

[54] TUBE BENDING MACHINE

[72] Inventors: Andrew Nothum, St. Louis; Billy W. Thomas, St. Ann; Abram L. White, De Soto, all of Mo.

[73] Assignee: Grover Machine Company, Kirkwood, Mo.

[22] Filed: March 2, 1970

[21] Appl. No.: 15,732

[52] U.S. Cl. 72/307, 72/312, 29/157 A

[51] Int. Cl. B21d 11/04

[58] Field of Search 29/157 A, 312; 72/307, 312

[56] References Cited

UNITED STATES PATENTS

496,354	4/1893	Fairman.....	72/307
2,104,993	1/1938	Holub.....	72/307
441,426	11/1890	Lindemann.....	72/307
776,038	11/1904	Tucker.....	72/307
166,029	7/1875	Piehl.....	72/307
706,030	8/1902	Cunin.....	72/307
979,724	12/1910	Tucker et al.....	72/307
541,472	6/1895	Cunin.....	72/307
646,021	3/1900	Fairman.....	72/307
519,062	5/1894	Hoell et al.....	72/307
748,686	1/1904	Baumle.....	72/307

Primary Examiner—Charles W. Lanham

Assistant Examiner—Michael J. Keenan

Attorney—Cohn and Powell

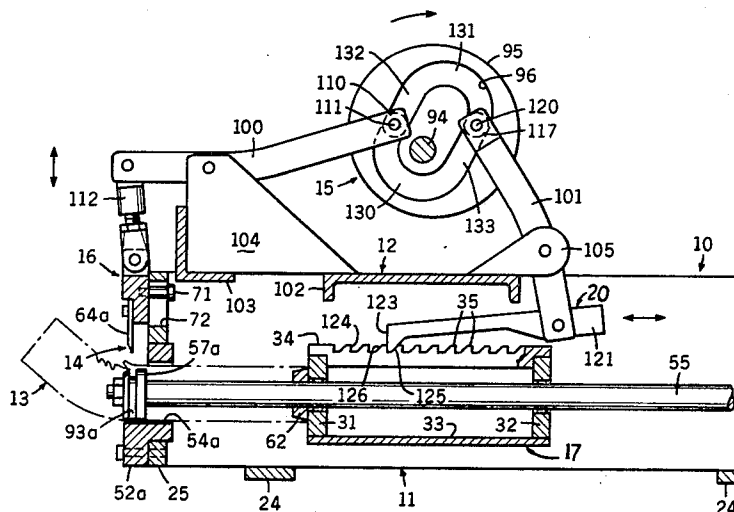
[57] ABSTRACT

This tube bending machine includes a base housing having an end aperture adapted to receive a hollow, rectangular tube. An inner die element is spaced from the margin of the aperture so as to be received by the tube and a toggle mechanism, carrying compatible outer die elements, is mounted to the housing and is adapted to crimp three sides of the tube. A crosshead carriage is mounted within the housing and connected to a pusher mechanism to advance the tube sequentially when the crimping action is completed. The toggle assembly and the pusher mechanism are actuated by a rotating cam connected to each assembly by rocker arms which reciprocate as the cam rotates. The cam is provided with an eccentric cam groove having a dwell portion which permits the toggle mechanism to be actuated when the pusher mechanism is quiescent and the pusher mechanism to be actuated when the toggle mechanism is quiescent.

A limit device, mounted within the housing, predetermines the number of applied crimps, thereby controlling the degree of bend induced into the tube.

A second cam is mounted to the cam shaft and actuates a second die assembly which is capable of crimping the ends of the tube following bending to permit these ends to be telescoped within a similar tube of regular cross section.

14 Claims, 12 Drawing Figures



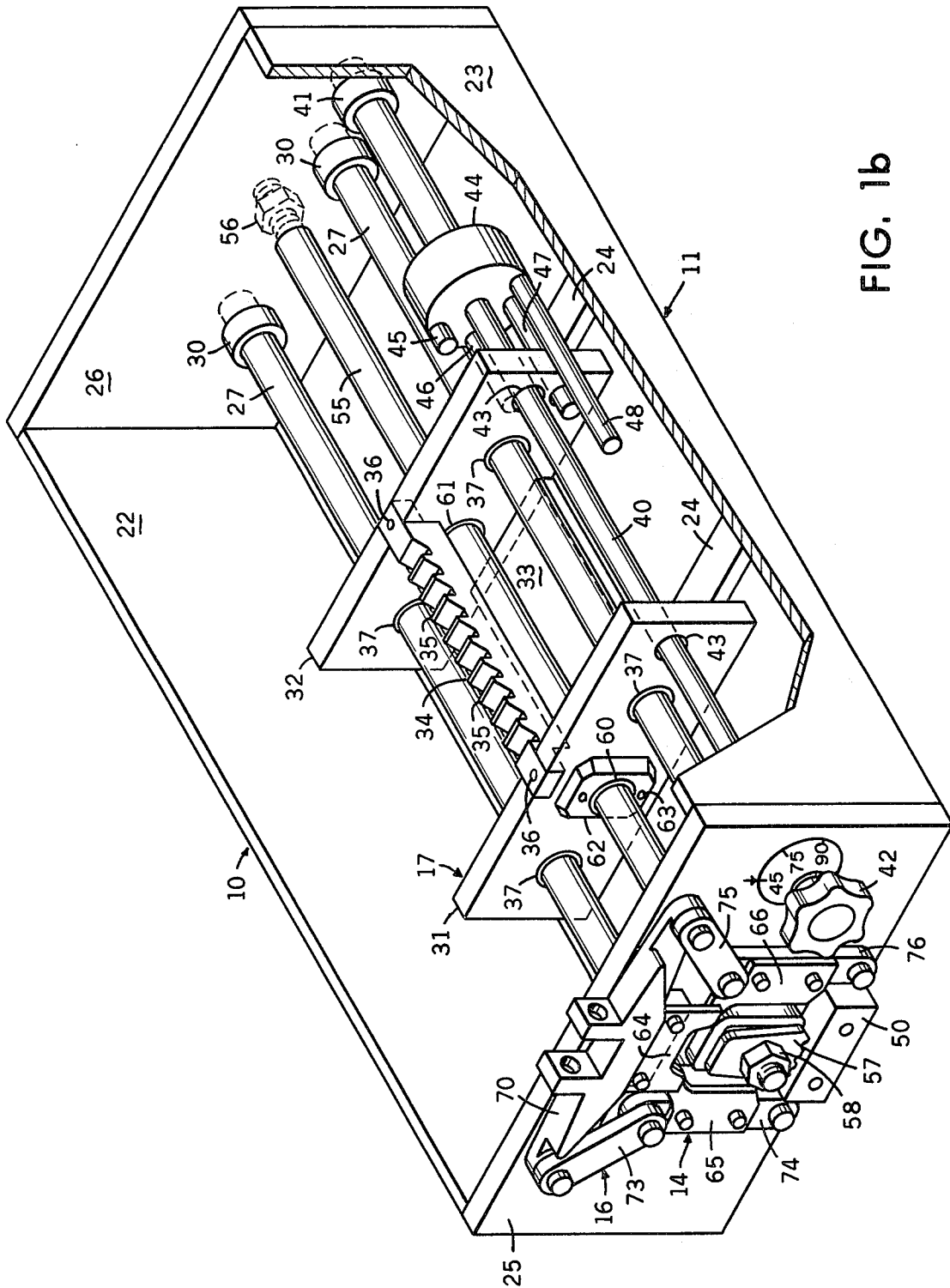


FIG. 1b

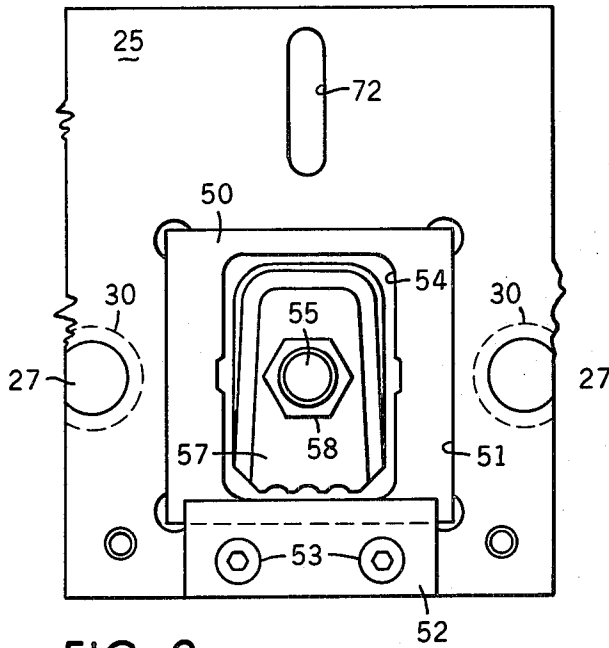


FIG. 2

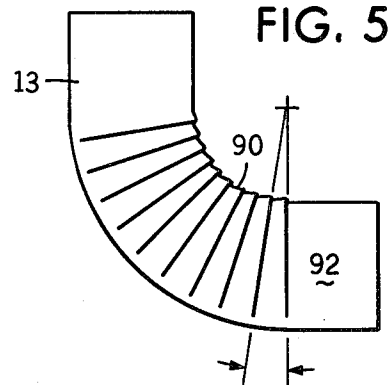


FIG. 5

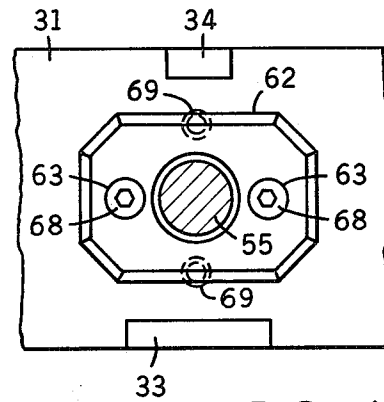


FIG. 4

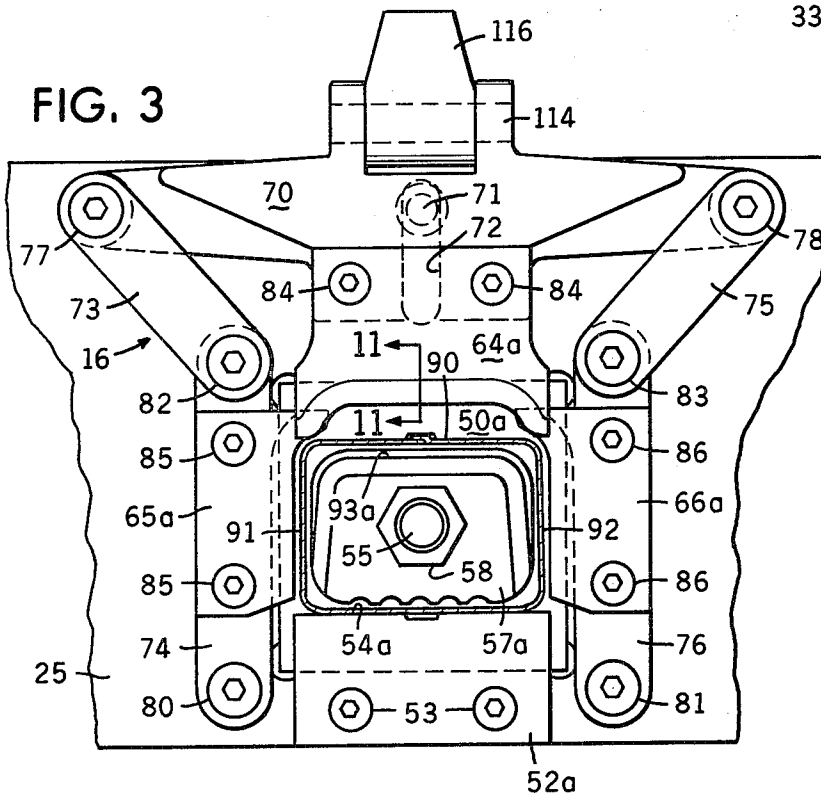


FIG. 3

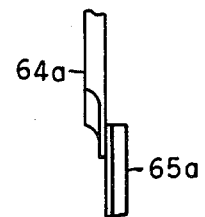
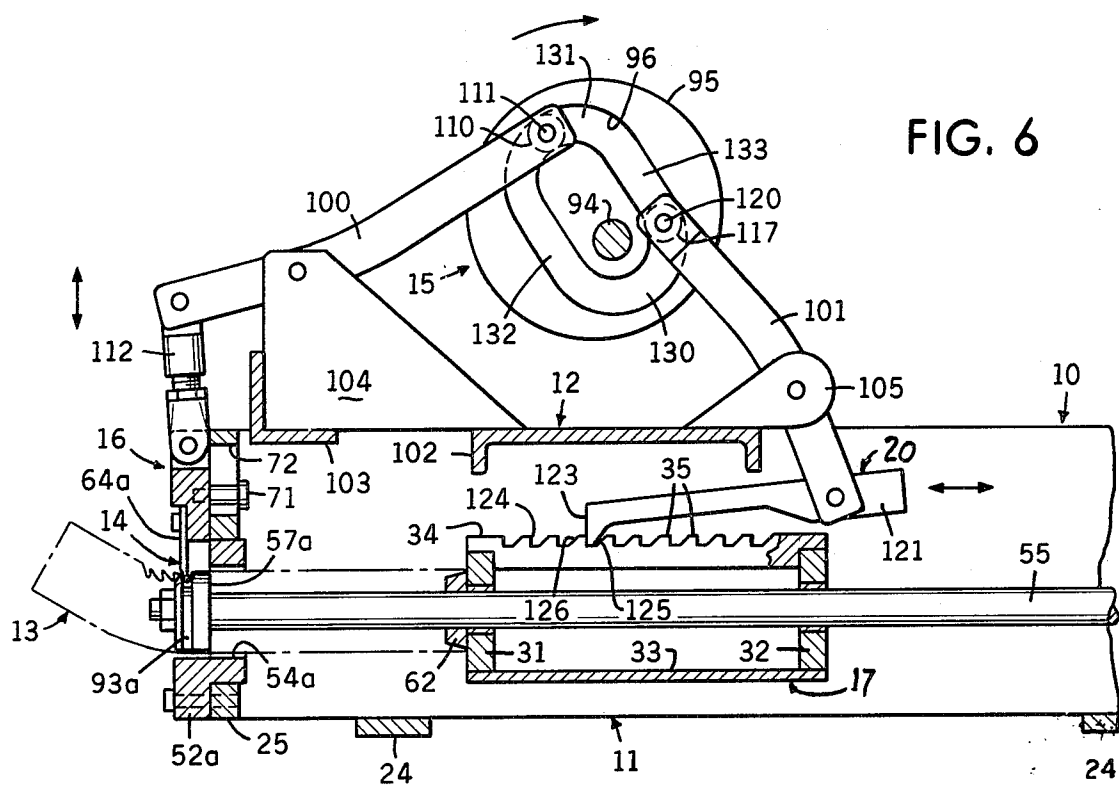
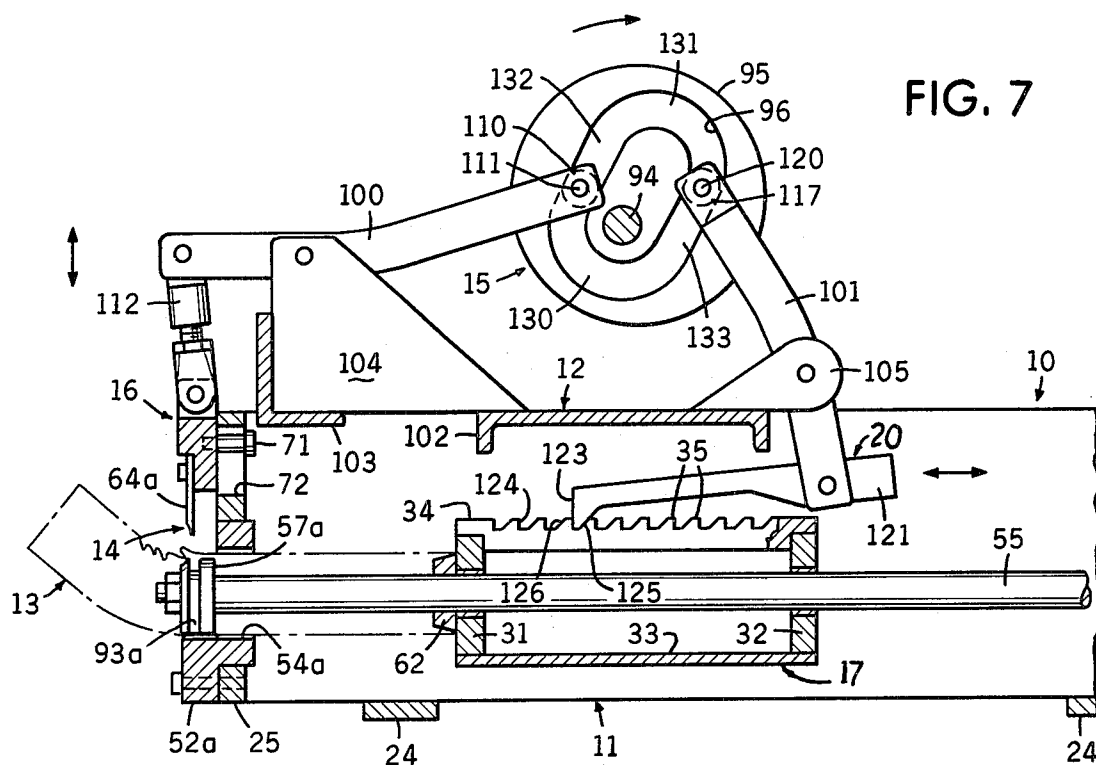


FIG. 11



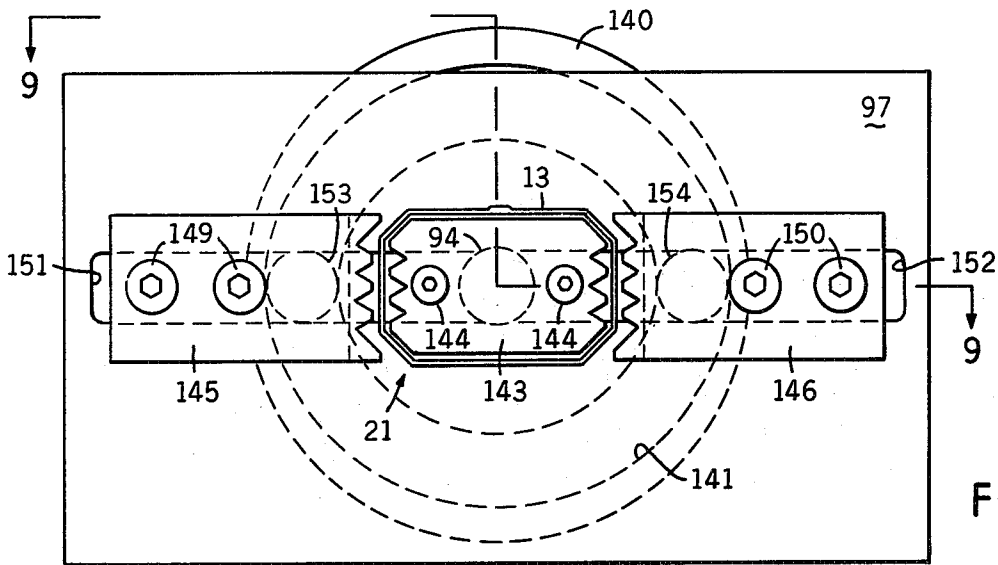


FIG. 8

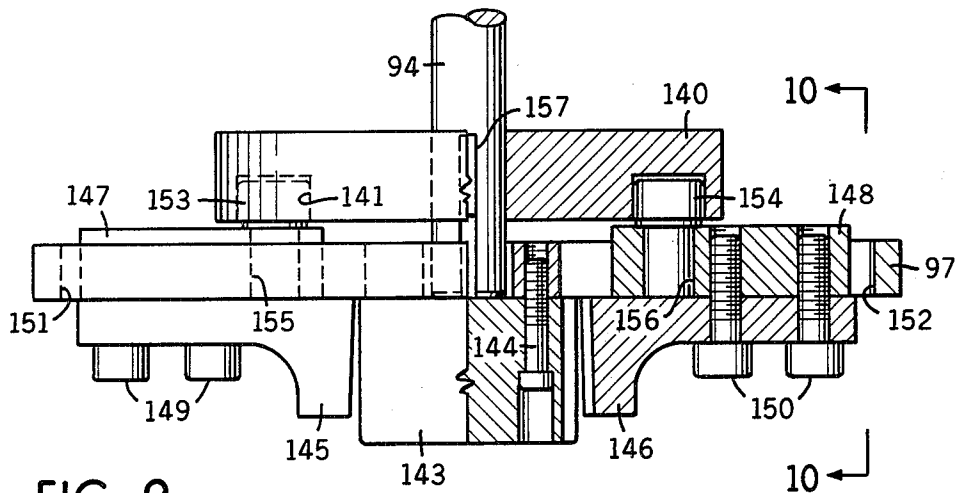


FIG. 9

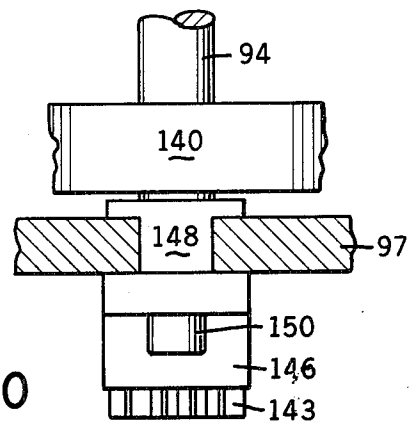


FIG. 10

TUBE BENDING MACHINE

BACKGROUND OF THE INVENTION

This invention relates to tube bending machines and particularly to a machine for forming elbows from sheet metal conductor pipes.

A continuous problem in the installation of water conductors, downspouts and the like is the formation of bends on such pipes or the formation of independent elbow fittings for such pipes. Machines which utilize dies to form bends and elbows are not, in themselves, new and such machines, employing matched dies brought together by hydraulic pressure, for example, are known. However, these existing machines do not appear to have met with general acceptance, either because of their complexity or their lack of versatility.

In the manufacture of pipe elbows, it is important that some versatility be available with regard to the variety of pipe size that the machine is capable of accepting. It is also important that there be an adjustment capability in the bending process so that the angle of bend is not limited to 90° or 45°. The reason for this is that actual dimensions encountered in the field, are frequently at variance with dimensions shown on drawings. Moreover, in the replacement of guttering and downspouts on existing buildings, accurate dimensions are rarely available in advance. Thus, much cutting and fitting of independent elbows is frequently necessary. It has frequently been impossible in the past to use one-piece offset fittings because of the heretofore difficulty of making such pieces accurately. Further, in pipe bending methods available up until the present, the length of conductor required for the formation of a bend or offset fitting has often resulted in considerable wastage of pipe and material.

SUMMARY OF THE INVENTION

This tube bending machine includes adjustment features which do not limit the elbows formed to a 90° or 45° configuration. Further, elbows may be formed directly on one or both ends of a length of conductor and thus, one-piece offset fittings can be manufactured to conform accurately with field dimensions. Another advantage of the present machine is that short lengths of conductor pipe, which would otherwise be scrapped, may be utilized to form elbows.

The versatility of the machine permits rectangular conductor piping to be bent about either the major or minor axis simply by changing the dies and the machine is adaptable to the bending of both rectangular and circular pipes. A special feature permits the crimping of pipe ends to facilitate telescoping fit between lengths of pipe.

The machine is simple to operate in the shop or in the field and elbows may be formed of painted or unpainted material. The elbows are of high quality and may be manufactured with a considerable saving in labor, thereby resulting in reduced final project costs.

The machine includes a base assembly providing a housing adapted to receive the tube which is to be bent. A die assembly, including compatible inner and outer die elements, is mounted to the base assembly and adapted to crimp the tube. A carriage assembly mounted in guided relation within the base housing, is adapted to engage and advance the tube following the crimping process. A toggle assembly, mounted to the base housing and connected to the outer die element, is actuated by a cam assembly which is operatively connected to the toggle assembly and to the carriage assembly whereby to sequentially actuate the die and carriage assembly.

The carriage assembly is preferably in the form of a crosshead carried by a pair of guide rails. The base housing includes an aperture receiving the tube and the inner die element is carried by a die rod and is peripherally spaced from said aperture. The die rod is mounted to the base assembly in side-by-side relation with and between the guide rails and is supported between its ends by the carriage assembly.

The toggle assembly includes a first, or upper link element mounted to the base housing for translational movement, and

opposed pairs of pivotally connected side toggle link elements. Each pair of side link elements includes one link pivotally connected to the upper link element and another link pivotally connected to the base housing. The die elements are carried in U-shaped crimping formation by the upper and side link elements for vertical and horizontal reciprocating movement relative to the fixed inner die element.

The cam assembly includes a cam follower riding the cam track. A rocker arm, pivotally mounted between its ends to the base assembly, carries the follower at one end and is operatively connected to the toggle assembly at the other end. The toggle assembly includes an adjustable link interconnecting the upper link element to the end of the rocker arm. The cam assembly includes a second cam follower riding the cam track and a second rocker arm, pivotally mounted between its end to the base assembly, carries said second follower at one end and operatively engages the carriage assembly at its other end. The carriage assembly includes a rack. A pawl carried by the end of the second rocker means operatively engages said rack.

The cam assembly includes a cam plate having a continuous groove eccentrically disposed about the center of rotation of the cam shaft and providing the cam track. The continuous groove includes a substantially constant radius arm dwell portion whereby one rocker arm is actuated while the other rocker arm is substantially quiescent as the cam shaft rotates.

A second die assembly including an inner die element and a pair of outer die elements is mounted to the base assembly and actuated by a second cam assembly. The second cam assembly includes a cam plate, having a substantially elliptical cam track, and opposed followers riding in said track engage said second outer die elements to urge said elements toward the inner die element whereby to crimp and reduce the cross section of the ends of a tube disposed between said die elements. The cam plates of each cam assembly are mounted on a common cam shaft.

Limit means mounted to the base assembly are selectively engageable with the carriage assembly whereby to limit travel of the carriage assembly and determine the bend angle induced into the tube by presetting the number of applied crimps. The limit means includes a plurality of stops mounted on a rotatable shaft for selective engagement with the carriage assembly.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1a is an exploded, perspective view of the upper portion of the machine illustrating the cam assembly;

FIG. 1b is a perspective view of the lower portion of the machine partly cut away to illustrate the carriage assembly;

FIG. 2 is a fragmentary end elevational view with the toggle assembly removed and illustrating the inner die set-up for bending a rectangular tube about its major axis;

FIG. 3 is a fragmentary end elevational view with the toggle assembly in place and illustrating the inner die set-up for bending a rectangular tube about its minor axis;

FIG. 4 is a fragmentary front view of the carriage assembly illustrating the tube end stop oriented for use with the die set-up shown in FIG. 3;

FIG. 5 is a side elevational view of a tube bent by the machine;

FIG. 6 is a side elevational view in cross section illustrating the disposition of machine parts during the crimping process;

FIG. 7 is a side elevational view in cross section illustrating the disposition of machine parts after crimping;

FIG. 8 is a side elevational view of the machine illustrating a second crimping assembly for reducing the cross section of the ends of the tube;

FIG. 9 is a plan view taken on line 9—9 of FIG. 8;

FIG. 10 is a fragmentary end view taken on line 10—10 of FIG. 9, and

FIG. 11 is a fragmentary, cross sectional view of the outer dies.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now by characters of reference to the drawings, and first to FIGS. 1a and 1b, it will be understood that the tube bending machine includes a base assembly 10 consisting essentially of a lower housing 11, and an upper mounting assembly, generally indicated by numeral 12. The upper mounting assembly 12 is attached to the lower housing 11 as by welding, in the assembled machine, but is shown separated therefrom for easier understanding of the details of the machine in FIGS. 1a and 1b.

FIGS. 6 and 7 indicate the structural arrangement of parts in the assembled machine and the relation thereto of a tube 13 when the machine is operative. Essentially, the rectangular tube 13 is received within the lower housing 11 and subjected to a succession of crimping and folding actions on three of its four sides. The crimping action results in the bending of the tube 13 to an arcuate configuration, the angle of which is dependent on the number of crimps formed, as shown in FIG. 5.

The crimping action is applied by means of a cam operated die set 14. The cam assembly is generally indicated by numeral 15 and is interconnected to the die set 14 by a toggle assembly 16. The cam assembly 15 is also interconnected to a carriage assembly 17 by a pusher assembly 20 and in this way the carriage assembly 17 sequentially advances and thereby folds the crimped portion of the tube 13.

A second cam operated die set, generally indicated by numeral 21 in FIG. 1a, provides a means of reducing the overall size of the end of the crimped tube 13, to permit said tube 13 to be telescopically received by tube of the same original size.

Referring now to the details of the machine, it will be understood from FIG. 1b, that the base assembly lower housing 11 includes opposed side plates 22 and 23 interconnected by a pair of bottom cross bars 24. Front and rear end plates 25 and 26 respectively extend between and are interconnected to the side plates 22 and 23, as by welding, to provide an overall box-like structure.

The carriage assembly 17 is in the nature of a crosshead and is slidably mounted for fore and aft movement within the lower housing 11 on a pair of guide rails 27 which extend between, and related, journal mounted in, the front and rear end plates 25 and 26. The guide rails are held in place by means of collars 30. The carriage assembly 17 includes front and rear transverse plates 31 and 32 interconnected by a bottom strut 33 and a rack element 34. The rack 34 includes a plurality of teeth 35 providing consecutive notches, and said rack 34 extends between and is connected to said transverse plates 31 and 32 as by a pair of threaded fasteners 36. Each of the transverse plates 31 and 32 includes a pair of bushings 37 receiving associated guide rails 27 in slidable relation.

The extent to which the tube 13 is bent is determined by the number of times the crimping action is applied as the carriage assembly 17 is sequentially advanced. The advance of the carriage assembly is relation as will appear, to the number of rack teeth 35 engaged by the pushed assembly 20. The starting point of the travel of the carriage assembly 17 is set by a limit device which, in the preferred embodiment, includes a rotatable shaft 40 journaled into the lower housing front and rear end walls 25 and 26 and held in place by collars 41 disposed at each end of the shaft 40. The shaft 40 extends beyond the lower housing front end and includes an attached dial knob 42. The shaft 40 is received through oversized clearance holes 43 provided in each of the carriage assembly transverse plates 31 and 32, and a relatively large collar 44 is mounted to the shaft 40 rearwardly of the rear transverse plate 32. A plurality of limit rods, generally indicated by numerals 45 through 48, are disposed orbitally about and parallel to the shaft 40 and each of the rods is engageable by the rear end plate 32 which constitutes an abutment. The limit rods, 45 through 48, are disposed on only one-half of the front face of the collar 44, so that only one rod is engaged with the rear face of the transverse plate 32 at any one time. The lateral overhang of the plate 32 relative to the shaft 40 is sufficiently small to permit the longer limit rods to be clear when a relatively short rod is engaged.

The machine is particularly adapted to bend a tube of rectangular cross section about either its major or minor axis and a change of set-up may be effectuated by a simple replacement of the dies and associated elements. Those elements which are utilized for crimping a tube having its major axis horizontal as opposed to vertical, are distinguished in the drawings and in the following description by the addition of a suffix letter *a*, it being understood that the elements so distinguished, perform essentially the same function.

As shown in FIG. 2, the lower housing 11 includes an insert adaptor plate 50, which is received within an aperture 51 provided in the front end plate 25. The adaptor plate 50 is secured to the end plate 25 by an attachment portion 52 which provides a seat for the tube 13. The attachment portion 52 is detachably secured to the end plate 25 as by threaded fasteners 53. The adaptor plate 50 includes an aperture 54 having a compatible configuration with the tube 13 when the major axis of said tube section is vertical. When the tube 13 is to be bent with its major axis horizontal, a substitute adaptor plate 50a is provided as shown in FIG. 3.

The carriage assembly 17 provides intermediate support for a die rod 55 which is attached to the lower housing rear end plate 26 by means of a nut 56 (FIG. 1b). At its remote end, the die rod 55 carries an inner die element 57 which is attached to the rod 55 by means of a nut 58. As shown in FIG. 1b, the die rod 55 is mounted to the carriage assembly 17 in sliding relation by means of bushings 60 and 61 provided in the carriage assembly front and rear transverse plates 31 and 32 respectively. It will be understood that the inner die element 57 is adapted to receive the tube 13 and that said inner die element 57 is, for this reason, peripherally spaced from the adaptor plate aperture 54. The carriage assembly 17 provides the necessary support for the relatively long die rod 55 to effectuate this peripheral spacing. Further, as shown in FIGS. 6 and 7, the inner end of the tube 13 is supported by an abutment adaptor 62. As shown in FIG. 4, the adaptor 62 is detachably attached to the front transverse plate 31 as by a pair of fasteners 63 threadedly received by apertures 68 when the major axis of the tube is horizontal. This adaptor 62 may be rotated through 90° and fastened to the front transverse plate 31 by utilizing the same fasteners 63, both threadedly received by apertures 69, when the major axis of the tube 13 is vertical. The abutment adaptor 62 includes chamfered lead edges to accommodate the fit of the tube 13 thereon.

The die set 14, constituting die means, includes, in addition to the inner die element 57, a plurality of outer die elements. These outer die elements are carried by the toggle assembly 16 and include an upper die element 64 and a pair of opposed side die elements 65 and 66. The toggle assembly 16, which is clearly indicated in FIG. 3, includes a first, upper link 70 mounted in slidable relation to the lower housing end plate 25 by means of a threaded fastener 71. Said fastener 71 is slidably received for reciprocating travel in a slot 72 provided in said end plate 25. The upper link 70 is pivotally connected at its end to opposed pairs of side, toggle link elements 73 and 74, and 75 and 76. Each of the upper toggle link elements 73 and 75 is pivotally connected to the upper link 70 at associated ends thereof by pivot pins 77 and 78 respectively and each of the lower toggle link elements 74 and 76 is pivotally connected to the end plate 25 by pivot pins 80 and 81. Associated toggle link elements 73 and 74 are pivotally connected to each other by pivot pin 82, and associated toggle link elements 75 and 76 are likewise pivotally connected by pivot pin 83. With this arrangement, reciprocating vertical translational movement of the upper link 70 results in inward rotation of the lower link elements 74 and 76 about pins 80 and 81 respectively. The upper die element 64a (FIG. 3) is detachably attached by a pair of fasteners 84 to the upper link element 70 and the dies 65a and 66a are detachably attached to the lower toggle link elements 74 and 76 respectively as by fasteners 85 and 86. Thus, as the upper die element 64a is depressed, the side elements 65a and 66a move inwardly, and thus each outer die element is urged toward the inner die element 57a. When the side walls of the tube 13 are interposed between inner and

outer die elements, the upper wall and side walls 90, 91 and 92 respectively of the tube 13, will be crimped by the shaped, chamfered edges of the outer die elements 54a, 65a and 66a which are received into the compatible U-shaped groove formation 93a provided on the inner die element 57a. This crimping action results in the upward bending of the tube 13 and, when the outer die elements 64a, 65a and 66a are reciprocated out of contact with the tube 13, forward pressure applied to the tube 13 by the carriage assembly 17, results in the crimped portion of the tube 13 being urged against the front of the groove 93a and folded rearwardly.

Cyclical reciprocating movement is induced into the toggle assembly 16 by means of the cam assembly 15, which also actuates the forward movement of the carriage assembly 17. As shown in FIG. 1a in particular, the cam assembly 15 includes a rotatable cam shaft 94 having a cam plate 95 mounted thereon. The cam shaft 94 is supported at its remote end by being journaled into an extension plate 97, which is attached to the upper mounting assembly 12 in the position indicated in broken outline by numeral 98 in FIG. 1a. Rotation of the cam shaft 94 is effectuated by an electric motor (not shown) which is connected by means of a belt 99 to a transmission unit T mounted to the upper mounting assembly 12. The cam plate 95 includes on its front face an eccentrically disposed groove 96 providing a cam track and rotation of the cam 95 induces reciprocating movement into a pair of rocker arms 100 and 101, which are mounted to the mounting assembly 12.

The upper mounting assembly 12 includes a channel element 102 and an angle element 103, both of which extend between the side walls 22 and 23 of the lower housing 11, said elements 102 and 103 being secured, as by welding, to provide a rigid base for the cam assembly 15. The rocker arms 100 and 101 are pivotally mounted for rocker movement between associated pairs of support plates 104 and 105, which are welded to the channel and angle elements 102 and 103, by means of pins 106 and 107 respectively.

A cam follower 110 is rotatably mounted at the cam end of the rocker arm 100 by means of fastener 111. At its other end, the rocker arm 100 is pivotally connected to an adjustable link element 112 by pivot pin 113. The adjustable link element 112 is pivotally connected by means of a pivot pin 114 to the toggle assembly upper link 70 whereby to induce reciprocating motion into the toggle assembly 16 as the cam plate 95 rotates. Said adjustment link element 112 includes threadedly connected upper and lower portions 115 and 116, whereby the length of said link element 112 may be adjusted.

A cam follower 117 is rotatably mounted at the cam end of the rocker arm 101 by means of a fastener 120. At its other end, the rocker arm 101 is pivotally connected to a pusher pawl 121 by means of pivot pin 122. As shown in FIGS. 6 and 7, the pusher pawl 121 includes a flat front face 123 selectively engageable with the rear face 124 of each rack tooth 35 whereby to apply pressure to the rack 34 and push the carriage assembly 17 forward, intermittently, as the eccentric cam groove 96 rotates and induces reciprocating motion into the pusher pawl 121. It will be understood that the inclined rear face 125 of the pusher pawl 121 rides up the inclined forward face 126 of each tooth 35 during the backstroke of the pusher pawl 121.

The cam groove 96 is substantially slot-shaped in the preferred embodiment and includes opposed semicircular portions 130 and 131, interconnected by opposed straight portions 132 and 133. The semicircular portion 130 is concentric with the cam shaft 94 and consequently, as a cam follower is riding this portion of the groove 96, the associated arm, which carries that cam follower, undergoes a quiescent or dwell period during which no movement is experienced by said associated rocker arm. On the other hand, during travel on the remaining groove portions 131, 132 and 133, a cam follower is subjected to reciprocating movement.

During one revolution of the cam 95, each of the rockers 100 and 101 experiences a period of dwell and also a reciprocating period. In the preferred embodiment, the fol-

lowers 110 and 117 are spaced about the continuous groove so that the active, reciprocating period of the rocker arms 100 and 101 are substantially sequential. As a practical matter, there may be some overlap of action between the reciprocation period of one follower and the dwell period of the other.

In FIG. 6, the follower end of the rocker arm 100 is indicated as approaching its high position and, as shown, this position is coincident with the maximum crimping action of the outer die elements which are connected to the toggle end of the rocker arm 100. At this time, the rocker arm 101 is experiencing a period of dwell. In FIG. 7, the rocker arm 100 is about to embark on a period of dwell and the follower end of the rocker arm 100 is indicated as approaching its low position, at which time the toggle end of the rocker arm 100 is approaching its high position. The follower end of the rocker arm 101 is rotating in a clockwise direction and the pusher pawl 121 is therefore pushing the carriage assembly 17 forwardly. The pusher pawl 121 experiences its complete reciprocating forward and rearward action before the tube 13 is again crimped.

In the preferred embodiment of this tube bending machine, a second cam assembly and die set are provided which reduce the size of the end of the tube 13, so that tube 13 may be telescopically received into a tube of regular dimensions. The second cam assembly and die set are clearly shown in FIG. 1a and include a cam plate 140, which is preferably mounted to the common cam shaft 94 adjacent the extension plate 97. The cam plate 140 includes a coaxial, elliptical groove 141 providing a cam track which actuates a die set 21 mounted to the outer face of the extension plate 97.

The second cam assembly and die set are shown in detail in FIGS. 8, 9 and 10. The die set 21 includes a stationary inner die element 143 attached to the extension plate 97 by fasteners 144. Outer die elements 145 and 146 flank the inner die element 143, each of said die elements 145 and 146 including a T-shaped keep indicated respectively by numerals 147 and 148. The T-shaped keeps 147 and 148 are attached to their associated outer die elements by pairs of fasteners 149 and 150 respectively and each includes a stem portion slidably received within an associated slot 151 or 152.

Cam followers 153 and 154 are mounted for rotation in associated outer die elements 146 and 146 respectively and the cam plate 140 is held in place, adjacent the extension plate 97 by grooving the cam shaft 94 and the cam plate 140 for the fitting of a spline key 157 thereon. Followers 153 and 154 are slidably received within the cam groove 141 and as the cam plate 140 rotates, each follower travels between limits controlled by the major and minor axes of the elliptical groove 141. Thus, two cycles of crimping action are performed during one revolution of the cam plate 140. It will be observed that the meshing teeth on the inner and outer dies provide the end of the tube 113 with somewhat of bellows configuration which effectively reduces the exterior dimensions of the tube and enables it to be inserted telescopically within a tube section of normal dimensions. As shown in FIG. 9, the outer die teeth are tapered to further facilitate the telescopic fit of the tube 13.

It is thought that the functional advantages of this tube bending machine have become fully apparent from the foregoing description of parts, but for completeness of disclosure, the operation will be briefly summarized.

The bending operation can be best understood by reference to FIGS. 6 and 7 read in conjunction with FIG. 3. These figures indicate that, as the eccentrically mounted cam plate 95 rotates about the cam shaft 94, the rocker arms 100 and 101 experience one cycle of reciprocation during each revolution of the cam plate 95. The cam groove 96 has a configuration which includes a concentric semicircular portion 130, and during the travel of the cam followers 111 and 117 in this portion of the groove 96, the associated rocker arms experience a period of dwell. Essentially, the rocker arm 100 is reciprocated while the rocker arm 101 is quiescent and vice versa. It will be understood from FIGS. 6 and 7 that the reciprocation of the toggle end of the rocker arm 100 is sub-

stantially upward and downward while the reciprocation of the pusher end of the rocker arm 101 is substantially fore and aft.

The bending operation is commenced by inserting a length of straight tube 13 over the inner die element 57a and through the aperture 54a until the tube 13 abuts the front end plate 31 of the carriage assembly 17. The tube 13 is located by means of the abutment adaptor 62. As the toggle assembly 16 is actuated, the outer die elements 64a, 65a and 66a move inwardly and crimp the tube walls 90, 91 and 92 with which they come into contact, into the U-shaped groove formation 93a provided on the inner die element 57. The application of this crimping force to only three walls of the rectangular tube 13 forces said tube 13 to bend upwardly. When the outer die elements 64a, 65a and 66a have been moved out of engagement with the tube 13, the second phase of the operation is commenced. During this second phase, the rocker arm 101 is reciprocated and force is thereby applied to the pusher pawl 121. This applied force advances the tube 13 outwardly from the housing a distance equal to the spacing between the individual teeth 35 of the rack 34 with which the pusher pawl 121 is in direct contact. This action not only relocates the tube 13 for further crimping, but also pushes the already crimped portion of the tube over the front edge of the inner die groove 93a, thereby folding the crimped material rearwardly. When the reciprocating cycle of the pusher pawl 121 is complete, the crimping cycle is sequentially performed. A succession of crimping and advancing actions produces a bent tube 13 having the appearance indicated in FIG. 5.

Each of the rocker arms 100 and 101 is cranked. The reason for this configuration is to avoid binding of the followers 110 and 117 in the cam groove 96. The cranking imparts an angle of inclination to each rocker arm relative to the cam groove 96 and thereby avoids perpendicular orientation of the arms, particularly with regard to the straight portions 132 and 133 of said cam groove 96.

It will be understood that the greater the number of crimping actions applied to the tube 13, the greater will be the angle to which the tube 13 is bent. Obviously, the depth of bite of the die elements can be suitably arranged so that a specific number of crimps provide a specific angle, said number being related to the number of rack teeth available. Thus, if 10 crimps produce a 90° turn, five crimps will produce a 45° turn and so on.

It is an advantage to provide a means of presetting the starting point of the carriage assembly 17 so that the tube 13 will not be bent more than a desired amount. In the preferred embodiment, this is accomplished by a limit device which includes a plurality of elongate limit rods 45-48. The limit rods 45-48 are attached to a collar 44 which constitutes a body, and extend a calibrated distance from the face of the collar 44. The differences between the lengths of these rods is related to a given number of tooth spaces. Thus, when the carriage assembly 17 is pushed backward until it is in contact with the shortest rod 45, for example, the full range of advancement will be experienced by the carriage assembly 17 and the tube 13 will be bent through 90°. Lesser amounts of bend may be achieved by rotating the limit shaft 40 until the desired limit rod engages the carriage assembly 17.

When it is required to bend the tube 13 with its major axis horizontal, as shown in FIG. 3, as opposed to vertical, as shown in FIGS. 1b and 2, the procedure is as follows. The inner die element 57 is removed from the die rod 55 and the outer die elements 64, 65 and 66 are removed from the toggle assembly 16. The insert adaptor plate 50 is removed from the aperture 51 in the end plate 25 and substituted by the insert adaptor plate 51a. The inner die element 57a and the outer die elements 64a, 65a and 66a are attached to the die rod 55 and the toggle assembly 16 respectively. It will be observed that the spacing of the fasteners 84, 85 and 86 which hold the outer die elements in place, is the same regardless of which die set is used. Likewise, a common spacing is used for the fasteners 53, which hold the insert adaptor plates 50 and 50a in place, and

of course, this arrangement facilitates the substitution of parts. The abutment seating adaptor 62 is rotated to the position shown in FIG. 4 and the change-over is completed. The carriage front transverse plate 31, indicated in FIG. 4, is provided with two sets of holes permitting the abutment seating 62 to be removed, rotated through 90° and replaced, using the same fasteners 63 but in conjunction with apertures 68, rather than apertures 69.

In its preferred embodiment, the machine includes a second crimping device which permits the tube 13 to be reduced at its ends so that it will telescope easily into a regular piece of tube, such as a gutter downpipe. The cam and die assembly by which this reduction is effectuated, is built directly into the machine by providing a cam plate 140 which is mounted upon the common cam shaft 94. After the first crimping has been performed and the bending operation is complete, the tube 13, now formed into an elbow, may simply be withdrawn from the lower housing 11 and each end of the tube 13 fitted in turn over the inner die element 143 indicated in FIG. 8. Rotation of the cam plate 140 urges the outer die elements 145, 146 into contact with the side walls of the tube 13, crimping said side walls and effectively reducing the size of the cross section, which considerably facilitates the telescopic fitting of the elbow into a straight tube.

We claim as our invention:

1. A tube bending machine comprising:

- a. base means,
- b. die means movably mounted to the base means and adapted to crimp the tube,
- c. carriage means movably mounted to the base means and adapted to engage the tube whereby to selectively induce movement into the tube,
- d. cam means mounted to the base means and operatively connected to the die means and the carriage means, whereby to sequentially actuate the die means and advance the carriage means,
- e. toggle means mounted to the base means and operatively connected to the cam means,
- f. the die means includes inner and outer die elements,
- g. the outer die elements are carried by the toggle means,
- h. a rocker arm interconnects the cam means to the toggle means,
- i. the toggle means including an adjustable link operatively connected to the rocker arm for selectively increasing the crimping capacity of the outer die elements.

2. A tube bending machine comprising:

- a. base means,
- b. die means movably mounted to the base means and adapted to crimp the tube,
- c. carriage means movably mounted to the base means and adapted to engage the tube whereby to selectively induce movement into the tube,
- d. cam means mounted to the base means and operatively connected to the die means and the carriage means, whereby to sequentially actuate the die means and advance the carriage means,
- e. the cam means including:
 1. a rotatable cam shaft,
 2. a continuous track mounted in eccentric relation to the cam shaft, and
 3. a first and a second cam follower riding the same said cam track,
- f. a first rocker arm operatively interconnecting the first cam follower to the die means, and
- g. a second rocker arm operatively interconnecting the second cam follower to the carriage means.

3. A tube bending machine as defined in claim 2, in which:

- h. a cam plate is mounted to the cam shaft for rotation therewith, the plate including a continuous groove eccentrically disposed about the center of rotation of the cam shaft and providing the track, and
- i. the continuous groove includes a dwell portion for the first and second cam followers whereby one rocker arm is

- substantially quiescent during reciprocation of the other rocker arm.
4. A tube bending machine comprising:
- a base means,
 - a die means movably mounted to the base means and adapted to crimp the tube,
 - a carriage means movably mounted to the base means and adapted to engage the tube whereby to selectively induce movement into the tube,
 - a cam means mounted to the base means and operatively connected to the die means and the carriage means, whereby to sequentially actuate the die means and advance the carriage means,
 - a second die means adapted to reduce the cross section of the tube mounted to the base means, said second die means including:
 - an inner die element,
 - a pair of outer die elements, and
 - a second cam means mounted to the base means, said second cam means including:
 - a rotatable cam plate having a continuous cam track,
 - a pair of opposed cam followers riding the track, each of said followers being operatively attached to an associated outer die element of the second die means whereby rotation of the cam plate urges said outer die elements toward said inner die element.
5. A tube bending machine as defined in claim 4, in which:
- the second cam track is substantially elliptical and coaxial with the axis of rotation of the cam plate.
6. A tube bending machine, comprising:
- a base assembly including guide means,
 - a carriage assembly movably mounted to the guide means and adapted to engage the tube whereby to selectively induce movement into the tube,
 - a die assembly including compatible, movably related inner and outer die elements, the die assembly being adapted to crimp the tube,
 - a toggle assembly mounted to the base assembly and connected to the outer die elements, said assembly operatively urging said inner and outer die elements relatively toward each other,
 - a cam assembly mounted to the base assembly, and including a cam shaft and a cam track mounted in eccentric relation to the cam shaft, the cam assembly being operatively connected to the toggle assembly and to the carriage assembly, whereby to sequentially actuate the die assembly, and advance the carriage assembly,
 - drive means rotating the cam shaft,
 - the base assembly including an aperture adapted to receive the tube,
 - the outer die elements including a first outer die element and a pair of second outer die elements transversely disposed to the first die element, each of said outer die elements being adjacently disposed of the margin of the aperture,
 - the die assembly including a die rod mounted to the base assembly at one end and having an inner die element attached to the other end, said inner die element being adapted to be received by the tube,
 - the carriage assembly including bearing means supporting the die rod intermediate its ends,
 - the toggle assembly including:
 - a first link element mounted to the base assembly for translational movement relative thereto,
 - opposed pairs of pivotally connected toggle link elements, each pair including one link element pivotally connected to the first link element, and another link element pivotally connected to the base assembly, and
 - the first outer die element being carried by the first link element and each of the second outer die elements being carried by one of the link elements of an associated pair of toggle link elements.
7. A tube bending machine, comprising:
- a base assembly including guide means,

- a carriage assembly movably mounted to the guide means and adapted to engage the tube whereby to selectively induce movement into the tube,
 - a die assembly including compatible, movably related inner and outer die elements, the die assembly being adapted to crimp the tube,
 - a toggle assembly mounted to the base assembly and connected to the outer die elements, said assembly operatively urging said inner and outer die elements relatively toward each other,
 - a cam assembly mounted to the base assembly, and including a cam shaft and a cam track mounted in eccentric relation to the cam shaft, the cam assembly being operatively connected to the toggle assembly and to the carriage assembly, whereby to sequentially actuate the die assembly, and advance the carriage assembly,
 - drive means rotating the cam shaft,
 - the toggle assembly including:
 - a first link element mounted to the base assembly for translational movement relative thereto,
 - opposed pairs of pivotally connected toggle link elements, each pair including one link element pivotally connected to the first link element, and another link element pivotally connected to the base assembly, and
 - a first outer die element carried by the first link element and a second outer die element carried by one of the link elements of an associated pair of toggle link elements,
 - the cam assembly including a cam follower riding the cam track, and
 - a rocker arm including opposed ends pivotally mounted between its ends to the base assembly, said rocker arm being pivotally connected to the first toggle element at one of said ends and carrying the follower at the other of said ends.
8. A tube bending machine, comprising:
- a base assembly including guide means,
 - a carriage assembly movably mounted to the guide means and adapted to engage the tube whereby to selectively induce movement into the tube,
 - a die assembly including compatible, movably related inner and outer die elements, the die assembly being adapted to crimp the tube,
 - a toggle assembly mounted to the base assembly and connected to the outer die elements, said assembly operatively urging said inner and outer die elements relatively toward each other,
 - a cam assembly mounted to the base assembly, and including a cam shaft and a cam track mounted in eccentric relation to the cam shaft, the cam assembly being operatively connected to the toggle assembly and to the carriage assembly, whereby to sequentially actuate the die assembly, and advance the carriage assembly,
 - drive means rotating the cam shaft,
 - the cam assembly including a cam follower riding the cam track,
 - a rocker arm including opposed ends pivotally mounted between said ends to the base assembly, said rocker arm operatively engaging the carriage assembly at one of said ends and carrying the follower at the other of said ends,
 - the carriage assembly including a rack, and
 - a pawl carried by said one end of the rocker arm operatively engageable with the rack.
9. A tube bending machine, comprising:
- a base assembly including guide means,
 - a carriage assembly movably mounted to the guide means and adapted to engage the tube whereby to selectively induce movement into the tube,
 - a die assembly including compatible, movably related inner and outer die elements, the die assembly being adapted to crimp the tube,
 - a toggle assembly mounted to the base assembly and connected to the outer die elements, said assembly operatively urging said inner and outer die elements relatively toward each other,

- e. a cam assembly mounted to the base assembly, and including a cam shaft and a cam track mounted in eccentric relation to the cam shaft, the cam assembly being operatively connected to the toggle assembly and to the carriage assembly, whereby to sequentially actuate the die assembly, and advance the carriage assembly, 5
- f. drive means rotating the cam shaft,
- g. the cam assembly including:
 - 1. a cam plate mounted to the cam shaft for rotation therewith, the cam plate including a continuous groove 10
 - eccentrically disposed about the center of rotation of the cam shaft and providing the cam track, and
 - 2. first and second cam followers riding the same cam track,
- h. a first rocker arm pivotally mounted to the base assembly 15
- operatively interconnecting the first cam follower to the toggle assembly, and
- i. the second rocker arm pivotally mounted to the base assembly operatively interconnecting the second cam follower to the carriage assembly. 20
- 10. A tube bending machine as defined in claim 9, in which:
 - j. the continuous groove includes a substantially constant radius dwell portion for the first and second cam followers whereby one rocker arm is substantially quiescent while the other rocker arm is actuated, as the cam shaft 25
 - rotates.
- 11. A tube bending machine, comprising:
 - a. a base assembly including guide means,
 - b. a carriage assembly movably mounted to the guide means and adapted to engage the tube whereby to selectively induce movement into the tube, 30
 - c. a die assembly including compatible, movably related inner and outer die elements, the die assembly being adapted to crimp the tube,
 - d. a toggle assembly mounted to the base assembly and connected to the outer die elements, said assembly operatively urging said inner and outer die elements relatively toward each other, 35
 - e. a cam assembly mounted to the base assembly, and including a cam shaft and a cam track mounted in eccentric relation to the cam shaft, the cam assembly being operatively connected to the toggle assembly and to the carriage assembly, whereby to sequentially actuate the die assembly, and advance the carriage assembly, 40
 - f. drive means rotating the cam shaft, 45
 - g. a second die assembly mounted to the base assembly, said second die assembly including:
 - 1. an inner die element,
 - 2. a pair of outer die elements, and
 - h. a second cam assembly mounted to the base assembly, 50
 - said cam assembly including:
 - 1. a cam plate having a substantially elliptical cam track, and
 - 2. opposed followers riding in said track and engaging 55

said second outer die elements.

- 12. A tube bending machine as defined in claim 11, in which:
 - i. the cam plates of each cam assembly are mounted on a common cam shaft.
- 13. A tube bending machine, comprising:
 - a. base means,
 - b. die means movably mounted to the base means and adapted to crimp the tube,
 - c. carriage means movably mounted to the base means and adapted to engage the tube whereby to selectively induce movement into the tube,
 - d. cam means mounted to the base means and operatively connected to the die means and the carriage means, whereby to sequentially actuate the die means and advance the carriage means,
 - e. limit means mounted to the base means and selectively engageable with the carriage means whereby to limit travel of the carriage means,
 - f. the carriage means including a limit abutment portion,
 - g. the limit means including a rotatable shaft, and
 - h. the stops being mounted to the shaft for selective engagement with the limit abutment portion on rotation of the shaft.
- 14. A tube bending machine, comprising:
 - a. base means,
 - b. die means movably mounted to the base means and adapted to crimp the tube,
 - c. carriage means movably mounted to the base means and adapted to engage the tube whereby to selectively induce movement into the tube,
 - d. cam means mounted to the base means and operatively connected to the die means and carriage means, whereby to sequentially actuate the die means and advance the carriage means,
 - e. limit means mounted to the base means and selectively engageable with the carriage means whereby to limit travel of the carriage means,
 - f. the carriage means including:
 - 1. a limit abutment portion,
 - 2. a rack having a plurality of teeth,
 - g. pusher means operatively connected to the cam means and selectively engageable with the teeth whereby to induce intermittent forward movement into the carriage means, and
 - h. the limit means including:
 - 1. a rotatable shaft,
 - 2. a body carried by the shaft and rotatable therewith, and
 - 3. a plurality of rods attached to the body and disposed about the shaft in orbital relation, each rod extending a calibrated distance from the body, the rods being selectively engageable with the limit abutment portion of the carriage means.

* * * * *

60

65

70

75