

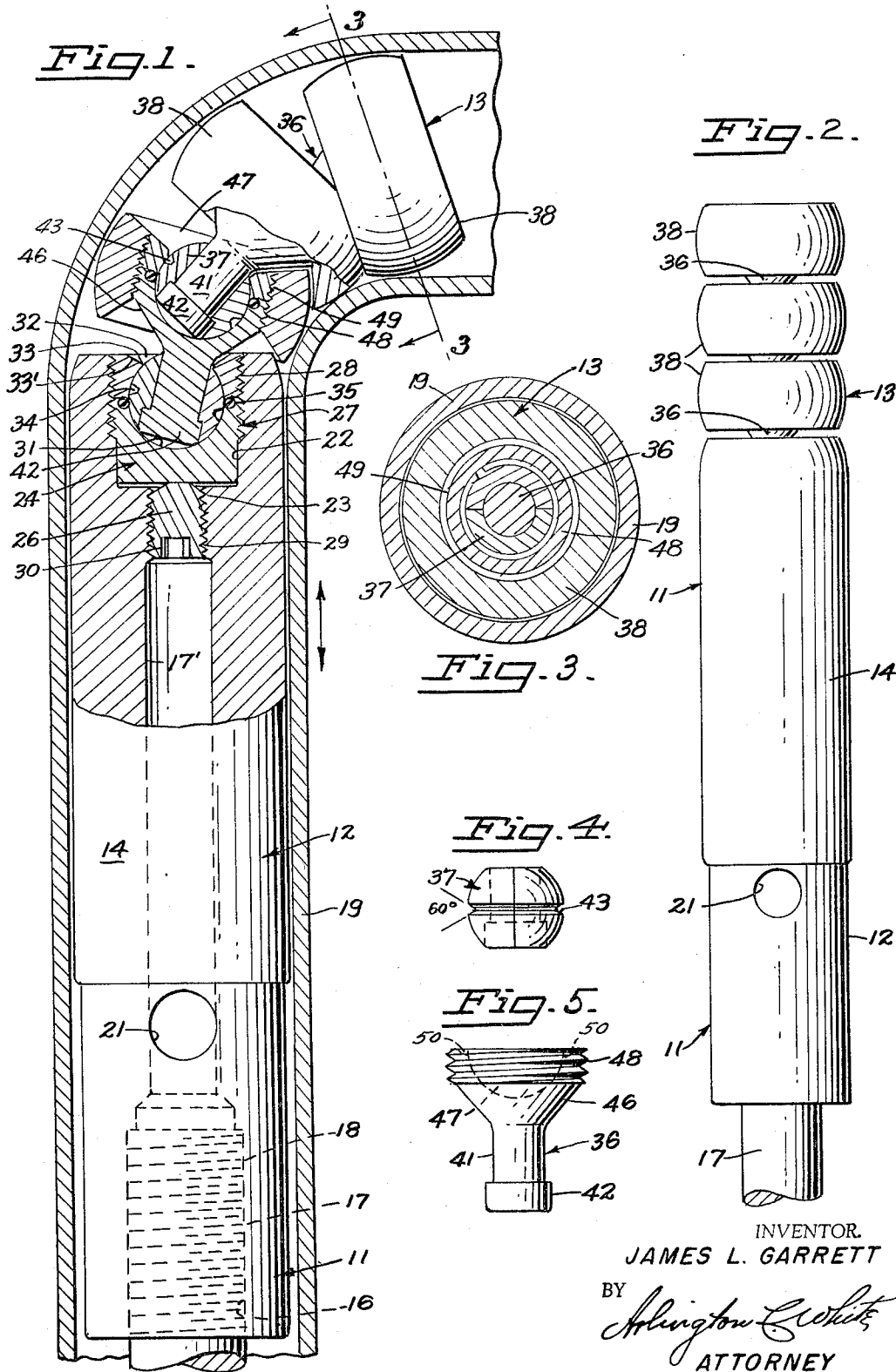
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METHOD OF BENDING TUBING AND MANDREL COMPONENT THEREOF

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METHOD OF BENDING TUBING AND MANDREL COMPONENT THEREOF

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3 Claims. (Cl. 72-466)

The invention, in general, relates to the art of tubing bending. More particularly, the invention relates to an improved method of and a unique tool for the bending of tubing fabricated from appreciably strong metals, such as steel and the so-called exotic metals presently used to a great extent and great advantage in aircraft, space craft and components thereof where instrumentation including metal tubing are installed in limited spaces or areas resulting in the requirement of increased strength of tubing.

It is perhaps well known that considerable attention has recently been devoted to means for eliminating crimps or kinks at the bend areas of tubing and for providing smooth inner walls throughout the entire lengths of metal tubing in order to reduce to a minimum eddy currents in fluids or liquids flowing therethrough as well as to avoid variations in the rate of flow of the fluids or liquids. In view of the development of appreciably strong metals from which metal tubing is fabricated, resistance to smooth and uniform bending thereof has increased. The present invention is directed to an improved method of bending relatively strong metal tubing as well as an improved mandrel component thereof which will accomplish in its bending technique a smooth inner wall at all bent areas of the tubing despite the toughness of the metal and despite the degree of the bend.

A primary object of my invention is to provide an improved method of bending tubing which lends itself admirably to the bending of tubing of any diameter and which effects desired bends in the tubing in a minimum of time and at minimum expense.

Another important object of the present invention is to provide an improved method of the indicated nature which is additionally characterized by its ability of affording either continuous single or compound bends in any desired location of tubing fabricated of appreciably strong metals with facility and with rapidity.

A still further object of my present invention is to provide an improved method of tube bending of the aforementioned character wherein the assembly of tool components for effecting the easy bending of any given tubing is facile, inexpensive and within the skill of the ordinary artisan once the method is learned and practiced.

Other objects of the invention, together with some of the advantageous features thereof, will appear from the following description of a preferred mode of practicing the invention as well as the following description of a preferred embodiment of the invention as exemplified in a mandrel, which is illustrated in the accompanying drawings. It is to be understood, however, that I am not to be limited to the precise method described nor to the precise embodiment of mandrel shown, as my invention, as defined in the appended claims, can be carried out in a plurality and variety of ways and can be embodied in a plurality and variety of forms.

Referring to the drawings:

FIG. 1 is a front elevational view, partly in section and partly in dotted lines showing, of a preferred embodiment of the invention as exemplified in a mandrel which is shown inserted in a metal tubing that is depicted in sectional elevation and bent in one area thereof adjacent to the flexible section of the mandrel.

FIG. 2 is a front elevational view of a preferred embodiment of the invention, as exemplified in a mandrel;

this view illustrating the mandrel supported on a mandrel rod shown in fragmentary elevation, and illustrating the flexible section of the mandrel latched in straight line projection from the shank to facilitate the placement of the mandrel in a tubing to be bent.

FIG. 3 is a sectional view of the embodiment of FIGS. 1 and 2, this view being taken on the line 3-3 of FIG. 1.

FIG. 4 is a front elevational view of one of the split link balls forming a part of a preferred embodiment of one of the articulated elements of the flexible section of the preferred embodiment of my invention, as exemplified in a tubing bending mandrel serving as a component of my preferred mode of bending tubing.

FIG. 5 is a front elevational view of a preferred embodiment of a link element forming one of the series of link elements in the articulated group constituting the flexible section of the preferred embodiment of my invention as exemplified in a tubing bending mandrel; this view showing in dotted line the recess in one end of each of the links for the reception of the link ball portion of an adjacent link in the articulated series of elements of the flexible section of the mandrel.

In its preferred mode, the method of making bends in metal tubing of my present invention preferably comprises the steps of rigidly connecting to a support a bending mandrel having a flexible section universally mounted thereon, causing a length of metal tubing to be placed over said mandrel including its flexible section with one end of said tubing connected to a power driven tube-drawing device, actuating said device to reciprocate said length of tubing as well as to advance the same over and beyond said mandrel at a constant rate of reciprocation and advancement while simultaneously bending said tubing at the flexible portion or section of said mandrel.

In its preferred form, the unique tubing bending mandrel component of my improved method preferably comprises a rigid straight shank, a flexible section universally connected to said shank and comprising a series of articulated balls each having a smooth outer convex surface, and interlocking means connecting successive balls of said series of articulated balls while permitting variable angular positioning of each ball in relation to others in the series upon flexing said flexible section in relation to said rigid shank by the application of an external force such as engaging a metal tubing therewith and drawing the tubing thereover while in engagement therewith.

As particularly shown in FIG. 1 of the annexed drawings, I provide a tubing bending mandrel of circular cross-section, which is generally designated by the reference numeral 11 and which preferably is entirely fabricated of steel or other suitable strong metal. As shown, the mandrel 11 consists of a straight rigid section 12, and a flexible section 13 removably connected as a unit to the rigid section 12 and universally mounted thereon. The rigid section 12 comprises a shank 14 which is fashioned with a longitudinally extending elongated threaded opening 16 at one end thereof for effecting the removable mounting of the mandrel 11 on a mandrel rod 17 having a threaded section 18 thereon for threadedly engaging the mandrel in the threaded opening 16 thereof. While not shown in the annexed drawings, the mandrel rod 17 extends from a power-driven device which is used in a conventional manner to hold the mandrel in a desired position in the tubing to be bent, as illustrated by the reference numeral 19 in FIGS. 1 and 3; and also is used to extract the mandrel from a bent position in the tubing 19 after the bending has been completed.

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The shank 14 of the mandrel also is formed with a transverse hole 21 therethrough for turning the mandrel 11 in relation to the mandrel rod 17 and thereby to tighten the mandrel thereon. The mandrel rod 17 is fixedly secured to a support, not shown, which may be a part of a reciprocable hydraulically operated piston operable within a cylinder mounted on a movable carriage, all not shown. As shown, the outer end of shank 14 is so fashioned as to provide a relatively large outer counter-bore 22 and a merging relatively small inner counter-bore 23 therein. The two counter-bores 22 and 23 function to receive a specially formed socket 24 and a set-screw 26, respectively, which form parts of a socket assembly, designated generally by the reference numeral 27, by means of which the flexible section 13 is universally as well as removably mounted upon rigid section 12 of the mandrel. Both the large outer counter-bore 22 and the small inner counter-bore 23 of the shank 14 of the mandrel are internally threaded, as at 28 and 29, respectively, for removably receiving the externally threaded socket 24 and the set-screw 26. As shown particularly in FIG. 1 of the annexed drawings, the socket 24 is fashioned with a nearly hemi-spherical recess 31 which opens to the exterior of the shank 14 of the mandrel through a relatively wide mouth 32 which is formed with a limited area 33 by a flared end surface 33' on the outer end of the socket. Moreover, the inner wall of the socket 24 is formed with a small annular recess 34 for receiving a ring 35 when the flexible section 13 of the mandrel is flexed. The set-screw 26 is formed with a small recess 30 of hexagonal shape at its inner end for receiving the hexagonal end of a screw-driver or like tool, not shown, which may be passed through a longitudinally extending bore 17' of the shank 14 when the mandrel is not on the mandrel rod 17 in order to tighten the set-screw 26 of the socket assembly 27 to a firm position in its counter-bore 23 and set up the mandrel for the removable and universal mounting of the socket assembly as an entirety on the outer end of the shank 14 as well as for the universal mounting of the flexible section 13 in the socket 24 of the socket assembly 27.

In accordance with the present invention, the flexible section 13 of my improved mandrel 11 preferably is constructed for increased strength with specially constructed links 36, specially constructed link balls 37 and specially constructed mandrel balls 38 constituting the series of articulated elements which comprise such flexible section 13. It is to be observed that while the mandrel balls 38 shown in the annexed drawings are not geometric spheres but only the sphere sections, they are nevertheless known in the art as balls or mandrel balls and will be so termed throughout the specification and claims. It is, of course, to be understood that the flexible section 13 of the mandrel 11 may consist of any desired number of units, each comprising a link 36, a link ball 37, and a mandrel ball 38. The limitation in the drawings to but three of these units on the flexible section 13 is solely because of space limitation on the drawing sheets, since any number of such units can be articulated in such flexible sections 13.

With especial reference to FIGS. 1, 4 and 5 of the annexed drawings, I preferably construct each of the links 36 with a straight stem 41 of cylindrical cross-section and with a flange or cuff 42 formed thereon at its end to serve as a restraining means during universal movement of each link ball 37 in relation to an adjacent link 36. The stem 41 of each of the links 36 is embedded within and forms an integral part of each link ball 37; the ball 37 being formed to a slightly smaller diameter than the diameter of the hemi-spherical recess, hereinafter described, in which it seats as well as rotates. Each of the link balls 37 of each of the aforesaid units constituting the articulated elements of the flexible section 13 of the mandrel 11 preferably is split in a vertical plane as well as split circumferentially in a horizontal plane

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by the formation therein of an annular groove 43, see FIG. 4. Upon assembly of the link ball 37 within its cooperating recess, a ring 35 is snapped into each of the grooves 43 of each of the link balls 37 to serve as one component of an interlock mechanism between each link ball 37 and its associated hemi-spherical recess. In addition to its function as a component of the interlock mechanism, as aforesaid, the link ring 35 affords smooth peripheries for the link balls 37, thus preventing undue wear therefrom from friction during their universal movement in the recesses.

The formed annular grooves 43 in the link balls 37 permit desired expansion of the split link balls during assembly thereof in operative positions, but because such grooves 43 are formed circumferentially of the split link balls 37 rather than radially or diametrically through the same, the split link balls of the present invention have appreciably greater strength and withstand much higher stresses imposed thereon during tubing bending operations of strong tubing, such as tubing fabricated of steel or from the so-called exotic metals. Each of the specially constructed links 36 includes a cup-like portion 46 which conveniently is formed integrally with the stem 41 and which, because of its construction, flares widely outwardly from the juncture thereof with the stem 41 to the opposite end of the link. The cup-like portion 46 of each link 36 is so formed as to define at its outer portion a generally hemi-spherical recess 47 for the reception of an adjacent split link ball 37 of an adjacently arranged and articulated link 36 of the series thereof comprising flexible section 13 of the mandrel 11.

In order to effect removable mounting of each mandrel ball 38 on each link 36, to permit ready replacement in case of damage to any of the balls 38, I provide an externally threaded section 48 on each of the cup-like portions 46 of the links 36 for threadedly receiving a complementary threaded section 49 formed on the inner surface of each mandrel ball. The threaded connections between the links and the mandrel balls permits a reasonable amount of yielding movement of each of the mandrel balls 38 during tubing bending operations; such movement materially aiding in the maintenance of smooth inner walls on the tubing at the bent areas thereof, without crimping or kinking of the tubing. It also is to be observed that at approximately midway of the height of each hemi-spherical recess 47 of each cup-like portion 46 of each link 36, I provide or form in the inner wall of the recess an annular groove 50 for the reception of the link ball ring 35 which is seated partially in each of the grooves 43 of the link balls 37; the latter being locked thereby against universal movement but unlatched by the application of but a slight force to permit the desired universal movement within the recesses 47.

It is to be observed that the flexible section 13 of the mandrel 11 can be moved in any direction in relation to the straight shank 12 by virtue of the universal mounting of the socket assembly 27 on the outer end of such shank as well as by reason that the units comprising the links 36, link balls 37 and mandrel balls are articulated for related movement. The link ball rings 35, cooperating with the grooves 43 of the split link balls 37 as well as with recess 34 in socket 24 and grooves 50 in the hemi-spherical recesses 47 of cup-like portions 46 of the links 36, function to latch or interlock the elements of such units together yet permit the desirable universal movement of the flexible section 13 as an entirety and the limited universal movement of each of the link balls 37 in recesses 47.

It is, of course, to be understood that the mandrel 11 can be made to any desired size to accommodate the pulling or drawing thereof, and the bending of a tubing of any inner diameter in any desired area thereof, from a relatively small tubing to a relatively large tubing, and despite the strength of the metal of which the tubing is fabricated. Consequently, the mandrel balls 38 can be

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made to any desired diameter for the bending of variable sizes of tubing; although it is essential that for any given mandrel, the diameters of the mandrel balls 38 are of the same size or uniform throughout all of the articulated elements of the flexible section 13 of the mandrel 11.

While the cup-like portions 46 of the links 36 undergo radial expansion by virtue of the annular recess 50 in each thereof and under the urging of the link balls 37 against the flared ends of such cup-like portions 46 into their hemi-spherical seats 47, once the connected relationships between the series of articulated elements constituting the flexible section 13 have been established, the link ball rings 35 are snapped into place to effect the desired interlocking relation for straight line arrangement of the flexible portion of mandrel to facilitate the placement of the tube over the mandrel. The junctures between the stems 41 and flaring cup-like portions 46 of the links 36 will engage the adjacently disposed links 36 in the series to prevent displacement of the link balls 37 from their sockets or hemi-spherical seats 47, and effectively retains the elements in interlocked or connected relation. The threaded relationship between the mandrel balls 38 and the flared outer ends 47 of the links 36 is maintained despite the pressure applied when the tube-drawing equipment such as a hydraulic cylinder, not shown, effects a reciprocation as well as advancement of the tubing over the mandrel balls and throughout the flexible section 13 of the mandrel. It is to be understood, of course, that during any tubing bending operation, the tubing to be bent is clamped to a bending die, not shown, in the conventional manner. Also, that in accordance with standard practice, the tube remains clamped to the clamping die after completion of the bending operation, and the mandrel is removed by means of the operation of the hydraulic cylinder, not shown, to the piston of which the mandrel rod 17 is connected.

The construction of my improved mandrel 11 is such that an appreciably stronger flexible section 13 with its series of articulated links and mandrel balls, is provided for withstanding stresses and strains imposed on the exterior surfaces of the mandrel balls 38 during the bending operations. Preferably, the several components of the mandrel components are fabricated of a hard steel alloy, and the mandrel balls 38, together with the rings 35 are preferably chromium plated to insure lasting service or better wear characteristics and resistance to abrasion.

In my improved method of bending metal tubing, the mandrel 11 is rigidly connected to a mandrel rod, and the flexible section 13 of the mandrel is passed through a metal tubing desired to be bent to a predetermined extent. At the desired area, the tubing is clamped to a bending device, not shown, and the reciprocating means, not shown, is connected to the end of the tubing adjacent to the mandrel rod. Thereafter, the reciprocating device is placed in operation for effecting the reciprocation of the tubing over the area at the flexible section 13 of the mandrel adjacent to the bending device, and simultaneously the reciprocating device is caused to be drawn rearwardly on a carriage, all not shown, to draw or advance the metal tubing over the mandrel balls 38 and thus to effect a smooth desired bend in the tubing without causing any kinks or crimps to be made in the

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tubing wall. The relative movement between link balls 37 and mandrel balls 38, by reason of the threaded connections therebetween, as at 48 and 49, aid in effecting the provision and maintenance of smooth inner walls on the tubing during bending thereof.

It is to be understood that the appended claims are to be accorded a range of equivalents commensurate in scope with the advances made over the prior art.

I claim:

1. In a bending mandrel for placement in a metal tubing to be bent, a flexible section of articulated elements comprising a series of links arranged in juxtaposition, an enlarged flaring portion on each of said links defining a recess, said recess having a groove therein, a split-link ball having an annular circumferentially disposed groove therein, on each link of said series of links, a link ball ring mounted on each of said split-link balls for reception in said annular groove of each link ball and said groove of each said recess to latch said articulated elements in a substantially straight line, and a rigid mandrel ball movably mounted on each enlarged portion of each of said links for relative movement between the mandrel and an encompassing metal tubing during bending operations to inhibit formation of kinks or crimps in the inner wall of the metal tubing.

2. In a tubing bending mandrel, a rigid cylindrical shank having a straight longitudinal axis and having a socket therein opening to one end thereof, and a flexible section universally mounted in said socket; said flexible section comprising a series of articulated elements consisting of identical links, each of said links having a recess therein provided with a groove, an integral link ball on each link having an annular circumferential groove therein, a rigid mandrel ball rotatably mounted on each link, and a link ball ring on each link ball seatable in each annular groove of each link ball and in each groove of each recess containing said link ball for holding said series of articulated elements in alignment with the longitudinal axis of said shank to facilitate placement of the mandrel in a tubing to be bent.

3. A tubing bending mandrel for placement in a metal tubing to be bent; said mandrel comprising a rigid shank, and a flexible section universally mounted on said shank; said flexible portion comprising a relatively movable articulated series of links and link balls, each of said links having a hemi-spherical recess formed thereon for the removable reception of a link ball, said recess having a groove therein, and each of said link balls having a circumferential annular groove therein which may be aligned with the groove in said recess, and a link ball ring on each link ball for fitting the groove of each said recess and each annular groove of each said link ball to latch said series of link balls in alignment with the longitudinal axis of said shank and facilitate placement of the mandrel within the metal tubing to be bent.

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