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Boose

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[54] **I-TYPE SEGMENTED FINNED TUBE AND ITS METHOD OF MANUFACTURE**

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Related U.S. Application Data

[63] Continuation of Ser. No. 49,874, June 25, 1970, abandoned.

[30] **Foreign Application Priority Data**

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June 23, 1971	Germany	G 71 24 100.4
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June 24, 1971	Italy	69157 A/71
June 25, 1971	Japan	46/45802

[52] **U.S. Cl.** **219/62,** 219/107
[51] **Int. Cl.** **B23k 1/16**
[58] **Field of Search** 219/62, 67, 104, 219/107, 117

[56] **References Cited**

UNITED STATES PATENTS

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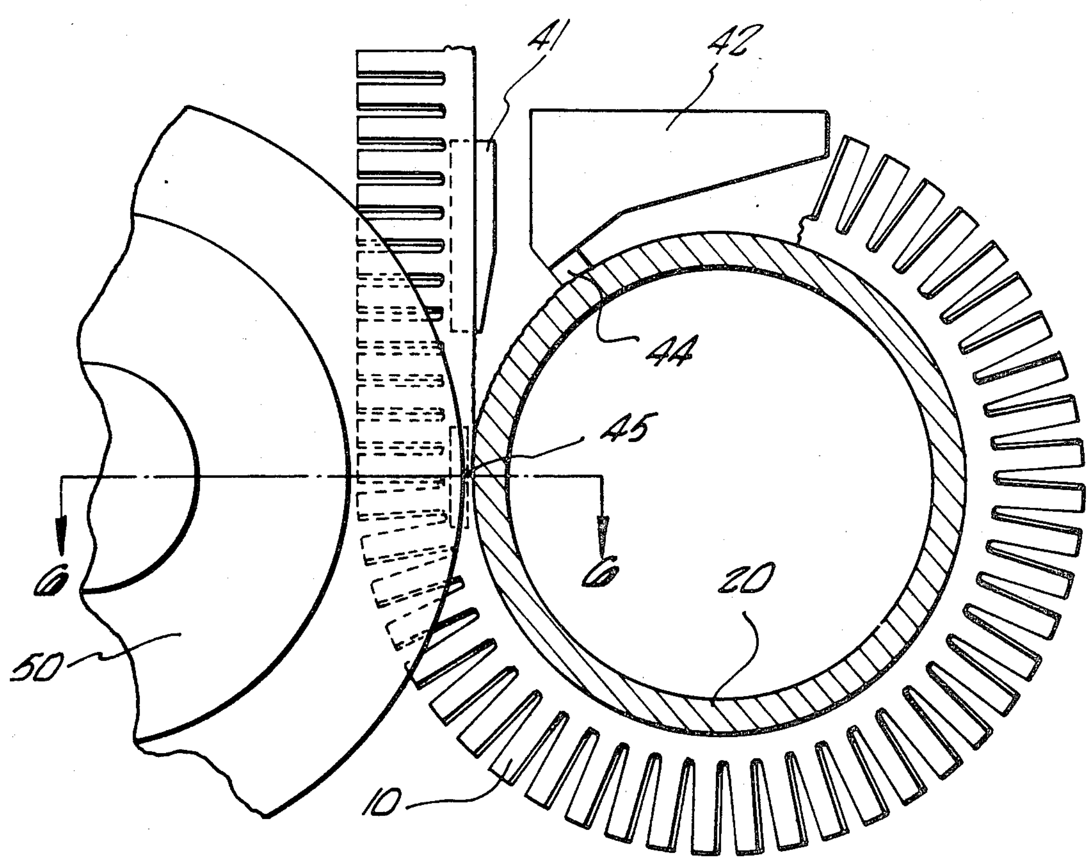
Attorney—Harold L. Jackson et al.

[57] **ABSTRACT**

An I-type segmented finned tube is disclosed having a fin composed of an elongated flat strip of metal, the upper portion of which forms the major fin portion having a plurality of segmented fins formed thereon and extending radially outward therefrom. The lower portion of the flat strip forms the base which serves as a contact area for a welding electrode.

The method of bonding the segmented fin to the tube is accomplished by an ultra-high frequency welding process which melts the root portion of the fin and the registering surface of the tube just prior to their mutual engagement. A force is then applied to the tips of the fins at the point of mutual engagement to forge the molten root portion of the fin to the molten surface of the tube to create a fused bond therebetween.

10 Claims, 8 Drawing Figures



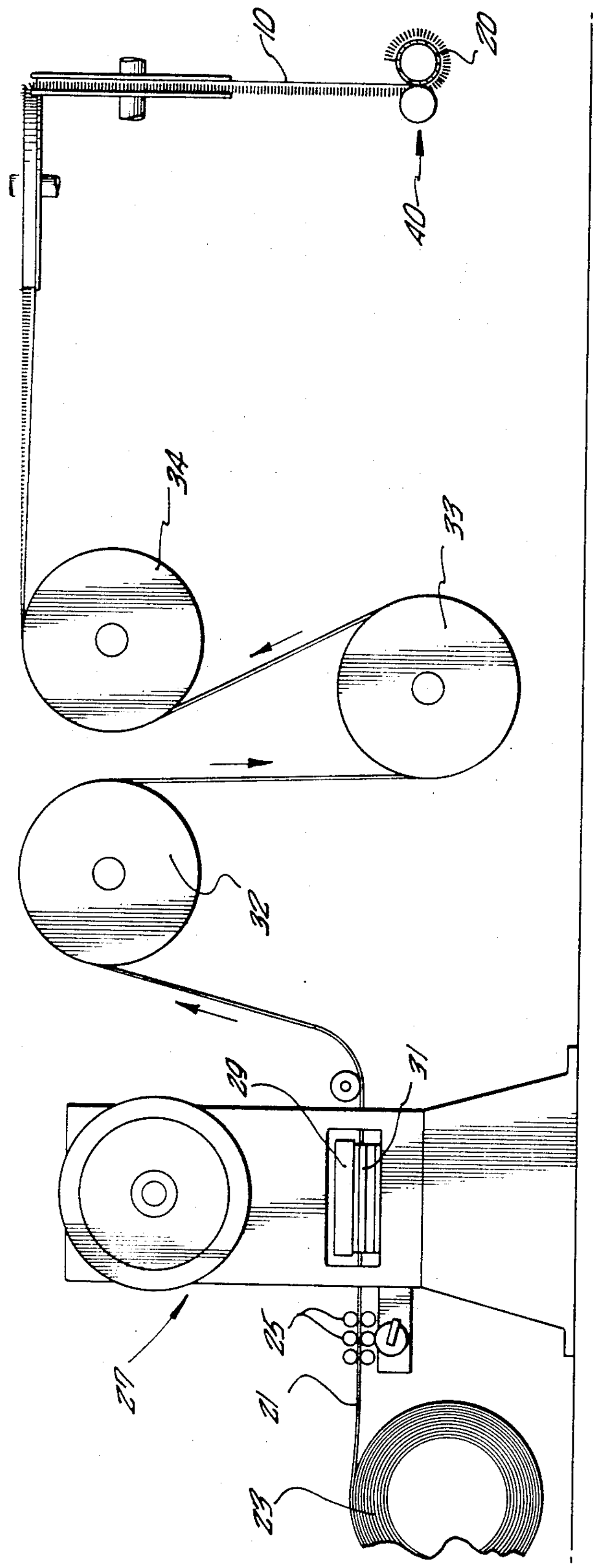


FIG. 2

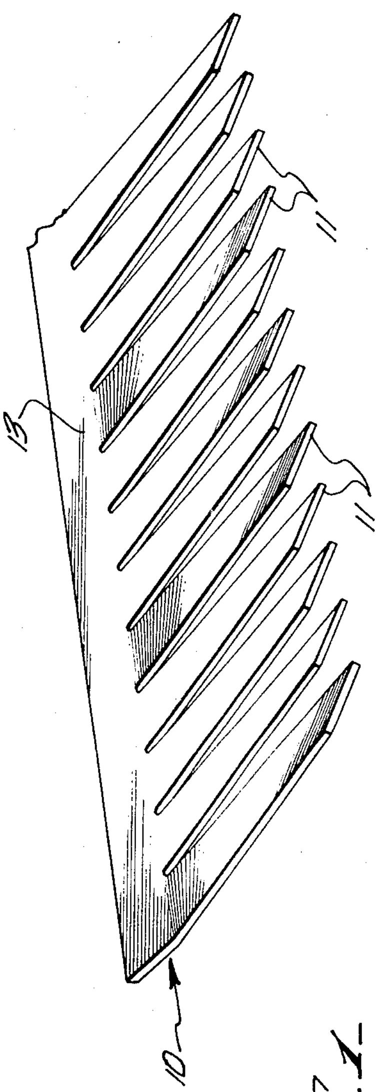


FIG. 1

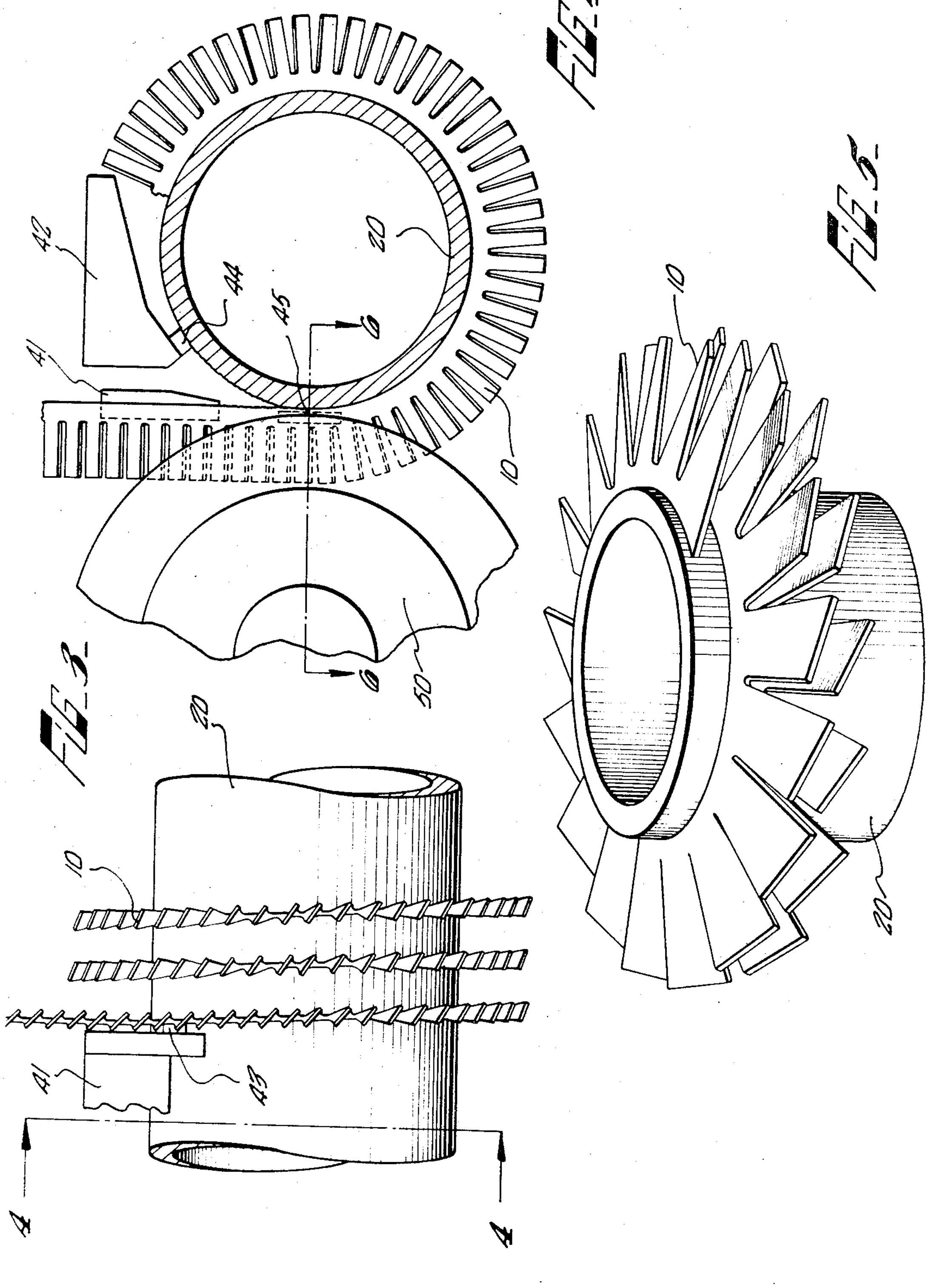


FIG. 3

FIG. 4

FIG. 5

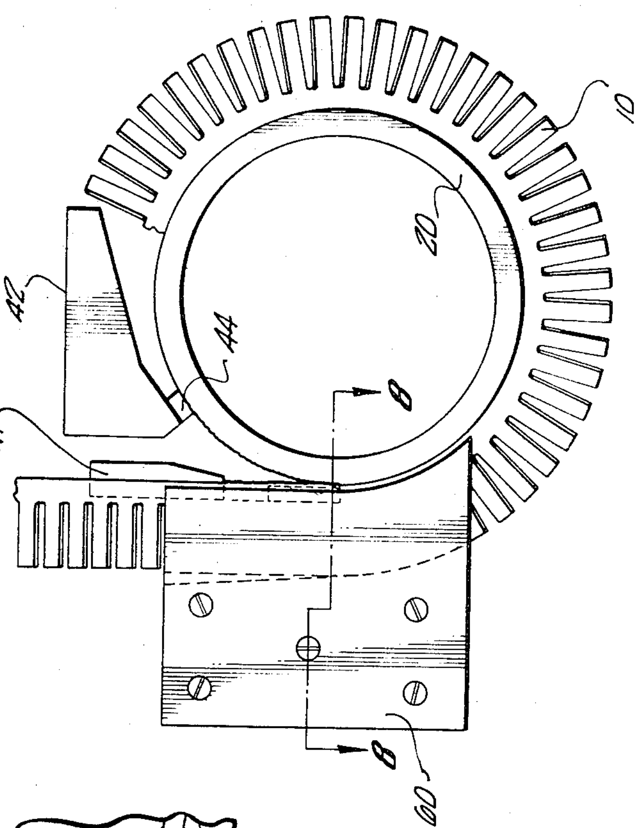


FIG. 7.

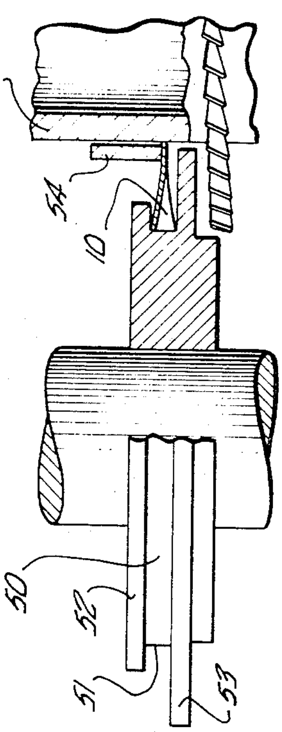


FIG. 6.

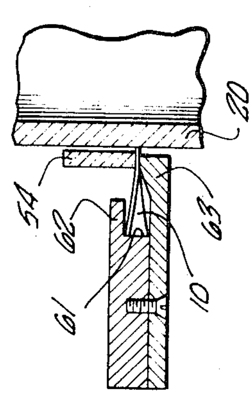


FIG. 8.

I-TYPE SEGMENTED FINNED TUBE AND ITS METHOD OF MANUFACTURE

RELATED APPLICATIONS

This application is a continuation of application Ser. No. 49,874, filed June 25, 2970 for I-TYPE SEGMENTED FINNED TUBE AND ITS METHOD OF MANUFACTURE, now abandoned.

BACKGROUND OF THE INVENTION:

1. Field of the Invention

This invention relates to finned tubing utilized in heat exchange apparatus and more particularly to an I-type segmented fin and the method of manufacturing the same.

2. Description of the Prior Art

It has long been customary to attach fins made of metal to the exterior of tubing used in heat exchanger bundles to increase the effective area for heat exchange between a fluid flowing through the interior of the tubing and in most cases a liquid or gas across the outside thereof.

Finned tube heat exchangers are used in a wide variety of applications for transfering heat from one source to another. For example, a plurality of tubes may be arranged within a casing in a parallel configuration for extracting heat from the hot exhaust gases of turbines. In this application water is normally circulated in the tubes while the hot exhaust gases are circulated over the external surface of the tubes. The hot water or steam generated is generally used for process plant requirements. Such exhaust heat recovery systems almost invariably dictate the use of extended heat transfer surfaces.

Finned tube heat exchangers are also extensively used in power generation, such as boilers and economizers. In some such applications it is desirable to make the fins thicker in order to have the finned tubes positioned closer to the radiant section of the exchanger.

The conventional tubing having extended heat transfer surfaces in finned tubing is manufactured in a variety of configurations. Various type fins include: (1) a flanged fin type in which a major fin portion has a bottom flanged base oriented perpendicular thereto; (2) a channel fin type in which a continuous base has a pair of fin portions extending radially upward therefrom in a U-shaped configuration; and (3) an I-type fin in which a flat fin portion has its lower edge forming the base for connection to the tube.

Each of these various fins can be of the continuous or segmented type. Continuous fins normally have a smooth continuous surface, although they could also be perforated to meet certain design conditions. The segmented fins are either oriented parallel to the root portion of the fin or are twisted at an angle thereto in any desired orientation in order to promote turbulence and increase the heat transfer rates. These fins may be engaged to the tube in a helical or longitudinal configuration with the method of securing the fins to the tube usually done by some type of welding, brazing, or tension winding.

It is well known that serrations, slots or perforations in the fins greatly increase the efficiency of heat transfer, especially when the fluid flowing across the outside of the tubing is a gas. This increase in efficiency is regarded as due to increased turbulence in the inter-fin spaces between adjacent fins on the same tube, as well as a reduction in the laminar film of fluid in contact with the fin. It should also be noted that certain segmented fins have more surface area than a continuous fin of the same height and thickness. Such fins are described in a co-pending U.S. Pat. application, Ser. No. 765,165 entitled "Segmented Finned Tubes For Use In Heat Exchangers".

Although most of the above-mentioned finned tubing is commercially available, the I-type segmented finned tubing has not been used extensively because of various mechanical difficulties encountered in the manufacturing thereof.

As stated above, I-type segmented fins have heretofore been bonded to tubing by either a brazing or a welding process.

Various shortcomings are encountered in utilizing a brazing process. Because of the mechanical characteristics of a brazed bond most users prefer a welded bond for high temperature applications. Moreover, the brazing process used in the production of I-type segmented finned tubing is very time consuming and expensive.

I-type slotted finned tubing has also been produced by standard arc or fillet welding processes. Such processes also suffer from serious shortcomings in that such processes also operate at a very slow rate which makes the cost of such production methods quite high. Slotted or perforated fintube configurations have the added disadvantage of removing metal, i.e. heat transfer surface, from the heat exchanger which is an obvious economic disadvantage.

As a result, the widespread use of I-type segmented finned tubing has been severely restricted by shortcomings encountered in the production thereof.

SUMMARY OF THE INVENTION

The present invention obviates the above-mentioned shortcomings by providing an I-type segmented finned tubing that is capable of being produced rapidly and economically.

The I-type segmented finned tubing includes a fin composed of an elongated flat strip of metal. The upper portion of the flat strip forms the major portion having a plurality of segmented fins formed thereon and extending radially outward therefrom. The lower portion of the flat strip forms the base which serves as a contact area for a welding electrode. The fin is helically wound or longitudinally formed on the tube with the base of the fin bonded thereto.

The method of bonding the segmented fin to the tube is accomplished by means of a high frequency welding process. The method of manufacture includes feeding the segmented fin onto a tube in a helical or longitudinal configuration. The welding apparatus then provides a first electrode to engage the contact area of the fin just prior to the point of mutual engagement with the tube. A second electrode is provided to contact a surface of the tube which is about to register the fin at the point of mutual engagement.

An ultra-high frequency current is applied to the electrodes with a current path being provided between the electrodes via the base portion and the tube, thereby causing the base portion and the tube to melt. A force is then applied to the tips of the fins at the point of mutual engagement to forge the molten root portion of the fin to the molten surface of the tube to create a fused bond therebetween.

Lateral support means are also provided to guide and laterally support the fin as the forging force is applied.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The present invention, both as to its organization and manner of operation, together with further objects and advantages thereof, may best be understood by reference to the following description, taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a fragmentary perspective view of a segmented twisted fin;

FIG. 2 is a schematic view of the apparatus for manufacturing the segmented twisted finned tubing;

FIG. 3 is an elevational view of the segmented twisted finned tube constructed in accordance with the present invention;

FIG. 4 is an elevational view, partly in section, of the finned tube taken along lines 4—4 of FIG. 3;

FIG. 5 is a perspective view of the segmented twisted finned tube constructed in accordance with the present invention;

FIG. 6 is an elevational view, partly in section, of the present invention taken along lines 6—6 of FIG. 4;

FIG. 7 is an elevational view, partly in section, of a second embodiment of the forging wheel; and

FIG. 8 is a sectional view of the second embodiment taken along lines 8—8 of FIG. 7.

DESCRIPTION OF THE PREFERRED EMBODIMENT:

Referring now to FIG. 1, there is shown an I-type segmented fin, generally indicated by arrow 10, which is comprised of a flat strip of metal. The upper portion of the flat strip forms the major fin portion having a plurality of radially extending segmented fins 11 formed thereon. The fins 11 are formed by serrations extending downwardly from the top of the fin. It should be noted that the segmented fins 11 can be parallel to the base portion or twisted at an angle with respect thereto, with a 45° angle being shown in FIG. 1. The twisted fin configuration is preferred for more efficient heat transfer characteristics.

A lower lateral portion 13 is provided at the base of the fin 10 to function as a contact area for a high frequency electrode. Although any size contact area 13 can be utilized to engage an electrode, the preferred embodiment is dimensioned at least 0.375 of an inch to accommodate present day commercial high frequency electrodes. The base of the fin 10 also includes a root portion 15 that is adapted to engage a tube and which will be described in greater detail hereinafter.

Referring now to FIG. 2, there is illustrated a process forming the segmented fin 10, helically winding the fin 10 onto a tube 20, and bonding the fin 10 to the tube 20.

The fin 10 originates from a flat coil stock strip 21 being continuously supplied from a roll 23. The strip 21 is fed by a plurality of drive rollers 25 into a forming assembly indicated generally at 27. The forming assembly includes a punch press apparatus 29 having a two-stage shear and form die 31 operatively contained therein. The initial stage of the die 31 serrates the strip 21 forming the plurality of fins 11, while the second stage twists the fins 11 at the preferred angle with respect to the base. It should be noted that the fins are serrated without removing any material from the strip 21.

The segmented twisted fin 10 is then fed through a plurality of rollers 32, 33 and 34 with the intermediate roller 33 being resiliently mounted to function as a take-up wheel for removing any slack developing in the strip travel.

The segmented twisted fin 10 is then turned 90° to be fed onto a welding station, shown schematically, at 40 for winding and bonding the fin 10 onto the tube 20.

As shown in greater detail in FIGS. 3-5 the segmented fin 10 is wound onto the tube 20 in a helical configuration. The winding process is accomplished by a driving unit (not shown) connected to one end of the tube 20 to rotate the tube, for example, in a counterclockwise rotation while simultaneously pulling the tube along a track and past the welding station 40.

The welding station includes a pair of electrodes 41 and 42. The first electrode 41 is positioned adjacent the segmented fin 10 and includes a contact 43 for engaging the contact area 13 of the fin 10. The second electrode 42 is positioned adjacent the tube 20 and includes a contact 44 for engaging the tube 20. Both electrodes 41 and 42 engage the respective fin 10 and tube 20 just prior to the mutual engagement point 45.

A forging wheel 50 is provided to apply a force to the tips of the fin above the point of mutual engagement 45. As shown in FIG. 6, the forging wheel includes a peripheral surface 51 for contacting the tips of the fin 10 and a pair of flanges 52 and 53 extending to the sides of the fin to act as guide means for the fin. The flanges 52 and 53 also function to laterally support the fin 10 as the forging force is being applied by the forging wheel 50. Finally, a ceramic contact 54 is positioned at the base of the fin to further act as a guide and lateral support for the base of the fin.

In welding the fin 10 to the tube 20, an ultra-high frequency current is applied to the electrodes 41 and 42. In such an application a current path is provided between the electrodes 41 and 42 via the root portion 15 of the fin 10 and the registering tube surface (see FIG. 4). This causes the root portion 15 from the point of engagement with the contact 43 to the mutual engagement point 45 to melt. In a like manner, the registering surface of the tube 20 from the point of engagement with the contact 44 to the mutual engagement point 45 is also caused to melt. The forging wheel 50 then functions to apply a force to the tips of the fins above the point of mutual engagement to forge the molten surfaces of the root portion 15 to the registering tube surface 20 to create a fused bond therebetween. It should be noted that the fin serrations enable the fin to be more tightly wrapped to the tube. As a result, a smaller forging force is required than that required for welding a continuous fin to a tube. A perspective view of the finished finned tube is shown in FIG. 5. As a result, the present invention provides an I-type segmented fin bonded to a tube in a rapid and economic fashion.

FIGS. 7 and 8 show a second embodiment wherein a forging plate 60 is substituted for the forging wheel 50. The forging plate 60 includes a planar surface 61 which is adapted to contact the tips of the fin 10 and a pair of flanges 62 and 63 function as guides and lateral supports similar to the flanges 52 and 53. Flange 63 also extends to the base of the fin 10 to cooperate with the ceramic contact 54 to further laterally support the base of the fin 10 as the forging force is applied.

The forging plate **60** is preferably used with relatively thick fins with respect to the tubing. As a result, a relatively thick I-type segmented fin is produced that can be especially adapted for power boilers and the like. With such an apparatus the heat exchanger can now be positioned closer to the radiant section of the boiler for more efficient heat transfer.

It should be noted that various modifications can be made to the apparatus while still remaining within the purview of the following claims.

What is claimed is:

1. A method of bonding a heat transfer I type flat fin stock to a cylindrical surface of a tube to form a heat exchanger for turbines, boilers and the like comprising the steps of:

cutting said I-type fin stock to form a plurality of radially extending major fin portions and a root portion;

providing a contact area on a side of said flat fin stock;

helically bending said segmented fin stock so that an edge adjacent the root portion is positioned onto said cylindrical surface and the major fin portion forms a serrated shape;

electrically contacting said side contact area with a first electrode for engaging said side contact area at a position just prior to the mutual engagement point of said I shaped fin stock and said tube;

electrically contacting said tube with a second electrode for engaging the registering surface of said tube just prior to said mutual engagement point;

applying an ultra-high frequency current to said electrode, a current path being provided between said electrodes via said side contact area and said tube surface thereby causing said root portion and said tube surface to melt; and

applying a forging force to said fin stock through the serrated fin portions to assist in creating a continuous fused permanent bond between said root portion and said tube surface.

2. The method of claim **1** further comprising the step of laterally supporting said fin stock as said forging force is applied to the tips of said fin stock.

3. The method of claim **2** further comprising the step of bending said fin portions out of the plane of said root portion after cutting and contacting said contact area in the plane of said root portion immediately adjacent the bent serrated fin tips.

4. The method of claim **1** further comprising the step of twisting said fin stock at least 90° after serration and before forming a fused bond between said fin stock and said tube.

5. The method of claim **1** further comprising the step of removing any slack from said fin stock after serration and before forming a fused bond between said fin stock and said tube with a resiliently mounted roller.

6. The method of claim **2** further comprising the steps of guiding and supporting the major fin portion's tips with a forging wheel having a peripheral surface adapted to engage the tips of said fin stock and a pair of flanges adapted to extend along the sides of said fin stock.

7. The method of claim **2** further comprising the step of twisting said fin stock at least 90° after serration and before forming a fused bond between said fin stock and said tube.

8. The method of claim **7** further comprising the step of removing any slack from said fin stock after serration and before forming a fused bond between said fin stock and said tube with a resiliently mounted roller.

9. The method of claim **8** further comprising the step of insulating and supporting the fin stock adjacent said contact area with a ceramic contact means and serrating the fin stock without substantially removing any fin stock material.

10. The method of claim **1** further comprising the step of insulating and supporting the fin stock adjacent said contact area with a ceramic contact means including a flange support member positioned within a plane containing said serrated fin portions, said flange support member supporting said lower side contact area.

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