United States Patent [19]

Pasternak

[11] **3,866,286**

[45] **Feb. 18, 1975**

[54] **METHOD OF MAKING A FINNED TUBE HEAT EXCHANGER HAVING A CIRCULAR CROSS SECTION**

[75] Inventor: **Stephen F. Pasternak,** Park Ridge, Ill.

[73] Assignee: **Peerless of America, Incorporated,** Chicago, Ill.

[22] Filed: **July 2, 1973**

[21] Appl. No.: **375,764**

[52] **U.S. Cl.**..... **29/157.3 A,** 29/157.3 V, 72/325

[51] **Int. Cl.**..... **B21d 53/02,** B23p 15/26

[58] **Field of Search**... 29/157.3 A, 157.3 B, 157.3 V; 72/325

[56] **References Cited**

UNITED STATES PATENTS

3,136,037	6/1964	Solnick et al.	29/157.3 V
3,202,212	8/1965	Kritzer	29/157.3 A X
3,222,764	12/1965	Hansson et al.	29/157.3 A
3,692,105	9/1972	O'Connor	29/157.3 B X
3,781,959	1/1974	O'Connor	29/157.3 A
3,791,003	2/1974	Pasternak	29/157.3 B

Primary Examiner—C. W. Lanham
Assistant Examiner—D. C. Reiley, III
Attorney, Agent, or Firm—Root & O'Keeffe

[57] **ABSTRACT**

A method of making heat exchangers in the form of an elongated tubular member, of substantially round transverse cross-section and having outwardly projecting fins thereon, which include initially forming the tubular member into a substantially rectangular transverse cross-sectional shape, forming the fins on the outer faces of the tubular member, and then expanding the tubular member into the aforementioned substantially round cross-sectional shape.

11 Claims, 8 Drawing Figures

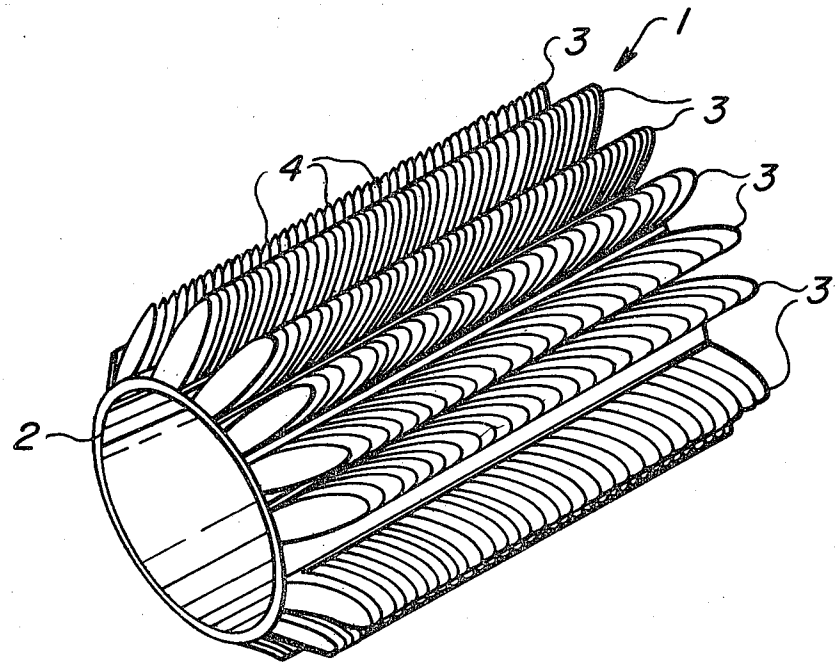


FIG - 1

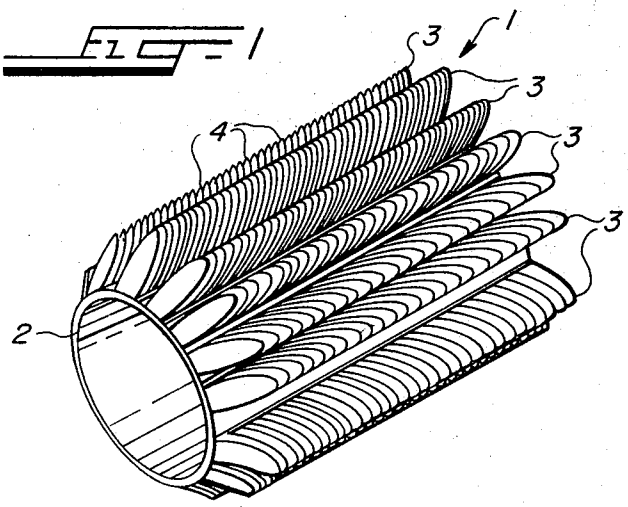


FIG - 7

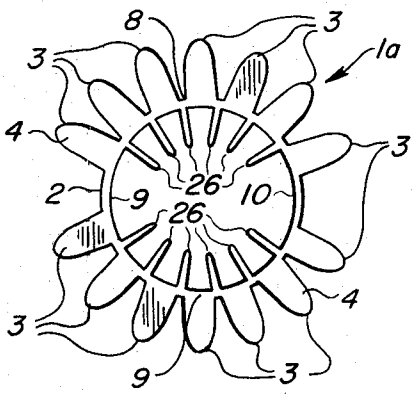


FIG - 2

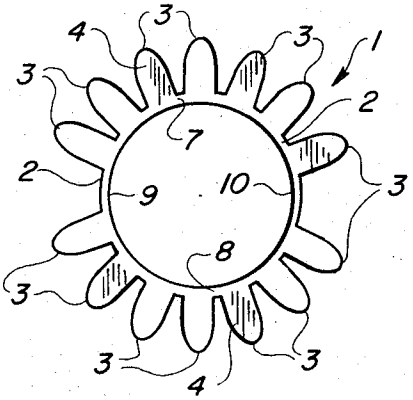


FIG - 3

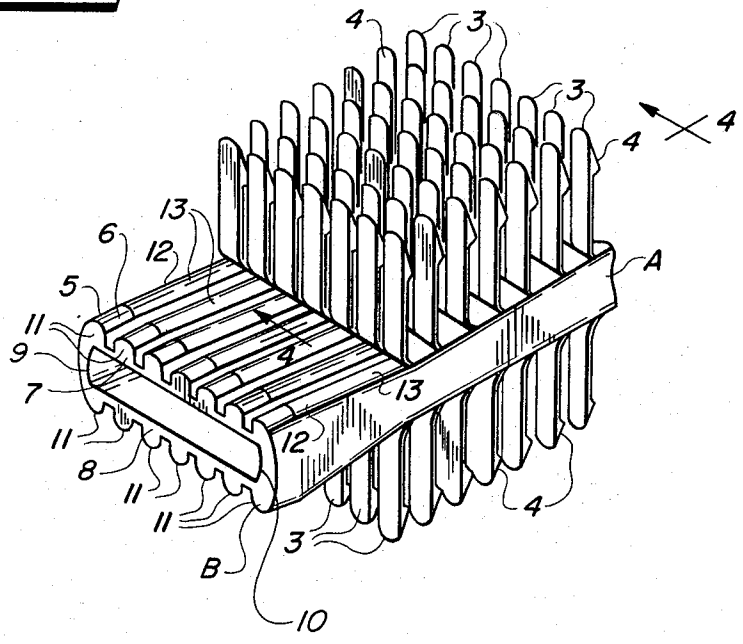


Fig - 4

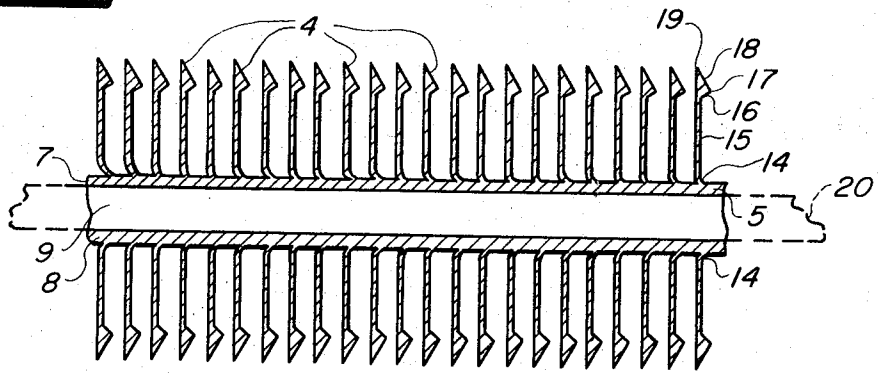


Fig - 5

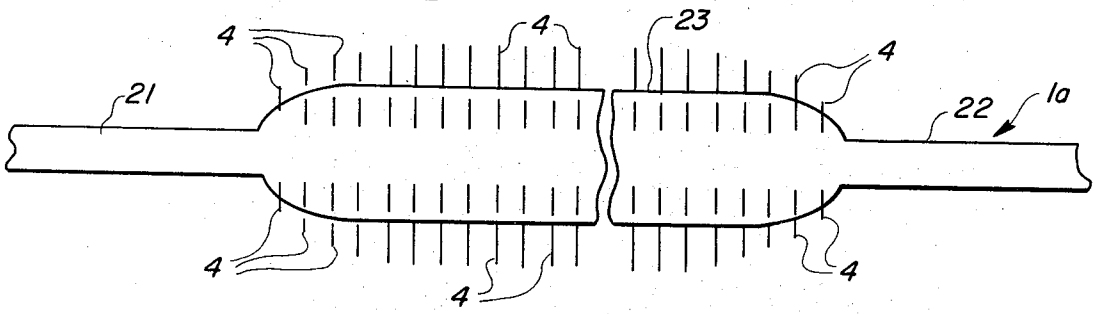


Fig - 6

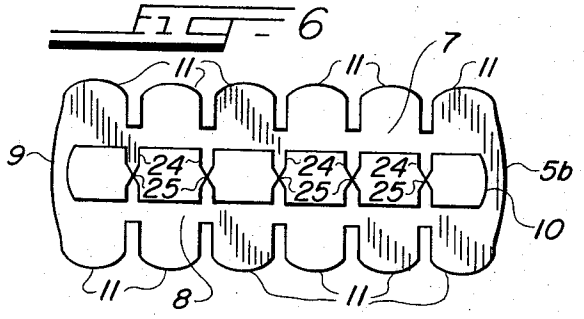
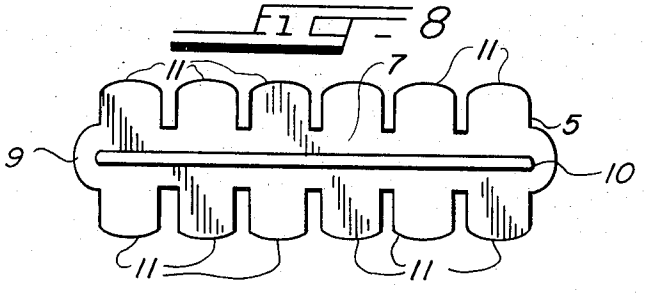


Fig - 8



METHOD OF MAKING A FINNED TUBE HEAT EXCHANGER HAVING A CIRCULAR CROSS SECTION

BACKGROUND OF THE INVENTION

This invention relates to methods of making heat exchangers, and, more particularly, to methods of making heat exchangers of the externally finned or spined type, which are substantially round in transverse cross-section.

It is a primary object of the present invention to afford a novel method of making heat exchangers.

Another object of the present invention is to afford a novel method of making a tubular heat exchanger, which is substantially round in transverse cross-section and has outwardly projecting spines or fins on the outer periphery thereof.

A further object of the present invention is to afford a novel method of making a substantially round heat exchanger embodying integrally formed spine-type fins.

Heat exchangers, which are susbstantially round in transverse cross section and embodying integral spine-fins on the outer periphery thereof have been heretofore known in the art, being shown for example in R. W. Kritzer U.S. Pat. No. 2,247,243 wherein needle-like spines are cut or gouged from the round, tubular wall of the heat exchanger in relatively thin, sharp slivers; in my U.S. Pat. No. 3,727,682, which discloses a round, tubular heat exchanger wherein spines are cut or sliced from the outer periphery of the heat exchanger during relative rotary movement between a cutting tool and the tubular member; and R. W. Kritzer U.S. Pat. No. 3,360,040 wherein longitudinally extending fins on the outer periphery of such a round tubular member are transversely slit to form the outwardly projecting spines.

Although spine-type, round, tubular heat exchangers of the aforementioned types heretofore known in the art have been highly successful and have had much commercial success and the methods of making the same have been successful, such methods have had certain inherent disadvantages, such as, for example, the speed of production realized therefrom being relatively slow; the number of spines which may be formed around the periphery of the tubular member being limited because of the necessity of affording space for the spine-forming mechanisms; requiring the expenditure of large sums of money for tooling; requiring different tools for different diameters of tubing; or requiring machines of desirably large size, and the like. It is an important object of the present invention to overcome such disadvantages.

Methods of making heat exchangers, which comprise successively cutting or gouging spines or fins from ribs formed on the outer periphery of a tubular member, which is substantially rectangular in transverse cross section, have been heretofore known in the art, being disclosed, for example, in R. W. Kritzer U.S. Pat. No. 3,202,212. It is another important object of the present invention to enable heretofore known methods of the aforementioned type to be utilized in a novel and expeditious manner as a part of a novel method of making outwardly spined, tubular heat exchangers which are substantially round in transverse cross section.

Another object of the present invention is to afford a novel method of making an externally spined heat exchanger, which is substantially round in transverse cross section, wherein the spines may be integrally formed on substantially flat surfaces of substantial width.

Yet another object of the present invention is to enable an internally ribbed, outwardly spined heat exchanger, which is substantially round in transverse cross section, to be made in a novel and expeditious manner.

A further object of the present invention is to afford a novel method of making an externally spined tubular heat exchanger, having a substantially round transverse cross section, which is practical and efficient, and which may be readily and economically used commercially.

Other and further objects of the present invention will be apparent from the following description and claims and are illustrated in the accompanying drawings which, by way of illustration, show the preferred embodiments of the present invention and the principles thereof and what I now consider to be the best mode in which I have contemplated applying these principles. Other embodiments of the invention embodying the same or equivalent principles may be used and structural changes may be made as desired by those skilled in the art without departing from the present invention and the purview of the appended claims.

DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** is a perspective view of a heat exchanger, exemplifying the preferred type of construction afforded by the present invention;

FIG. **2** is an end view of the heat exchanger shown in FIG. **1**;

FIG. **3** is a fragmentary, perspective view of a tubular member, illustrating an intermediate step in the formation of the heat exchanger shown in FIG. **1**;

FIG. **4** is a fragmentary longitudinal sectional view taken substantially along the lines **4—4** in FIG. **3**;

FIG. **5** is a somewhat diagrammatic view, illustrating a modified form of the present invention;

FIG. **6** is an end view of a tubular member, illustrating a step in another modified form of the present invention;

FIG. **7** is an end view, similar to FIG. **2**, but illustrating the type of heat exchanger afforded by the method embodying the step illustrated in FIG. **6**; and

FIG. **8** is an end view of a tubular member, illustrating an intermediate step in another modified form of the present invention.

DESCRIPTION OF THE EMBODIMENTS DISCLOSED HEREIN

A tubular heat exchanger or heat transfer element **1** is shown in FIGS. **1** and **2** of the drawings to illustrate a a preferred form of heat transfer element to be afforded by the preferred method of the present invention.

The heat exchanger **1** is substantially round in transverse cross section and embodies an elongated tubular sidewall portion **2**, from the outer periphery of which a plurality of rows **3** of fins in the form of elongated spines **4** project outwardly. The rows **3**, preferably, are disposed in parallel relation to each other, and extend longitudinally of the wall portion **3** in parallel relation to the longitudinal axis of the latter.

In making the heat exchanger **1** in accordance with the preferred method of the present invention, a tubular member **5**, FIGS. **3** and **4**, is first formed of any suitable material, such as, for example, aluminum, the tubular member having the construction of the end portion **6** of the tubular member **5**, shown in FIG. **3**. With this construction, it will be seen that the tubular member **5**, when it is so formed, is substantially rectangular in transverse cross section, and embodies two substantially parallel, oppositely disposed sidewall portions **7** and **8**, interconnected at their respective, opposite longitudinal edges by two other oppositely disposed sidewall portions **9** and **10**, which, preferably, are slightly convex outwardly, as shown in FIG. **3**. The tubular member **5** is of greater width between the sidewall portions **9** and **10** then it is between the sidewall portions **7** and **8**. Each of the sidewall portions **7** and **8** has a plurality of elongated ribs **11** projecting transversely, outwardly from the outer face thereof, and extending longitudinally thereof in parallel, transversely spaced relation to each other, FIG. **3**.

After the tubular member **5** has been so formed, the fins **4** may be formed thereon in the rows **3** by successively, from one end portion of the tubular member A toward the other end portion B thereof, cutting or gouging the rows **3** of fins **4** from the respective ribs **11** in the manner disclosed in the aforementioned Kritzer U.S. Pat. No. 3,202,212. In this operation, the spines or fins **4** are formed on each rib **11** by means of a suitable cutting tool, which first cuts along lengthwise of the respective rib to form the surface **12**, FIG. **3**, and then continues to form the surface **13**. The spine thus cut or gouged from the rib is then bent outwardly preferably to approximately 90° with respect to the plane of the rib. This gives each spine a configuration illustrated in FIGS. **2** and **3** wherein it may be said that each spine **4** has a base portion **14**, integral with the respective wall portion **7** or **8** to which it is attached, an intermediate thin portion **15** of rectangular cross section, a portion **16** sloping outwardly from the intermediate portion **15** to afford an enlarged portion **17**, and another portion **18** sloping inwardly from the enlarged portion **17** and terminating at the outer end of the spine **4** in a thin edge **19**, FIG. **4**. Although, because of the spacing of the fins **4** along the ribs, the spines **4** are initially formed with the enlarged portions **17**, the cutting operation causes the fins **4** to compress longitudinally so that, as a practical matter, the enlargements **17** substantially disappear on fins of usual thickness, to thereby afford a relatively smooth-sided appearance for the outer ends of the fins **4** similar to that shown in FIG. **1**.

Thereafter, in the practice of the preferred method of the present invention, the tubular member **5** may be cut off to the desired length, such as, for example, the length of the heat exchanger **1**, FIG. **1**, and expanded into a form wherein the transverse cross-sectional shape thereof is round, or substantially round, to thereby afford the heat exchanger **1** shown in FIGS. **1** and **2**. It will be seen that in the expanded form of the original tubular member **5**, which affords the heat exchanger **1**, the sidewall portions **7–10** are disposed in such relation to each other as to afford the substantially circular shaped sidewall portion **2**, with the rows **3** of fins **4** on the sidewall portions **7** and **8** separated by the arcuate shaped sidewall portions **9** and **10**, FIG. **2**. The spacing of the rows **3** on the sidewall portion **7** from the rows **3** on the sidewall portion **8** may be controlled by controlling the width of the sidewall portions **9** and **10**, the spacing being greater with greater widths of the sidewall portions **9** and **10** and being lesser with lesser widths of the sidewall portions **9** and **10**.

During the cutting or gouging of the spines **4** from the ribs **11**, the tubular member **5** may be internally supported, if desired, such as, for example, by inserting a supporting block or rod, such as the rod **20** shown in broken lines in FIG. **4** thereinto, the rod **20**, preferably, complete filling the tubular member **5** and being disposed therein with a snug but freely slidable fit. After the fins **4** have been formed on the tubular member **5**, the rod **20** may be removed prior to expansion of the tubular member **5** into the finished form represented by the heat exchanger **1**.

The expansion of the tubular member **5** from the shape shown in FIGS. **3** and **4** into the shape which affords the substantially round tubular member **2** of the heat exchanger **1**, shown in FIGS. **1** and **2**, may be accomplished in any suitable manner such as, for example, mechanically expanding it by passing a mandrel, such as, for example, an internal expanding mandrel or draw rod therethrough. However, where the various factors, such as, for example, the wall thickness and the material from which the tubular member **5** is constructed, permit, I prefer to effect the expansion of the tubular member **5** into the rounded form of the tubular member **2** by passing working fluid, such as, for example, compressed air or hydraulic fluid or the like, thereinto at a confined pressure suitable for effecting such expansion but less than the pressure required to burst the tubular member. For example, with the tubular member **5** made from aluminum, and with the tubular member **2** having an inside diameter of 1 ¼ inches and a wall thickness of .040 inches, and with **14** ribs or rows of spines **4** disposed around the outer periphery of the finished tubular member **2**, a pneumatic or hydraulic pressure in the nature of from 550 to 750 pounds per square inch is suitable for effecting the desired expansion of a tubular member of the type of the member **5**, shown in FIG. **3**, to a substantially round tubular member, such as the tubular member **2**, shown in FIGS. **1** and **2**. The initial, slightly convex-outwardly shape of the narrower sidewalls **9** and **10** assists in the forming of the round shape of the sidewall **2** in the finished heat exchanger.

If desired, the fins **4** may be formed on the tubular member **5** at an intermediate portion thereof, which is spaced from the opposite ends of the tubular member **5**. Subsequently, during the expansion of the tubular member **5** into the aforementioned substantially round, transverse cross sectional shape, the opposite end portions of the tubular member **5** may be firmly clamped by suitable means such as clamping dies, or the like, not shown, so as to prevent expansion of the end portions, and working fluid may then be passed into the tubular member **5** to thereby cause expansion of the intermediate portion thereof, disposed between the aforementioned opposite end portions. This method is effective to produce a heat exchanger of the type somewhat diagrammatically illustrated in FIG. **5**, wherein an elongated heat exchanger **1***a*, embodying two end portions **21** and **22**, disposed on opposite sides of an intermediate portion **23** is shown. The fins **4** were formed on only the intermediate portion **23** of the tubular member so that the end portions **21** and **22** of the finished heat ex-

changer 1*a* have smooth outer peripheries. In this latter type of construction, the end portions 21 and 22 afford highly practical members for quickly and easily connecting the heat exchanger 1*a* to headers, to other tubular members, or to an accumulator, and the like.

In FIG. 6, a tubular member 5*b* is shown which comprises a modified form of the original tubular member 5, as represented by the end portion 6 of the tubular member 5 shown in FIG. 3. The tubular member 5*b* is identical in construction to the aforementioned tubular member 5 except that the tubular member 5*b* embodies a plurality of ribs 24 extending between the sidewall portions 7 and 8 and disposed in substantially parallel, spaced relation to each other between the sidewalls 9 and 10. The internal ribs 24 extend longitudinally of the tubular member 5*b* throughout the full length thereof, and preferably embody weakened portions 25 midway between the sidewall portions 7 and 8. The tubular member 5*b* may be formed in any suitable manner such as, by extruding the same. and the weakened portions 25 may be formed therein by reducing the thickness of the aforementioned mid portion of the ribs 24 to a thickness substantially less than the thickness of the remainder thereof.

With the tubular member, which is formed as the first step of the method of making a heat exchanger in the practice of the present invention, constructed in the manner of the tubular member 5*b*, shown in FIG. 6, effective internal support is afforded for the sidewall portions 7 and 8 during the forming of fins 4 on the ribs 11. Preferably, the weakened portion 25 is of sufficiently narrow thickness that the internal ribs 24 may be severed therealong merely by the application of the pressure afforded by the working fluid fed into the tubular member 5*b*, after the spines have been formed on the ribs 11 thereof, in the same manner as hereinbefore described with respect to tubular member 5, shown in FIG. 3. However, if desired, the internal ribs 24 may be slit along the mid-portions thereof after the fins 4 have been formed on the tubular member 5*b*, and before the latter is expanded by the passing of working fluid thereinto.

As is illustrated in FIG. 7, the heat exchanger which results from the method including the formation of a tubular member such as the tubular member 5*b*, FIG. 6, is similar in construction to the heat exchanger shown in FIG. 2, but instead of having an unobstructed passageway therethrough, embodies internal ribs 26, which are afforded by the severed portions of the ribs 24.

In FIG. 8, an intermediate step in another modified form of method of the present invention is shown. In the modified method illustrated in FIG. 8, after the original tubular member 5, with the ribs 11 disposed thereon has been formed, and prior to the formation of the spines 4, the tubular member 5 is flattened from the form shown in FIG. 3 to a form such as that shown in FIG. 8, wherein the sidewall portions 7 and 8 are disposed in close adjacent relation to each other and the sidewalls 9 and 10 are bowed outwardly. Such flattening of the tubular member 5 may be accomplished in any suitable manner such as, for example, passing the same between rollers having ribs thereon, which mate with the spaces between the ribs 11. Such flattening of the tubular member 5 preferably is accomplished by the cold working thereof so as not to effect any welding together of the sidewall portions 7 and 8.

Preferably, in this method, the flattening is carried out to such an extent that the sidewall portions 7 and 8 are disposed in abutting engagement with each other, or, at least, to an extent that the passageway through the tubular member 5 is reduced to such a narrow slit that support is afforded between the adjacent sidewall portions 7 and 8 during the subsequent operation, wherein the fins 4 are cut of gouged from the ribs 11.

As will be appreciated by those skilled in the art, although it is preferred that the flattening of the tubular member 5, during the method illustrated in FIG. 8, is of such magnitude that the aforementioned support is afforded between the sidewall members 7 and 8, if the flattening is not carried out to such an extent, suitable support for the sidewall members 7 and 8 during the fin-cutting operation, may be afforded by passing a block or rod, not shown, of suitable dimensions into the tubular member 5, in a manner similar to that in which the rod 29 is shown inserted into the tubular member 5 in FIG. 4, to afford the desired support for the sidewall portions 7 and 8 during forming of the fins 4.

It will be remembered that during the flattening operation of the tubular member 5, the sidewall portions 9 and 10 are bowed outwardly, as shown in FIG. 8. This is true whether the flattening operation is carried out to the greatest extent possible or to a lesser extent. In either event, the sidewall portions 9 and 10 have been changed from a substantially flat form, as shown in FIG. 3, to a convex-outwardly shape, as shown in FIG. 8, so that during subsequent expansion of the tubular member 5, from the shape shown in FIG. 8 to the substantially round configuration, such as illustrated in FIGS. 1 and 2, the sidewall portions 9 and 10 are more readily converted into a rounded configuration, which is desirable in order to afford, or at least approach a true circular configuration for the cross sectional shape of the tubular sidewall portion 2 of the finished heat exchanger.

Preferably, in the practice of the last mentioned method of the present invention, wherein the tubular member 5 is flattened, as illustrated in FIG. 8, after such flattening of the tubular member 5, the rows 3 of the fins 4 are formed on the ribs 11 in the same manner as hereinbefore described with respect to the method wherein expansion is effected of a tubular member from the shape shown in FIG. 3.

Preferably, in the expansion of the tubular member 5 from flattened condition, such as shown in FIG. 8, a suitable tool such as, for example, a wedge-shaped tool, not shown, is inserted into one end portion of the tubular member 5 for a suitable distance such as, for example 2 to 3 inches, to thereby open the end portion sufficiently to facilitate the subsequent expansion of the tubular member. This preliminary expansion of the one end portion of the flattened tubular member 5 may be of any suitable amount, such as, for example, that sufficient to move the end portions of the sidewalls 7 and 8 away from each other a distance of between ¼ and ½ inch.

The subsequent expansion of the flattened tubular member 5, after the aforementioned initial opening or expansion of the one end portion thereof may be effected mechanically or by the use of pressurized working fluid as previously discussed with respect to the method illustrated in FIGS. 1–4. If it is to be performed mechanically, preferably it is accomplished by the passage of a suitable expanding mandrel, such as, for ex-

ample, a bullet-shaped mandrel, which may be inserted into the preliminarily expanded one end portion of the tubular member, and then passed onwardly through the tubular member **5**. If working fluid such as, for example, compressed air or hydraulic fluid is used for expanding the tubular member **5**, it may be fed thereinto through the aforementioned one end thereof.

Upon completion of the expansion of the tubular member **5**, by the method which includes flattening thereof, as illustrated in FIG. **8**, a heat exchanger similar to the heat exchanger as shown in FIGS. **1** and **2**, and which is round or substantially round in cross section, is afforded.

From the foregoing, it will be seen that the present invention affords a novel method of making an externally spined tubular heat exchanger which is substantially round in transverse cross section.

Also, it will be seen the present invention affords a novel method of the aforementioned type which is commercially practical and efficient.

Thus, while I have illustrated and described the preferred embodiments of my invention, it is to be understood that these are capable of variation and modification, and I therefore do not wish to be limited to the precise details set forth, but desire to avail myself of such changes and alterations as fall within the purview of the following claims.

I claim:

1. The method of making a heat transfer element comprising
- a. forming an elongated tubular member having
  - **1.** a transverse width in one direction which is greater than the width thereof in the direction perpendicular to said one direction,
  - **2.** oppositely disposed outer wall portions extending along said first mentioned width, and
  - **3.** transversely spaced, outwardly projecting elongated ribs on the outer surfaces of said wall portions and extending longitudinally of said tubular member
- b. successively, longitudinally of said tubular member, cutting fins from said ribs,
- c. turning said fins outwardly into outwardly projecting relation to said wall portions, and
- d. then expanding said tubular member into a more rounded transverse cross-sectional shape.

2. The method of making a heat transfer element comprising
- a. forming an elongated tubular member having
  - **1.** a substantially rectangular transverse cross-sectional shape,
  - **2.** two oppositely disposed, substantially parallel walls extending the width of said tubular member, and
  - **3.** a plurality of transversely spaced, elongated ribs projecting outwardly from said walls and extending longitudinally of said tubular member,
- b. successively, longitudinally of said tubular member, cutting fins from said ribs,
- c. turning said fins outwardly into outwardly projecting relation to said walls, and
- d. expanding said tubular member, with said fins thereon, into a substantially round, internal, transverse cross-sectional shape.

3. The method as defined in claim **2**, and in which
- a. said forming of said tubular member includes forming a plurality of internal ribs therein, which
  - **1.** extend longitudinally thereof, and
  - **2.** extend between said two walls in substantially parallel relation to each other, and
- b. said expanding of said tubular member includes separating each of said internal ribs into two spaced parts.

4. The method as defined in claim **3**, and in which
- a. said forming of said internal ribs includes forming the portions thereof which are disposed substantially midway between said two walls of reduced thickness as compared to the remainder of said ribs.

5. The method as defined in claim **2**, and which includes
- a. flattening said tubular member into position wherein said two walls are disposed in more closely adjacent relation to each other prior to said cutting of said fins.

6. The method as defined in claim **5**, and in which
- a. said flattening of said tubular member is performed to an extent wherein, during the subsequent cutting of fins from said ribs, said two walls are disposed in abutting engagement with each other.

7. The method of making a heat transfer element comprising
- a. forming an elongated tubular member having
  - **1.** a substantially rectangular transverse cross-sectional shape.
  - **2.** two oppositely disposed, substantially parallel walls extending the width of said tubular member, and
  - **3.** a plurality of transversely spaced elongated ribs projecting transversely outwardly from each of said walls and extending longitudinally of said tubular member,
- b. successively, longitudinally of said tubular member, cutting elongated spines from said ribs,
- c. turning said spines outwardly into outwardly projecting relation to said walls, and
- d. passing expanding means into said tubular member and thereby expanding said tubular member into a substantially round transverse cross-sectional shape, with said spines projecting outwardly and forming the outermost peripheral portion thereof.

8. The method defined in claim **7**, and in which
- a. said expanding means comprises a mandrel.

9. The method defined in claim **7**, and
- a. which includes flattening said tubular member into position wherein said two walls are disposed in more closely adjacent relation to each other prior to said cutting of said spines, and
- b. in which
  - **1.** said expanding means includes a tool,
  - **2.** said tool is passed into one end portion of said tubular member to cause initial expansion thereof, and
  - **3.** thereafter other expanding means is passed into said tubular member to effect final expansion thereof.

10. The method defined in claim **7**, and in which
- a. said expanding means comprises working fluid.

11. The method defined in claim **10**, and which includes
- a. clampingly holding spaced opposite end portions of said tubular member during said passing of said working fluid into said tubular member to thereby restrain said end portions against said expansion and thereby limit said expansion to the portion of said tubular member disposed between said end portions.

* * * * *