United States Patent

French

[15] **3,662,582**

[45] **May 16, 1972**

[54] **HEAT-EXCHANGE TUBING AND METHOD OF MAKING IT**

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[73] Assignee: **Noranda Metal Industries Inc.**

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[52] **U.S. Cl.** ....**72/367,** 29/157.3 A, 165/177
[51] **Int. Cl.** **B21d 53/06**
[58] **Field of Search** ......72/256, 367; 29/157.3 A, 157.3 AH, 29/157.3 B; 113/118 A, 118 B; 165/177, 179

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Primary Examiner—Lowell A. Larson
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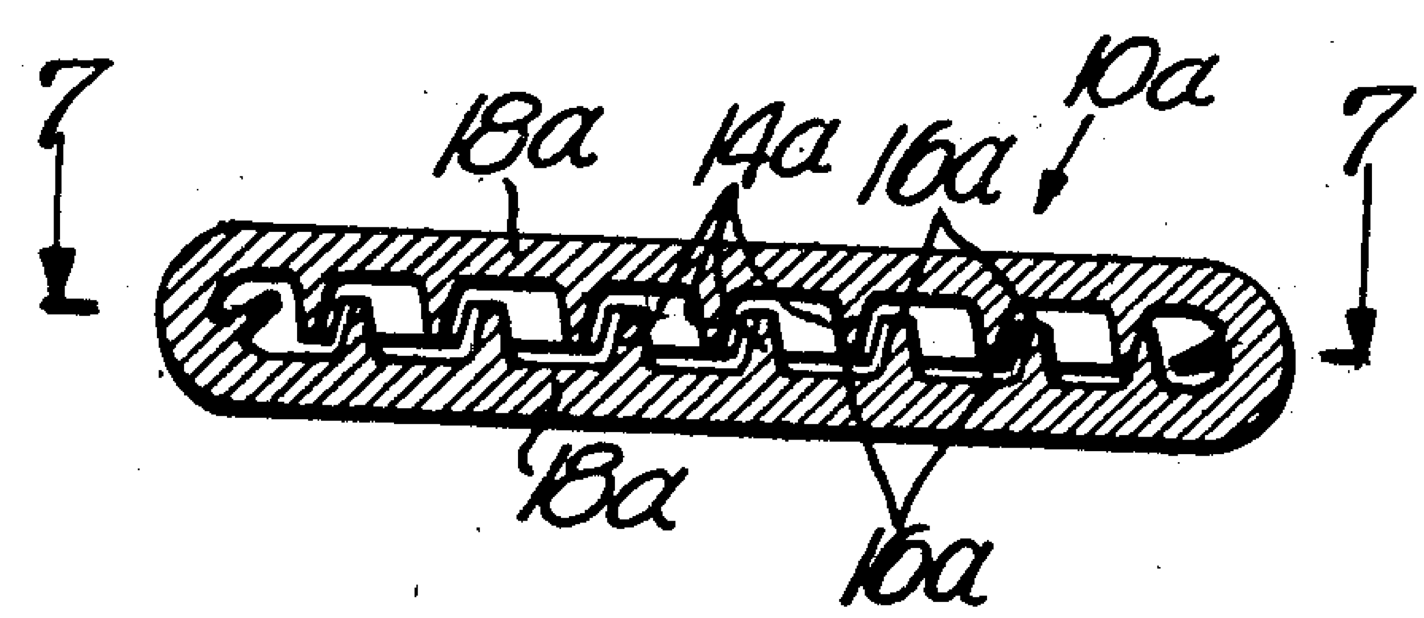
[57] **ABSTRACT**

Heat-exchange tubing with a peripheral wall of oblong cross-section, and inner fins on the wall of which the fins on either of two opposite flat wall sections extend with their tips at least to the level of the tips of the fins on the other flat wall section, and a method of forming the tubing from a round inner-fin tube blank, involving partially flattening the round blank into the tubing with its peripheral wall of oblong cross-section.

8 Claims, 23 Drawing Figures



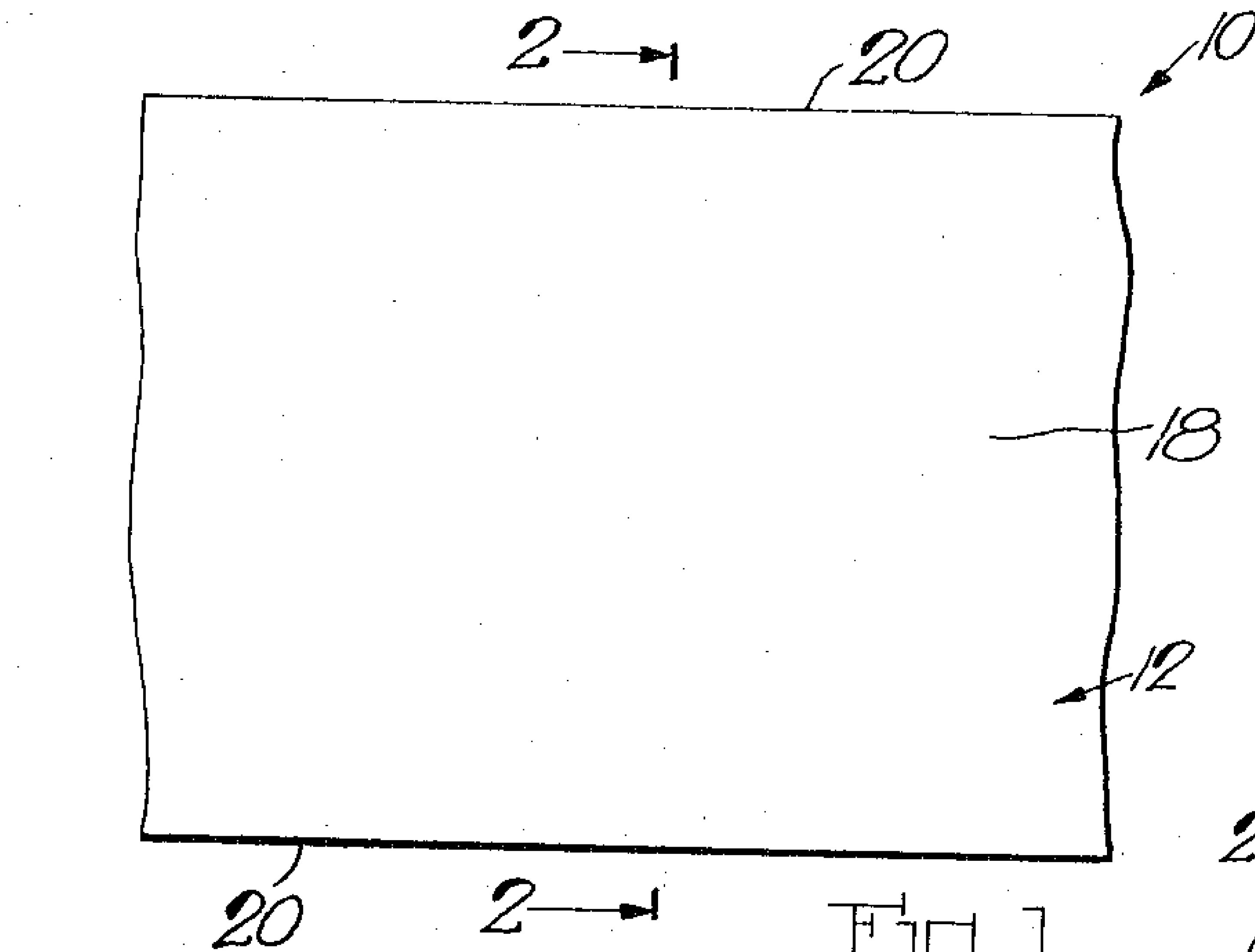


Fig.1

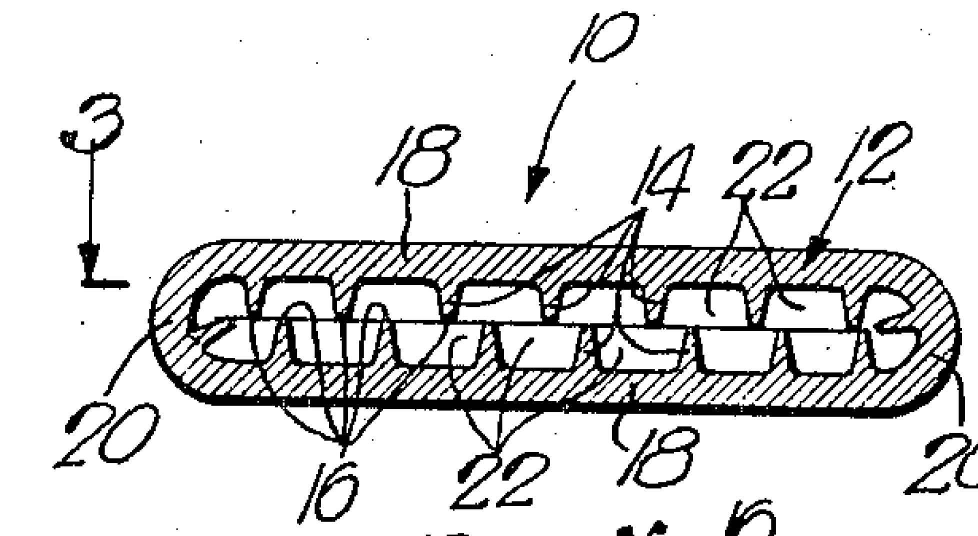


Fig.2

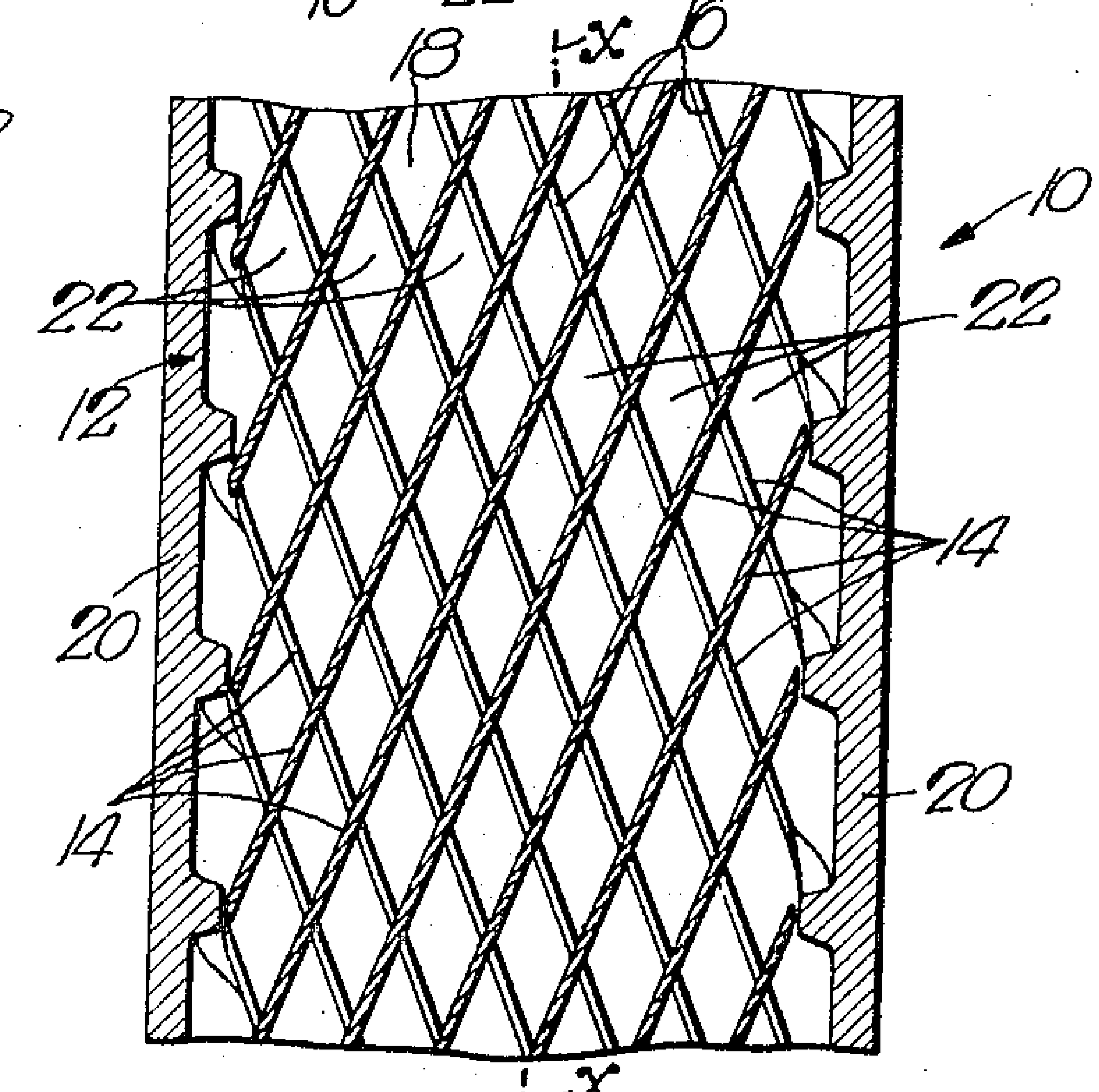


Fig.3

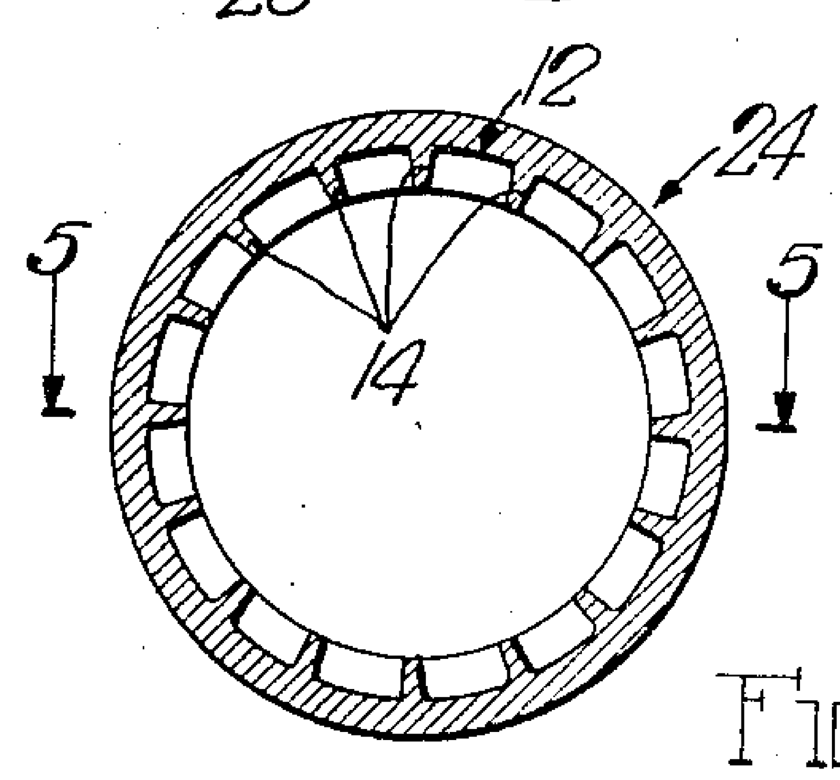


Fig.4

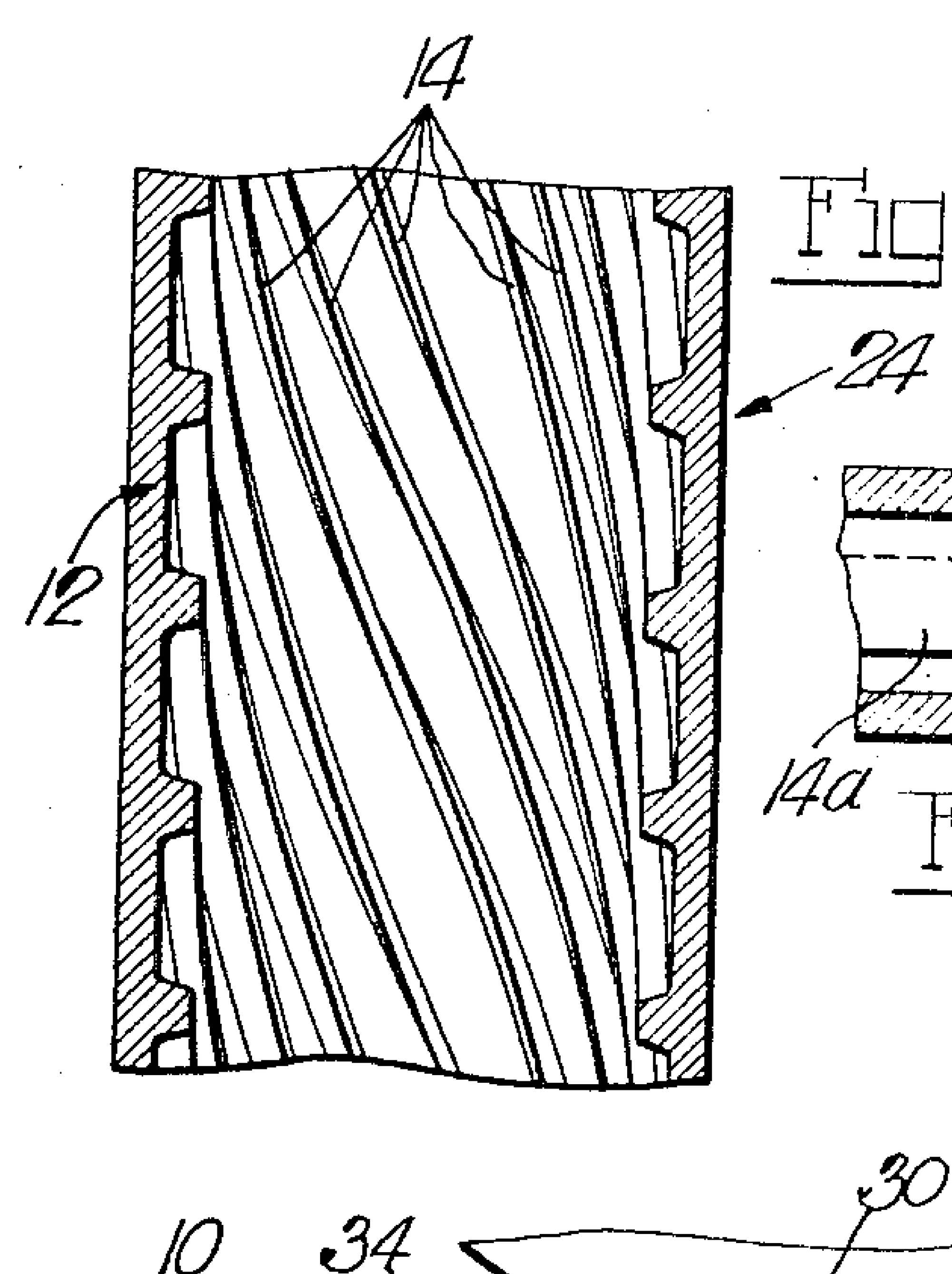


Fig.5

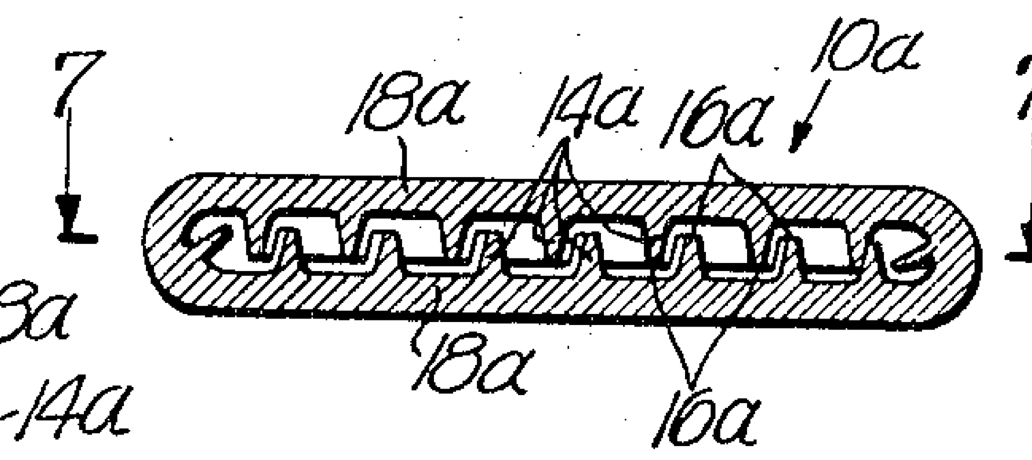


Fig.6

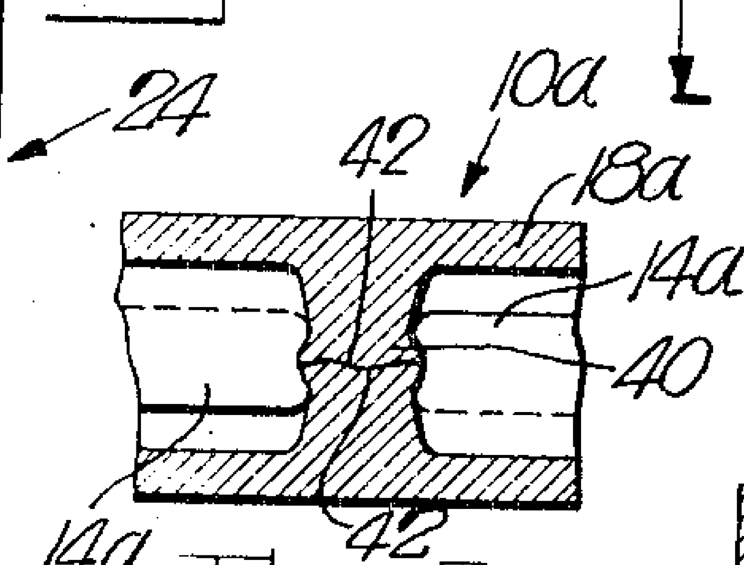


Fig.8

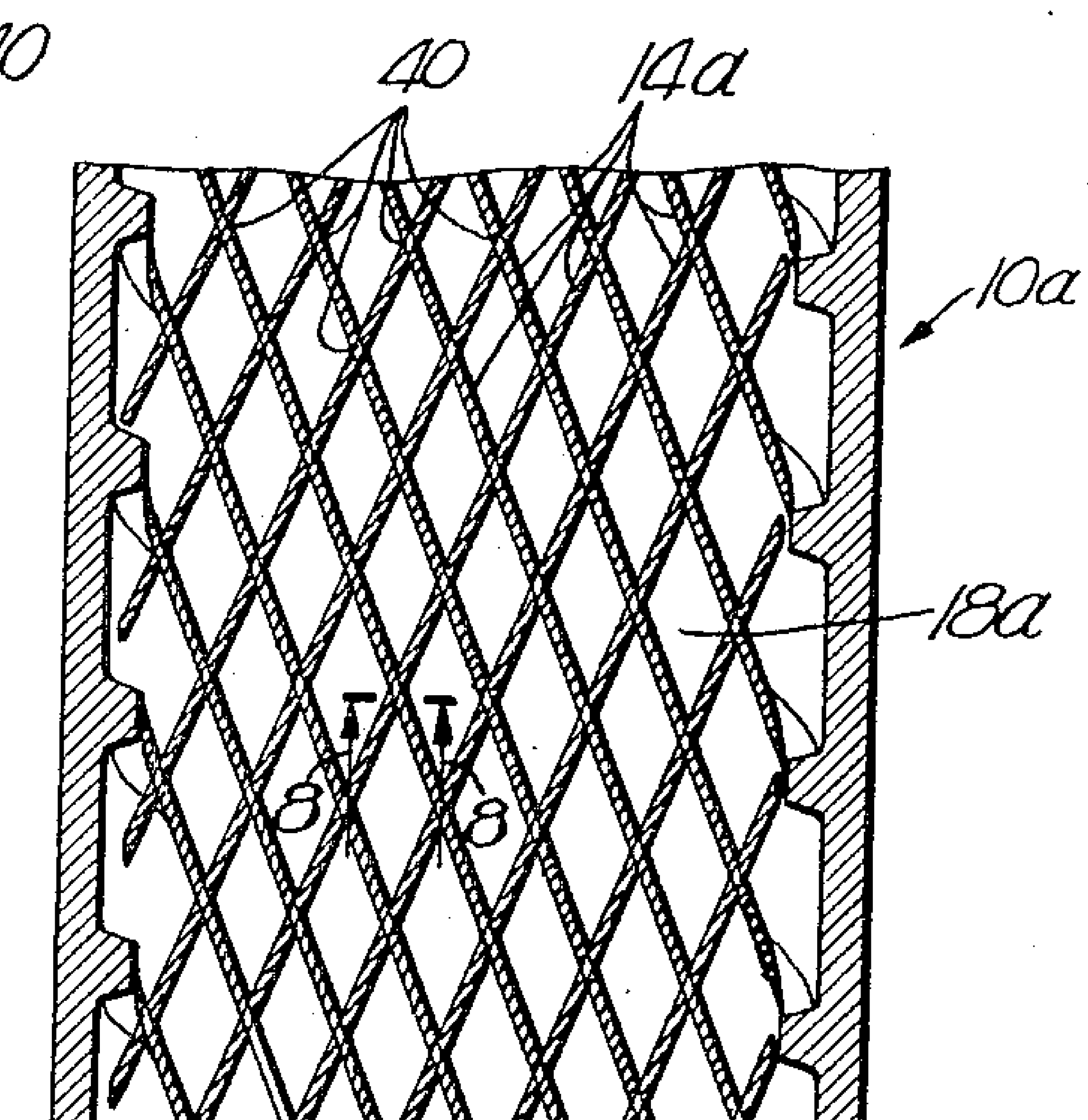


Fig.7

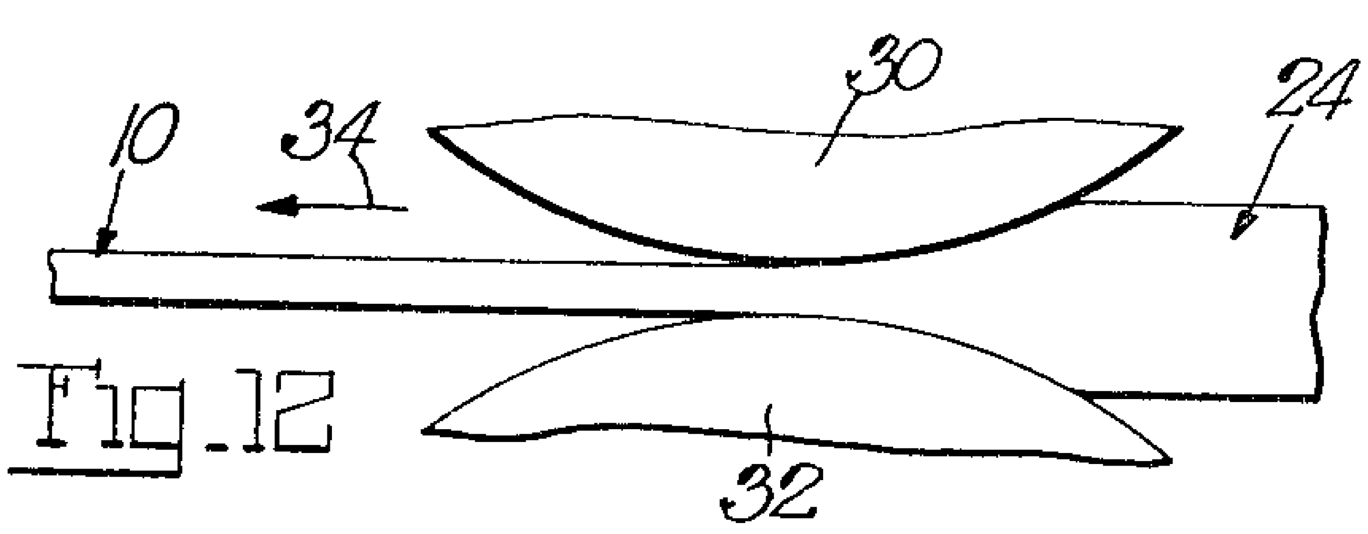


Fig.12

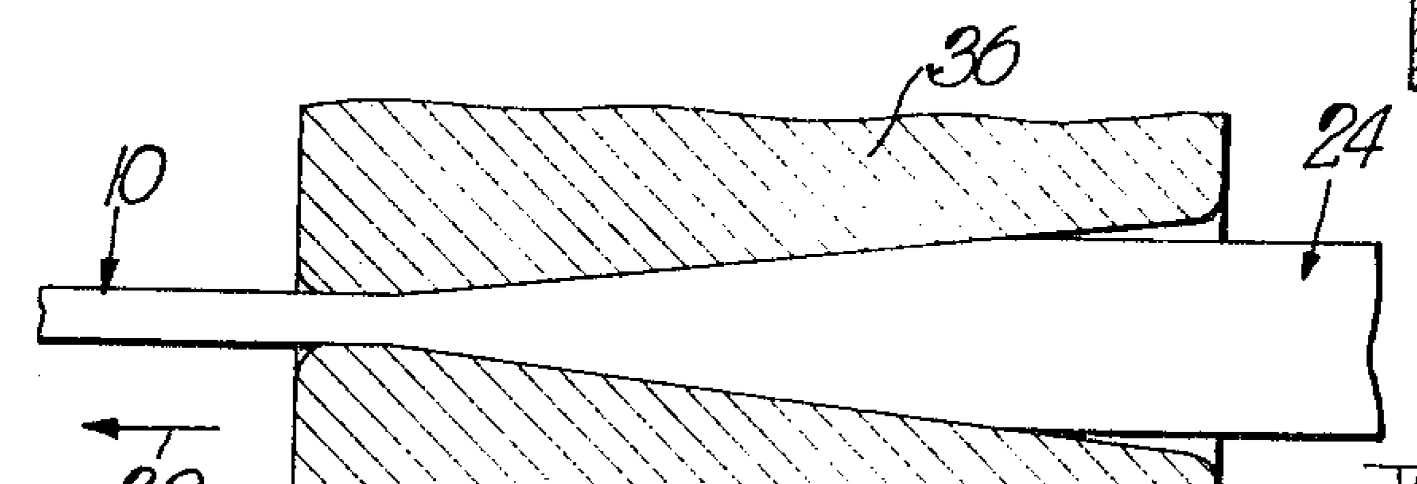


Fig.13

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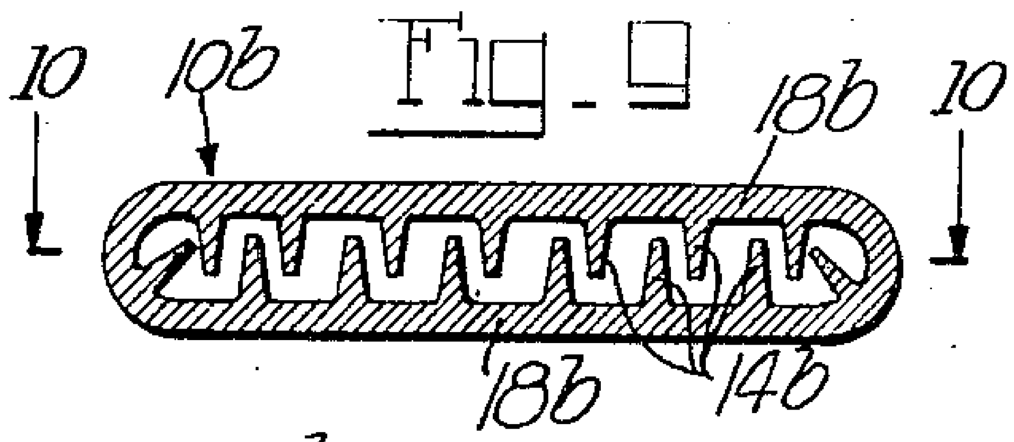
Fig. 9



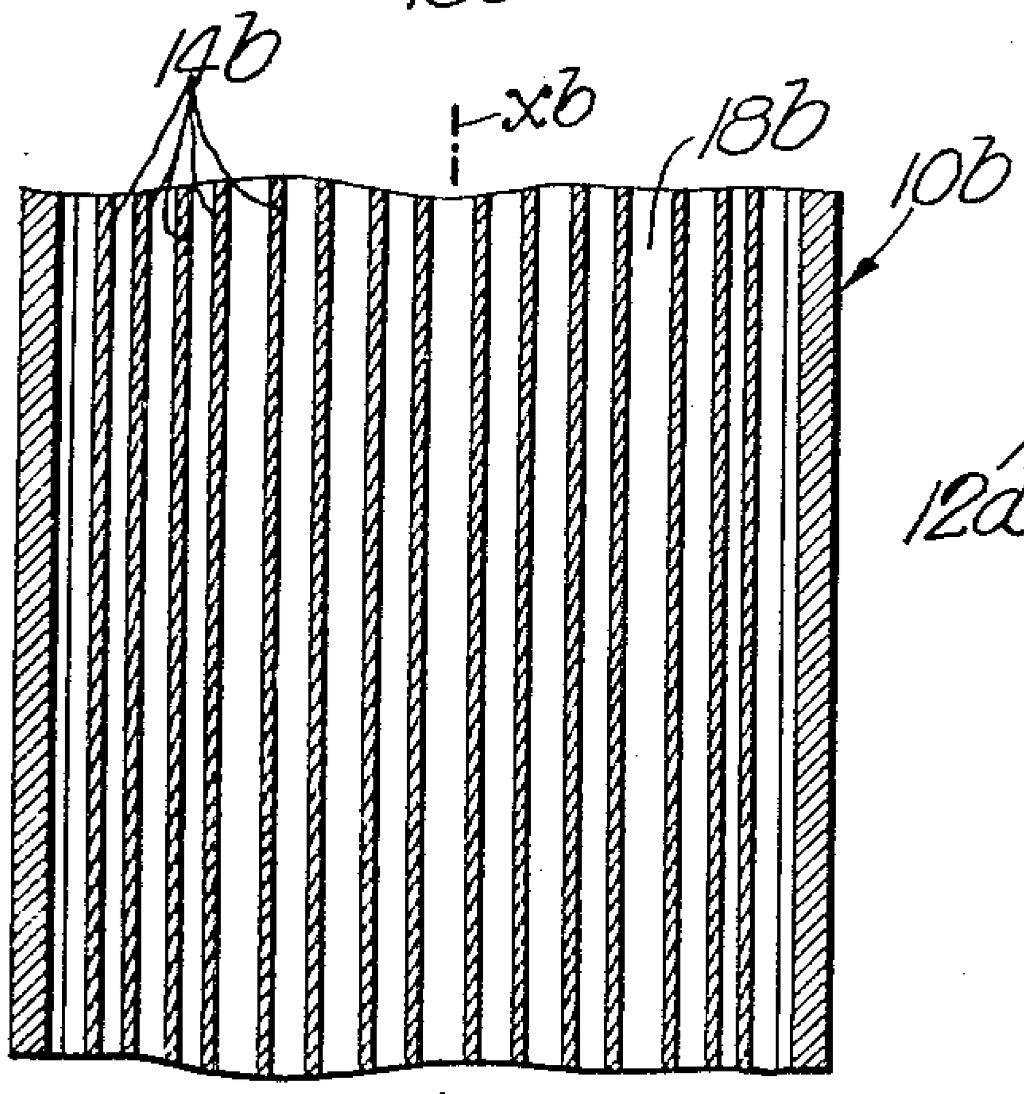


Fig. 10

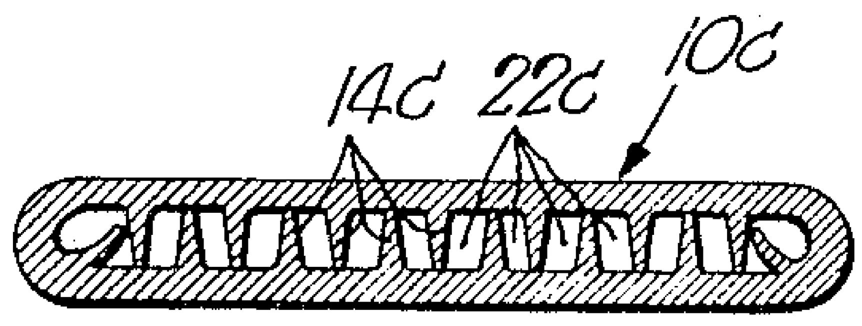


Fig. 11

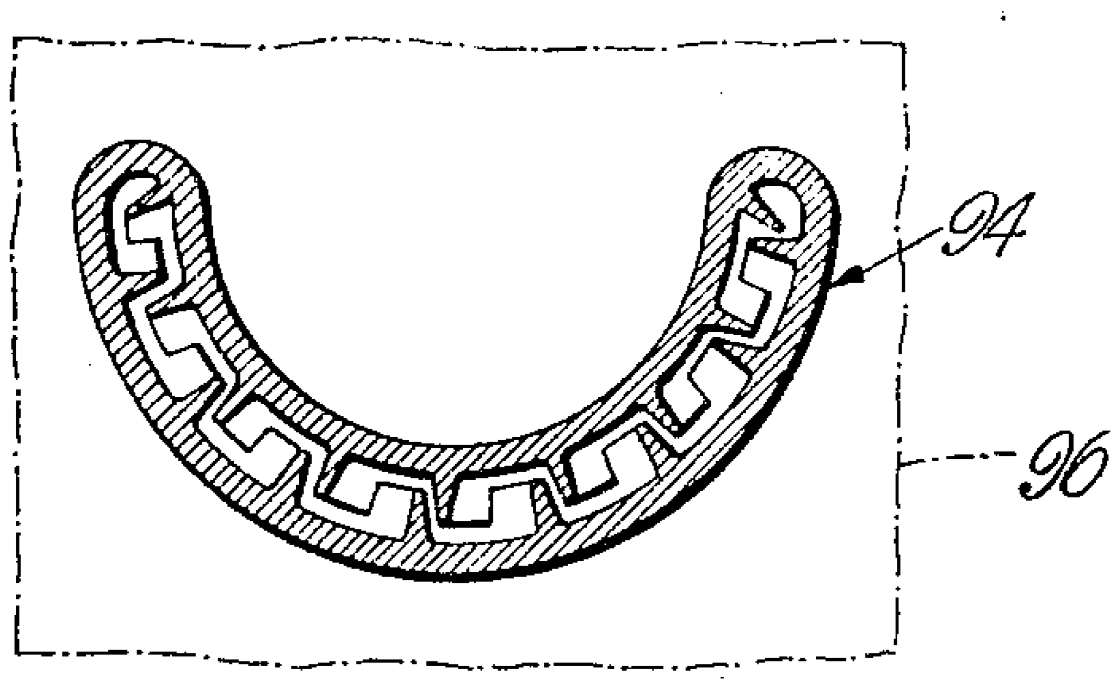


Fig. 19

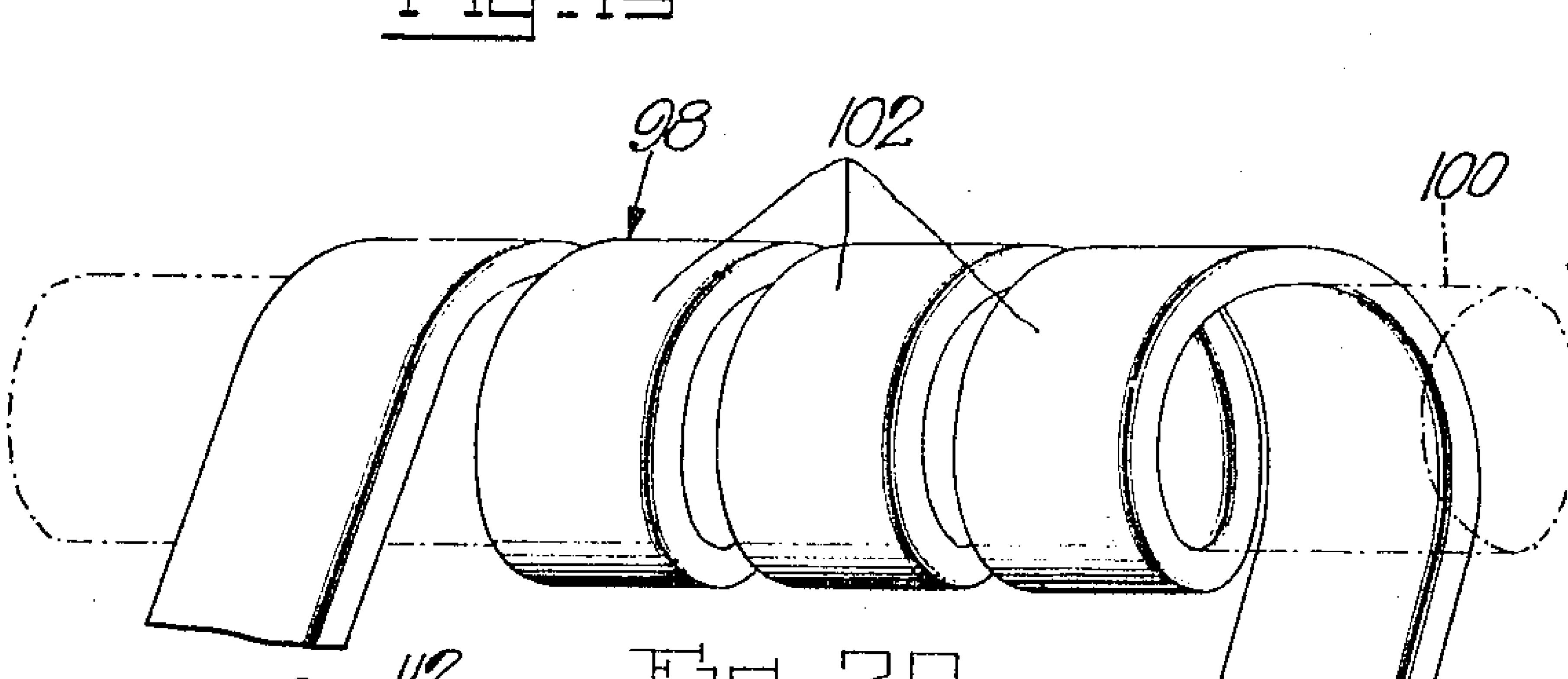


Fig. 20

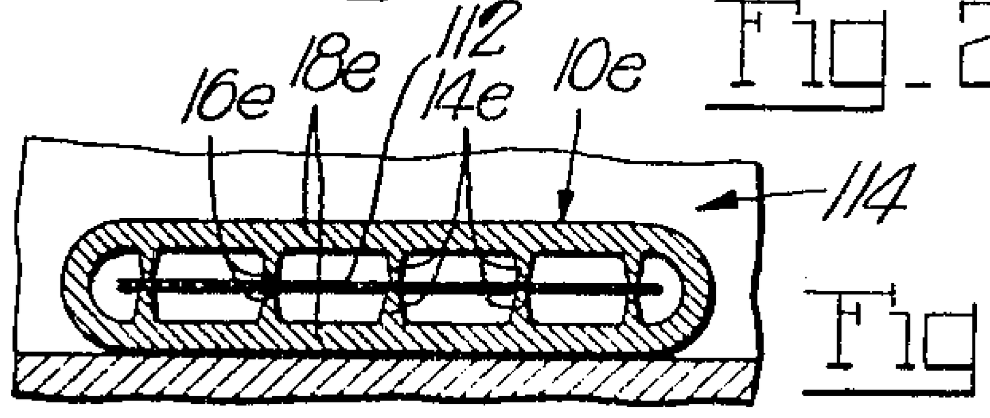
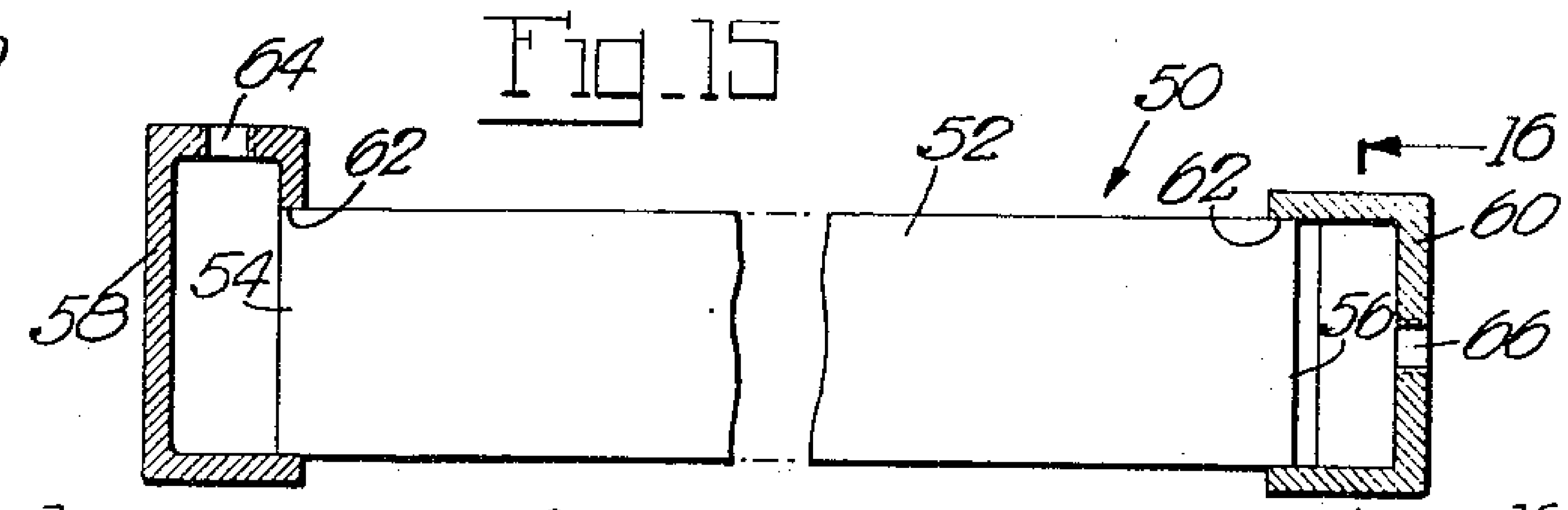


Fig. 23

Fig. 15



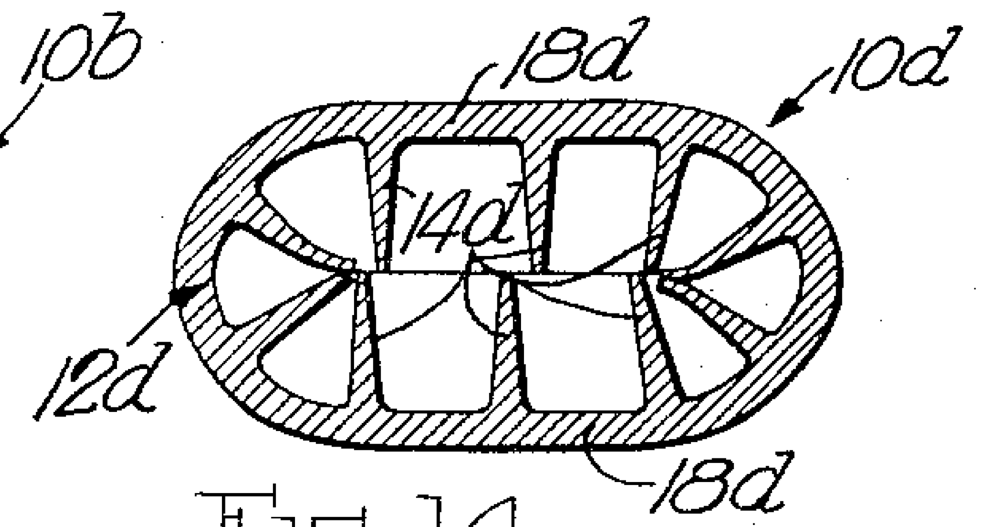


Fig. 14

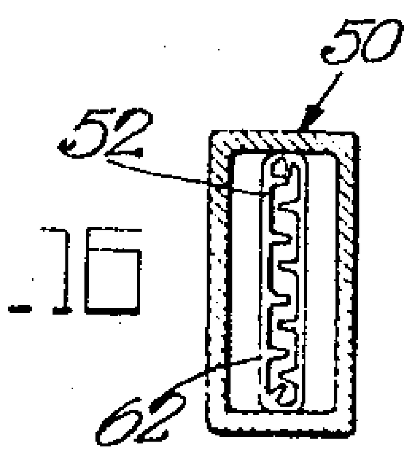
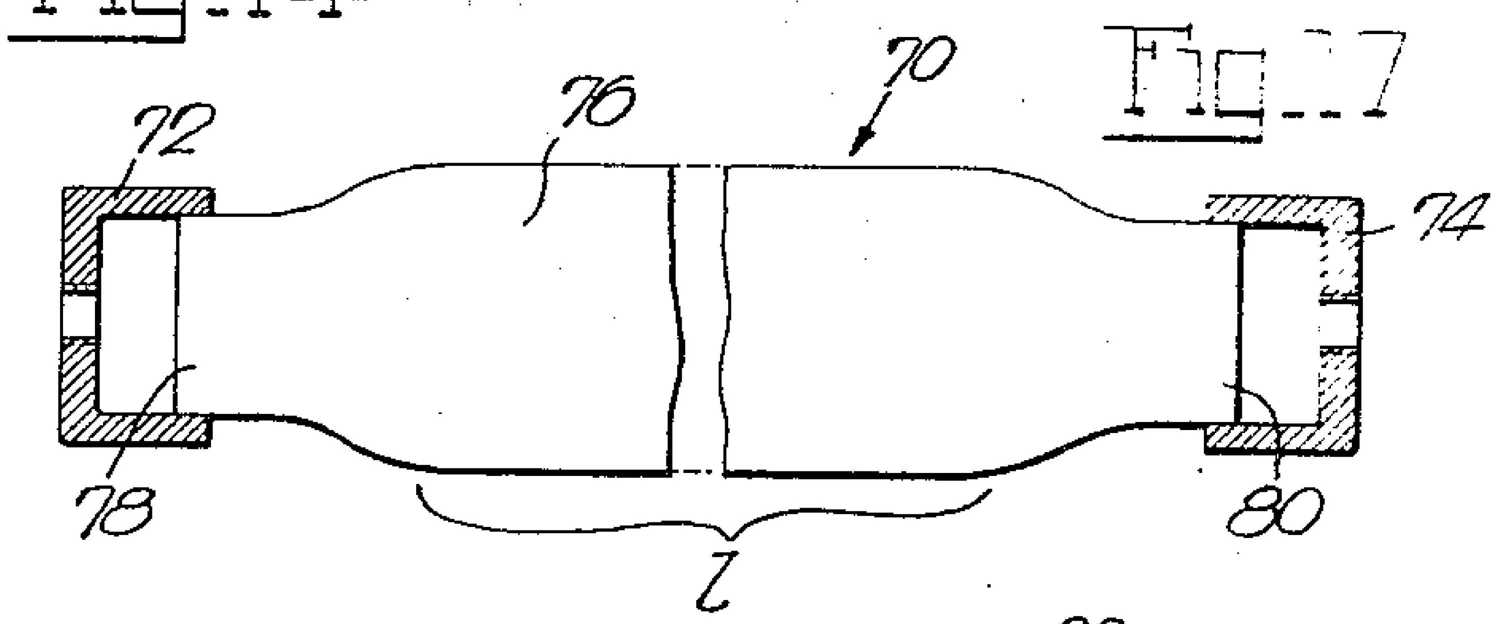


Fig. 16

Fig. 17



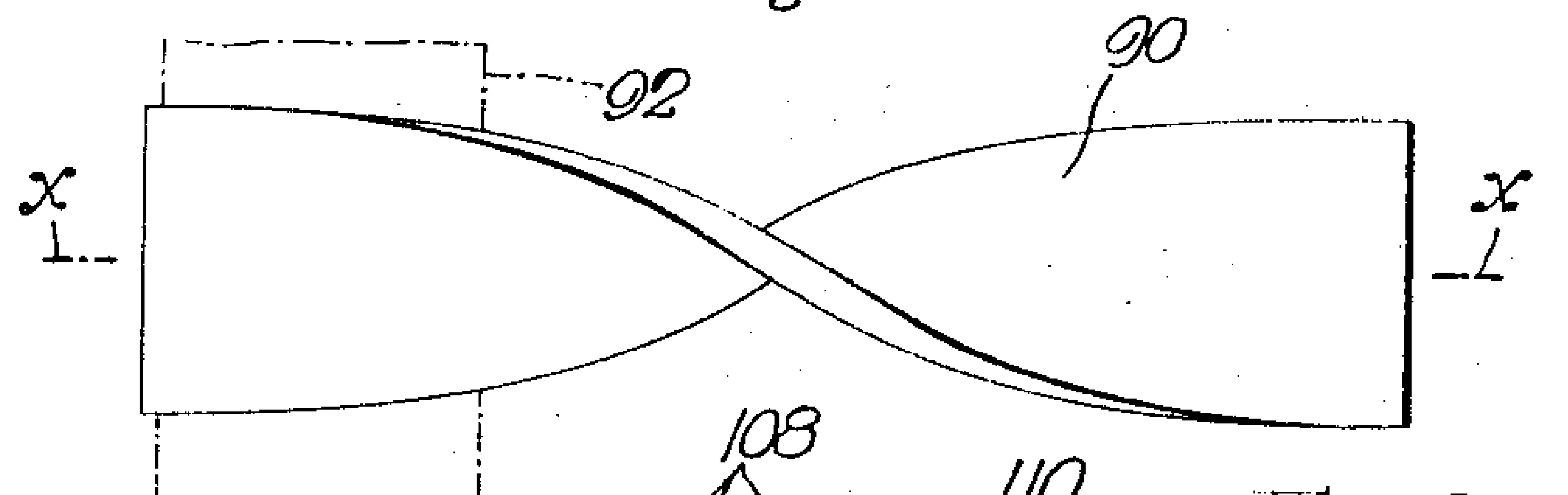


Fig. 18

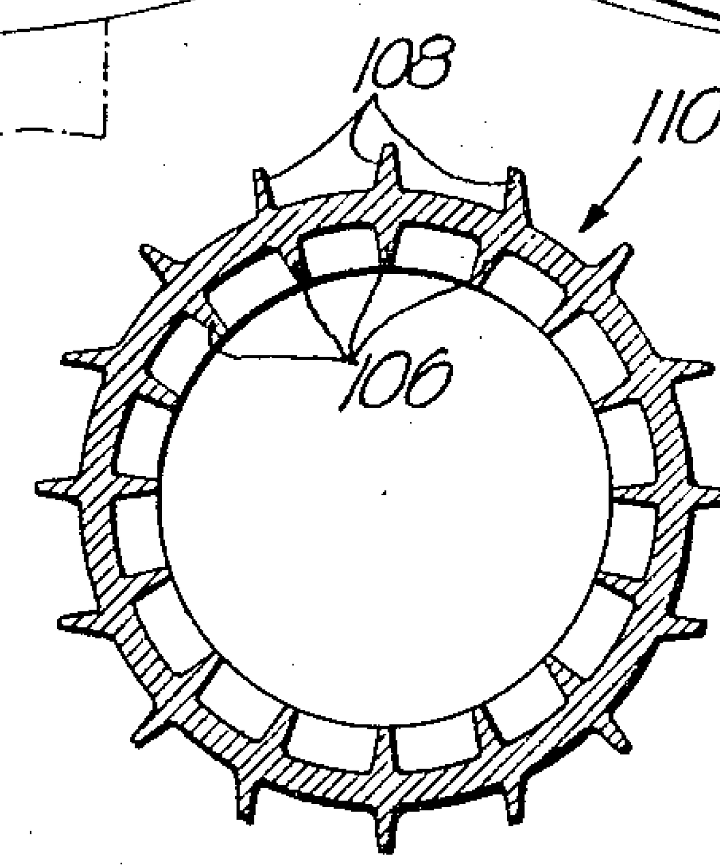


Fig. 22

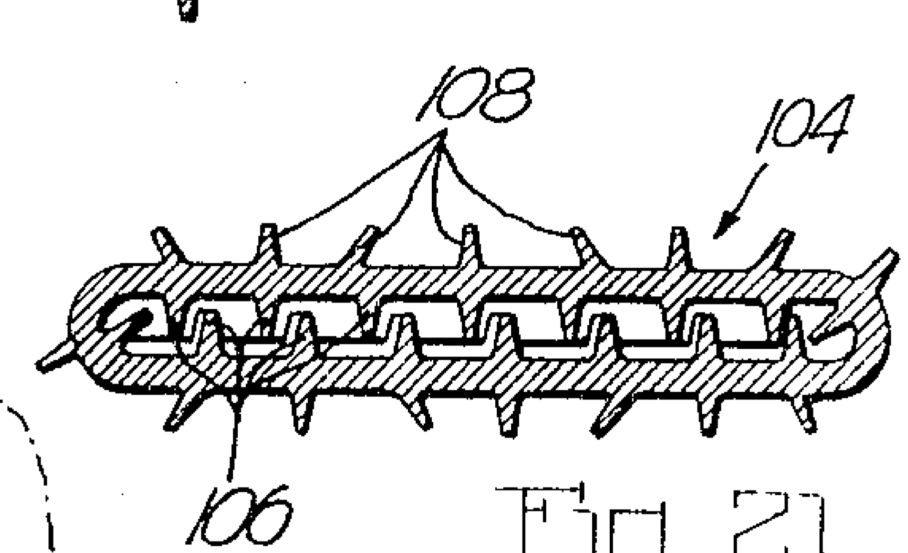


Fig. 21

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HEAT-EXCHANGE TUBING AND METHOD OF MAKING IT

This invention relates to heat-exchange tubing in general, and to finned heat-exchange tubing in particular.

The type of heat-exchange tubing with which the present invention is concerned is provided with inwardly extending fins, or so-called "inner" fins, on its peripheral wall. Tubing of this type is well known for its heat-exchange properties which vary from good to excellent, depending on the inner-fin pattern and size, the particular heat-exchange application, and other factors. However, even this type of tubing does not lend itself to certain exacting heat-exchange requirements for various applications. There are several reasons for this, and chief among them is that heat-exchange of the fins and also peripheral wall of such tubing with fluid passing through the latter is inadequate for certain purposes regardless of the height and number of the fins.

It is the primary object of the present invention to provide heat-exchange tubing of this type which meets many exacting heat-exchange requirements that cannot be met by the aforementioned known inner-fin tubing.

It is another object of the present invention to provide heat-exchange tubing of this type of which the peripheral wall and the inner fins are arranged to divide the entire interior of the tubing into individual flow channels of a number, depth and width to best meet specified heat-exchange requirements as well as other requirements, such as a specified volumetric flow rate of a fluid through the tubing, or to keep pressure drop of the fluid in the tubing within specified limits, for example.

It is a further object of the present invention to provide heat-exchange tubing of this type the interior of which is divided into flow channels for meeting various specific, including heat-exchange, requirements as aforementioned, by making the peripheral wall generally oblong in cross-section, with the same providing two opposite flat wall sections and opposite return wall sections which join the flat wall sections, and the fins on either flat wall section extend with their tips at least to the level of the tips of the inner fins on the other flat wall section. It is thus within the wide parameters of oblong cross-section of the peripheral wall and the number, height and spacing of the fins, that a great variety of heat-exchange tubing for many different applications may be fashioned.

Another object of the present invention is to devise a method of forming heat-exchange tubing of this type, which comprises providing a round inner-fin tube blank, and partially flattening the blank into the aforementioned oblong cross-section of its peripheral wall at which the fins on either one of the then opposite flat wall sections extend with their tips at least to the level of the tips of the fins on the other flat wall section. In thus forming the heat-exchange tubing, which may aptly be termed "flat" tubing, the number, height, spacing and direction of the fins therein may be selected from the wide variety of fin patterns and sizes which may readily be formed in round tubular blanks according to different known methods, but which could hardly, and never practically, be formed in flat tubing. Moreover, extreme simplicity characterizes the reformation of a round inner-fin tube blank into flat tubing of this kind in accordance with the present method, as by passing the round blank between rotary companion rolls or drawing the same through a die, all in a single pass, for example. Moreover, reformation in this fashion of a round tube blank particularly with helical inner fins into flat tubing of this type brings the fins into an entirely new and extremely effective cooperative relation, in that the then-straight fins on the respective flat wall sections abut and are inclined to and cross each other, with the result that these fins sharply divide and divert into different directions at each cross-section of the tubing much of the fluid flowing through the entirely finned passage in the tubing.

A further object of the present invention is to provide flat tubing of this type whose heat-exchange with a fluid passing therethrough is further enhanced, in that in the aforementioned partial flattening of a round inner-fin tube blank into the flat tubing, the flat opposite wall sections are spaced apart a distance at which the fins on either flat wall section extend with their tips beyond the level of the tips of the fins on the opposite flat wall section but remain spaced from the latter. With this arrangement, the path of fluid through the tubing is even more tortuous past the fins therein especially where the fins on the opposite flat wall sections cross each other, involving additional diversion of fluid within the channels between successive fins over the tips of opposite fins projecting within the confines of the channels. Further, where the fins on the opposite flat wall sections are inclined to and cross each other, the fins will over the extent of their interpress at their crossings readily give way in denting and there interlock without distorting the fin pattern.

It is another object of the present invention to provide heat-exchange tubing of this type which, if desired, may have graduated heat-exchange properties over different lengths or from one end to the other end, by simply partially flattening a round inner-fin tube blank to different extents so that the sets of inner fins on the respective flat opposite wall sections vary in their relative projection from level at their tips to interprojection.

It is a further object of the present invention to form heat-exchange tubing of this type according to the aforementioned method, and which is subsequently further deformed in cross-sectionally or longitudinally curved fashion, thereby to reenforce the tubing against spread-apart of their opposite flat wall sections under pressure from fluid passing through the tubing.

Another object of the present invention is to provide heat-exchange tubing of this type which for any, and even exceptional, length and, hence, heat-exchange capacity, may be of very condensed lengthwise construction, by lengthwise bending the tubing into more or less closely adjacent, successive helical turns, as around a cylindrical mandrel, for instance.

It is another object of the present invention to provide heat-exchange tubing of this type which is formed, according to the aforementioned method, from a round tube blank with inner and outer fins, so that the tubing has by virtue of the additional outer fins further enhanced heat-exchange properties. The outer fins on the round tube blank may longitudinally extend parallel to, or helically about, the tube axis, with neither axial nor helical outer fins interfering with orderly partial flattening of the blank on providing for suitable clearance of the outer fins in the blank-flattening tooling.

Further objects and advantages will appear to those skilled in the art from the following, considered in conjunction with the accompanying drawings.

In the accompanying drawings, in which certain modes of carrying out the present invention are shown for illustrative purposes:

FIG. 1 is a plan view of heat-exchange tubing embodying the invention;

FIGS. 2 and 3 are sections through the tubing taken on the lines 2—2 and 3—3, respectively, in FIGS. 1 and 2;

FIG. 4 is a cross-section through a round inner-fin tube blank from which the tubing of FIGS. 1 to 3 is fashioned;

FIG. 5 is a section through the tube blank on the line 5—5 in FIG. 4;

FIG. 6 is a cross-section through heat-exchange tubing embodying the invention in a modified manner;

FIG. 7 is a section through the modified tubing substantially along the line 7—7 in FIG. 6;

FIG. 8 is an enlarged section through part of the modified tubing substantially along the line 8—8 of FIG. 7;

FIG. 9 is a cross-section through heat-exchange tubing embodying the invention in another modified manner;

FIG. 10 is a section through the modified tubing of FIG. 9 along the line 10—10 thereof;

FIG. 11 is a cross-section through heat-exchange tubing embodying the invention in a further modified manner;

FIG. 12 demonstrates a step in the formation of heat-exchange tubing according to a method which also embodies the invention;

FIG. 13 demonstrates a modified step in the formation of heat-exchange tubing according to a method of the invention;

FIG. 14 is a cross-section through heat-exchange tubing of still another modification;

FIG. 15 is a side view, partly in section, of a heat exchanger embodying the featured tubing;

FIG. 16 is a section through the heat-exchanger along the line 16—16 in FIG. 15;

FIG. 17 is a side view, partly in section, of a modified heat-exchanger embodying the featured tubing;

FIG. 18 is a view of the featured heat exchange tubing with a longitudinal twist;

FIG. 19 is a section through the featured heat-exchange tubing which is also cross-sectionally curved;

FIG. 20 is a perspective view of the featured heat-exchange tubing which is also bent longitudinally into successive helical turns;

FIG. 21 is a cross-section through heat-exchange tubing embodying the invention in a further modified manner;

FIG. 22 is a cross-section through a round finned tube blank from which the heat-exchange tubing of FIG. 21 is fashioned; and

FIG. 23 is a cross-section through heat-exchange tubing embodying the invention in a still further modified manner.

Referring to the drawings, and more particularly to FIGS. 1 to 3 thereof, the reference numeral 10 designates heat-exchange tubing having a peripheral metal wall 12 of oblong cross-section and a multitude of metal fins 14 with tips 16. The peripheral wall 12 provides two flat opposite, and preferably parallel, wall sections 18, and opposite return wall sections 20 which join the flat wall sections 18, with the flat wall sections 18 constituting in this instance a far predominant part of the wall 12. The fins 14, which project inwardly from the wall 12 and are preferably formed integrally therewith, are of the same height which is such that the fins on either flat wall section 18 extend with their tips 16 to the level of the tips of the fins on the opposite flat wall section (FIG. 2), so that the entire interior of the flat tubing is within reach of the fins. Successive fins 14 on the wall 12 are preferably equally spaced, and the fins on either flat wall section 18 extend parallel to each other and at an inclination to the longitudinal axis x of the tubing, with the fins on the respective wall sections 18 being also inclined to and crossing each other (FIG. 3).

With the interior of the flat tubing being within full reach of the fins 14, the entire passage through the tubing is divided into individual flow channels 22, which makes for good heat-exchange between a fluid passing through the tubing and the fins 14 as well as peripheral wall 12 of the tubing. Heat-exchange between such fluid and the fins and peripheral wall of the tubing is even enhanced by the inclination to each other of the channels 22 on the opposite flat wall sections 18 (FIG. 3), in that they sharply divide and divert into different channels much of the fluid passing therein at each cross-section of the tubing.

The "flat" metal tubing 10 is advantageously formed from a round inner-fin tube blank 24 (FIGS. 4 and 5) in accordance with an exceedingly simple method. For reasons more fully apparent hereinafter, the peripheral wall of the blank 24 is of the same thickness and peripheral extent as the wall 12 of the flat tubing 10, and the fins of the blank are of the same height and thickness, and also spaced, as the fins 14 of the tubing, wherefore the peripheral wall and fins of the blank are appropriately designated by the reference numerals 12 and 14, respectively, i.e., the same as their counterparts of the flat tubing. Further, the fins 14 on the round wall 12 of the blank 24 extend longitudinally helically at the same helix angle throughout (FIG. 5).

The inner-fin tube blank 24 itself may be formed in any known manner, including brazing or otherwise joining inserted fins to the round wall of the blank, but preferably by displacement, according to different known methods, of metal from the wall of the blank into grooves on a mandrel therein to form the fins 14 integral with the wall. One such method is disclosed in my prior U.S. Pat. No. 3,422,518, dated Jan. 21, 1969, with this method involving externally swaging a cylindrical tube blank against a grooved mandrel therein in a single pass of the blank over and beyond the mandrel, whereby metal from the blank wall is displaced into the mandrel grooves to form the fins. This method is preferred, not only because the same is highly efficient and readily lends itself to the formation of an inner-fin tube blank of most any desired fin pattern and size, but also because the swaging of the blank over the mandrel entails quite extensive elongation of the blank. Such extensive elongation of the blank and the formation of the fins exclusively by metal from the blank wall entail a considerable reduction of the wall thickness of the finished inner-fin tube blank, which is highly advantageous in point of heat-exchange of the tube wall, and hence also entire tube, with a surrounding temperature-modifying medium, such as a coolant, for example.

The method of forming the inner-fin tube blank 24 into the flat tubing 10 simply involves partially flattening the blank to form opposite peripheral wall portions thereof into the flat parallel wall sections 18, which concludes the formation of the flat tubing 10. Such partial flattening of the round blank 24 may be achieved in any suitable manner, as by passing the blank between rotary companion rolls 30 and 32 in the direction of the arrow 34 (FIG. 12), or by drawing the blank through a die 36 in the direction of the arrow 38 (FIG. 13).

It follows from the preceding that the peripheral wall 12 of the flat tubing 10 is indeed the same wall 12 of the blank 24 which remains of the same thickness and peripheral extent. It is now also apparent that the fins 14 of the blank 24 and of the flat tubing 10 are indeed the same and retain their height and thickness as well as their spacing from each other. Further, in the course of partially flattening the round blank 24, the helically extending fins 14 will over the extent of the flat wall sections 18 of the tubing be extended into straight disposition (FIG. 3).

To bring the fins 14 for all practical purposes within full reach of the interior of the flat tubing 10, the fins in the round tube blank must obviously be spaced some distance from the axis of the blank. In this connection, it has been found that for a given inside diameter of the blank, the fin height may vary widely from less than the thickness of the peripheral blank wall to many times such wall thickness, with the fins of any height within this wide range being adequately spaced from the axis of the blank for its formation into flat tubing in which the fins are within full reach of the interior of the tubing. Within this wide range of fin height, and with available round inner-fin tube blanks of many different fin patterns and sizes, it is possible to obtain widely different flat inner-fin tubing which not only has good heat-exchange properties, but also meets other requirements, such as a specified volumetric flow rate of fluid through the tubing, or to keep pressure drop of passing fluid in the tubing within prescribed limits, for example. Thus, the number of fins, also their height within the above wide range, and the peripheral extent of the wall, of flat tubing may vary widely to meet many different, including heat-exchange, requirements. Insofar as the height of the fins is concerned, the same is for many, but not all, applications greater than the thickness of the peripheral wall of the tubing.

Reference is now had to FIGS. 6 and 7 which show flat inner-fin tubing 10*a* that basically differs from the described tubing 10 in that the fins 14*a* on either flat wall section 18*a* extend with their tips 16*a* beyond the level of the tips of the fins on the opposite flat wall section but remain spaced from the latter. The flat tubing 10*a* may otherwise be like the tubing 10 and, hence, formed from the same round inner-fin tube blank 24 (FIGS. 4 and 5), with the tubing 10*a* being formed by the same method as the tube 10, except that the round blank is partially flattened to an extent at which the fins on the opposite flat wall sections interproject. In thus partially flattening the round blank, the fins 14*a* on the opposite flat wall sections 18*a* are at, and over the extent of, their crossings 40 interpressed and thereby interlocked due to mutual denting of the fins thereat as at 42 (FIG. 8). Thus, due to the mutual denting of the fins at their crossings in consequence of partially flattening the round blank to the extent of part-way interprojecting the fins on the opposite flat wall sections, the fin pattern as such remains intact and is not distorted (FIG. 7). Owing to the part-way interprojection of the fins in this tubing, the fluid path therethrough is quite tortuous in any event, and may even vary considerably with different degrees of interprojection of the fins. Different interprojection of the fins is thus another tool toward achieving good heat-exchange and meeting other widely varying requirements, such as volumetric flow rate of a fluid passing through the tubing, or to keep pressure drop of the passing fluid within prescribed limits.

Reference is now had to FIGS. **9** and **10** which show flat heat-exchange tubing **10*b*** that is formed from a round inner-fin tube blank (not shown) in which the fins extend parallel to the axis of the blank. Thus, in partially flattening the round blank in accordance with the present method, all the fins **14*b*** in the flat tubing extend parallel to the longitudinal axis *xb*. In this exemplary flat tubing, the fins **14*b*** on the opposite flat wall sections **18*b*** interproject to some extent, though it is entirely obvious that by different partial flattening of the blank the fins on the flat opposite wall sections **18*b*** may interproject to a different extent, or the tips of the fins on either flat wall section **18*b*** may with their tips extend to the level of the tips of the fins on the other flat wall section **18*b***.

In the case of flat tubing in which the fins extend parallel to the longitudinal axis of the tubing, as in FIGS. **9** and **10**, it is also feasible partially to flatten the round inner-fin tube blank to the extent where the fins on either flat wall section extend with their tips to the opposite flat wall section, with such heat-exchange tubing **10*c*** being shown in FIG. **11**. In this tubing **10*c***, successive fins **14*c*** divide the interior of the tubing into flow channels **22*c*** which, in contrast to those in the described tubing **10**, **10*a*** and **10*b***, are closed to each other.

In the described flat heat-exchange tubing **10** to **10*c***, the two opposite flat wall sections constitute the predominant part of the peripheral wall of the tubing. While this is preferred for exacting heat-exchange and also other requirements of many applications, such as cooling the transmission oil of automotive vehicles, just to mention one such application, the advantages of having the fins within full reach of the interior of flat tubing are secured even where the two flat opposite wall sections do not constitute a predominant part, or even constitute less than one-half, of the peripheral wall of the tubing. Thus, FIG. **14** shows flat heat-exchange tubing **10*d*** of which the flat opposite wall sections **18*d*** constitute less than one-half of the peripheral wall **12*d*** of the tubing, with the round inner-fin tube blank (not shown) from which the tubing is fashioned being, in accordance with the present method, partially flattened to an exemplary extent at which the fins **14*d*** on either flat wall section **18*d*** extend with their tips to the level of the tips of the fins on the other flat wall section **18*d***. Further, the indicated fin height for the also indicated peripheral extent and thickness of the wall of the tubing obviously falls within the aforementioned fin-height range within which the fins in flat tubing are brought within full reach of the interior of the tubing.

Reference is now had to FIGS. **15** and **16** which show a heat-exchange unit **50** using a length of piece **52** of the featured flat inner-fin tubing, for example a piece of the flat tube **10*a*** of FIGS. **6** and **7**. The opposite ends **54** and **56** of the tube piece **52** are in communication with the interior of casings **58** and **60**, with the tube ends **54** and **56** being fitted in, and conveniently brazed to, slots **62** in the respective casings **58** and **60**. The casings **58** and **60** have tapped holes **64** and **66** for connection with conduits through which to lead a fluid, liquid or gas, to and from the unit **50** for temperature modification, such as cooling, for instance.

While in the described heat-exchange unit **50** the end casings **58** and **60** and their slots **62** are rectangular in section (FIG. **16**), FIG. **17** shows a heat-exchange unit **70** of which the end casings **72** and **74** are circular in section. To this end, the length or piece **76** of featured inner-fin tubing is, in its formation from a round inner-fin tube blank, partially flattened only over its longitudinal extent *l* so that opposite end lengths **78** and **80** of the tubing remain cylindrical, and these cylindrical end lengths **78** and **80** are connected with the casings **72** and **74**.

In many heat-exchange applications, the fluid passing through the featured flat inner-fin tubing is under operating pressure which may be sufficiently high to "open" the tubing by forcing the opposite flat sections of the peripheral wall more or less apart, such as the flat wall sections **18** to **18*c*** of the described tubing **10** to **10*c***, for example, and thereby greatly reducing the heat-exchange capacity of the tubing, if not rendering the tubing unfit for further use in a particular heat-exchange application. Opening of the tubing in this fashion and from this cause is in many cases prevented by additionally curving the same longitudinally, or transversely, or both, and thereby reenforcing the tubing against such opening. Thus, a length **90** of the featured flat inner-fin tubing may be twisted about its longitudinal axis *x* (FIG. **18**), whereby the tubing becomes curved, longitudinally as well as transversely, over its lengthwise extent, and is thereby reenforced against opening under internal pressure. The tube length **90** may be twisted by forcing the same through a correspondingly twisting opening in a die **92**.

FIG. **19** shows a piece **94** of the featured flat inner-fin tubing which is transversely curved for reenforcement against opening under internal pressure. The initially flat tube piece **94** may to this end be drawn through a die **96** with an opening of the outline of the curved tubing.

FIG. **20** shows a piece **98** of the featured flat inner-fin tubing which is longitudinally curved for reenforcement against opening under internal pressure. This is achieved in this instance by bending the flat tubing around a cylindrical arbor **100**. The exemplary tube piece **98** is of quite extensive length with correspondingly large heat-exchange capacity, and in order greatly to reduce the lengthwise expanse of the longitudinally curved tubing, the tubing is bent around the arbor **100** in successive and more or less closely adjacent helical turns **102**.

While the flat heat-exchange tubing described so far has only inner-fins, such flat tubing may have both, inner and outer fins. Thus, FIG. **21** shows flat heat-exchange tubing **104** which has inner and outer fins **106** and **108**. The tubing **104** is, in accordance with the present method, formed from the round inner-and outer-fin tube blank **110** (FIG. **22**). The outer fins **108** extend in this instance parallel to the axis of the blank, but they may also extend helically, with the partial flattening of the round tube blank into the flat tubing being in either case entirely feasible on providing companion flattening rolls, for example, with suitable slots for clearing the outer fins.

Reference is now had to FIG. **23** which shows flat heat-exchange tubing **10*e*** that may be like the tubing **10** of FIG. **2**, except that there is interposed between the tips **16*e*** of the fins **14*e*** on the opposite flat wall sections **18*e*** a longitudinal strip **112** of any suitable brazing material. One of these strip materials, which is commercially available, is known to the trade as SIL-FOS and manufactured by Handy and Harman. The brazing strip **112** is inserted in the course of flattening the initially round inner-fin tube blank into the flat tubing **10e**, with the strip **112**, which is shown of exaggerated thickness for clarity's sake, being engaged by the tips of the fins. The flat tubing **10*e*** is then heated, as in a furnace **114**, for example, to melt the brazing strip **112** and brace the fins together at their crossing tips, with the excess brazing material spreading over nearby portions of the fins. The tubing **10*e***, being thus brazed together at the crossing tips of the fins, will not open under operational, including particularly high, internal fluid pressures. Brazing of flat tubing at the crossing tips of the fins is indicated where higher internal operational fluid pressures are involved, and especially for applications of such tubing which require that the same remains flat and is not to be curved for reenforcement against opening under internal fluid pressure. Of course, brazing of flat tubing in this manner applies as fully for tubing in which the inner-fins become interpressed in the course of flattening the initially round inner-fin tube blank into the flat tubing, as in FIG. 6, for example.

I claim:

1. Method of forming longitudinal heat-exchange tubing, which comprises providing a round metal tube blank having an axis, a peripheral wall about said axis, and longitudinal inner-fins on said wall, with said fins being of equal height and spaced from said axis; and forming the entire interior of the blank into individual flow channels of a depth within the height of the fins, by partially flattening the blank from two opposite sides into oblong cross-section with two opposite flat parallel wall sections at a spacing at which the fins on one flat wall section extend with their tips at least to the level of the tips of the fins on the other flat wall section.

2. Method of forming longitudinal heat-exchange tubing as in claim 1, in which the fins on the peripheral wall of the round tube blank extend helically thereof at the same helix angle, whereby in said partial flattening of the blank the fins on said flat wall sections are extended straight and are inclined to and cross each other.

3. Method of forming longitudinal heat-exchange tubing as in claim 2, in which the blank is partially flattened until the fins on either flat wall section extend with their tips beyond the level of the tips of the fins on the other flat wall section but are spaced from the latter, and metal of the fins on the flat wall sections, respectively, is displaced at their crossings for interpress of the fins at their crossings into interlock with each other.

4. Method of forming longitudinal heat-exchange tubing as in claim 1, in which the tubing is subsequently bent into curved extension longitudinally thereof.

5. Method of forming longitudinal heat-exchange tubing as in claim 1, in which the flat wall sections are subsequently bent into transversely-curved parallel disposition.

6. Method of forming longitudinal heat-exchange tubing as in claim 1, in which the tubing is subsequently bent longitudinally into successive helical turns.

7. Longitudinal heat-exchange tubing as in claim 2, in which the fins on the respective flat wall sections are brazed together at their crossings.

8. Method of forming longitudinal heat-exchange tubing as in claim 2, which further comprises, in the course of partially flattening the blank and before the fins on one flat wall section extend with their tips to the level of the tips of the fins on the other flat wall section, inserting between the tips of the fins on said flat wall sections, respectively, a longitudinal metal brazing strip; and subsequent to the partial flattening of the blank heating the tubing to melt said strip and thereby braze the fins together at their crossings.

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