

May 21, 1968

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3,383,893

APPARATUS FOR PRODUCING INTEGRAL FINNED TUBING OF FINE PITCH

Filed Aug. 16, 1965

FIG. 1

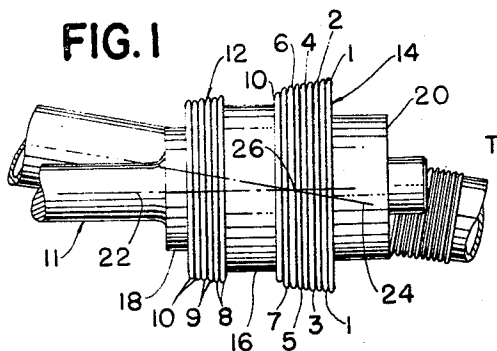


FIG. 2

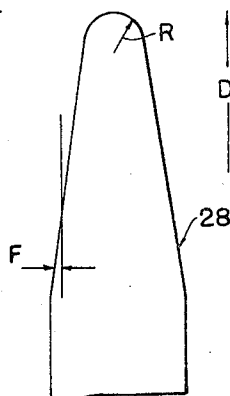


FIG. 3

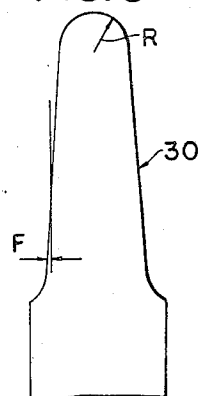


FIG. 4

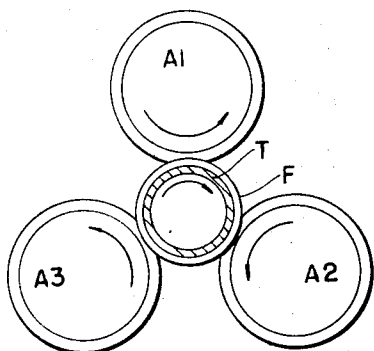
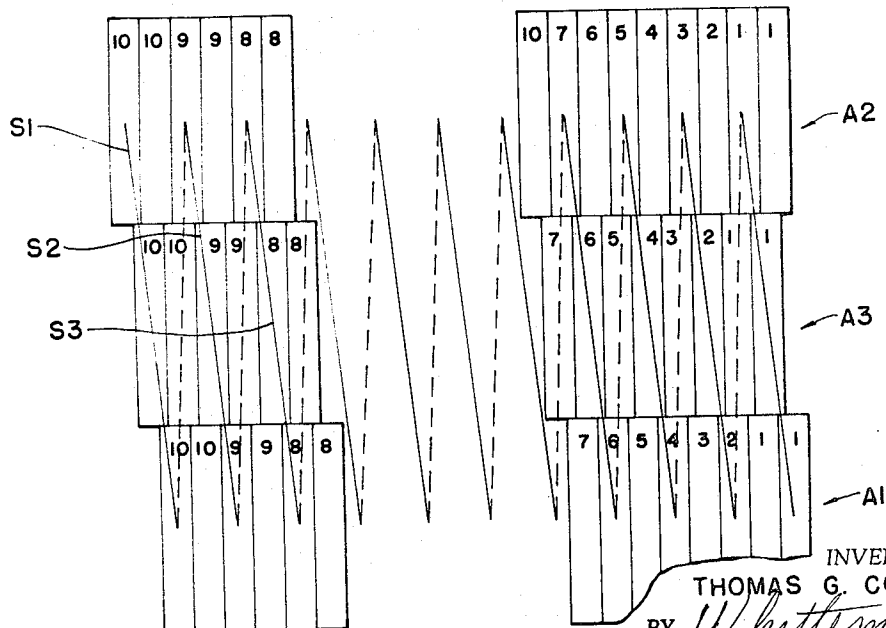


FIG. 5



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APPARATUS FOR PRODUCING INTEGRAL FINNED TUBING OF FINE PITCH

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Filed Aug. 16, 1965, Ser. No. 479,982

7 Claims. (Cl. 72-98)

ABSTRACT OF THE DISCLOSURE

Apparatus for finning tubes comprising three arbors provided with a multiplicity of finning discs and inclined at an angle such that two-start fins are produced. The discs are separated by a spacer into groups. The first group is composed of a plurality of pairs of identical discs having peripheral portions the side walls of which converge at an angle of approximately $13\frac{1}{2}$ degrees, the diameters of the pairs of discs increasing progressively, and the edge surfaces of the pairs of discs being of circular cross-section of progressively increasing radius. The discs of the second group are all of progressively increasing diameter and of generally increasing cross-sectional peripheral radius.

It is an object of the present invention to provide a novel arrangement of discs on the arbors for the purpose of producing fine pitch helical fins on tubing.

More specifically, it is an object of the present invention to provide the discs on each arbor in two groups which are spaced apart a substantial distance, the first group of discs constituting a group effective principally to displace metal from the fin root spaces, and the second group effective principally to shape the fin profile.

It is a further object of the present invention to provide the arbors as described in the foregoing with the common perpendicular to the axis of each arbor and the axis of the tube being located adjacent the first disc of the second group of discs on each arbor.

It is a further object of the present invention to provide tube finning apparatus as described in the foregoing in which the first group of discs on each arbor comprises three different sizes of discs and the discs on the several arbors are arranged such that each space formed between each adjacent pair of fins is traversed by three discs of the same diameter in order.

Other objects and features of the invention will become apparent as the description proceeds, especially when taken in conjunction with the accompanying drawings, illustrating a preferred embodiment of the invention, wherein:

FIGURE 1 is a diagrammatic elevational view of an arbor containing fin forming discs.

FIGURES 2 and 3 are fragmentary elevational views on an enlarged scale showing the cross-sectional shape of the peripheral portion of certain of the finning discs.

FIGURE 4 is a diagrammatic view illustrating the relationship between a tube being finned and the three finning rolls.

FIGURE 5 is a diagrammatic view illustrating the relationship and sequence of operation of the several discs on the several arbors.

The development of fine pitch integral finned tubing has been made possible by a departure from prior conventional methods of fin formation. When employing the usual or standard progression of diametral increases it was found that the finned tubing was unsatisfactory because of root diameter defects or overlays occurred as well as "whiskers." "Whiskers" is the term applied to fine

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slivers of metal which are partially separated from the finned tubing adjacent the roots of the fins. This problem has been overcome by arranging the discs in a particular sequence, by employing a disc as the first disc of the second group of discs on one arbor which is smaller than the last disc of the first group.

The provision of the small disc as the first disc of the second group of discs of course changed the tracking relationship of the succeeding discs.

The necessity for a change in tracking and cold working relationship of discs is due not only to elongation which takes place in the initial start of the multiple finning and disc design, but also in the transition from raw stock diameter to root diameter as the helix angle changes with the diameter change. Disparities of the two diameters (that is, raw stock diameter and final root diameter) are great enough that proper tracking cannot exist from the raw stock outside diameter to final root size.

This development also has required a change in spacer design and location. While normal 19-fin tubing for example, has employed two spacers, it has been found necessary to use a single spacer for the fine pitch or 26-fin production. The spacer is designed to overcome the elongation of the tube created in starting, provide for the tube to return to a state of equilibrium, place succeeding discs in proper relationship to the original fins which have so far been produced, and prevent squaring of the tube. The spacer location is not only for fin formation, but for the necessity of making a continuous diametral transition from the beginning raw stock size to root diameter size. It has been found that not only the disc arrangement but also the arbor location is an important factor in permitting commercial production of 26-fin tubing.

Referring now to the drawings, there is illustrated in FIGURE 1 an arbor 11 having first and second groups of discs 12 and 14 thereon separated by a spacer 16. As shown, the assembly of discs and spacers is clamped against a radially extending flange 18 on the arbor by suitable means such for example as a clamping nut 20 or the like.

In practice, three arbors are employed spaced at approximately 120-degree intervals around the path of advance of a tube, a portion of the tube being indicated at T in FIGURE 1.

The three arbors are rotated in unison with the tube and due to the crossed angular relationship, the rotation of the arbors causes the tube to advance as it rotates, thus forming helical grooves thereon and ultimately shaping the metal between adjacent convolutions into the form of efficient heat transfer fins. In accordance with the present invention the angle at which the axis of the arbor, here indicated at 22, crosses with respect to the axis of the tube T, here designated 24, is such that during one revolution of the tube the tube advances a distance equal to the thickness of two discs. Accordingly, two fin formations are produced starting at diametrically opposite points on the end of the advancing tube.

The first groups of discs 12 on the several arbors is primarily for the purpose of beginning fin formation and produces the major metal movement as the root diameter is formed and pushed down. Once the primary fin is formed the succeeding discs operate principally to control the profile of the fins, and the changes produced by the discs in the second group are accordingly of smaller magnitude.

In general, the discs in the first group are shaped to have their peripheral portions relatively narrower so as to penetrate more readily into the material of the raw tube stock. In practice, the assembly of discs is made up of ten differently shaped and dimensioned discs which have been identified in the drawings by the numbers 1-10.

Referring to FIGURE 1, it will be observed that the first group 12 of discs comprises six discs, being from starting end two No. 10 discs, two No. 9 discs, and two No. 8 discs. Intermediate the groups of discs 12 and 14 is the cylindrical spacer 16. The second group of discs comprises a single relatively small No. 10 disc, followed in order by discs in the sequence: Nos. 7, 6, 5, 4, 3, 2, 1, 1. It will be observed from the figure that the arbor is disposed such that a line perpendicular to the axis 22 of the arbor and also perpendicular to the axis 24 of the tube T is adjacent the No. 7 disc of the second group of discs, this point being indicated in FIGURE 1 at 26.

Referring now to FIGURES 2 and 3, in FIGURE 2 there is diagrammatically shown at 28 the elevational view of a portion of the periphery of one form of disc, this being the type of disc used for discs Nos. 7-10. It will be observed that the extreme edge of the disc is relatively narrow and that its sides are inclined at a substantial angle. It may be mentioned at this time that all of the discs are of identical thickness at their central portions.

Referring to FIGURE 3, there is illustrated at 30 the other type of disc which is used in producing the discs Nos. 6-1. This disc differs essentially from the disc having the peripheral portion 28 in that it is relatively wider at the extreme periphery, and its side portions are tapered at a lesser angle.

The significant changes from disc to disc is represented in the table below, where diameter of the discs is represented by D, the radius of curvature of the peripheral cross-section is represented by R, and the angle of the sides by F.

Disc No.	Diam. D	Radius R	Angle F (degrees)
1-----	2.062	.010	5
2-----	2.060	.010	5
3-----	2.057	.009	5
4-----	2.054	.008	5
5-----	2.050	.007	5½
6-----	2.045	.007	7
7-----	2.040	.006	9
8-----	2.029	.006	13½
9-----	2.024	.0055	13½
10-----	1.995	.005	13½

It will of course be appreciated that all of the discs from No. 10, which is the smallest, to No. 1 which is the largest, are of a progressively increasing major diameter. The increase in diameter between the first discs to contact the tube (that is, the higher numbered discs) is greater than the increase in diameter between the final or lower numbered discs. Thus for example, the difference in diameter between the consecutive sizes of discs from the No. 6 to the No. 1 disc may decrease from about .006 to about .002 inch. On the other hand, the difference in diameter between the No. 10 and the No. 9 disc may be approximately .030 inch, and the increase in diameter between the No. 8 and the No. 7 disc may be about .010 inch.

Not only are the consecutive discs of increasing height, but their shape is also modified so as to produce a thinning and desired shaping of the material of the fins as it is formed outwardly by displacement.

In describing the disc forming roll shown in FIGURE 1, this was intended to be typical and in practice two differently constituted fin forming rolls are provided. The roll shown in FIGURE 1 is unique and the remaining two rolls differ in the omission of the relatively small No. 10 disc which constitutes the first disc of the second group 14 of discs.

Referring now to FIGURES 4 and 5 there is illustrated the exact arrangement of discs on the arbors and the arrangement of the rolls with respect to the tube.

Referring first to FIGURE 4, the tube is illustrated at T with a partially formed fin F thereon. The tube is shown in simultaneous contact with discs on three arbors identified respectively as A1, A2 and A3. In this figure the di-

rection of rotation of the tube and arbors is as illustrated and it will therefore be observed that any particular point on the tube moves in sequence from discs carried by the arbor A1 to discs carried by the arbor A2 and the discs carried by the arbor A3.

Referring now to FIGURE 5 there is illustrated diagrammatically the arrangement of the several discs on the several arbors, and in addition, the special relationship between the arbor is indicated. In this figure the arbors A1, A2 and A3 are identified. It will be observed that the arbor A2 has the first group 12 of discs made up in the sequence 10, 10, 9, 9, 8, 8. The spacer 16 has a length which is approximately 7.2 times as great as the width of each of the discs. This causes the discs of the second group 14 to engage with a minimum of axial stress the spaces between adjacent fins as they have been formed by the discs of the first group. The second group 14 of discs on arbor A2 is made up of discs in the following sequence: 10, 7, 6, 5, 4, 3, 2, 1, 1.

The arrangement of discs on the arbors A1 and A3 are identical. The left hand or first group of discs 12 on these arbors is made up of discs in the following sequence: 10, 10, 9, 9, 8, 8. Identical spacers 16 are employed on all arbors. On the arbors A3 and A1, the second group of discs 14 is made up with the following sequence of discs: 7, 6, 5, 4, 3, 2, 1, 1.

It will thus be seen that the second group of discs on the arbor A2 differs from the second group of discs on the arbors A1 and A3 in the provision of a small No. 10 disc as the first disc of the second group.

It will be understood that in order to provide double-start helical finning the second No. 10 disc on the arbor A2 will initiate formation of a fin space at a point 180 degrees from the start of the fin space formed by the left hand disc No. 10. In other words, the advance of the tube due to the angular relationship of the arbors is such that when the start of the helical space, groove or channel initiated by the left hand disc No. 10 has reached a point 180 degrees, or at the diametrically opposite side of the tube from the arbor A2, then the second No. 10 disc on the arbor A2 will initiate its operation.

From the foregoing, and from a consideration of FIGURE 4, it will be observed that the sequence of spaces on any particular area of the tube with respect to the arbors is A2, A3, A1, A2, A3, etc. In FIGURE 5 there is a diagram illustrating the sequence of operation of the several discs on the several arbors to produce the helical grooves on the tube, the grooves of course providing the fins therebetween. In this figure the full lines S1, S2, S3, etc. indicate the progression of a groove or space formed by the rolls, and the dotted lines connecting the ends of the full lines merely represent the travel or advance of the groove or space as it is being formed from the arbor A1 to the arbor A2.

From the foregoing it will be observed that one of the two continuous helical grooves or channels formed by the rolls is acted on in the following sequence: Left hand disc No. 10 on arbor A2, left hand disc No. 10 on arbor A3, left hand disc No. 10 on arbor A1, left hand disc No. 9 on arbor A2, left hand disc No. 9 on arbor A3, left hand disc No. 9 on arbor A1, left hand disc No. 8 on arbor A2, left hand disc No. 8 on arbor A3, left hand disc No. 8 on arbor A1, . . . disc No. 7 on arbor A2, disc No. 6 on arbor A3, disc No. 6 on arbor A1, disc No. 5 on arbor A2, disc No. 4 on arbor A3, disc No. 4 on arbor A1, disc No. 3 on arbor A2, disc No. 2 on arbor A3, disc No. 2 on arbor A1, disc No. 1 on arbor A2, disc No. 1 on arbor A3, and disc No. 1 on arbor A1. Therefore, the sequence of action of the differently sized discs in producing the illustrated groove of FIGURE 5 is: 10, 10, 10, 9, 9, 9, 8, 8, 8, . . . 7, 6, 6, 5, 4, 4, 3, 2, 2, 1, 1, 1, 1. Similarly, the other groove which is formed by the discs is acted on by differently sized discs in the following sequence: 10, 10, 10, 9, 9, 9, 8, 8, 8, . . . 10, 7, 7, 6, 5, 5, 4, 3, 3, 2, 1, 1, 1.

From the foregoing it will be apparent that each groove is initially formed by engagement with three discs No. 10, three discs No. 9, three discs No. 8; and in the second group by a progression of discs from No. 7 to No. 1 with two identical discs acting in sequence intermediate action between single discs of selectively smaller and larger size respectively.

From the table presented in the foregoing it will be observed that the increase in diameter between successive sized discs, starting with the small disc No. 10, is .029, .005, .011, .005, .004, .003, .003, and .002. In general terms it will be observed that the amount by which successive discs increase in diameter diminishes toward the finishing section of each arbor. Similarly, it will be observed that the radius determining the shape of the entering edge portion of the successive discs, commencing with the small disc No. 10, increases as follows: .0005, .0005, no change, .0010, no change, .0010, .0010, .0010, no change.

Similarly, it will be observed that the angle F between the sides of the edge portions of the discs, starts at the relatively large value of $13\frac{1}{2}$ degrees for discs Nos. 10-8 and thereafter, decreases successively to 9 degrees for disc No. 7, 7 degrees for disc No. 6, $5\frac{1}{2}$ degrees for disc No. 5, and 5 degrees for discs Nos. 4-1.

With this arrangement the entry of the discs into the material of the tube is facilitated while the shaping of the discs in the second group results in proper forming of the fins. The foregoing arrangement is essential in the production of the exceptionally fine pitch finned tubes to which the present invention relates.

The drawing and the foregoing specification constitutes a description of the improved apparatus for producing integral finned tubing of fine pitch in such full, clear, concise and exact terms as to enable any person skilled in the art to practice the invention, the scope of which is indicated by the appended claims.

What I claim as my invention is:

1. Apparatus for forming exceptionally fine pitch helical fin formations on tubing which comprises three arbors positioned with their axes spaced laterally from and substantially equally spaced around the axis along which a tube advances during a progressive finning operation and disposed at a small angle with respect thereto, a plurality of finning discs mounted on said arbors for rotation therewith, said discs being of generally increasing diameter in the direction of advance of the tube, of increasing peripheral cross-section radius of curvature,

and of decreasing angularity between peripheral portions of the side walls of the discs, a spacer on each of said arbors providing axial separation between a first and a second group of discs, said arbors being disposed at the angle at which their axes cross the axis of advance of the tube such that continuous two-start helical finning is produced, the discs of the first group to engage a given portion of an advancing tube being provided in a plurality of pairs of identical discs, the second group on each arbor comprising discs of progressively increasing diameter from disc to disc.

2. Apparatus as defined in claim 1 in which the included angle between the side portions adjacent the periphery of all discs making up the first groups of discs is approximately 27 degrees.

3. Apparatus as defined in claim 2 in which the included angle between the side portions adjacent the periphery of the last several discs of the second groups is approximately 10 degrees.

4. Apparatus as defined in claim 1 in which the first disc in the second group of discs on one of the arbors is a relatively small diameter disc having substantially the same diameter as the first disc of the first groups of discs, the first discs of the remaining two second groups of discs on the remaining two arbors being of larger diameter than the last disc in the first groups of discs.

5. Apparatus as defined in claim 1 in which the average difference between the diameters of adjacent discs decreases progressively in the direction of tube advance.

6. Apparatus as defined in claim 1 in which the discs have edge portions of circular cross-section, the radius of curvature of the cross-section of the edge portions of the discs increasing in the direction of tube advance from about .0050" to about .0100".

7. Apparatus as defined in claim 6, the radius of curvature increasing by about .0005" between adjacent discs in the first group and by about .0010" between most of the different sized discs in the second group in the direction of tube advance.

References Cited

UNITED STATES PATENTS

2,868,046 1/1959 Greene ----- 72-98

FOREIGN PATENTS

852,368 10/1960 Great Britain.

RICHARD J. HERBST, *Primary Examiner.*