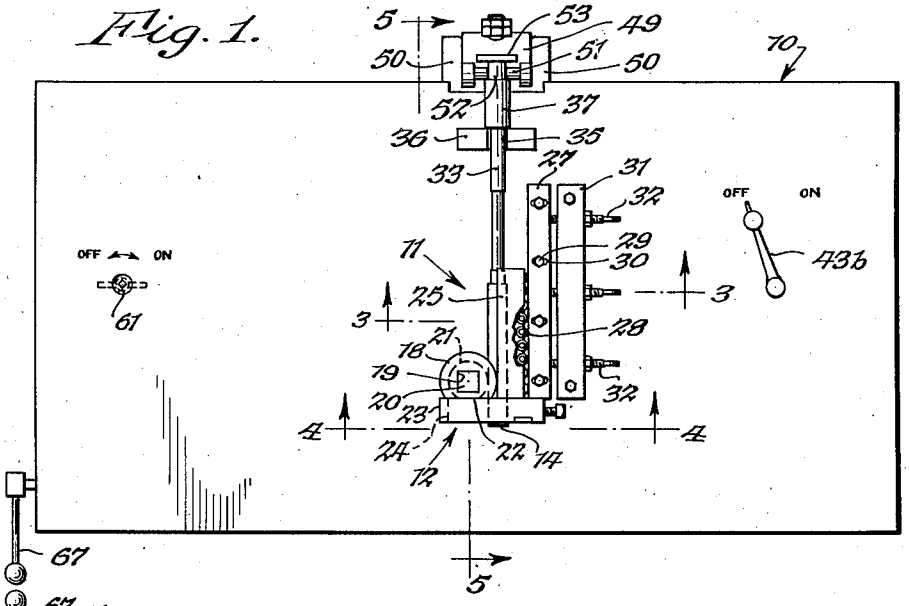
Nov. 27, 1945. A. SCHMITT 2,389,937

TUBE BENDING MACHINE

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Fig. 1.



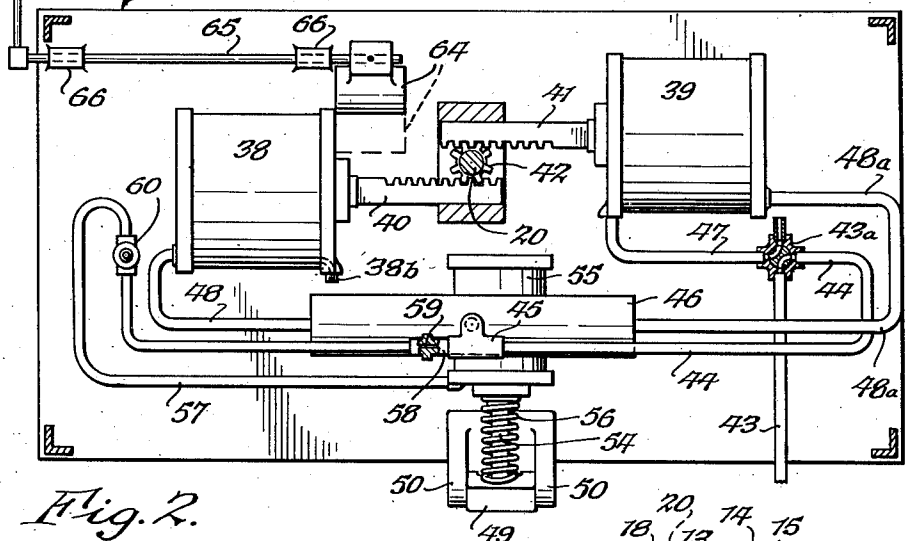


Fig. 2.

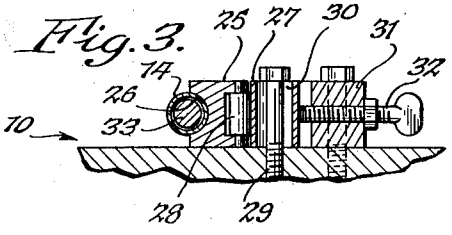


Fig. 3.

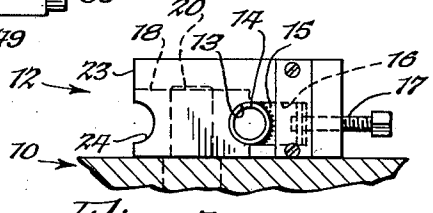


Fig. 4.

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TUBE BENDING MACHINE

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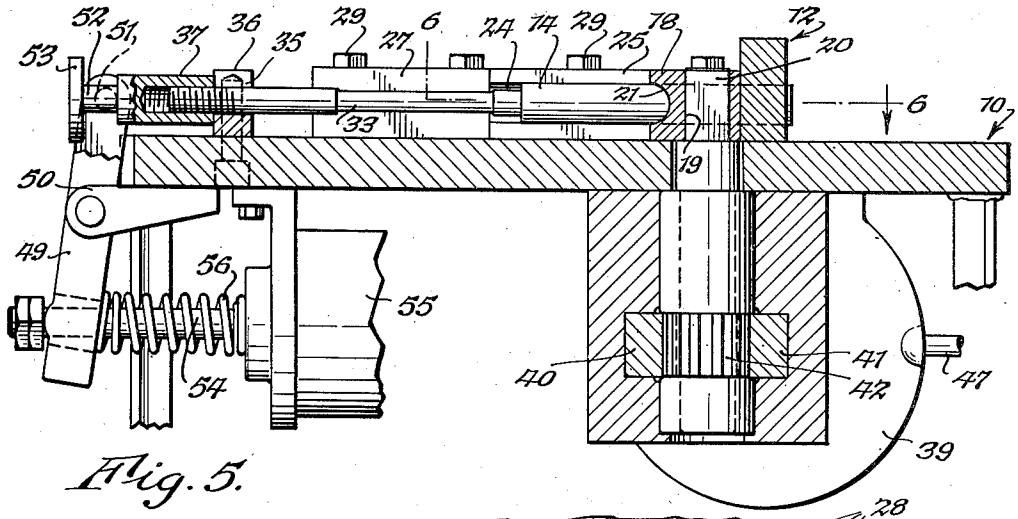


Fig. 5.

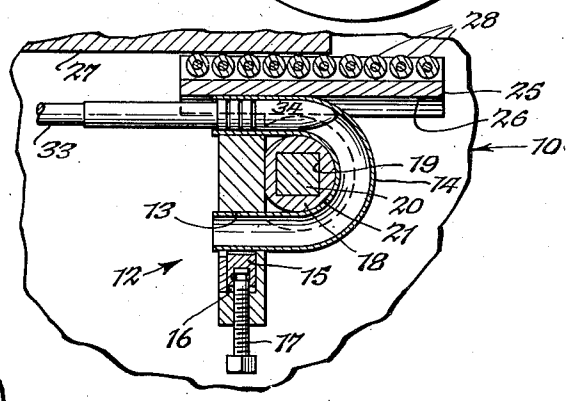
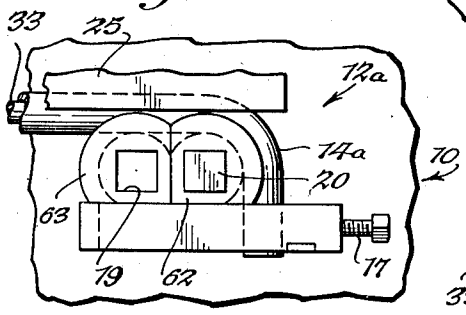


Fig. 6.

Fig. 7.



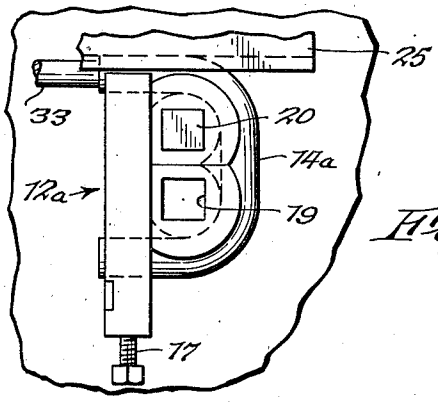
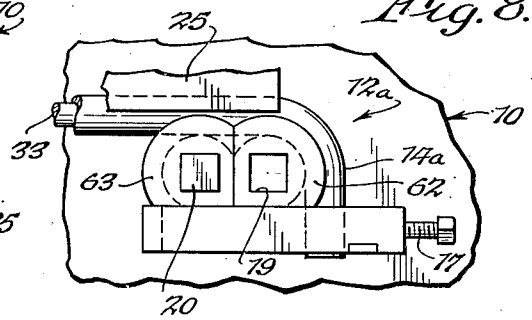


Fig. 9.

Fig. 8.



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TUBE BENDING MACHINE

Alfred Schmitt, Buffalo, N. Y.

Application March 29, 1943, Serial No. 480,914

7 Claims. (Cl. 153—40)

This invention relates to improvements in tube bending machines.

One object of the invention is a machine which is so designed that the bends formed by the machine will be of a uniform curvature and may be obtained without distortion of the cross-sectional contour of the tubes.

A further object is to provide a machine which is available for forming bends of various sizes and shapes.

A still further object is a novel construction and arrangement of the parts of the machine, whereby to obtain simplicity in design and provide for facility in securing the tubes in, and removing them from, the machine.

The invention is illustrated in the accompanying drawings in which:

Figure 1 is a top plan view of a machine embodying the features of the invention.

Figure 2 is a bottom view.

Figure 3 is an enlarged section taken along line 3—3 of Figure 1.

Figure 4 is a similar section taken along line 4—4 of the same figure.

Figure 5 is an enlarged section taken along 5—5 of Figure 1.

Figure 6 is a detail section taken along line 6—6 of Figure 5.

Figures 7, 8 and 9 are top views illustrating successive positions of a modified form of bender.

The machine, as illustrated, includes a table 10 by which the various mechanisms are carried, the bending mechanism being mounted upon the upper side of the top of the table and the actuating mechanism upon the under side. The bending mechanism, indicated generally at 11 (Figure 1), includes a holder 12 which is in the form of a block and which is formed with an opening 13 in which an end of a tube 14 is adapted to be removably secured by a jaw 15, the latter being accommodated in a recess 16 and having an adjusting screw 17 for securing the tube to the holder preparatory to the bending operation and for releasing it upon completion of such operation. A hub 18 on one end of the holder is formed with a multi-sided bore 19 for accommodating a similar-sided end of an actuating shaft 20, the periphery of the hub being formed to provide a circumferential channel 21 which conforms to the cross-sectional contour of the tube and to the shape of the bend to be formed in the tube. In the embodiment illustrated in Figure 1, the channel 21 has a circumferential extent exceeding 180°, a flat side 22 of the hub, being joined to the holder, being parallel with one of the sides of the bore 19 and determining the extent of the channel. In this connection it will be noted that the wall of the opening 13 against which the tube is clamped by the jaw 15 is so located that when the tube is secured to the holder the portion of the tube adjacent the engaged end occupies the channel 21 in tangential relation to the wall of the channel. At the opposite side of the hub 18 the holder 12 terminates in an end wall 23 which is formed with a channel 24, the upper and lower edges of the end wall being substantially tangential with the upper and lower peripheral edges of the hub 18 while the walls of the channel 24, which conform in contour to the tube 14, bear a tangential relation with respect to the corresponding walls of the channel 21.

A carriage 25 cooperates with the holder 12, the said carriage being elongated and being formed with a longitudinally extending channel 26 conforming in contour to the tube 14 and in which the said tube is accommodated. A track is provided for the carriage 25 by a bar 27 and the upper surface of the table top, rollers 28 on the carriage having a rolling contact with the front wall of the bar. Bolts 29 are employed to secure the bar 27 to the table in such a manner that any movement of the carriage as may result from a corresponding movement of the tube 14 will be in a direction such as to maintain the tangential relation between the tube and the hub 18 of the holder, i. e., a position in which with respect to a line through the axis of the hub 18 normal to the carriage the tube 14 is engaged substantially throughout its entire circumference, one half by the hub and one half by the carriage. In order to provide for angular and lateral adjustments of the bar 27 transverse slots 30 are formed in the bar to accommodate the bolts 29. A backing bar 31, which is bolted to the top of the table 10, carries adjustable elements 32 which are engageable with the back of the bar 27 and cooperate with the bolts 29 in holding the bar in any position to which it may be adjusted.

Bending of the tube 14 in the manner desired is effected by rotating the shaft 20 in a clockwise direction through an angle of 180° to rotate the holder 12 through the same angular distance. During such movement of the holder the tendency of the tube 14 to rotate with the holder causes it to firmly engage the carriage 25 and the latter is advanced lengthwise, thereby bending the tube around the hub 18, as best shown in Figure 6.

In order to prevent the tube from collapsing, or being otherwise deformed, during the bend-

ing operation a mandrel 33 is preferably employed. The said mandrel includes a head 34 having a diameter slightly less than the internal diameter of the tube 14 and tapering to a rounded tip, the taper of the tip being arcuate and being concentric with axis of the shaft 20. The mandrel is supported in coaxial relation with respect to the tube 14, its outer end occupying a notch 35 which is formed in a bracket 36 on the top of the table. A sleeve 37 on the outer end of the mandrel is engageable with the bracket 36 to hold the mandrel against axial movement as the tube is drawn off the mandrel during the bending operation, the said sleeve being adjustable to locate the head 34 of the mandrel in proper relation with respect to the axis of the shaft 20.

Rotary movement of the shaft 20 in one direction to bend the tube 14 in the manner described and in the opposite direction to restore the parts to their original positions upon completion of the bending operation is effected, in the embodiment of the invention illustrated, by air cylinders 38 and 39 (Figure 2), the pistons of the said cylinders operating racks 40 and 41, respectively, which mesh with a gear 42 fixed to the lower end of the shaft 20. Compressed air from a supply line 43 may be admitted by a valve 43*a* either into a line 44 which communicates through a fitting 45 with a manifold 46 or into a line 47 which communicates with the cylinder 39 directly, the control lever for the said valve being indicated at 43*b* (Figure 1). A line 48 connects the manifold 46 with the cylinder 38 while a line 48*a* connects the manifold with the side of the cylinder 39 opposite to the side to which the line 47 connects the manifold. When the valve 43*a* is moved to the position shown in Figure 2, the air which is admitted to the manifold 46 is supplied to the cylinders 38 and 39 through the pipes 48 and 48*a*, respectively, and the pistons of the said cylinders are moved toward one another, the exhaust side of the cylinder 38 communicating with the atmosphere through a vent 38*b* while the exhaust side of the cylinder 39 is vented through the valve 43*a*. The movement of the pistons is transmitted by the racks 40 and 41 to the gear 42 and thereby causes the shaft 20 to rotate in a clockwise direction.

In bending the tube around the hub 18 the zone of the tube under tension is drawn around the head 34 of the mandrel and the latter acts against said zone to prevent it from collapsing. Upon completion of the bending operation the mandrel is automatically retracted, thereby freeing it in the tube so that it may be readily withdrawn from the tube and the latter removed from the holder. To this end a lever 49 (Figure 5) is pivotally mounted between arms 50 which are suitably secured to the underside of the top of the table. The upper end of the lever 49 is forked and carries pins 51 which are located at opposite sides of a shank extension 52 on the sleeve between the outer end of the sleeve and annular enlargement 53. The lever 49 is actuated by a rod 54 which is connected to the piston of an air cylinder 55, a spring 56 which is located on the rod 54 between the lever 49 and the head of the cylinder 55 acting against the lever normally to hold the mandrel 33 extended in a position in which the inner end of the sleeve 37 abuts the stop provided by the bracket 36. Referring to Figure 2, it will be noted that one end of a line 57 is connected to the cylinder 55 while the other end is connected to the manifold 46 through an arm 58 of the fitting 45. A restricted passage 59 through the arm 58 limits the flow of air from the manifold to the cylinder 55, a valve 60 in the line 57 being accessible through an opening 61 in the top of the table and being available to cut off communication between the manifold and the cylinder, if desired.

It will be noted that the holder, carriage and mandrel are removable, at will; and in the operation of the machine the bending and related operations are facilitated by the attachment of the tube to the holder when the latter is removed from the shaft 20. At this time the mandrel may be inserted in the tube and the carriage arranged so that the leading end abuts the holder while the tube occupies the channel 26, the engaged end of the tube being reinforced by a suitable removable plug, if desired. The assembly comprising the holder, tube, mandrel and carriage may thereupon be manipulated as a unit so that all of said parts may be reassembled in their proper positions in the machine, the shaft 20 entering the bore in the hub of the holder as the assembly is lowered to position the carriage in front of the bar 27 and the outer end of the mandrel entering the notch in the bracket 36 as the shank extension on the sleeve 37 moves between the pins 51 on the lever 49. The parts are thereby caused to occupy the positions illustrated in Figure 1. Thereafter when the lever 43*b* is operated to admit compressed air to the manifold 46, compressed air from the latter will be admitted to the cylinders 38 and 39 and the pistons thereof will actuate the racks 40 and 41 to rotate the shaft 20 and thereby bend the tube 14 around the hub 18. The resistance which the tube offers to bending is transmitted to the carriage 25 as the latter is advanced along the bar 27 by the tube, the carriage providing for the necessary movement of the tube with a minimum of friction and at the same time reinforcing the head of the mandrel in such a manner that substantially the only frictional resistance offered by the mandrel to relative movement of the tube is that offered by that portion of the head which engages the zone of the tube under tension.

Compressed air from the manifold 46 enters the cylinder 55 at the same time it enters the cylinders 38 and 39. The restricted passage 59, however limits the flow of air to the cylinder 55 so that the cylinders 38 and 39 will be operative to bend the tube 14 before a substantial pressure is developed in the cylinder 55. The flow of air into the latter is so controlled that upon completion of the bending operation the pressure will reach a value high enough to actuate the lever 49 to retract the mandrel 33 and thus loosen it so that it may be readily withdrawn from the tube. The assembly comprising the holder, tube, mandrel and carriage may then be detached from the machine and the jaw 15 loosened to permit removal of the bent tube and its replacement by one to be bent. The parts may then be restored to their original positions by turning the valve 43*a* to vent the manifold 46 and simultaneously admit air from the line 43 into the cylinder 39 through the line 47 to drive the piston of the cylinder in the opposite direction, said piston in such movement, through the gear train 41, 42, 40, effecting the movement of the piston of the cylinder 38 to its original position as the latter is preferably single-acting and is utilized only to drive the shaft 20 in the bending operation. Simultaneously the spring 56 will be operative to restore the lever 49

and the piston of the cylinder 55 to their original positions.

A modified form of holder 12a is illustrated in Figures 7, 8 and 9. In this embodiment of the invention the bend in the tube 14a is also through an angle of 180° but is formed in two stages, the bend in each stage being through an angle of 90° and the two sections of the bend being connected by an unbent section. In order to enable bending of a tube in this manner the holder 12a is formed with a dual hub, each of the sections 62 and 63 thereof being formed with a multi-sided bore to accommodate the end of the shaft 20 and the spacing and sizes of the hub sections determining the shape of the bent sections of the tube and the extent of the unbent section. In other respects structurally the holder is similar to that illustrated in connection with the embodiment first described, it being noted that that portion of the tube which connects the two bent portions occupies portions of the channel in each hub section in tangential relation with respect to the bottom wall of the channel.

In its use the holder 12a is initially arranged so that the shaft 20 will enter the bore in the hub section 62 (Figure 7) and the shaft is then rotated through an angle of 90°, a stop 64 (Figure 2) which occupies the position indicated in dotted lines arresting further movement of the rack 41 when this limit has been reached. The stop is carried by a shaft 65 which is mounted upon the underside of the table top in bearings 66, a lever 67 on the outer end of the shaft being available to move the stop to its operative and inoperative positions. Upon completion of the 90° bend, the stop 64 is moved out of the path of the rack 41 and the holder, tube, mandrel and carriage assembly is elevated to withdraw the shaft 20 from the bore of the hub section 62 and the assembly is then advanced and lowered to cause the shaft 20 to enter the bore in the hub section 63 (Figure 8). The shaft 20 is then rotated through a second angle of 90° (Figure 9) to complete the bending operation; and the tube is removed from the holder.

The machine described has the advantage that the only substantial frictional resistance offered to the advancing movement of the tube being bent is that offered by the small portion of the head of the mandrel which acts against the part of the tube under tension. The power required to compensate for frictional losses is thus reduced to a minimum. A further advantage obtained as a result of facilitating the advancing movement of the tube during the bending operation while supporting the zone under tension is that the tendency of the tube to collapse is minimized. Tubes having thin walls may, therefore, be bent in the manner described, and the bends will be uniform as to shape and curvature and will be produced without distortion. In this connection it is understood, of course, that in the use of the machine the parts will ordinarily be so adjusted that the angular movement of the holder will be through a slightly greater angle than actually called for by the desired bend. Compensation can thus be made for the reflex action which may accompany the release of the tube upon completion of the bending operation.

I claim as my invention:

1. A tube bending machine including a holder having a hub, means for removably securing a tube to said holder in a predetermined relation with respect to the periphery of said hub, means for rotating said holder about the axis of said hub to bend said tube around said hub, said means including an air cylinder, a carriage which is engageable with said tube along the side opposite that which is engageable with said hub, said carriage being freely movable and being adapted to maintain the predetermined relation between said tube and hub, a mandrel which extends into said tube and around which the tension zone of the bend is drawn during the bending operation, means, including an air cylinder, for retracting said mandrel upon completion of the bending operation, and a line through which compressed air is supplied simultaneously to both of said cylinders, said line including a restricted passage through which air flows to said second mentioned cylinder, whereby the pressure therein is permitted to reach a value high enough to retract said mandrel only after said first mentioned cylinder has been operated to rotate said holder.

2. A tube bending machine including a supporting table, an upright actuating shaft projecting above said table, a tube holder supported upon the table and including a hub removably fitted upon the shaft for actuation thereby, means carried by the holder for removably securing a tube thereto in a predetermined relation with respect to the periphery of said hub, a carriage in engagement with the tube along the side opposite that which is engaged by the hub, a mandrel which extends into the tube and around which the tension zone at the bend is caused to pass during the bending operation, a fixed stop to limit the movement of the mandrel into the tube, and means for retracting the mandrel sufficiently to release it from the tube upon the completion of the bending operation, the mandrel being removable with respect to said stop and retracting means and a track for the carriage carried by the table, the holder, carriage and mandrel being removable and replaceable as an assembly with respect to the table.

3. A tube bending machine including a supporting table, an upright actuating shaft projecting above said table, a tube holder supported upon the table and including a hub removably fitted upon the shaft for actuation thereby, means carried by the holder for removably securing a tube thereto in a predetermined relation with respect to the periphery of said hub, a carriage in engagement with the tube along the side opposite that which is engaged by the hub, a mandrel which extends into the tube and around which the tension zone at the bend is caused to pass during the bending operation, a fixed stop to limit the movement of the mandrel into the tube, an element for retracting the mandrel sufficiently to release it from the tube upon the completion of the bending operation, the mandrel being removable with respect to said stop and element, a track for the carriage carried by the table, the holder, carriage and mandrel being removable and replaceable as an assembly with respect to the table, fluid operated means for rotating the actuating shaft to effect the bending operation, fluid operated means for actuating the element in the mandrel retracting operation and a delayed action connection between said means whereby the means for operating the element is operative upon the completion of the operation of said first-named means.

4. A tube bending machine including a supporting table, an actuating shaft projecting above said table, a tube holder supported upon said table and having a hub formed with a bore for accommodating said shaft and an arcuate groove in which a tube may be fitted, means carried by

the holder for removably securing the tube thereto in a predetermined relation with respect to said hub, the tube fitting in the groove of the hub, a carriage supported by the table and, as supported, having engagement with said tube along the side thereof opposite to that which is engageable with said hub, a track for said carriage, means for driving said shaft to rotate said holder about the axis of said hub and thereby bend said tube around said hub, said carriage being freely movable and being adapted to maintain the predetermined relation between said tube and hub, a mandrel which extends into said tube and around which the tension zone of the bend is caused to pass during the tube bending operation, means for loosening the mandrel from the tube at the completion of the tube bending operation, the mandrel being disengageable and removable from said means, said holder, carriage and mandrel being removable and replaceable as an assembly with respect to said table, shaft and mandrel loosening means, the bent tube being included in the assembly as removed and a tube blank being included in the assembly as replaced.

5. A tube bending machine including an actuating shaft, a holder having a hub mounted upon said shaft, means for removably securing a tube in a predetermined relation with respect to the periphery of said hub, a mandrel which extends into the tube and around which the tension zone of the bend is caused to pass during the bending operation, means for rotating the shaft to effect the bending operation, means for retracting the mandrel sufficiently to disengage it from the tube and operative connections between said shaft rotating means and said mandrel retracting means, said connections including means for automatically retracting means, said connections including means for automatically delaying the operation of said mandrel retracting means until the completion of the tube bending operation.

6. A tube bending machine including an actuating shaft, a holder having a hub mounted upon said shaft and means for removably securing a tube in a predetermined relation with respect to the periphery of said hub, a mandrel which extends into the tube and around which the tension zone of the bend is caused to pass during the bending operation, an element for retracting the mandrel sufficiently to release it from the tube, fluid operated means for rotating the actuating shaft to effect the bending operation, fluid operated means for actuating the element in the mandrel retracting operation and an automatically operating delayed action connection for causing the operation of the means for actuating the element and for delaying such operation until the completion of the operation of said first-named means.

7. A tube bending machine including a supporting table, an actuating shaft projecting above the table, a tube holder supported upon the table and having driving engagement with the actuating shaft, the tube holder being removable from said shaft, a clamp carried by the tube holder for clamping a tube thereto in a predetermined relation, a mandrel which extends into the tube and around which the tension zone of the tube bend is caused to pass during the bending operation, an element for retracting the mandrel from the tension zone of the tube upon the completion of the bending operation, the mandrel being removable and replaceable with respect to said element, means for turning the actuating shaft in one direction to effect the tube bending operation and in the opposite direction to restore said shaft to initial position, a manually operable element for the selective determination of the operation of said means, means acting upon the mandrel retracting element to effect its operation, means automatically operative upon the operation of the means for turning the actuating shaft to effect the tube bending operation for causing the operation of the means for actuating the mandrel retracting element, and for delaying the operation of said last-named means until the completion of the bending operation, and a carriage supported by the table and, as supported, having engagement with the tube along the side thereof opposite to that which is engaged with said tube holder, said holder, carriage and mandrel being removable and replaceable as an assembly with respect to said table, shaft and mandrel retracting element, the bent tube being included in the assembly as removed and a tube blank being included in the assembly as replaced, the manually operable element being available when the said assembly is removed from the machine to effect the return of the actuating shaft and the mandrel retracting element to their initial positions.

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