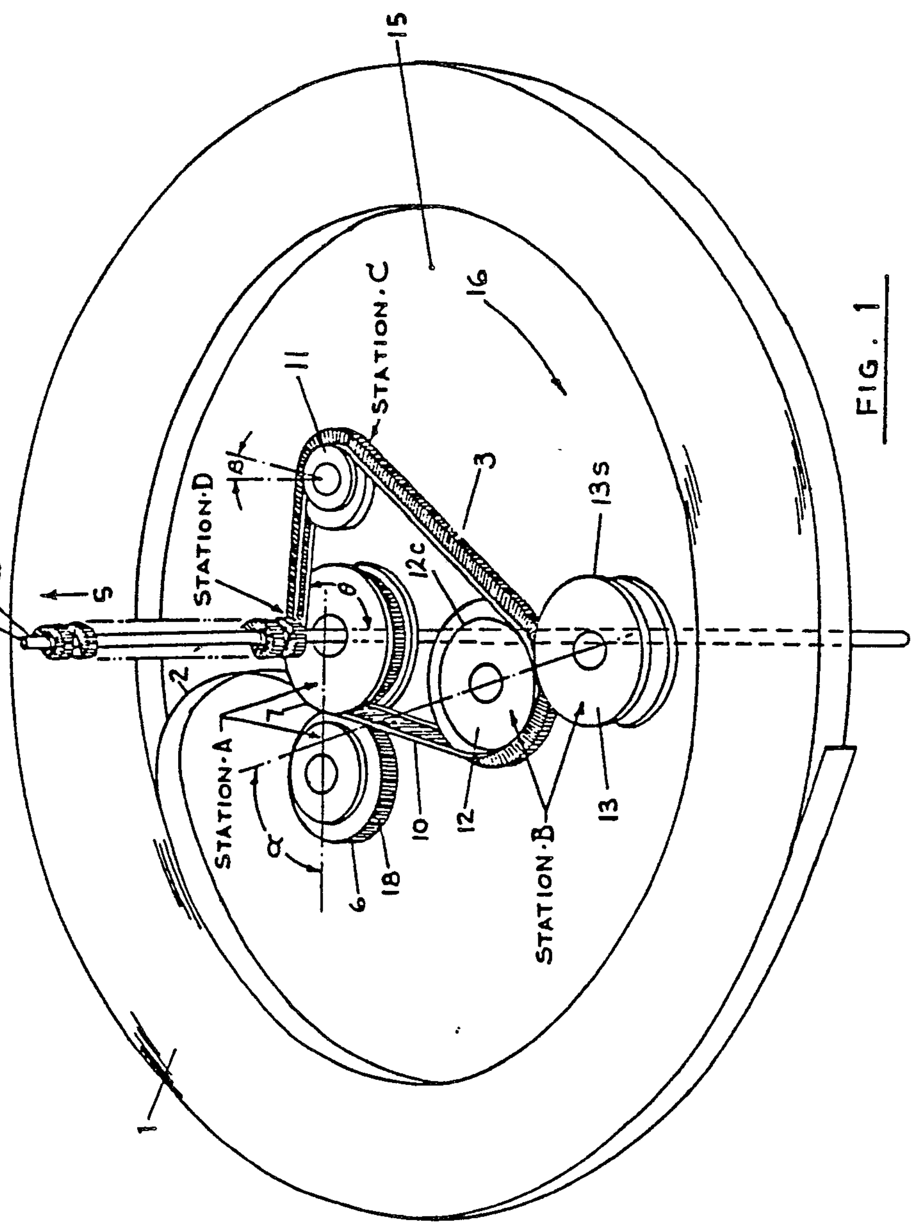
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FIG. 1

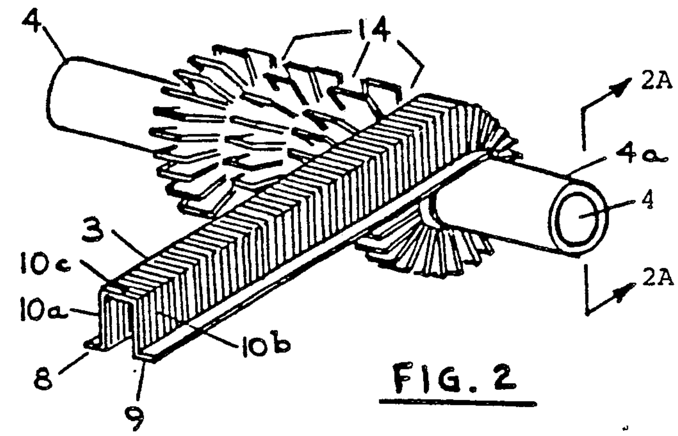


FIG. 2

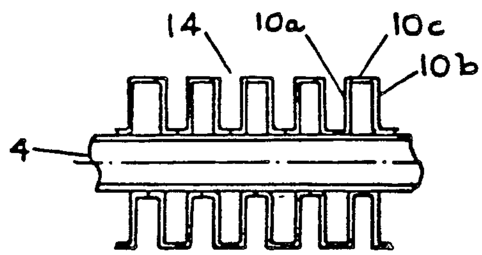


FIG. 2A

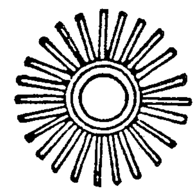


FIG. 2B

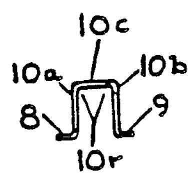


FIG.3A

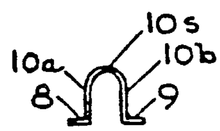


FIG.3B

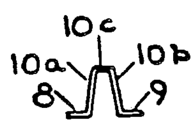


FIG.3D

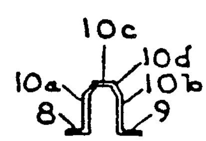


FIG.3c

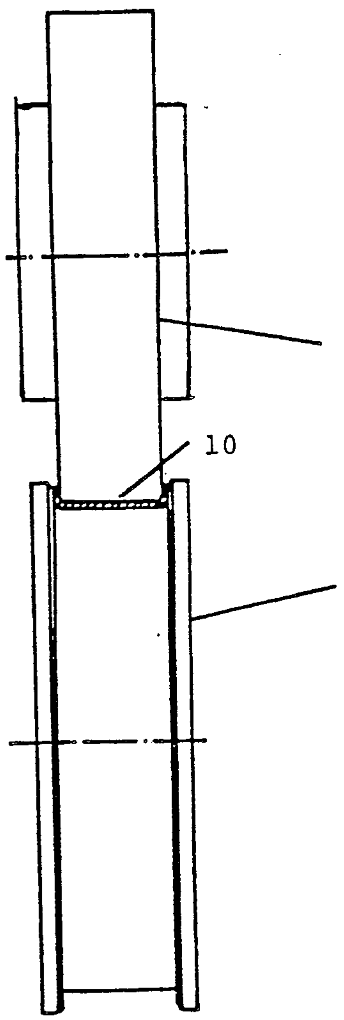


FIG. 4

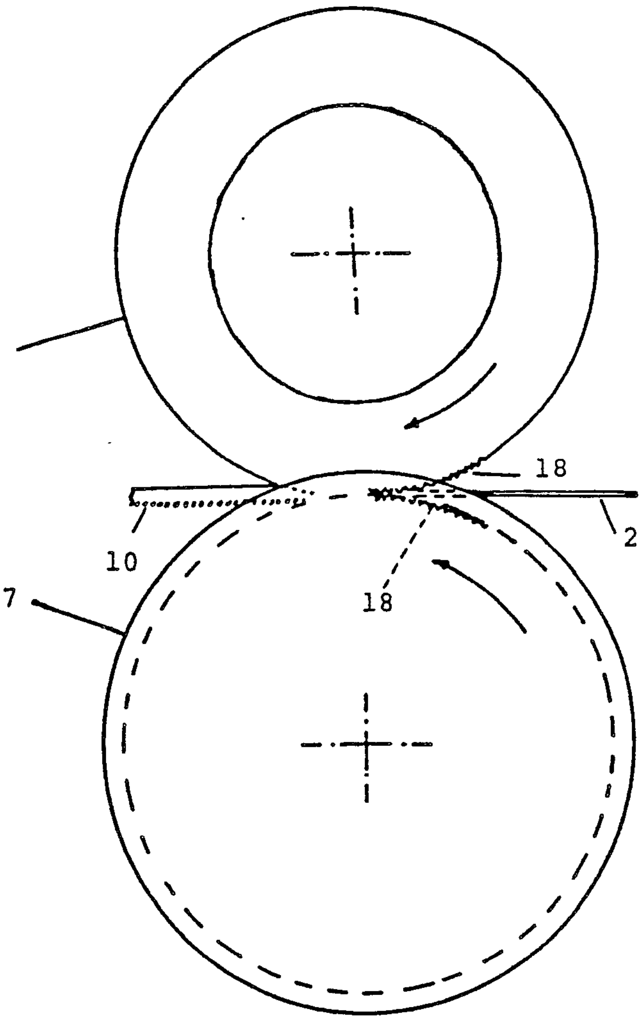


FIG. 5

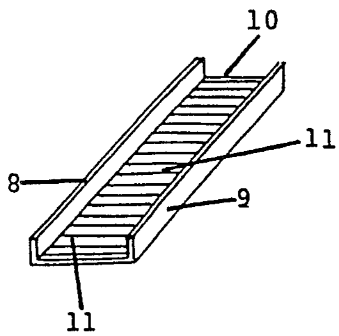


FIG. 6

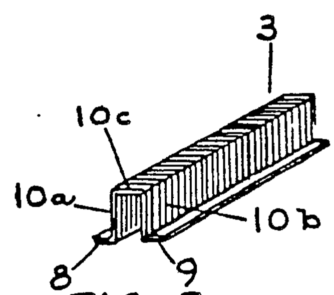


FIG. 9

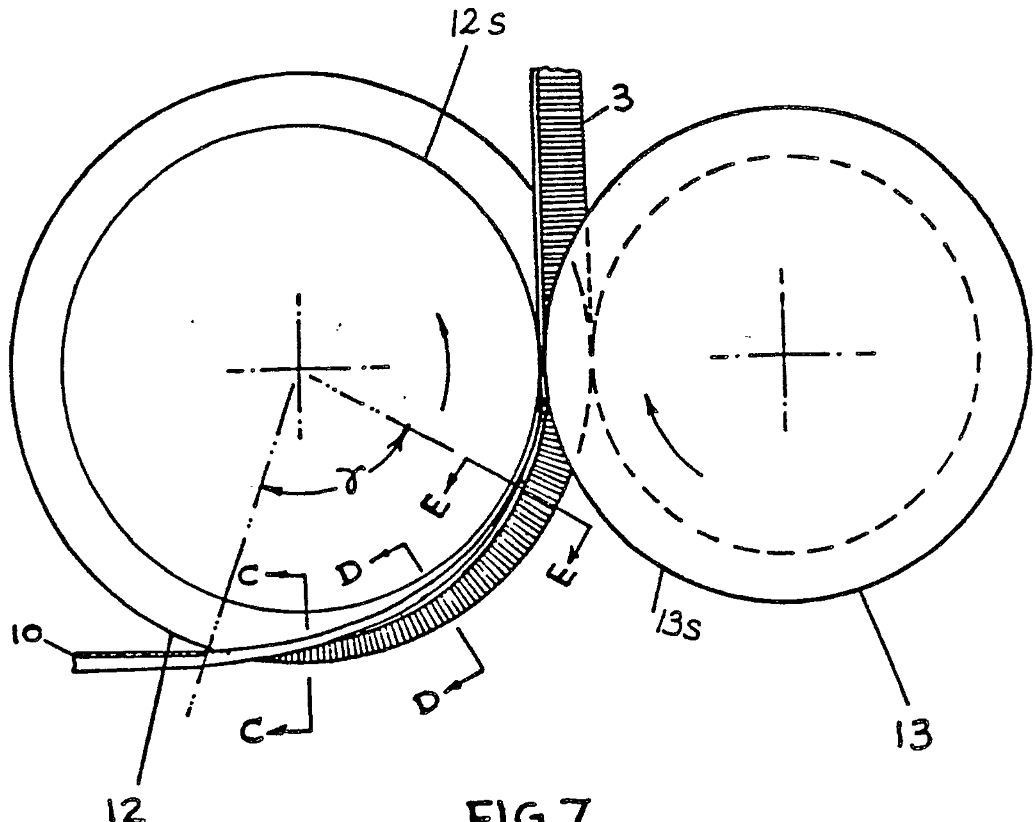


FIG.7

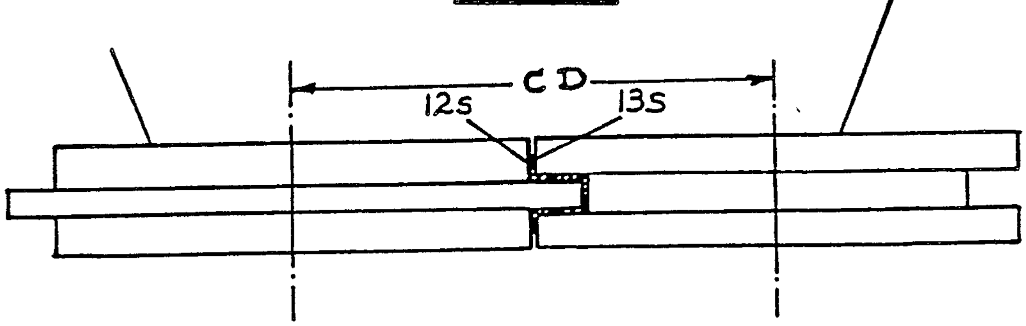
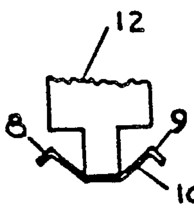


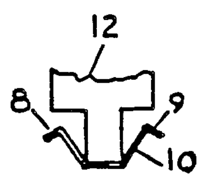
FIG.8

FIG. 7C



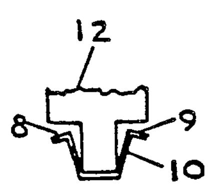
SECTION C-C

FIG. 7D



SECTION D-D

FIG. 7E



SECTION E-E

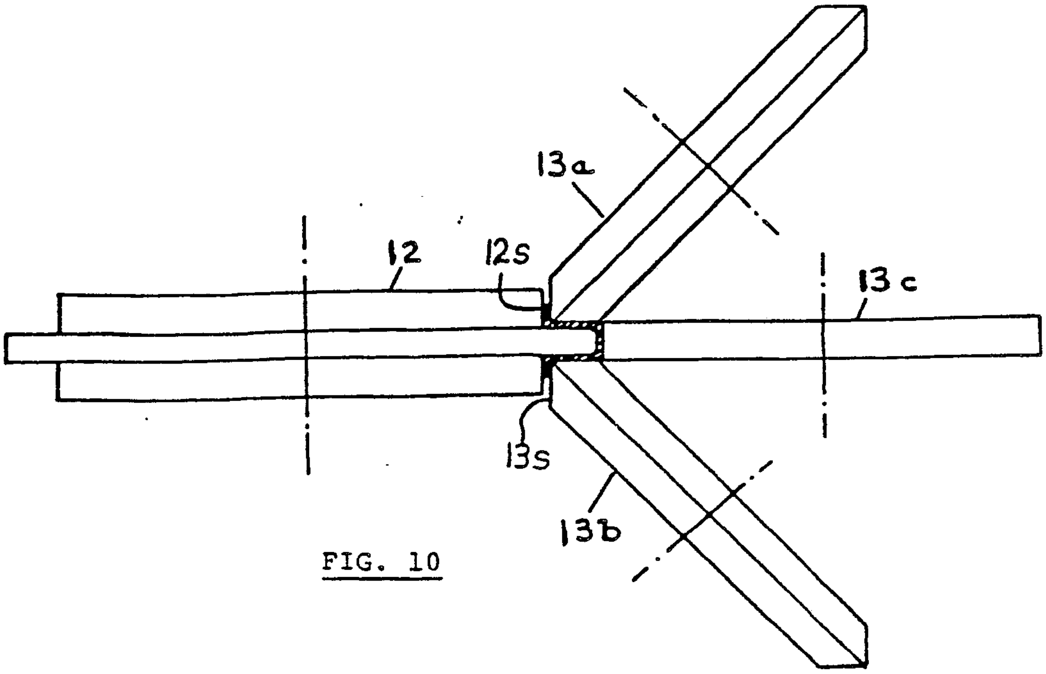


FIG. 10

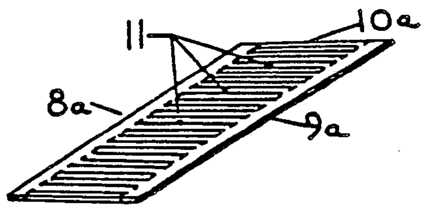


FIG. 13

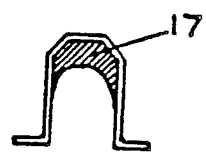


FIG. 15

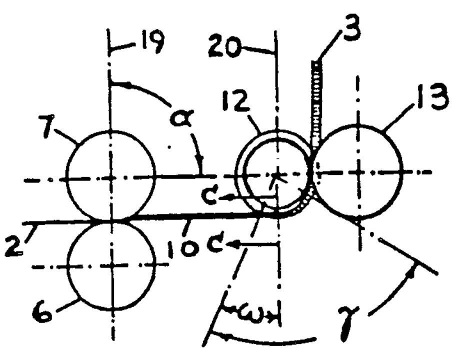


FIG. 14a

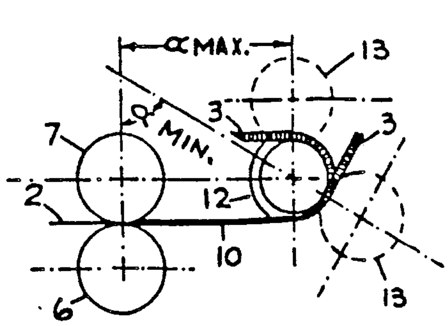


FIG. 14b

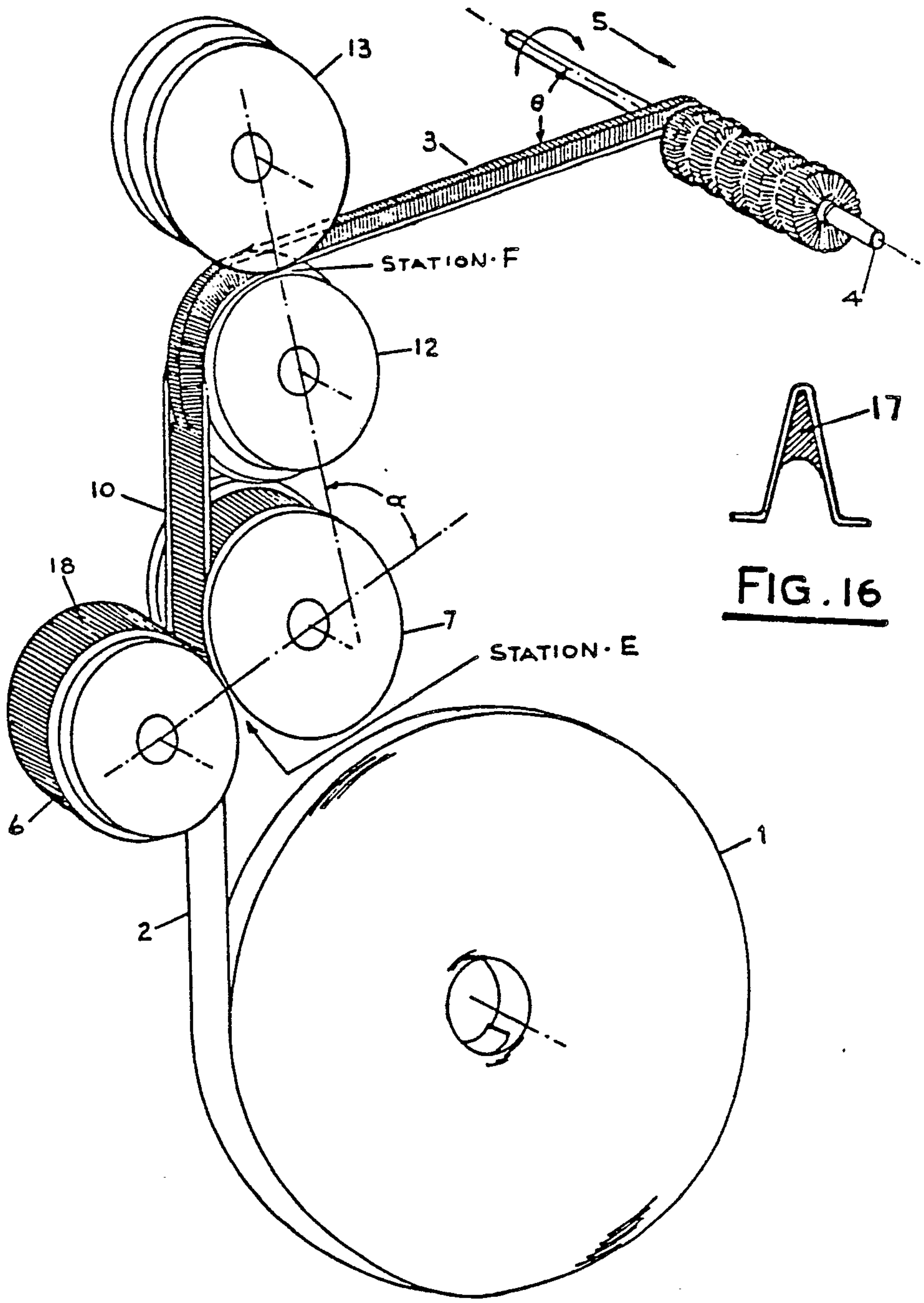


FIG. 16

FIG. 11

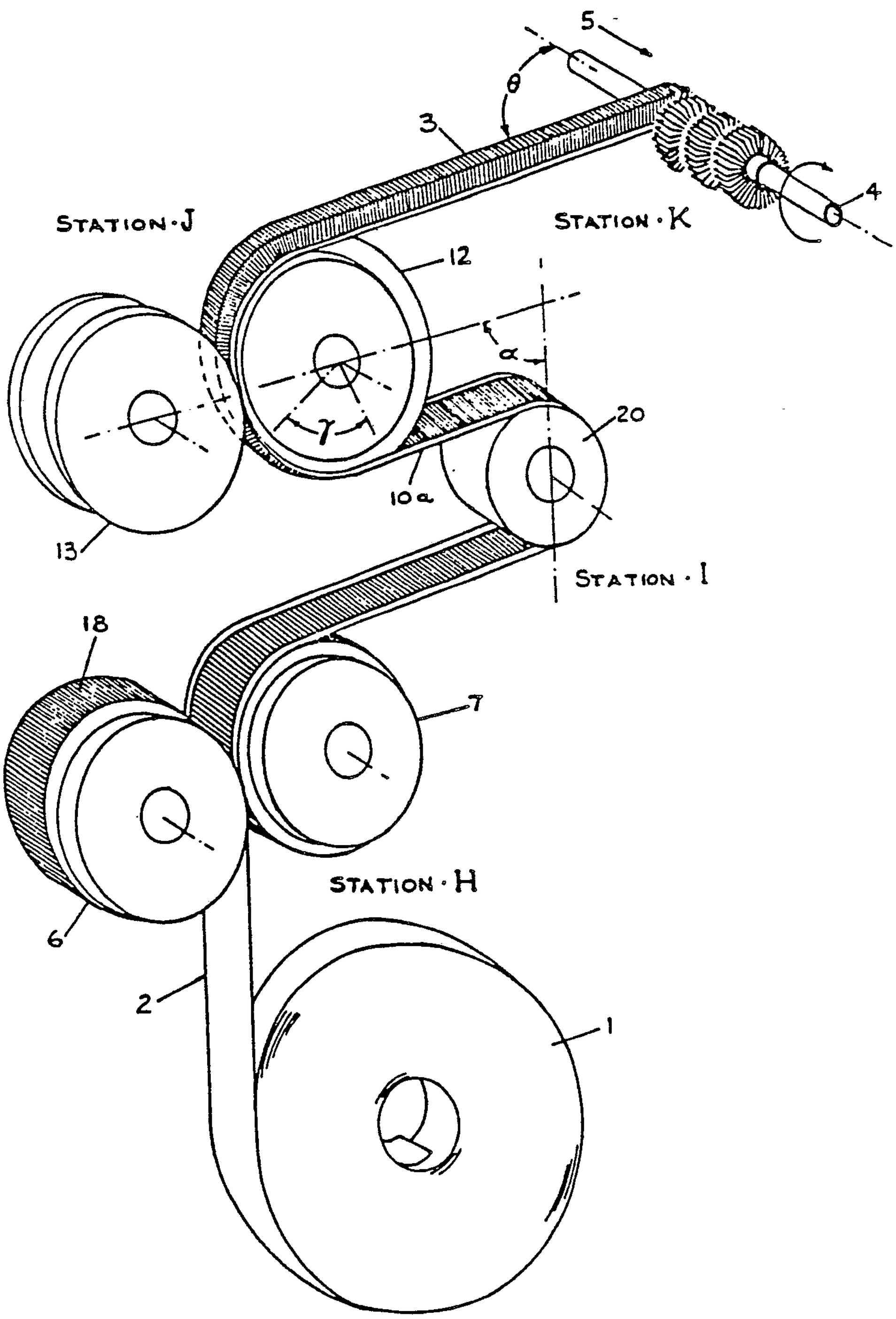

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FIG. 12