March 18, 1958 E. A. DE VOSS 2,827,101

PIVOTED TUBE BENDER WITH TUBE POSITIONING MARK AND ADJUSTABLE TUBE LOCATING DEVICE

Filed Oct. 4, 1954 3 Sheets-Sheet 1

Fig. 1

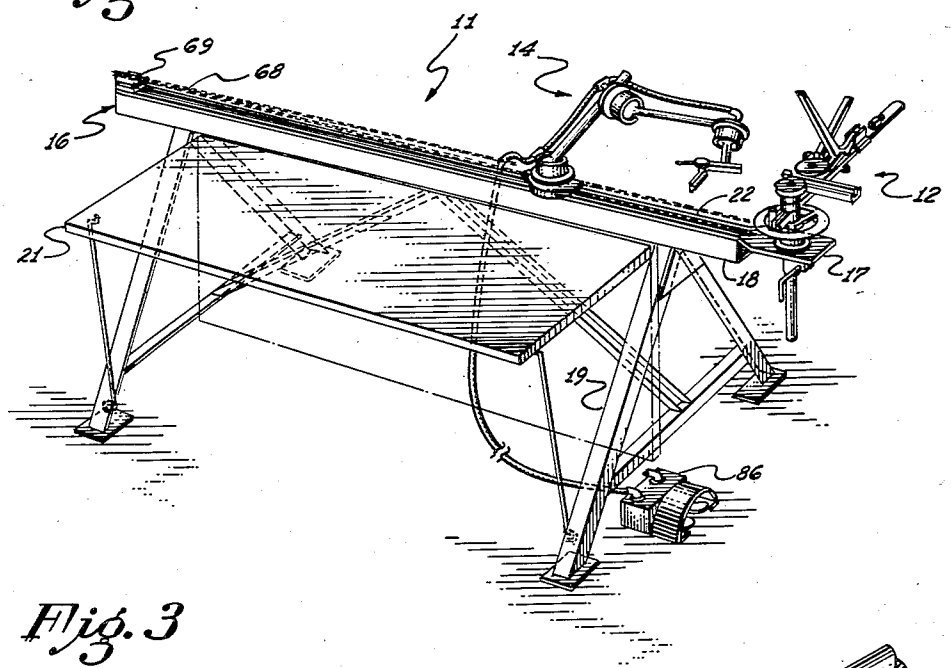



Fig. 3

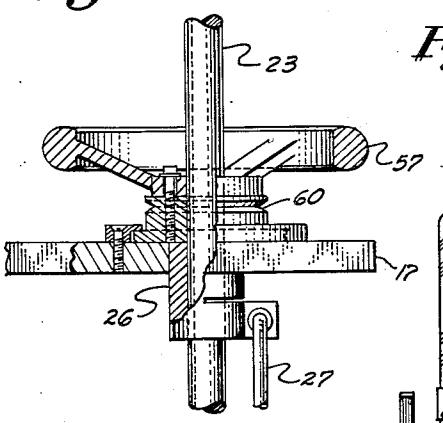



Fig. 4

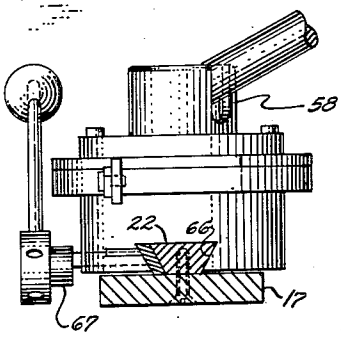



Fig. 5

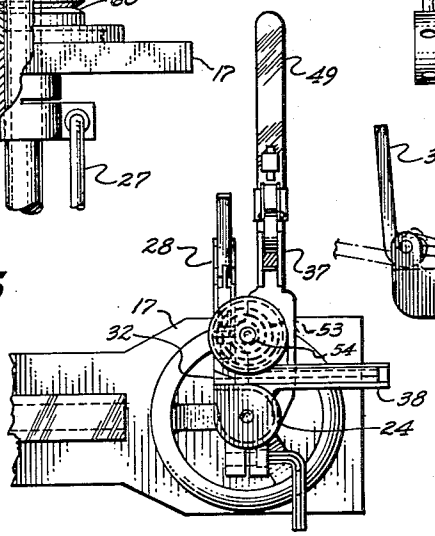
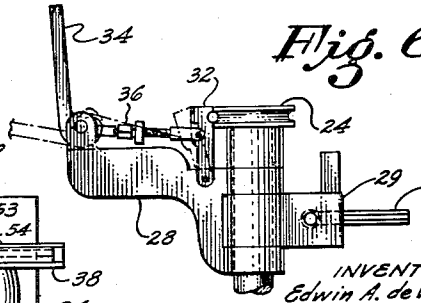



Fig. 6




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PIVOTED TUBE BENDER WITH TUBE POSITIONING MARK AND ADJUSTABLE TUBE LOCATING DEVICE

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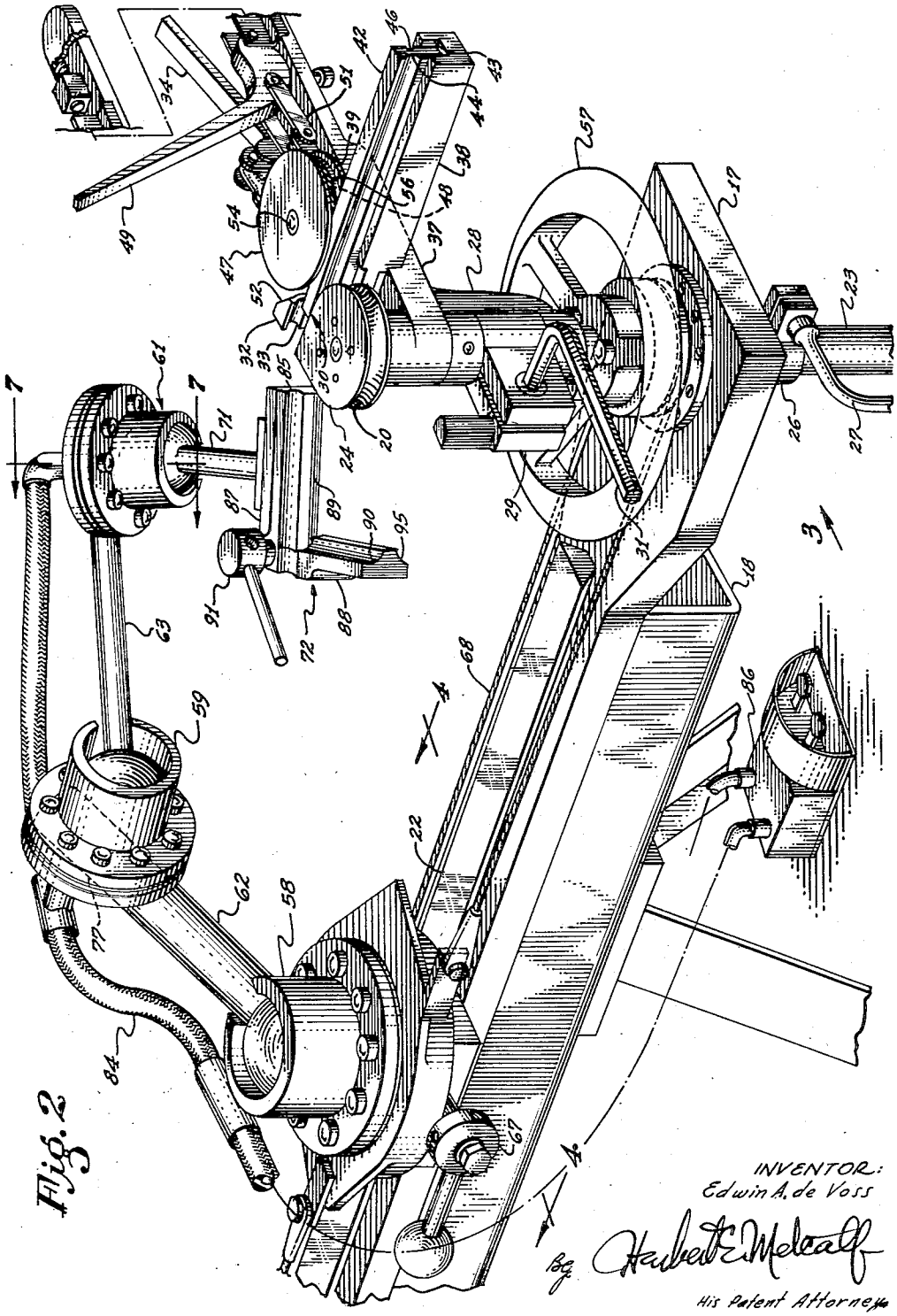


Fig. 2

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PIVOTED TUBE BENDER WITH TUBE POSITIONING MARK AND ADJUSTABLE TUBE LOCATING DEVICE

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Fig. 7

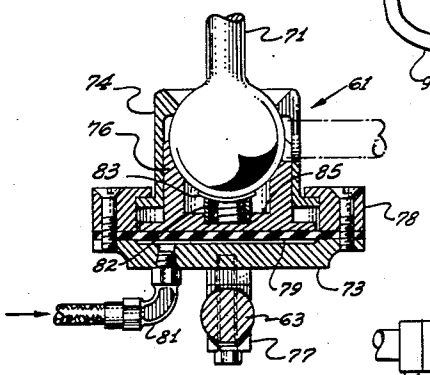



Fig. 9

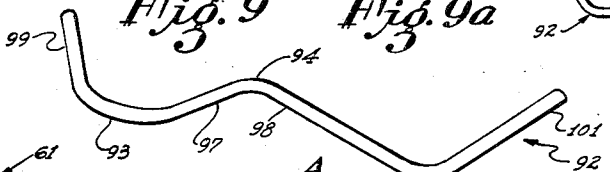



Fig. 9a




Fig. 10

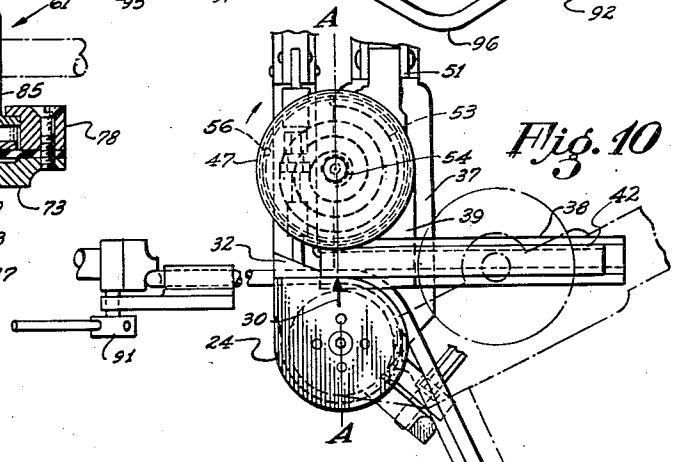



Fig. 11

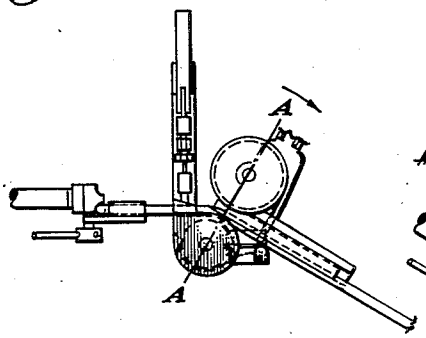



Fig. 12

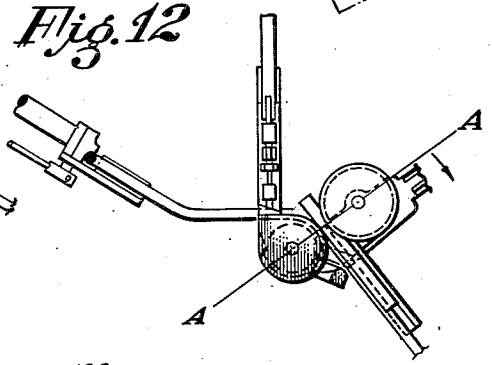



Fig. 8

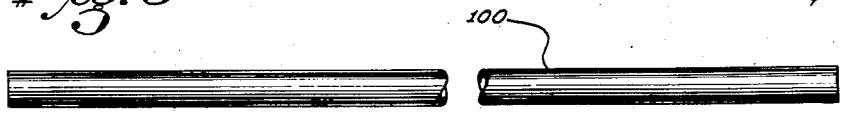
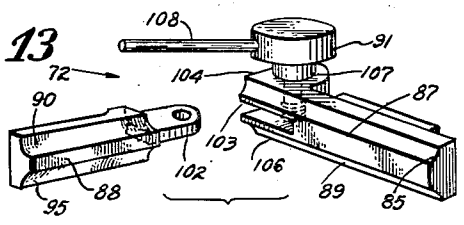



Fig. 13




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2,827,101

Patented Mar. 18, 1958



2,827,101

# PIVOTED TUBE BENDER WITH TUBE POSITIONING MARK AND ADJUSTABLE TUBE LOCATING DEVICE

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Application October 4, 1954, Serial No. 459,900

3 Claims. (Cl. 153—46)

The present invention relates to tube bending apparatus and more particularly to a tube bending machine including a tube positioning facility, the use of the latter being made possible by the novel construction and arrangement of the component parts of the machine.

Tube assemblies, comprising one or more lengths of bent or preshaped tubes, are well known and extensively utilized for conveying fluid between various parts of a machine which are responsive to fluid pressures. A modern aircraft constitutes a typical example in which numerous preshaped tube assemblies function in the aforementioned capacity. Such bent or preshaped tubes are normally fabricated with the aid of an automatic or a hand bending machine depending on the number required. Either of the above machines has objectional features rendering them unsatisfactory for certain bending operations. For example, if a small number of preshaped tubes is required, the time required to set up an automatic machine will undoubtedly exceed the time required to bend the same number of tubes with a hand machine. It is also obvious that regardless of the number of preshaped tubes required forming them on a hand operated machine constitutes a time consuming operation. Therefore, the need for a tube bending machine enabling either large or small quantities of tubes to be shaped accurately and expeditiously is quite apparent.

The present invention discloses a tube bending machine in which the bending operation and the movement of the respective parts thereof are reversed as compared with the procedure and movement of parts in conventional tube bending machines. Briefly the present invention employs a stationary radial block and a movable slide block. Employing a movable slide block results in a previously executed bend maintaining a fixed relationship, with respect to stationary portions of the machine, while a subsequent bend is being executed. Accordingly a fixture of the type disclosed herein may be secured to the stationary portions of the machine to facilitate the location, plane, and degree of all bends to be made in a tube. The specific manner in which the instant tube bending machine operates, also the manner in which the locating fixture cooperates with the tube bending facility, will become more apparent as the disclosure progresses.

Accordingly it is an object of the instant invention to provide a tube bending machine in which small quantities of preshaped tubes of identical configuration may be fabricated accurately and expeditiously.

Another object is to provide a tube bending machine in which previously bent portions of a tube will maintain a fixed relationship with respect to non-movable portions of the machine during a subsequent bending operation.

Another object is to provide a tube bending machine incorporating means whereby the location, plane, and degree of bends to be made in a tube are readily locatable.

These and other objects will become more apparent



from the following description and drawings in which like reference characters denote like parts throughout the several views. It is to be expressly understood, however, that the drawings are for the purpose of illustration only and not a definition of the limits of the invention, reference being had for this purpose to the appended claims.

In the drawings:

Figure 1 is a perspective view of the tube bending machine of the instant invention.

Figure 2 is a detailed perspective view of certain parts of the tube bending machine shown in Figure 1.

Figure 3 is a fragmentary elevational view of the tube bending machine viewed as indicated by the arrow 3 in Figure 2, this view in particular shows the hand wheel of the instant invention and associated parts.

Figure 4 is a cross-sectional view of the tube bending machine as viewed along the line 4—4 of Figure 2.

Figures 5 and 6 are plan and elevational views, respectively, of the tube bending assembly of the instant invention.

Figure 7 is a cross-sectional view of one of the connectors of the tube locating assembly as viewed along the line 7—7 of Figure 2.

Figure 8 is a perspective view of a length of tubing to be fabricated.

Figures 9 and 9*a* are perspective and elevational views, respectively, of a preshaped tube.

Figure 10 is an elevational view of the tube bending assembly showing the preshaped tube of Figures 9 and 9*a* in a typical locating position.

Figures 11 and 12 are elevational views of the tube bending assembly showing various positions assumed by the component parts thereof in forming a tube of the configuration shown in Figures 9 and 9*a*.

Figure 13 is an exploded perspective view of the tube locating member of the instant invention.

Referring to the drawings, Figure 1 shows a complete tube bending machine 11 of the type disclosed herein. Principal component parts of the machine include a tube bending assembly 12 and tube locating assembly 14 each mounted on a common supporting structure 16. The supporting structure, in the present embodiment, consists of a bed plate 17 supported at a suitable height by a channel member 18 and legs 19. A folding leaf or shelf 21 is also provided on which tubes to be or that have been fabricated may be supported. Mounted on the upper surface of the bed plate is a guide rail 22 on which the assembly 14 is mounted for longitudinal movement thereof with respect to the guide rail and bed plate. The bed plate extends beyond one end of the channel member 18 to provide a suitable support for the tube bending assembly 12.

Referring to Figures 2, 3, 5, and 6 it is seen that the tube bending assembly 12 consists of a supporting shaft 23 having a disk-like radial block 24 fixedly secured thereto at its upper end as viewed in Figure 2. A major peripheral portion of the radial block is provided with a continuous tube receiving groove 20, the latter being semi-circular in cross-section. A major portion of the groove 20 is of arcuate configuration so that similar wall portions thereof are spaced equal radial distances from the axis of the shaft 23. The groove 20 terminates at one end in a straight portion which cooperates with a clamp block 32 to be described presently. A reference mark 30 extends normal to the periphery of the block 24 at the point at which the arcuate portion of the groove 20 becomes tangent to the straight portion thereof.

The shaft 23 is mounted in a vertical attitude on the overhanging portion of the bed plate by means of a sleeve 26 fixedly secured to the bed plate. Angular movement of the shaft 23 is prevented by a conventional

key and keyway associated with the shaft and sleeve, however, the shaft may be raised or lowered as desired and held in any suitable vertical position by a hand screw 27.

Mounted on and extending from the shaft 23, at a position intermediate the plate 17 and the radial block 24, is an arm 28. The portion of the arm 28 encompassing the shaft 23 is bifurcated to allow an adjustable stop member 29 to be mounted on the shaft between the respective forks of the arm 28. The arm 28 is fixedly secured to the shaft 23 by means of conventional set screws or the like. The stop member 29 is mounted for angular movement on the shaft 23 and may be secured thereto in any desired position by a hand screw 31. The function of the stop member 29 will become more apparent as the disclosure progresses. Mounted on the arm 28 is a clamp block 32 provided with a straight tube receiving groove 33 which is also semi-circular in cross-section. The block 32 is mounted for pivotal movement on the arm 28 between a first position in which the walls of the groove 33 cooperate with the straight portion of the groove 20 to firmly hold a length of tubing therebetween and a second position in which the tubing may be freely removed from the grooves 20 and 33. The block 32 is manually moved between the two positions described above by a lever 34, also pivotally mounted on the arm 28, acting in conjunction with an over-center type linkage 36.

A radially extending arm 37 is also mounted on the shaft 23 at a position between the block 24 and the upper fork of the arm 28. The arm 37 being supported by the upper portion of the arm 28 and being free to pivot on the shaft 23. The arm 37 is further characterized by having a longitudinal reference axis A—A extending radially from the axis of the shaft 23. A flat member 39 is mounted on the arm 37 for sliding bidirectional radial movement toward and away from the axis of the shaft 23 and along the aforementioned longitudinal axis of the arm 37. The member 39 is moved by means of a manually operable lever 49 pivotally mounted on the arm 37 and by a cooperating toggle type linkage 51. An elongated holding member 38 is fixedly secured to the member 39. A groove 43 having a rectangular cross-section is formed in the member 38. The groove 43 is further characterized in that the side walls thereof are normal to the aforementioned axis A—A of the arm 37. The groove 43 is adapted to slidably receive an elongated slide block 42 which is also rectangular in cross-section.

In the assembled position of the various parts of the assembly 12, as best seen in Figure 2, the following relationships are found. The elongated side of the block 42, opposing the block 24, is provided with a straight tube receiving groove 44 which is semi-circular in cross-section. A groove 46 is also provided in the side of the block 42 opposite the side containing the groove 44. Also pivotally mounted on the member 39, by means of a pin 54, is a hollow roller element 47 having a circumferential groove 48 formed in its outer peripheral surface. Accordingly it will be apparent that the axes of the grooves 44 and 46 will also be normal to the aforementioned axis A—A of the arm 37 regardless of the latter's angular position with respect to the shaft 23. The axes of the semi-cylindrical grooves 20, 33, and 44 are located in a common horizontal plane. Portions of the outer peripheral surface of the roller 47 are in firm contact with portions of the side of the block 42 containing the groove 46. At such times as the member 39 is moved to a position most adjacent block 24, the roller 47 and block 24 will bear tangentially on the block 42 at directly opposite positions. In other words a plane containing the axes of the shaft 23 and roller 47 will also contain the points of tangency of block 24 and roller 47 with the slide block 42. The position of the arm 37 and block 42, with respect to the blocks 24 and 32, as best seen in Figures 2 and 10, constitutes the initial position which these parts are caused to assume prior to a bending operation. One end of the block 32 is chamfered as indicated at 52 to provide clearance for the roller 47 to assume its initial position as described above.



With a length of tubing held in the grooves 20 and 33, and with the tubing firmly bottomed in the groove 44, it is apparent that the block 42 will not move longitudinally of the tubing as the arm 37 is angularly moved about the shaft 23. However, there will be a relative movement between the block 42 and holder 38 during the above angular movement of the arm 37. Spring means is provided to restore the initial relative position of the block 42 in the holder 38 after the completion of a bending operation. This is necessary in order that the arm 37 may be returned to its initial position without interference of the blocks 32 and 42.

The above mentioned spring means consists of a prestressed spiral spring 53 positioned in the hollow portion of the roller 47 as shown in Figure 10. One end of the spring 53 is attached to the pin 54, about which the roller 47 rotates, its other end is secured to the inner periphery of the disk 47. One end of a flexible metal cable 56 is attached to the periphery of the roller 47 and the other end is attached to the side of the block 42 in which the groove 46 is formed so that intermediate portions thereof are located in the grooves 46 and 48. The roller 47, spring 53, and cable 56 cooperate to return the block 42 to its initial relative position in the holder 38 upon completion of a bending operation and the releasing of the block 42 from the tubing. Return movement of the block 42 is arrested by a projecting stop (not shown) formed on the holder 38. It is apparent that the grooves 46 and 48 mate with each other to provide clearance for the cable 56.

A hand wheel 57, having an annular V-shaped groove 60, is mounted for free angular movement on the shaft 23. The hand wheel rests on the upper surface of the plate 17 and serves to move a cable 68 thereby shifting a connector 58 of the tube locating assembly 14 in a manner presently explained in connection with the detailed description of the assembly 14.

In the present embodiment the tube locating assembly 14 includes three fluid operated ball and socket connectors 58, 59, and 61. The connector 58 is slidably secured to the plate 17 for longitudinal movement thereon, the other two connectors are supported by the connector 58 on rigid arms 62 and 63. The connector 58 includes a base portion provided with a groove 66 adapted to receive the guide rail 22 as seen in Figure 4. To facilitate the aforementioned longitudinal movement of the connector 58 a cable 68 is rigged to operate in the groove 60 of the hand wheel 57 and through a pulley 69, the latter being attached to the end of the plate 17 opposite the assembly 12. The ends of the cable 22 are attached to opposite sides of the base portion of the connector 58. With the cable rigged as described above it will be apparent that the connector 58 responds to rotary movements of the hand wheel 57. A conventional locking device 67 is provided in the base portion of the connector 58. This locking device allows or arrests longitudinal movement of the connector 58 as desired by an operator of the machine 11.

The aforementioned connectors are of substantially identical construction. Accordingly a description of the connector 61 follows which will also be applicable to the connectors 58 and 59. The connector 61 comprises a disk-like closure element 73, retainer and auxiliary retainer elements 74 and 76, respectively, a ring element 78, and a flexible diaphragm 79. The above recited component parts of the connector 61 are assembled as shown in Figure 7 with the spherical end of the arm 71 contained between spherical surface portions of elements 74 and 76. Fluid at superatmospheric pressure is uti-

lized to render the spherical end of the arm 71 nonmovable with respect to the elements 74 and 76. The aforementioned fluid enters the connector 61 through the elbow 81 and communicates with the side of the diaphragm 79 opposite the element 76. At such times as fluid at superatmospheric pressure is not in contact with the diaphragm 79 the arm 71 may be manually adjusted as desired. During these latter periods the spherical end of the arm 71 is firmly but adjustably held between the spherical surface portions of the element 74 and a supporting element 83 by a precompressed helical spring 82. The spring 82 is selected so that the force exerted thereby allows the arm 71 to be manually adjusted but retains it in any desired position. A snug sliding fit between the mating cylindrical walls of the element 74 and 76, the action of the spring 82, and the configuration of the element 83 preclude any lateral movement of the ball in the element 74 at such times as fluid is not present in the connector. The upper end of the element 83 is provided with a concave surface which mates with the spherical end surface of the arm 71. The lower portion of the element 83 comprises a cylindrical shell the outer surface of which bears a snug sliding relationship with a counterbore 85 formed in the base of the element 76.

Referring again to Figure 2 it is apparent that the spherical end portion of the arm 62 is contained in the connector 58 while the other end of the arm is rigidly attached to the connector 59 as indicated at 77. Similarly the arm 63 is associated with the connectors 59 and 61. Attached to the free end of the arm member 71 is a tube locating member 72 to be presently described. A flexible conduit 84 provides a passage for fluid between a source of fluid at superatmospheric pressure (not shown) and the connectors 58, 59, and 61. The flow of fluid to and from the above connectors is controlled by a valve mechanism 86 located in the conduit 84.

The tube locating member 72 consists of a pair of elongated bar members 87 and 88 of similar configuration hinged together at respective ends to permit relative angular movement therebetween. The elongated bar members may be hinged together by means of a tongue 102, formed in an end of the member 88, and a tongue receiving slot 103, formed in an end of the member 87, and defined by side portions 104 and 106 of the latter member. In the assembled position of the members 87 and 88 the side surfaces defining the slot 103 provide a snug sliding fit for the tongue 102. Also in the assembled position of the members 87 and 88 a bolt-like element 91 extends through registering apertures in the portions 104, 106, and tongue 102 and engages mating threads in the portion 106. Upon sufficient engagement of the aforementioned threads a shoulder 107, formed on the element 91, bears against the upper surface of the portion 104 thereby rendering the members 87 and 88 immovable with respect to each other. Rotary movement is imparted to the element 91 by means of a radially extending handle 108. In view of the above discussion it will be apparent that the element 91 provides means whereby the members 87 and 88 may be freed for relative angular movement or rendered immovable with respect to each other in any desired angular relationship with a predetermined range.

The member 87 is fixedly secured at its mid-portion to the free end of the tube 71 as by welding or the like. A pair of spaced quarter circular parallel grooves 85 and 89 extend longitudinally of the member 87. A pair of identical grooves 90 and 95 are similarly formed in the member 88. The location of the grooves 85 and 90, in the assembled position of the members 87 and 88, respectively, is further characterized in that the axes of these grooves are located in a common plane. Similarly the axes of the grooves 89 and 95 are also located in a common plane. The hinged connection between the members 87 and 88 permits angular movement thereof between a first position in which the axes of the grooves 85 and 90 coincide with a straight line and a second position in which the included angle between their axes constitutes an acute angle. The radius of the grooves 85, 89, 90, and 95 is substantially equal to the outside radius of a tube being shaped in the machine 11.

The component parts of a preferred embodiment of the instant invention having been described a more complete understanding of its novel features and advantages will be forthcoming from the following description of its operation.

For illustrative purposes it may be assumed that a straight length of tubing 100 is to be fabricated to conform with the performed tube 92 as shown in Figures 9 and 9*a*. The tube 92 includes three typical bends 93, 94, and 96, straight portions 97 and 98, and end portions 99 and 101. The radius of each of the bends in the tube 92 is equal and is further characterized in that the bend 93 is located in a first plane while the bends 94 and 96 are located in a second plane positioned at ninety degrees (90°) with respect to the first plane.

Inasmuch as the procedure involved in the executing each of the bends 93, 94, and 96 is substantially the same only the operations in effecting the bend 94 will be described in detail. The preformed tube 92 is first utilized to locate the member 72 in a position corresponding to the bend 94. To accomplish this the tube 92 is positioned in the assembly 12 with the bend 93 thereof located to the left of the radial block 24 as shown in Figure 10. The tube 92 is located in the position shown by positioning the point of tangency of the bend 94 with the straight portion 97 directly opposite the reference mark 30 at such time as the bend 94 is bottomed in the arcuate portion of the groove 20. The tube 92 is now secured in the above position by the blocks 24 and 32. With the tube 92 thus secured in the assembly 12 the bend 93 will be positioned in a vertical plane with the end portion 99 extending downwardly. The assembly 14 is now adjusted so that the straight portions 97 and 99 of the tube 92 are bottomed in the grooves 85 and 90, or 89 and 95, respectively, of the member 72. The assembly 14 is now rendered immovable by means of the locking device 67 and by causing pressurized fluid to communicate with each of the connectors 58, 59, and 61. The members 87 and 88 are also locked in position by means of the locking device 91. The stop member 29 is also set at this time to govern the extent of the bend 94. To accomplish this the slide block 42 is urged into contacting relationship with the tube 92 and the arm 37 rotated in a clockwise direction until the straight portion 98 of the tube 92 is bottomed in the groove 44 of the block 42. The stop member 29 is now moved into abutting relationship with the arm 37 and secured in this position by means of the hand screw 31. The tube 92 is now removed from the assembly 12.

The tube 100 to be fabricated is now positioned in the assembly 12. It is understood that a bend in the tube 100, identical to the bend 93 of the tube 92, has been effected during a previous operation. Accordingly the straight portions of the tube 100, corresponding to the portions 97 and 99 of the tube 92, are bottomed in the grooves 85 and 90 or 89 and 95, respectively, with the straight portion 99 extending vertically downward. At this time the straight portion of the tube 100, corresponding to the portion 97 of the tube 92, is bottomed in the straight portion of the groove 20. This procedure locates the tube 100 in the proper position so that the bend 94 may be executed. The tube 100 is now secured between the blocks 24 and 32, the slide block 42 urged into firm contacting relationship with the tube, and the arm 37 rotated in a clockwise direction until it contacts the stop 29. The bend in the tube 100, corresponding to the bend 94 in the tube 92, has thus been effected. Any number of identical bends may now be made in tubes

corresponding to the tube **100** without further adjustment of the assemblies **12** or **14**.

During the above operation it should be noted that the preshaped portion of the tube **100** remains fixed while the straight portion of the tube is moved in response to movements of the slide block **42**. In conventional equipment the reverse procedure is followed, that is the preshaped portions of a tube being fabricated are moved while the unfabricated portion remains stationary or moves longitudinally. It should be apparent that the assembly **14** enables a tube to be positioned in the assembly **12** so that the longitudinal location and plane of a bend to be made in the tube will be automatically determined. The degree of bend is determined by the position of the stop **29** with respect to the arm **37**.

Figures 11 and 12 show the relative positions which certain parts of the assemblies **12** and **14** assume at the completion of the bends **94** and **96**. These views are believed to be self explanatory and further explanation is not deemed necessary.

While in order to comply with the statute, the invention has been described in language more or less specific as to structural features, it is to be understood that the invention is not limited to the specific features shown, but that the means and construction herein disclosed comprise a preferred form of putting the invention into effect, and the invention is therefore claimed in any of its forms or modifications within the legitimate and valid scope of the appended claims.

What is claimed is:

1. In tube bending apparatus, the combination comprising: a base structure; tube gripping and bending means including a disk-like radial block, having arcuate and straight edge portions, fixedly secured to said base structure, a clamping block pivotally mounted on said base structure, and a slide block mounted on said base structure for relative movement with respect to said radial block; a tube positioning mark on a side face of said radial block intersecting said arcuate edge portion; an elongated tube locating device, which may be rendered either flexible or rigid, one end of which is secured to said base structure; a pair of adjustable elongated members secured to the other end of said tube locating device; portions of said elongated members defining complementary tube receiving grooves; and means for rendering said tube locating device either flexible or rigid.

2. Apparatus as set forth in claim 1 further characterized in that end portions of said elongated members are hinged together to permit relative angular movement therebetween, and including manually operable means passing through said hinged end portions and having a tightened and an untightened position permitting and arresting relative angular movement, respectively, between said elongated members.

3. Apparatus as set forth in claim 2 further characterized in that said complementary tube receiving grooves consist of at least one tube receiving groove, having a partial cylindrical surface, formed in each of said elongated members with the axes thereof lying in a common plane.

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