INTEGRAL FINNED TUBE

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The invention relates to the manufacture of heat exchange apparatus and more particularly to the tubing used in such structures as, for instance, condensers, evaporators for refrigeration, etc.

It is the primary object of the invention to obtain a construction of heat exchange tube which can be readily assembled with other parts of the apparatus and which in the assembled structure will have increased strength and rigidity.

More specifically, it is an object to obtain a finned tube having unfinned portions of an external diameter at least as great and preferably greater than that of the fins.

It is a further object to obtain a tube of this character in which the wall thickness of the unfinned portions is greater than that of the finned portions.

Still further it is an object to obtain a construction in which the finned portions are harder and of greater rigidity than the unfinned portions or conversely the unfinned portions are free from work hardening which facilitates rolling the same into engagement with a wall of a casing. This eliminates the necessity of an annealing operation subsequent to the finning operation which is detrimental as it softens and decreases the rigidity of said finned portions. With most methods of finning tubing as heretofore practiced, the fins are developed from the wall of a plain tube to project radially outward beyond the original diameter of said tube. If such tubes are to extend within a casing, the latter must have apertures in at least one wall thereof which are large enough for the passage of the fins therethrough. Consequently, it is necessary to expand the diameter of the unfinned end portion of each tube to fit the aperture before it can be attached to the wall. Such expansion in diameter reduces the wall thickness and also causes work hardening. This, in turn, requires an annealing operation.

In view of the difficulties above referred to, I have devised a method of finning tubes in which the original diameter of the tube is at least as great as the peripheral diameter of the fins developed therefrom. Also, the wall of the finned portions of the tube is reduced in diameter and in thickness so that the unfinned portions are relatively of greater wall thickness and diameter. The broad method and general features of the product form the subject matter of U. S. Patent No. 2,508,517 issued May 23, 1950 and the instant application is directed to more specific features. Referring to the broad method the fins are developed by helically rolling axially spaced portions of the tubular blank to radially depress the same leaving between successive convolutions an unrolled helical portion. The radially inwardly displaced material is compelled to flow axially beneath the displacing surfaces but may be extruded radially outward between said surfaces. However, a portion of the displaced material may be absorbed in the tube wall causing an axial elongation thereof. Thus, the degree of outward extrusion is dependent upon a number of factors including the diameter of the mandrel within the tube and the amount of reduction in wall thickness between successive convolutions of the fin.

The more specific product which forms a portion of the subject matter of the instant application is a tube having unfinned portions and finned portions with the diameter of the fins no greater than the external diameter of the unfinned portions. These unfinned portions are preferably at opposite ends of the tube but there may also be one or more intermediate unfinned portions where the tube is designed to extend through baffles. The apparatus used in carrying out the method is not a part of the instant invention and will only be described generally as comprising one or more forming rolls for relatively travelling helically about the tube operated upon and a mandrel for supporting the tube permitting axial advancement thereof.

In the drawings:

Fig. 1 is a longitudinal section showing one of the forming rolls in engagement with a tube to be finned;

Fig. 2 is a diagrammatic cross section showing a plurality of rolls distributed about the work tube and mandrel;

Figs. 3, 4 and 5 are diagrams showing the successive operations in the finning of a tube;

Fig. 6 is a longitudinal section through a finned tube having unfinned end portions;

Fig. 7 is a similar view showing a tube with unfinned end portions and one or more intermediate unfinned portions;

Fig. 8 shows a portion of a wall of a casing with a tube connected into the same;

The rolls A are mounted upon arbors B and are distributed about the axis of the work tube C which latter has within the same a mandrel D connected by a shank E to an anchor point (not shown). The axes of the arbors B are at such an angle to the axis of the mandrel and tube as to travel a helical path thereof and there is also provision for moving the arbors radially towards or from the axis of the tube. Each roll A has a series of spaced disc-like portions F, F', F", F'" and F'" to form therebetween in-
wardly slightly tapering grooves G, G', C and G'. The portion F has its peripheral face extending axially in a straight line parallel to the axis of the tube. The portion F is of a substantially V-shape cross section but with a radius curve at its outer end. The portions F', F', F' have their peripheral faces inclined axially with respect to the tube and also generally tapering radially inward from the portion F' to the portion F. Adjacent to the root of the portion F is a conical portion tapering in the same direction as the portions F', F', F' and F.

In carrying out the process, plain tubing C of a diameter and wall thickness suitable for the unfinned portions of the finned tube is placed about the mandrel D and shank E thereof and is positioned thereon so that an end portion C' thereof extends axially beyond the portion F' of each roll. The rolls A together with their arbors B are then moved radially inward with respect to the axis of the tube and by frictional contact with the outer surface of said tube, will rotate and axially advance the same causing the rolls to traverse a helical path. Due to the tapering form of each roll, the tube diameter portion F' thereof will first come in contact and by its radial pressure will progressively contract the tube to form a tapering portion C' and an opposite flaring portion C'. This continues until all of the portion F', F', F' and F' are in contact with the portion C' whereupon continued helical advancement of the tube will develop fins on the contracted diameter portion thereof. In other words, the portion F' first presses inward to form a helical groove and the portions F', F', F', F' and F' successively track this groove but when it is pressed inward additional areas of the tube until finally the groove is of a width equal to the axial width of the portion F'. All of the grooves are formed by radial inward displacement of material in the helical path and substantially without axial displacement of material between adjacent convolutions of the helix. Consequently, this intermediate material will form a fin of substantially uniform texture and with but slight work hardening of its outer faces. The displaced material which lies beneath the displacing surface and also by the reaction of the tube wall against elongation will tend to extrude some of the material radially outward in the grooves G, G', G' and G'. However, by limiting the depth of these grooves, the extruded fins cannot exceed the diameter of the original tube. Thus, the continuing operation will reduce the diameter and thickness of the tube wall and develop fins projecting therefrom which all are of a uniform height not greater than the external diameter of the original tube. Wherever in the length of the tube it is desired to leave an unfinned portion, this may be accomplished by gradually withdrawing the rolls radially outward during the continued helical advancement of the tube until they completely clear the tube. If there is a further fin portion the process may be repeated as above described. It is, therefore, apparent that the finned and unfinned portions may be alternated as many times as desired throughout the length of the tube operated upon. Also, it will be understood that the unfinned portions of the tube are not subjected to any work hardening operation so that they will remain in the same condition as the original blank. This is particularly advantageous where these unfinned portions are to be subsequently fashioned in the attachment of the same to a casing wall. The wall thickness of the finned portions of the tube can be regulated by the diameter of the mandrel and displaced material in excess of that required for forming the wall will produce an axial elongation thereof. Thus, the original wall thickness of the tubing may be selected with respect to the desired thickness of the unfinned portions of the tube, while the finned portions thereof may be made of any predetermined wall thickness.

With finned tubes formed by my improved process, residual stresses throughout the tube are considerably lessened in comparison with those in tubes formed by other processes. This is very beneficial from a stress corrosion standpoint and is due to the lesser amount of cold working imparted to the tube and by a better plastic flow during the finning operation.

The gradual taper between the unfinned portions and the finned portions avoids any abrupt shoulder which would be detrimental in resisting flow of fluid through the tube.

By my improved process much thinner fins may be developed and as great as the diameter of each fin is substantially reduced throughout its height. This will increase the area of radiating surface for a given length of tube.

The tips of the fins will be convex in cross sectional contour and free from any roughness or cracks which might initiate a fracture of the tube.

What I claim as my invention is:

1. A length of finned tubing comprising axially spaced plain sections having cylindrical walls with malleable characteristics corresponding to the original stock from which the tubing is produced, a finned section of substantial length integrally connecting the plain sections and having a part intermediate its ends of less internal and external diameters than the corresponding diameters of the plain portions, the wall portions progressively increasing in depth from the plain sections to said intermediate part gradually decreasing in thickness and also in internal and external diameter from the plain sections to the intermediate part and having a maximum diameter at the intermediate part no greater than the external diameter of the plain sections.

2. The length of finned tubing defined in claim 1 in which the wall portions of the finned section progressively increase in hardness from the cylindrical plain sections to the intermediate part.

3. A length of finned tubing comprising a finned section and a plain section provided with a cylindrical wall having malleable characteristics corresponding to the original stock from which the length of the tubing is produced, said finned section having a part spaced a substantial distance axially from the plain section and said part having internal and external diameters less than the corresponding diameters of the plain section, the wall portion of the finned section extending from the plain section to said part gradually decreasing in thickness and also in internal and external diameter from the plain section to said part and the axial extent of said wall portion being at least as great as the diameter of the plain section, and fins projecting outwardly from the finned section, said fins pro-
gressively increasing in depth from the plain section to said part and having a maximum diameter no greater than the external diameter of the plain section.

WALTER P. HILL.

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