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FLOATING ROTATING MANDREL FOR FINNING

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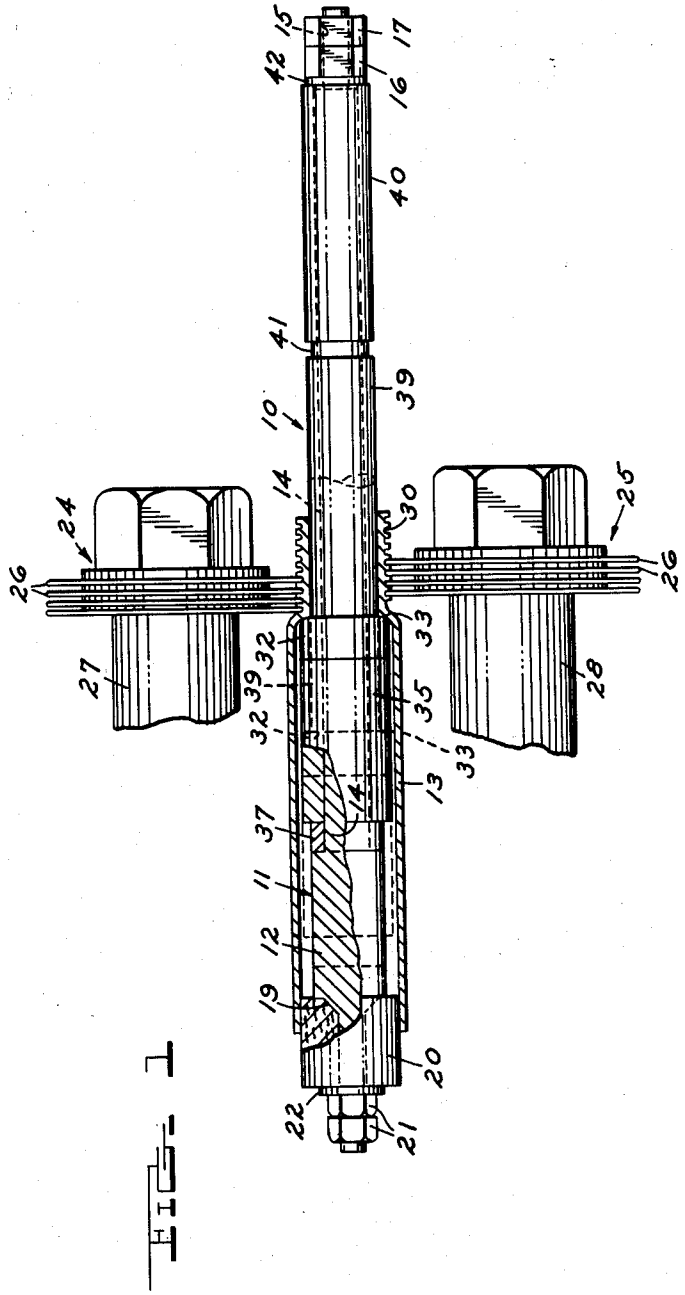

FIG. 1

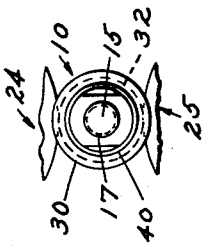

FIG. 2

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FLOATING ROTATION MANDREL FOR FINNING

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The present invention relates to an improved floating rotating mandrel for finning metal tubing, in particular tubing intended for use in heat transfer applications. The mandrel is of the general type illustrated and described in the patent to Greene and Keyes, No. 2,761,336 of September 4, 1956, in that it employs a mandrel which floats freely within a metal tube while coacting with finning discs or roller means with which the tube has relatively rotatable engagement in the operation, as distinguished from previous commonly employed mandrels rigidly supported at the rear thereof by an elongated mounting rod.

It is a general object of the invention to provide a floating mandrel which, in addition to its floating action within the tube, also has components whch freely rotate with the tube and relative to one another in the finning operation of associated finning or grooving discs. Thus, a combination of pilot and internal forming mandrel components are rotatably supported in coaxial, end-to-end relation to one another upon an internal bearing support or rod holding the components, as well as certain interposed antifriction washers or spacers, in a unitary assembly.

Such provisions make possible a floating and rotating mandrel which accommodates, at the various component pilot and forming parts thereof, the various tube supporting and constricting and grooving, or finning, forces externally imposed on the tube surrounding the mandrel. That is, the ability of each component member of the mandrel to rotate freely prevents the building up of opposing or counteracting forces at the mandrel, and thus allows the metal to flow over the mandrel freely while keeping it in place in the axial sense within the tube and preventing the tube from tearing.

Another general object is to provide a floating and rotating grooving or finning mandrel which, by reason of its composite construction as described, enables the ready production of extremely long lengths which are very straight.

A still further object of the invention is to provide a mandrel of the type described composed of successive pilot and forming sections of tungsten carbide or like extremely hard alloy to withstand the action of the grooving discs on the tube without indenting such sections, with certain of these sections spaced for independent rotation upon an internal elongated bearing rod by annular spacers or sleeves of a suitable bearing metal, such as bronze, yet wtih certain of such hard sections which serve as pilot and forming components of the mandrel at a zone of critical forming action being in direct end engagement with one another for independent rotation, in view of the heavy axial thrust at this zone which would unduly wear a softer metal.

The foregoing as well as other objects will become more apparent as this description proceeds, especially when considered in connection with the accompanying drawing illustrating a preferred embodiment of the invention, wherein:

FIG. 1 is a fragmentary longitudinal view showing the mandrel as operatively associated with grooving or finning discs and a metal tube, the latter being shown in axial section and the mandrel being shown as partially broken away and also in axial section; and

FIG. 2 is an end view of the mandrel, as from the right of FIG. 1.

The improved mandrel of the invention is generally

designated by the reference numeral **10**; and it has at its center an elongated bearing and mounting rod **11** of a suitable composition of bronze, brass or other appropriate bearing metal.

This rod **11** is an integral one extending the entire overall length of the mandrel **10**. It is comprised of a cylindrical portion **12** of substantial length and of a diameter substantially less than that of a metal base tube **13** to be finned. The rod **11** extends forward of this portion **12** in a reduced diameter at **14**, upon which it rotatably sustains a number of forming and pilot mandrel sections (hereinafter described); and still further forwardly or to the right (FIG. 1) terminates in a reduced diameter threaded extremity **15**, to which flat sided securing and lock nuts **16**, **17** are applied.

Rearwardly of the cylindrical body portion **12** of rod **11**, the latter is reduced in diameter at **19**, at which portion it receives a felt oiler ring or sleeve **20** whose outer diameter substantially equals the I.D. of the base tube **13** being finned. The components are held in assembly at this end by jam nuts **21** threadedly applied to the outer end of reduced rod portion **19**, with a pressure washer **22** acting between these nuts and the oiler ring or sleeve **20**. The latter is, of course, appropriately impregnated with lubricant to facilitate the forming and finning operation by reducing friction between tube **13** and mandrel **10**.

A set of tube reducing and grooving or finning disc units coacts with the mandrel **10** in the basic manner described in the patent to Greene et al identified above. This set may comprise assemblies **24**, **25** of rolling, and grooving or finning discs **26** of a known type mounted upon arbors **27**, **28**, respectively. Ordinarily there are three such sets spaced equally in the circumferential sense about the axis of mandrel **10** and tube **13**, although this is not always the case; and provision of a known sort is made to bring the sets **24**, **25** strongly inwardly radially under heavy pressure to initiate and complete the reduction of the tube **13** in diameter at **30**, and to form, fin or groove the latter. This will preferably involve a progressively increased application of finning pressure to the tube by the discs **26**, in the manner illustrated and described in the patent to Hill, No. 2,508,518 of May 23, 1950.

The axes of the discs **26** are inclined at a desired angle to the tube axis so as, in conjunction with the mandrel, to conjugate with and form an extruded helical fin on the tube; and for this purpose, appropriate known means are provided to produce relative rotation of the tube and disc sets **24**, **25**, in reference to the axes of mandrel **10** and tube **13**, such that the disc sets produce an axial forward advance of tube **13** as the forming, grooving and finning proceeds.

As held in place upon the rod **11** between the respective pairs of end nuts **16**, **17** and **20**, **21**, yet not under sufficient axial force to substantially impede the independent rotation of its pilot and forming components, the mandrel **10** includes the following.

There is a primary carbide mandrel section **32** which is sleeved upon the reduced forward portion **14** of rod **11** as a bearing, and ultimately takes its forming position, illustrated in solid line in FIG. 1, just to the rear of the finning and grooving sets **24**, **25**. The forming section **32** is of relatively short axial length, for minimum rotative friction on the rod **11**, and its forward side is shaped to provide an annular forming or abutment shoulder **33** of relatively sharply convex curvature. The rear radial surface of the sleeve-like primary forming section **32** has running engagement against the forward end of a secondary or pilot mandrel **35**, also of tungsten carbide to resist wear at the axial engaging ends under the heavy axial rear thrust exerted on forming mandrel section **32**. Sections **32** and **35** have a running bearing clearance on rod

portion 14 (as do other mandrel sections to be described) amounting to in the neighborhood of 0.002 inch, although this dimension is capable of variation.

The outer diameter of the forming and pilot mandrel sections 32, 35 is, as shown in FIG. 1, the same, and substantially less than the inner diameter of the base tube 13 being finned, needing a substantial radial reduction of tube diameter at the forming and finning sets 24, 25.

An anti-friction bronze washer 37 sleeved on rod portion 14 to the rear of pilot mandrel section 35 separates the same from the forward end of the integral enlarged cylindrical portion or formation 12 of the rod 11, which thus rearwardly sustains the assemblage of pilot and forming mandrel sections against a very substantial axial thrust at the forming or abutment shoulder 33 of mandrel section 32. It is to be noted that when mandrel 10 is inwardly inserted in the tube body 13 for the finning operation, its carbide forming and pilot sections will be spaced somewhat to the rear of the disc sets 24, 25. The action of the latter in commencing reducing and finning operation on the tube is to draw the mandrel forwardly from the dotted line position indicated in FIG. 1 to the solid line position, in which the shoulder 33 directly sustains the axial thrust exerted by the mandrel in the finning operation.

The mandrel 10 is completed by a pair of like, relatively elongated, rearward and forward pilot mandrels 39, 40, respectively. These are formed of a hard, wear and indentation resistant material, such as tungsten carbide, and are separated axially by a bronze bearing washer 41, for reduced friction operation of members 39 and 40. Finally, a small size bronze thrust washer 42 is interposed at the forward end of mandrel section 40, between the latter and the nuts 16, 17.

It is desirable to provide a small length carbide forming mandrel 32 as a component separate from the equal diameter carbide pilot mandrel 35, in the interest of reducing running friction on rod portion 14 at the critical forming zone to a minimum.

Similarly, it is desirable to provide carbide pilot structure at forward mandrel sections 39, 40 which is considerably elongated in character. These mandrel sections have the same outer diameter as the inner diameter of the finned tube portion (assuming a very slight radial outward spring of the latter after finning) and the elongated pilot construction provides a desired length of internal tube bearing area to result in a very straight product. The two sections 39, 40 are employed, not only to reduce radial running friction, but also in view of the fact that it is easier to obtain a pair of carbide coacting section lengths than a single elongated mandrel section of the overall forward pilot length. The presence of the spacing bronze washer 41 contributes to a desired independence of rotation of the sections 39, 40 relative to one another, just as the washer 37 contributes in this manner at the rear of the forming and pilot carbide sections 35.

The invention provides a mandrel in which extremely long lengths of tube can be expeditiously finned with a low power requirement, in so far as producing relative rotation of tube and forming discs is concerned, the mandrel and any or all of its sections rotating freely upon the mounting and bearing rod, thus enabling the mandrel to withstand the various forces in axial tension and radial compression to which it is subjected at various points along its length; while the mandrel is firmly held in place at the shoulder 33 and stresses tending to tear the tube are prevented from arising.

The drawing and the foregoing specification constitute a description of the improved floating rotating mandrel for finning 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. A floating mandrel for forming base tubing for unsupported action within the tubing, comprising a plurality of axially arranged, cylindrical mandrel sections rotatable coaxially relative to one another, including a pilot section and a cylindrical forming section of greater outer diameter than said pilot section, said forming section being disposed to the rear of said pilot section, and means rearwardly sustaining said sections and mounting the same as a unit for coaxial rotation relative to one another.

2. A floating mandrel for forming base tubing for unsupported action within the tubing, comprising a plurality of axially arranged, cylindrical mandrel sections rotatable coaxially relative to one another, including a pilot section and a cylindrical forming section of greater outer diameter than said pilot section, said forming section being disposed to the rear of said pilot section and having a convex rounded shoulder directly to the rear of the latter, and means rearwardly sustaining said sections and mounting the same as a unit for coaxial rotation relative to one another.

3. A floating mandrel for forming base tubing for unsupported action within the tubing, comprising a plurality of axially arranged, cylindrical sleeve-like mandrel sections rotatable coaxially relative to one another, including a pilot section and a cylindrical forming section of greater outer diameter than said pilot section, said forming section being disposed to the rear of said pilot section and having a convex rounded shoulder directly to the rear of the latter, and means rearwardly sustaining said sections and mounting the same as a unit for coaxial rotation relative to one another, comprising a rod extending through said sections, said sections having running bearing engagement on said rod.

4. A floating mandrel for forming base tubing for unsupported action within the tubing, comprising a plurality of axially arranged, cylindrical mandrel sections rotatable coaxially relative to one another, including a forward pilot section, and a pair of axially sequential cylindrical forming and pilot sections of like outer diameter and greater outer diameter than said pilot section, said last named forming and pilot sections being disposed coaxially to the rear of said first named pilot section, and means to the rear of said last named forming and pilot sections rearwardly sustaining the latter and said first named pilot section and mounting all of said mandrel sections as a unit for coaxial rotation relative to said means and one another.

5. A floating mandrel for forming base tubing for unsupported action within the tubing, comprising a plurality of axially arranged, cylindrical mandrel sections rotatable coaxially relative to one another, including a pair of forword pilot sections separated axially from one another by a member of bearing material, and a pair of cylindrical forming and pilot sections of greater outer diameter than said pilot sections, said last named forming and pilot sections being disposed coaxially to the rear of said first named pilot sections, and means to the rear of said last named forming and pilot sections rearwardly sustaining the latter and said first named pilot sections and mounting all of said mandrel sections as a unit for coaxial rotation relative to said means and one another.

6. A floating mandrel for use in reducing and finning metal base tubes by unsupported action within the tube, comprising a cylindrical, relatively forward pilot mandrel section of an outer diameter substantially equal to the desired internal diameter of a finned portion of the tube, a cylindrical forming mandrel section of an outer diameter substantially greater than said pilot section in a forward annular shoulder zone of the forming mandrel coaxially to the rear of said pilot mandrel section, but less than the inner diameter of the base tube to be finned, said sections being coaxially rotatable relative to one another adjacent said shoulder zone, said forming mandrel section having an annular shoulder at a zone which is rounded at said zone to support said tube rearwardly of said finned portion of the latter, and means rearwardly

sustaining said sections as a unit and rotatively mounting the same for said relative rotation thereof.

7. In combination, a floating mandrel for use in reducing and finning metal base tubes by unsupported action within the tube, comprising a cylindrical, relatively forward pilot mandrel section of an outer diameter substantially equal to the desired internal diameter of a finned portion of the tube, a cylindrical forming mandrel section of an outer diameter substantially greater than said pilot section in a forward annular shoulder zone of the forming mandrel coaxially to the rear of said pilot mandrel section, but less than the inner diameter of the base tube to be finned, said sections being coaxially rotatable relative to one another adjacent said shoulder zone, said forming mandrel section having an annular shoulder at a zone which is convexly rounded radially inwardly in a relatively abrupt curvature at said zone to support said tube rearwardly of said finned portion of the latter, and means rearwardly sustaining said sections as a unit and rotatively mounting the same for said relative rotation thereof, and rotary finning disc means in rotative, radial compressive engagement with said base tube surrounding said mandrel, said disc means acting rotatively relative to and on said tube on a portion thereof directly forwardly of the shoulder of said forming mandrel section.

8. In combination, a floating mandrel for use in reducing and finning metal base tubes by unsupported action within the tube, comprising a cylindrical tubular, relatively forward pilot mandrel section of hard, indentation-resistant material of an outer diameter substantially equal to the desired internal diameter of a finned portion of the tube, a cylindrical tubular forming mandrel section of similarly hard material and of an outer diameter substantially greater than said pilot section in a forward annular shoulder zone of the forming mandrel coaxially to the rear of said pilot mandrel section, but less than the inner diameter of the base tube to be finned,

said sections being coaxially rotatable relative to one another adjacent said shoulder zone, said forming mandrel section having an annular shoulder at a zone which is radially inwardly and convexly rounded in a relatively abrupt curvature at said zone to support said tube rearwardly of said finned portion of the latter, and means rearwardly sustaining said sections as a unit and mounting the same for said relative rotation thereof, comprising an elongated rod extending through said mandrel sections and journaling the same for rotation, said rod having means in the form of an integral formation thereon which is in rearward axial supporting relation to said sections, and rotary finning disc means in rotative, radial compressive engagement with said base tube surrounding said mandrel, said disc means acting rotatively relative to and on said tube on a portion thereof directly forwardly of the shoulder of said forming mandrel section.

9. A floating mandrel for forming base tubing for unsupported action within the tubing, comprising a plurality of axially arranged, cylindrical mandrel sections rotatable coaxially relative to one another, including a pilot section and a cylindrical forming section of greater outer diameter than said pilot section, said forming section being disposed to the rear of said pilot section and having a convex rounded shoulder directly to the rear of the latter, which shoulder extends radially inwardly of said forming section and is of relatively abrupt curvature.

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