

[54] **INTERNAL FINNED TUBE AND METHOD OF FORMING SAME**

[72] Inventor: Charles E. Drake, Stroudsburg, Pa.

[73] Assignee: The Patterson-Kelley Co., Inc., East Stroudsburg, Pa.

[22] Filed: Feb. 16, 1970

[21] Appl. No.: 11,623

[52] U.S. Cl. 138/38, 165/109, 165/179, 165/186

[51] Int. Cl. F28f 13/12

[58] Field of Search 165/109, 179, 186; 138/38

[56] **References Cited**

UNITED STATES PATENTS

2,895,508	7/1959	Drake	165/109
2,869,836	1/1959	Huet	165/179

2,864,405 12/1958 Young 165/109

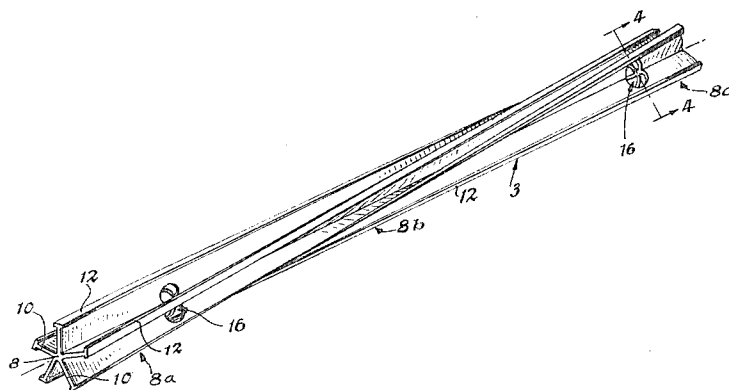
Primary Examiner—Charles Sukalo
Attorney—Bean & Bean

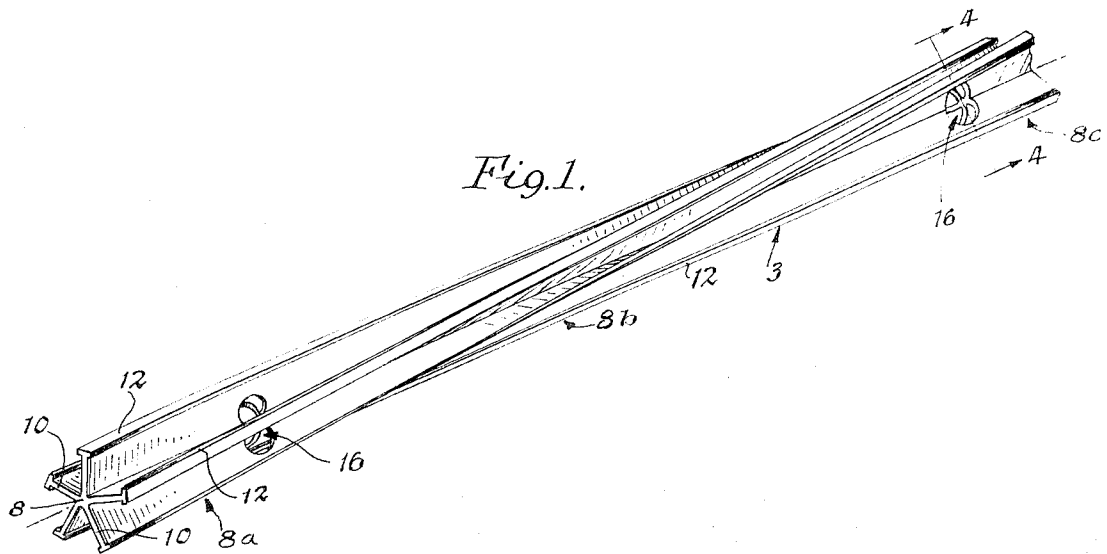
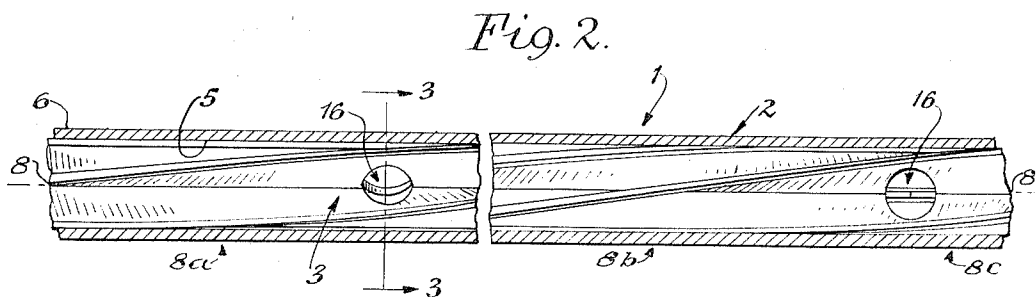
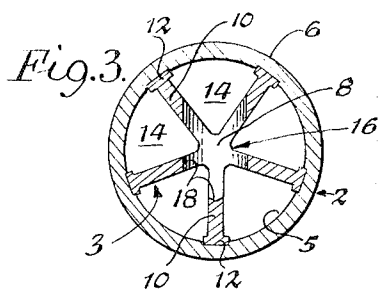
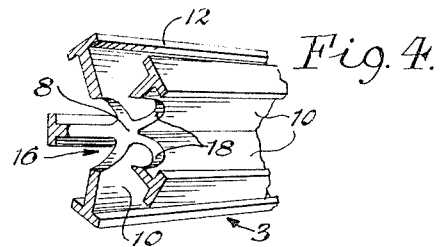
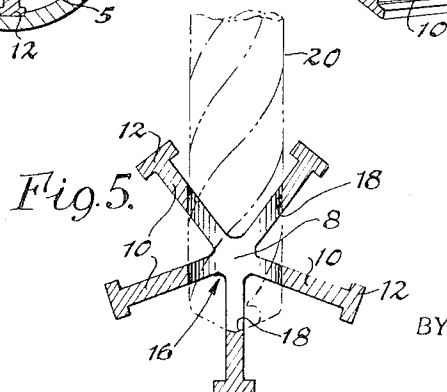
[57] **ABSTRACT**

A tube-type heat exchanger wherein a fin member, including a central core portion and a plurality of fins extending radially therefrom, is located within a tube such that the fins have a close interference fit with the inner wall of the tube. The core portion is composed of a plurality of axially spaced segments, and the fins bridge a space between and interconnect adjacent segments. The space between adjacent segments establishes communication across the core portion between flow paths bounded radially of the core portion by the tubular member and fins.

The core portion is segmented subsequent to extrusion forming of the fin member by directing a cutting member into engagement with the core portion along a line extending transversely of the fin member.

4 Claims, 5 Drawing Figures





INVENTOR
CHARLES E. DRAKE

BY

Bean & Bean
ATTORNEYS

INTERNAL FINNED TUBE AND METHOD OF FORMING SAME

BACKGROUND OF THE INVENTION

In U.S. Pat. No. 3,394,736 there is disclosed a fin-type heat exchanger, wherein a fin member having a central core portion and a plurality of fins extending radially therefrom is placed within a tubular member and the tubular member swaged, drawn, or otherwise reduced in diameter so as to form an intimate interference engagement between the radial outer edges of the fins and the inner surface of the tubular member. By interconnecting the fin and tubular members in this manner, there is obtained a very effective heat transfer connection. Heat exchangers of this type have found use in refrigeration systems, wherein the medium to be cooled is exposed to the exterior of the tubular member and refrigerant is passed through the tubular member along flow paths defined by the fins.

Primary features of the tubular heat exchanger disclosed by the aforementioned patent are the arranging of the fins in a spiraled relationship relative to the longitudinal axis of the fin member and the provision of openings at axially spaced locations in the fins immediately adjacent the inner surface of the tubular member. The openings establish communication between adjacent flow paths defined by the tubular member and the fins, whereas movement of the medium through the openings is encouraged by the centrifugal forces acting upon the medium as a result of the spiraling of the fins. The provision of openings in the fins adjacent the inner surface of the tubular member is intended to prevent unequal ratios of refrigerant and gas from existing in the various flow paths in an effort to maintain the heat absorbing characteristics of the heat exchanger consistent throughout the circumference of the tubular member.

One drawback of the above mentioned heat exchanger is its increased construction costs, due to the fact that each fin opening requires a separate punching or other machining operation. Furthermore, care must be exercised during the fin opening forming operation and subsequent fin member handling operations to prevent deformation of the radially outer free edge areas of the fins immediately adjacent the openings. Such deformation of the fins would tend to interfere with or prevent insertion and/or joining of the fin member with the tubular member, and if not corrected prior to joining of the members would result in partial blockage of the refrigerant flow paths into which the deformed areas of the fins extend.

Further, normal refrigerant flow rates do not for practical purposes, permit a single set of fin openings arranged at any given point along the heat exchanger to equalize conditions existing in all of the flow paths at such point. This problem becomes increasingly acute as the number of fins or flow paths increases, since equalizing of conditions may require the passage of medium transversely of several adjacent flow paths. While uniform conditions could of course be established by increasing the number of openings per unit length of the heat exchanger, the machine costs would likely render the resultant heat exchanger financially noncompetitive with similar but less effective products.

SUMMARY OF THE INVENTION

The present invention relates to an improved fin-type tube heat exchanger of the type described in U.S. Pat. No. 3,394,736 and to a method of forming same. More particularly, the present invention provides an improved fin member construction, which insures uniform heat characteristics throughout the circumferential dimension of the tubular member, while overcoming the disadvantages inherent in prior art constructions.

In accordance with the present invention the fin member is provided with a core portion composed of a plurality of segments, which are interconnected in axially spaced relationship by the fins. The space between adjacent segments is effective to simultaneously establish free flow communication between

all of the flow paths defined by the fin and tubular members, thereby resulting in uniform heat exchange conditions within the several flow paths regardless of number.

In the preferred form of the invention, the free inner edges of portions of the fins bridging the space between adjacent segments define notches, which open towards the space and serve to facilitate flow between adjacent flow paths bounded by fins with which the notches are associated. The nonnotched portions of the fins, which bridge the space between adjacent segments, cooperate to maintain rigidity of the fin member. Furthermore, with this construction there exists no fin areas which are readily subject to being deformed out of the plane of its associated fin, during the notch forming or subsequent fin member handling operations.

It is a specific feature of the present invention that the core portion of an extrusion formed fin member may be segmented and the fins simultaneously notched by a single material removing operation, thereby greatly facilitating and reducing the cost of manufacture of the present heat exchanger.

DRAWINGS

The nature and mode of operation of the present invention will be more fully described in the following detailed description taken with the accompanying drawings, wherein:

FIG. 1 is a perspective view of a fin member constructed in accordance with the present invention;

FIG. 2 is an elevational, sectional view of a heat exchanger constructed in accordance with the present invention;

FIG. 3 is a sectional view taken generally along the line 3—3 in FIG. 2;

FIG. 4 is a sectionalized perspective view taken generally along the line 4—4 in FIG. 1; and

FIG. 5 is a sectional view of a fin member illustrating the preferred mode of segmenting the core portion thereof and simultaneously forming notches in the fins.

DETAILED DESCRIPTION

A tubular fin type heat exchanger formed in accordance with the present invention, which is generally designated as 1 in FIGS. 2 and 3, comprises a tubular member 2 and a fin member 3 located within the tubular member.

Tubular member 2 is defined by cylindrical inner and outer surfaces 5 and 6, respectively, and preferably formed of a relatively soft metal, such as copper or aluminum, having a high coefficient of thermal conductivity.

Now referring particularly to FIGS. 1-3, it will be understood that fin member 3 in its preferred form comprises an axially extending core portion 8 and a plurality of fins 10, which are integral with and extend radially from core portion 8. Preferably, fin member 3 is spiraled with respect to its longitudinal axis, that is each of fins 10 is spiraled in a longitudinal direction about the axis of core 8. Fins 10 may be, as desired, spiraled during fin member forming or by a subsequent operation. In practice, it has been found that for a fin member having an overall diameter of about 0.6 inch, a one complete spiral for every 2 feet of linear length of the fin member produces advantageous results.

Fin member 3 is preferably formed by an extrusion process from a metal having a high coefficient of thermal conductivity. The material of fin member 3 is preferably of a greater hardness than the material of tubular member 2 in order to permit proper interference fit to be accomplished in the manner to be hereinafter described. Normally, the tubular member is formed of copper and the fin member is formed of an alloy having a greater hardness than that of copper, such as one of the aluminum alloys 63S-T5, 63S-T6 or 63S-T2, properly aged.

Fins 10, which may be three or more in number depending on the requirements of the heat exchanger, are preferably equally spaced about the axis of core portion 8, and are formed with a generally T-shaped section on the radially outer boundary edges thereof, as indicated at 12. The T-shaped sec-

tion increases the circumferential length of the fin edges and thereby greatly increases the area of contact between the tubular and fin members when assembled.

To assemble heat exchanger tube 1, fin member 3 is located within tubular member 2 and the tubular member thereafter radially contracted, as by a drawing operation, so as to bring tube inner surface 5 into interference fit relationship with fin edges 12. With tube 1 assembled in this manner, there are defined a plurality of flow paths 14 for heat exchange medium, which are bounded outwardly of core portion 8 by adjacent pairs of fins 10 and the tube inner surface 5.

Conventionally, heat exchangers of the type thus far described are employed for chilling or refrigeration purposes, and a suitable refrigerant comprises the heat exchange medium which is to be passed through flow paths 14. Refrigerant is normally in the form of a gas having particles of liquid entrained therein. However, it will be understood that heat exchangers formed in accordance with the present invention may be employed in any heat transfer application, wherein a material is passed through flow paths 14.

It will be understood that the specific structural features of tube 1, as thus far described, are conventional, and are shown only for purposes of illustration. Thus, it will be appreciated that applicant's invention, which will now be described in detail, may be employed with heat exchangers, wherein fin members having any desired number of fins, wherein the fins are of any desired cross-sectional configuration and are either straight or spiraled; and wherein the fin member is formed by means other than an extrusion operation and joined to the tubular member in any desired fashion.

In accordance with the present invention, core portion 8 is composed of a plurality of segments, designated generally at 8a, 8b and 8c in FIGS. 1 and 2, which are interconnected in an axially spaced relationship by fins 10. The space or opening between the ends of adjacent segments, which is generally indicated at 16 serves to simultaneously establish communication across core portion 8 between all of flow paths 14. As a result, heat exchange media may be uniformly distributed throughout the cross-sectional configuration of the heat exchange tube, thereby insuring that the heat absorbing characteristics of the heat exchanger will remain constant throughout the circumferential dimension of tubular member 2.

As a practical matter, except where the diameter of core 8 is relatively large as compared to the overall diameter of fin member 3 such that fins 10 cover only a relatively limited portion of the surface of the core portion, it is necessary to provide notches 18 adjacent the radially inner edges of those portions of fins 10, which bridge between adjacent core portion segments. As will appear from FIGS. 1-4, notches 18 open into space 16 and serve to greatly facilitate the flow of heat exchange medium both between relatively remote flow paths across core portion 8 and between pairs of adjacent flow paths bounded by the fins with which the notches are associated.

The positioning of notches 18 adjacent the radially inner edges of fins 10 permits a substantially greater amount of fin material to be removed without objectionably reducing the elastic strength of fin member 3, than would be the case if notches were to be arranged adjacent the radially outer edges of fins 10. When fin member 3 is formed of common aluminum alloys mentioned above, the radial depth of notches 18 may exceed 50 percent of the radial dimension of their associated fins, thereby insuring equalizing flow between the several flow paths at each point along the heat exchanger at which core portion 8 is segmented.

Moreover, by positioning notches 18 in the manner described, there exists no projecting or unsupported corners adjacent the notches, which would be subject to deformation during the notch forming or subsequent fin member handling operations.

FIG. 5 illustrates the preferred mode of segmenting core portion 8 and/or simultaneously segmenting the core portion and forming notches 18 in all of fins 10. In the simplest form of

this operation, a fin member is laid in a suitable jig, not shown, and a "single hole" is formed therein by moving a suitable metal cutting device of circular cross section, such as a drill, shown in phantom at 20 along a line, which is substantially normal to the axis of core portion 8 and substantially bisects the angle defined by a pair of adjacent fins. Any burrs produced during the cutting operation would be removed in order to prevent blockage of the notches and/or flow paths. Of course, it will be understood that material may be removed from the fin members to form opening 16 and/or notches of any desired configuration and in any suitable manner, such as for instance by punching or flame cutting operations. As will be apparent, cuts may be made along lines at angles other than 90° to the axis of the core portion, so long as the strength of the fin members is not critically diminished, as by cutting through the radially outer boundary edges of the fins.

It will be understood that the "single hole" forming operation preferably results in both the segmenting of the core portion and notching of the fins. The spacing between openings formed by the "single hole" forming operation described is normally on the order of about 6 to 8 inches for a five finned fin member having nominally one complete spiral for every 2 feet of length, depending on the accuracy of the spiraling operation. Of course, opening spacings less or greater than that described may be employed depending on heat exchange operating requirements.

As will be apparent from viewing FIG. 5, a disparity between the sizes of notches 18 formed in the respective fins of a five-finned member illustrated results from a "single hole" forming operation. However, as a practical matter, slight disparities in notch sizes obtained by forming a "single hole" in fin members having 3, 4 or 5 fins does not unduly reduce efficiency of their operation. Of course, efficiency is maximized by employing a cutting tool whose diameter is limited only by the requirement that a notch formed by any given fin will have an effective radial dimension less than that which would result in damage to the fin, and by performing material removing operation through the fin member at the same or substantially the same point along a line bisecting the angle defined by more than one pair of adjacent fins.

Alternatively, fluid communication across the core portion may be provided by a grouping of two or more closely adjacent "single holes" at each station lengthwise of the fin member at which it is desired to obtain uniform heat exchange conditions. When employing groupings of holes, each hole is preferably "clear through" the core portion and provides notches in all of the fins, since otherwise maximum possible efficiency is not realized.

Also, it is within the scope of the present invention to provide for fluid communication at any given station lengthwise of the fin member, by replacing a "single hole" opening or a grouping thereof with a slot opening or axially spaced slot openings, which are preferably elongated in a direction lengthwise of the fin member. Slot openings may be formed by milling or grinding operations, as well as any of the cutting operations mentioned above. Of course it will be understood that materials other than those specifically discussed above may be employed in forming the tubular and fin members.

I claim:

1. In a heat exchange tube construction including an outer tubular member, and an internal fin member disposed within and extending axially of said tubular member, said fin member having a central core portion and a plurality of fins joined to and extending radially from said core portion, said fins being elongated axially of said core portion and each being radially outwardly bounded by an outer edge portion, said fin outer edge portions being joined to an inner surface of said tubular member for providing an intimate heat-conductive engagement between said fin member and said tubular member, the improvement wherein:

said core portion is composed of a plurality of axially spaced segments, and said fins bridge a space between and interconnect adjacent segments, said space between adjacent

5

6

segments establishing communication across said core portion between flow paths bounded radially of said core portion by said tubular member and said fins.

2. The improvement in a heat exchange tube according to claim 1, wherein portions of said fins bridging said space are radially inwardly bounded by free inner edge portions, said inner edge portions defining notches opening towards said space and having radial dimensions less than the radial dimen-

sion of their associated fins.

3. The improvement in a heat exchange tube according to claim 1, wherein said core portion and said fins are integrally formed.

4. The improvement in a heat exchange tube according to claim 3, wherein said fins are spiraled relative to the longitudinal axis of said fin member.

* * * * *

10

15

20

25

30

35

40

45

50

55

60

65

70

75