March 20, 1945. B. R. LANCASTER 2,371,695

TUBE BENDER

Filed Sept. 14, 1942 2 Sheets-Sheet 1

Fig. 1

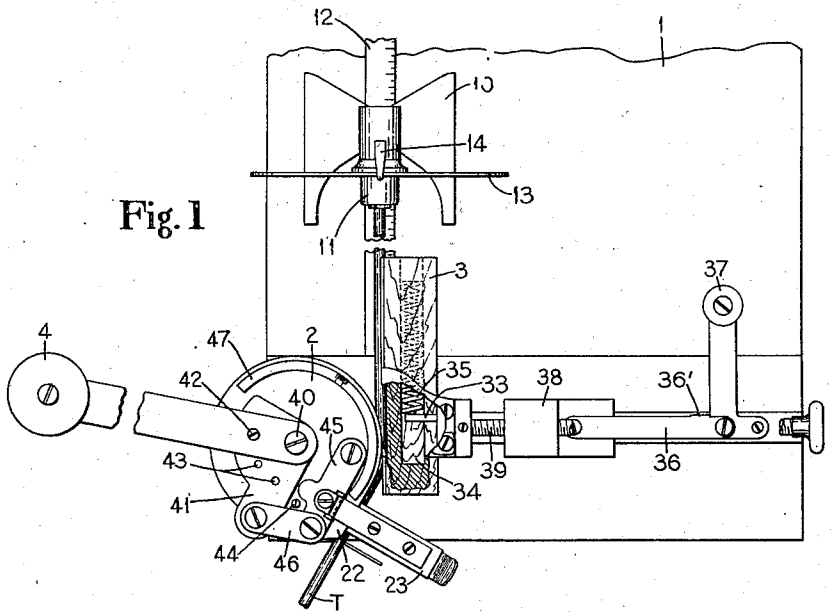
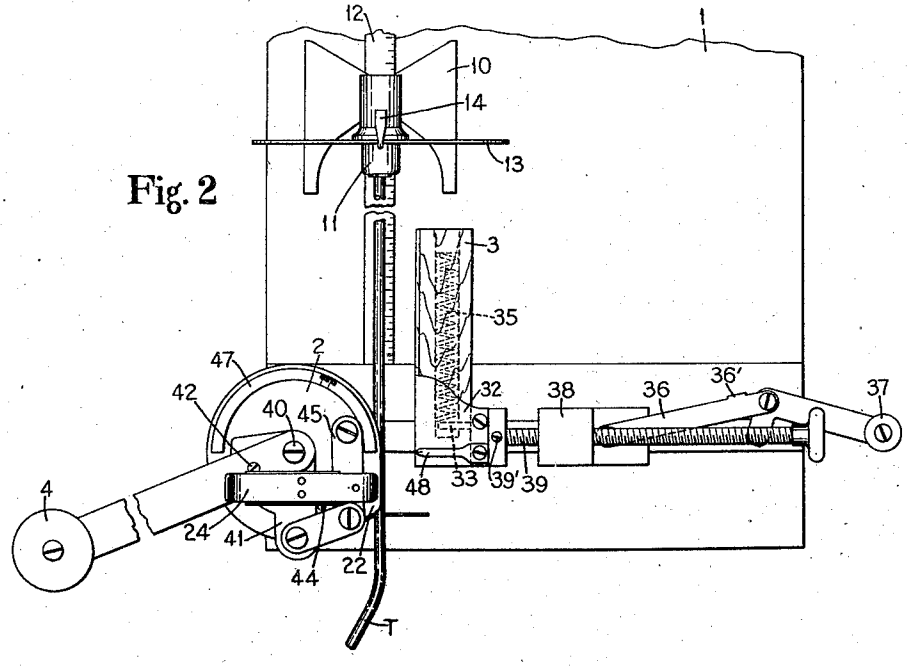


Fig. 2



BILLY R. LANCASTER
Inventor

By Reynolds & Beach

Attorneys

March 20, 1945. B. R. LANCASTER 2,371,695

TUBE BENDER

Filed Sept. 14, 1942 2 Sheets-Sheet 2

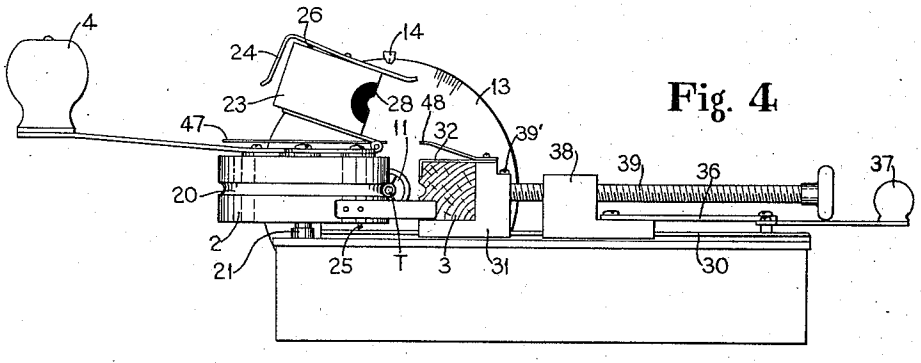


Fig. 4

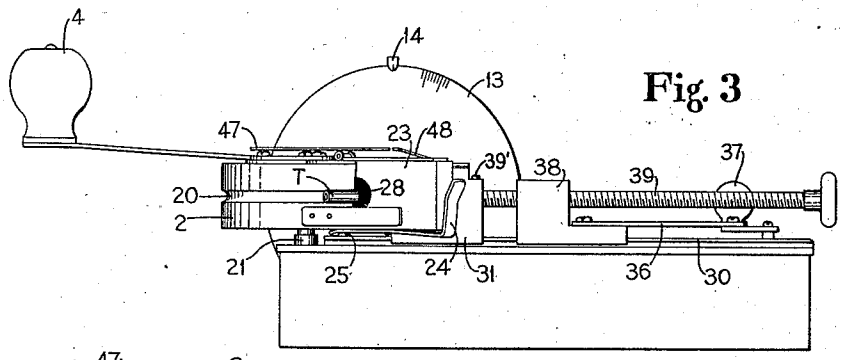


Fig. 3

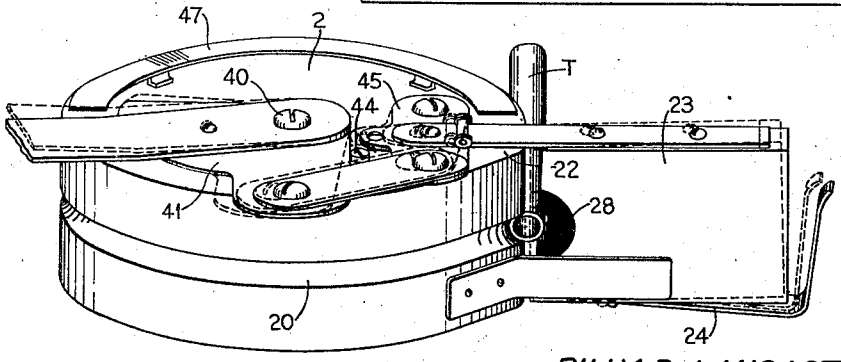


Fig. 5

BILLY R. LANCASTER, Inventor

By Reynolds & Beach

Attorneys

Patented Mar. 20, 1945 2,371,695

UNITED STATES PATENT OFFICE

2,371,695

TUBE BENDER

Billy R. Lancaster, Seattle, Wash., assignor to Boeing Aircraft Company, Seattle, Wash., a corporation of Washington

Application September 14, 1942, Serial No. 458,255

11 Claims. (Cl. 153—40)

This invention relates to a machine for bending tubes and is particularly adapted for deflecting through various angles tubes of small diameter made of fairly soft material, such as copper, brass or aluminum.

It has been difficult heretofore to bend such tubes accurately and quickly to the desired degree without crushing or otherwise damaging the tube. Machines which have been able to prevent such injury have required a fine adjustment operation preceding each bending manipulation, which consumed an unwarranted amount of time.

My invention provides quick engageable and releasable mechanism which enables a tube to be secured in the bending machine expeditiously, yet in precisely the relationship desired, where it will be held firmly against slippage without the exertion of excessive pressure. Moreover the tube is adequately supported to prevent inadvertent deformation of portions adjacent to the zone of the bend.

With my machine also the tube is subjected to stress only during the actual bending operation and such stress is relieved the instant the bending force is discontinued.

An object of my invention is to secure these operational advantages while enabling the bending operation itself to be performed accurately. Within the term "bending operation" I include not only the formation of a single bend or offset in a tube, but any number of bends in succession along the length of the tube, which may be formed all in the same plane or in different planes, as the final form of the tube may require.

More specifically, I accomplish these and other objects by providing a tube clamp operated to grip the tube by initial movement of the member for rotating the forming block, and simultaneously backing the tube with a member movable by quick-release mechanism into an accurately predetermined backing position. A preferred form of such mechanism is described in detail hereafter and illustrated in the drawings, but it will be evident that various changes may be made in it within the scope of my invention as defined in the appended claims.

Figure 1 is a plan view of my machine showing a tube clamped in it at the completion of a bending operation, and Figure 2 is a similar plan view showing the parts in position ready to clamp the tube to perform a further bending operation.

Figure 3 is an end elevational view of the machine with the parts in the same relative positions as in Figure 1, while Figure 4 is a similar end elevation view with the parts in the positions shown in Figure 2.

Figure 5 is a top perspective view of the forming block and the tube clamp associated with it.

Provision is made in the machine for supporting the tube T in position for bending without assistance from the operator. Moreover, after being initially clamped in the machine a number of successive bending operations may be performed on it without completely releasing the tube from the machine. Reference devices are provided so that not only may the proper degree of bend be produced locally in each instance, but the successive bends will be spaced apart the correct distance and adjacent bends will be in planes having the desired angular relationship. Throughout the bending operation, however, the tube will be held properly so that in each instance the bend will occur only in the local zone being operated upon, without deformation of other portions of the tube.

To carry out this operation the bending machine includes a base 1 along which a wheeled carriage 10 may roll. This carriage has a collet 11 for gripping the trailing end of the tube fixedly throughout the entire sequence of bending operations on such tube. The carriage with its collet may be moved along the base 1 between, as well as during, successive bending operations, so that adjacent bends will be spaced apart the proper distance. To determine accurately when the tube has been fed along sufficiently to provide the desired spacing between the bends, the carriage 10 may cooperate with a scale 12 secured to the base 1 along the path which it traverses. The desired angular relationship between the planes of successive bends may be established by rotating the collet 11 upon carriage 10 and a protractor disc 13, which turns with the collet, may cooperate with an index finger 14 fixedly mounted on the carriage to indicate the angle through which the tube is rotated.

The section of the tube immediately forward of the portion to be bent is secured to the rotatable forming block 2 which has a peripheral groove 20 of almost semicircular cross section. Preferably such cross section is slightly less than a semicircle for reasons which will be explained hereafter. This forming block is rotatable on a central pivot 21, located so that the center line of collet 11 is tangent to or spaced slightly from the periphery of the block 2. While this forming block is generally circular, having a radius substantially equal to the desired mean radius of a tube bend, it preferably has a protuberance 22

on one part of its periphery, defining a planar face of appreciable length perpendicular to the block's rotative axis. Such face is tangential to the convex portion of the block's periphery with which it merges. At the initiation of a bending operation this planar face of block 2 will be rotated into the position of Figure 2, in which it is parallel with the center line through collet 11. The portion of tube T immediately in advance of the zone of the bend may thus be laid in that section of groove 20 formed in this planar face, so that the tube will contact the block groove over a substantial distance, without being deflected from its original linear shape.

With the tube T and block 2 in this relationship, a clamping block 23, hinged at the upper face of block 2 to pivot about an axis generally parallel with the planar face of protuberance 22, may be swung downward over the tube. On the edge of block 23 which is at the bottom in this position is mounted a latch bar 24, having an aperture in the end projecting beneath block 2 for engagement over a pin 25 projecting below the lower face of block 2. Bar 24 is bent slightly, as shown best in Figure 4, and pivotally secured at the crown of such bend to such edge of block 23 to rock as its aperture is engaged with pin 25. This end of the bar is immediately pressed upward into contact with the lower face of block 2 by a spring 26 reacting between the edge of block 23 and the portion of the bar on the opposite side of such center. The bar aperture may be released from pin 25, of course, by rocking the bar against the resistance of this spring to move its apertured end downward clear of the pin. This action may be accomplished easily by pressing the upturned end of the latch bar toward the end of block 23 which it overlies.

When initially swung downward over the tube to engage latch bar 24 with pin 25, block 23 does not clamp the tube T tightly, but will be spaced somewhat from it as illustrated in exaggerated fashion in Figure 5. The edge of block 23 adjacent to block 2 will have in it a groove disposed in alignment with groove 20 and of substantially the same size, being slightly less than a semicircle in cross section. This is particularly important in connection with block 23, for the tube engaging groove is preferably not cut directly in the rigid block but is formed in an insert of slightly resilient material, such as a plastic, which will grip the tube tightly as block 23 is pressed toward the tube, and the wedging action of the tube being forced into the groove in the insert will expand it somewhat.

After the tube has been laid in the linear portion of groove 20, in the manner shown in Figure 2, and prior to rotation of block 2, a backing block 3 is moved from the position of Figures 2 and 4 into that of Figures 1 and 3 to back up the tube, thus to prevent deformation of the straight portion behind the zone of the bend during performance of the bending operation.

When in the backing position of Figures 1 and 3, this block must engage the tube accurately and firmly in order to hold it securely, and yet must not be pressed against the tube with sufficient force to squash it against block 2, or to impede the bending operation. Despite the accuracy of adjustment required, my mechanism enables the block to be moved quickly and positively into and from a precise backing position.

Ways 30, which may be of T-bar section, arranged perpendicular to the center line of collet 11, guide the movement of a slide 31 in which block 3 is mounted for movement directly toward and away from the tube. This slide, as shown in Figures 3 and 4, is of generally angle shape to engage contiguously a portion of the bottom of block 3 and the side opposite the tube. Over the top of this block is a plate 32 secured to the top of slide 31 by one edge and having its opposite edge flanged downward to fit into a channel in the face of block 3 toward the tube. The block is thus held between slide 31 and plate 32 against lateral movement or tilting in any direction but is slidable endwise. This endwise movement, however, is limited by a finger 33 which projects from slide 31 through a slot along the adjacent side of block 3 into a hollow 34 extending lengthwise within the block. The block is urged to the limiting position permitted by finger 33 by the action of a compression spring 35 received within the hollow 34 and reacting between such finger and the remote end of the hollow. Movement of the block in the opposite direction is limited, of course, by compression of this spring 35. Reciprocation of this block will always be along a line precisely perpendicular to ways 30, because the extent of slide 31 and plate 32 transversely of the ways will be sufficient to guide movement of the block in such relationship.

To enable block 3 to be moved quickly toward or away from its tube backing position a toggle linkage, operated by a bell crank handle 37 incorporated in the linkage, is interconnected between the ways 30 and slide 31. As far as rapid movement of block 3 is concerned the toggle linkage might be pivoted directly to both the ways and slide. If the position of the slide is to be adjusted in the first instance in order to block the tube accurately, however, some provision must be made for initial adjustment between the toggle linkage 36 and either slide 31 or ways 30. In the construction illustrated, a block 38 is interposed between the linkage and slide, and the linkage is pivoted upon this block. The block and slide are adjustably but positively interconnected by an adjusting screw 39 threaded into the block and rotatable in the slide 31 without endwise movement. A hand wheel may be provided on the end of this screw to facilitate its rotation for moving the slide toward or away from the block, and when the proper relationship has been established between them, the screw may be locked against further rotation if desired, such as by a set screw 39' in the top of slide 31.

If the toggle linkage were pivoted directly to slide 31 suitable adjusting mechanism could be provided for the other end of the linkage to shift it to the desired position along ways 30. Thus the toggle linkage 36 might be interposed between slide 31 and a member equivalent to block 38, which member would be adjustable relative to the ways or base by an interconnecting adjusting screw such as 39, or equivalent mechanism.

In rotating the forming block 2 during a bending operation, pressure is exerted on handle 4. This handle, however, is not rigidly secured to the block but is pivoted concentrically with it by pivot 20. Since the handle can not transmit rotary movement from itself to the block by means of this pivot some additional interconnecting mechanism is required. This may take the form of a quadrant plate 41 to which the handle may be secured rigidly in any one of a number of different positions of adjustment, such as by insertion of a pin or screw 42 into a se-

lected one of the quadrant plate holes 43 corresponding to the position of the handle most convenient for the immediate use contemplated. By such engagement the handle 4 and the quadrant plate 41 are secured together for conjoined movement, but the quadrant plate, in turn, is merely pivoted upon pivot 40 instead of being secured rigidly to block 2. As the handle 4 is moved counterclockwise from the position shown in Figure 1, however, this quadrant plate is moved into engagement with a stop screw or pin 44 which is fixed to the block 2. Upon engagement of the quadrant plate with this stop screw or pin, therefore, the block 2 will be rotated as the handle is rotated in a counterclockwise direction into the position of the parts shown in Figure 2. If desired, suitable stop means, not shown, can be provided to terminate counterclockwise rotation of the parts upon reaching this position.

If the handle were moved in a clockwise direction, however, the structure thus far described would not effect conjoint rotation of block 2 in a clockwise direction. As previously stated, the clamping block 23 is hinged upon an axis above block 2 and substantially parallel to the center line of collet 11 when block 2 is in the position shown in Figure 2. The hinge, however, is not secured directly to the upper face of the forming block, but on the contrary it is carried by an arm or a link 45 pivoted upon the upper face of such block eccentrically of its pivot, and is disposed generally parallel to the planar face of protuberance 22. This link is connected by a second link 46 to the quadrant plate 41.

The effective length of link 45 is substantially equal to the distance between pivot 40 and the pivot interconnecting quadrant plate 41 and link 46, and furthermore the distance between the pivots of link 46 is substantially equal to that between pivot 40 and the pivot of link 45 upon block 2. Thus, the several pivots of the quadrant plate and the two links 45 and 46 define a parallelogram in all swung positions, and the intercept of quadrant plate 41 in conjunction with link 45 constitute parallel linkage. Consequently link 45 will be swung relative to block 2 through an angle substantially equal to the angle through which quadrant plate 41 and handle 4 swing relative to this block. Such swinging of link 45 in a counterclockwise direction is limited by engagement of the quadrant plate with stop pin 44, just as is the movement of such plate itself thus limited. Conversely swinging of link 45 in a clockwise direction is limited by its engagement with stop pin 44, and this in turn terminates clockwise movement of quadrant plate 41 and handle 4 because of the interconnection of these parts by link 46.

Actually the movement of link 45 in a clockwise direction when a tube is clamped by block 23 would be stopped prior to its engagement with the stop pin because of the limited movement of the clamping block between the solid line position and the dotted line position of the parts to grip the tube, as shown in Figure 5. The manner in which clockwise movement of the parts is thus stopped will be more evident from a discussion of the operating sequence which follows.

Considering first the initial adjustment of the parts, we may assume that the blocks 2 and 3 are in the relative positions of Figure 2, preparatory to making the first bend in a tube T. With the trailing end of the tube securely clamped in collet 11 the carriage 10 will be run forward until the opposite end of the tube can be laid in the linear portion of groove 20 in the protuberance 22. Screw 39 will now be well retracted, whereupon the toggle linkage 36 will be swung by operation of handle 37 into the aligned position of the linkage shown in Figure 1. In this relationship the interconnecting pivot of the links is forced just sufficiently past center to prevent the linkage buckling when a compression force is exerted upon them. Engagement of the handle lever with the stop lug 36' will prevent the linkage buckling in the opposite direction. Block 3 will now be in a position close to tube T and screw 39 may be rotated by its hand wheel until the tube-receiving groove in block 3, shown in Figure 4, engages the tube snugly but does not squeeze it between this block and block 2. Block 3 will then be in exactly the correct backing position.

It is next necessary to clamp the end of the tube T securely to block 2 prior to initiating the bending operation. This is done by swinging clamping block 23 from the position above block 2, as shown in Figures 2 and 4, into its lower position of Figures 1, 3 and 5. By this operation the aperture in the end of latch bar 24 underlying block 2 is snapped over pin 25, as explained previously. This engagement does not clamp the tube tightly to block 2, as will be evident from Figure 5. No independent manual clamping manipulation is necessary, however, prior to initiation of the bending operation.

The operator now grasps handle 4 and rotates it in a clockwise direction from the position shown in Figures 2 and 4 and in solid lines in Figure 5. The quadrant plate 41 immediately starts to swivel about its pivot 40 with respect to block 2, while the latter remains stationary. This movement of the quadrant plate simultaneously swings link 45 toward the broken line position of Figure 5, which, as indicated, moves the hinge of block 23 bodily away from protuberance 22. This displacement, of course, draws the clamping block from the solid line position shown in Figure 5 toward the protuberance and presses its resilient insert 28 against the tube. As previously stated, it is preferred that groove 20 and the groove in insert 28 be somewhat less than a semicircle in cross section so that even when block 23 has been drawn into clamping position it will not quite touch the planar face of protuberance 22. The tube T may thus be clamped with unlimited tension, for as long as the forming block does not rotate, the greater the force applied to handle 4 the tighter will tube T be gripped between the clamping and forming blocks. Nevertheless, all pressure on the tube can be released immediately merely by reversing the direction of the force upon handle 4, and the tube can be released completely by unlatching block 23 and swinging it upward on top of block 2 as in Figs. 2 and 4.

With the tube thus firmly clamped to block 2, continued force on handle 4 in a clockwise direction will cause the block to be rotated in the manner shown in Figure 1, which will wrap the tube around the periphery of the forming block in its groove 20. However great the endwise pull on the tube may be it cannot slip between blocks 2 and 23, for the pressure on handle 4 which increases the force on the tube also presses the clamping block 23 more tightly against the tube. The extent of tube bend may be indicated either by a suitable protractor arc 47 mounted on block

2 and cooperating with a fixed pointer or index 48 which may be carried by the slide 31, or by progression of carriage 10 along scale 12. Because of the frictional engagement of backing block 3 with the tube it will be moved endwise as block 2 rotates, thus continually backing up the tube to prevent its deformation. During this movement of block 3 spring 35 would, of course, be compressed, but the resistance thus created would be insufficient to slide this block backward along the tube while pressed against it.

When the block 2 has been rotated sufficiently to reduce a bend in the tube of the desired angle, handle 37 will be swung in a clockwise direction from the position of Figure 1 to that of Figure 2 to withdraw block 3 from engagement with the tube. Immediately upon cessation of such engagement spring 35, reacting against finger 33, will slide block 3 from the position shown in Figure 1 back to its initial position of Figure 2. Handle 4 may now be rotated slightly in a counterclockwise direction to swing link 45 for relieving the clamping action of block 23, and latch bar 24 may then be released and the block swung into the position illustrated in Figure 4. Tube T can now be drawn endwise, rolling carriage 10 along table 1 a distance equal to the spacing desired between the adjacent bends. Also the tube may be rotated about its axis, if necessary, to dispose such adjacent bends in the proper relative angular relationship. Swinging of handle 4 will next be continued in a counterclockwise direction until quadrant plate 41 engages stop pin 44, whereupon it will rotate the forming block 2 back to the starting position of Figure 2.

The machine is now ready to begin a further bending cycle by swinging handle 37 to move backing block 3 quickly into the position contacting with the tube, for which it has been preset, after which clamping block 23 will be swung downward and handle 4 rotated clockwise to make the next bend. Such bending steps may be continued in sequence until the entire length of the tube has been shaped into the formation desired, whereupon the trailing end of the tube will be released from the collet and the tube will be removed from the machine and another tube to be bent will be inserted.

What I claim as my invention is:

1. A tube bending machine comprising a forming block rotatable to bend a tube engaged therewith, a backing block, toggle linkage operable to move said backing block quickly into a position to hold the tube against said forming block during the bending operation, a handle pivoted on said forming block concentrically with its rotative axis, parallel linkage connected to said handle and carried by said forming block, and a clamping block hinged upon said linkage to swing downward over the tube engaged with the forming block, said handle being rotatable in a direction corresponding to tube bending rotation of said forming block to rotate said forming block while simultaneously pressing said clamping block into gripping engagement with the tube.

2. A tube bending machine comprising a forming block rotatable about a fixed axis to bend a tube engaged therewith, a backing block adjacent to said forming block operable to hold the tube against it during the bending operation, toggle linkage operable to move said backing block quickly toward or away from said forming block between tube holding and tube released positions, respectively, adjusting means operable to vary the tube holding position of said backing block established by said toggle linkage in moving it to its limiting position toward said forming block, a handle pivoted on said forming block concentrically with its rotative axis, parallel linkage connected to said handle and carried by said forming block, and a clamping block hinged upon said linkage to swing downward over the tube engaged with the forming block, said handle being rotatable in a direction corresponding to tube bending rotation of said forming block to rotate said forming block while simultaneously pressing said clamping block into gripping engagement with the tube.

3. A tube bending machine comprising a forming block rotatable to bend a tube engaged therewith, a backing block, means supporting said backing block adjacent to said forming block for holding the tube against it, means for rotating said forming block to bend the tube thus held between said forming and backing blocks, means guiding said backing block for lengthwise reciprocation in one direction conjointly with rotation of said forming block, means operable to retract said backing block out of its tube holding position and away from said forming block at the completion of the bending operation, and means operable automatically upon such retraction and independently of return rotation of said forming block to reciprocate said backing block lengthwise in the opposite direction to return it to its initial lengthwise position.

4. A tube bending machine comprising a forming block rotatable to bend a tube engaged therewith, means independent of said forming block operable to hold said tube against it during the bending operation, a handle pivoted on said forming block concentrically therewith and rotatable relative thereto, parallel linkage connected to said handle and carried by said forming block, and a tube clamp connected to said parallel linkage and movable into tube gripping position by swinging of said parallel linkage in response to rotation of said handle relative to said forming block in a direction corresponding to tube bending rotation of said forming block, said handle operating further to rotate said forming block after movement of said clamp into tube gripping position.

5. A tube bending machine comprising a forming block rotatable to bend a tube engaged therewith, means independent of said forming block operable to hold the tube against it during the bending operation, a handle pivoted on said forming block concentrically with its rotative axis, parallel linkage connected to said handle and carried by said forming block, and a clamping block hinged upon said linkage to swing downward over the tube engaged with the forming block, said handle being rotatable in a direction corresponding to tube bending rotation of said forming block to rotate said forming block while simultaneously pressing said clamping block into gripping engagement with the tube.

6. A tube bending machine comprising a forming block rotatable to bend a tube engaged therewith, means independent of said forming block operable to hold the tube against it during the bending operation, a handle pivoted on said forming block concentrically with its rotative axis, a clamping block adapted to be disposed in tube clamping position alongside said forming block, means securing the lower edge of said clamping block to said forming block beneath the tube, and means connecting the clamping block above the

tube to said handle for transmitting force from said handle to said forming block through said clamping block, said handle being rotatable in a direction corresponding to tube bending rotation of said forming block, first to move said clamping block to press the tube against said forming block, and thereafter to rotate said forming block to bend the tube.

7. A tube bending machine comprising a base, a forming block rotatable relative to said base to bend a tube engaged therewith, means supported by said base independent of said forming block and operable to hold the tube against said forming block during the bending operation, tube clamping means carried by said forming block including an arm having one end pivoted upon the upper side of said forming block for swinging in a plane substantially perpendicular to the axis of rotation of said forming block, and a clamping block secured to said arm at a location spaced from its pivot and movable, by swinging of the arm, between a tube clamping position abutting the periphery of the forming block and a tube released position, and means secured to said arm at the side of the clamping block remote from the arm pivot, and operable to swing said arm for moving said clamping block into tube clamping position and to rotate said forming block for bending the tube thus clamped.

8. A tube bending machine comprising a forming block rotatable to bend a tube engaged therewith, a backing block adjacent to said forming block for holding the tube against it during the bending operation, tube clamping means including an arm having one end pivoted to the top of said forming block for swinging about an axis adjacent to the periphery of the block and generally parallel to the axis of rotation of said forming block, a clamping block, and pivot means connecting said clamping block to a portion of said arm spaced from its pivot axis and supporting said clamping block to swing about an axis, which axis lies in a plane generally perpendicular to the rotative axis of said forming block, between a tube clamping position abutting the periphery of the forming block and a tube released position, and means connected to said arm at the side of said clamping block remote from the arm's pivot axis, and operable to swing said arm for moving said clamping block into tube clamping position and to rotate said forming block for bending the tube thus clamped.

9. A tube bending machine comprising a forming block rotatable about a fixed axis to bend a tube engaged therewith, a backing block adjacent to said forming block operable to hold the tube against it during the bending operation, means operable to guide said backing block for movement toward and away from said forming block, toggle linkage pivotally connected to said backing block and operable by swinging of its links into alignment independently of rotation of said forming block to move said backing block quickly toward or away from said forming block between tube holding and tube released positions, respectively, adjusting means operable to vary the tube holding position of said backing block established by aligning the links of said toggle linkage in moving the backing block to its limiting position toward said forming block, means for rotating said forming block, and clamping means operable to hold the tube against said forming block during its rotation.

10. A tube bending machine comprising a forming block rotatable upon a fixed axis to bend a tube engaged therewith, a backing block, means operable to guide said backing block for movement toward and away from said forming block, quick acting means operable independently of rotation of said forming block to move said backing block between a preset tube holding position adjacent to said forming block and a tube released position retracted from such preset position, precision adjusting means connected to said quick acting means and operable to locate accurately the preset position into which said backing block is moved by tube holding operation of said quick acting means, and means for rotating said forming block to bend the tube.

11. A tube bending machine comprising a forming block rotatable about a fixed axis to bend a tube engaged therewith, a backing block, means operable to guide said backing block for movement toward and away from said forming block, toggle linkage pivotally connected to said backing block, including links swingable from alignment into misaligned position independently of rotation of said forming block to move said backing block quickly between a preset tube holding position adjacent to said forming block and a tube released position retracted from such preset position, an adjusting screw movable to establish accurately the preset tube holding position of said backing block when the links of said toggle linkage are aligned, and means for rotating said forming block to bend the tube thus held between said forming and backing blocks.

BILLY R. LANCASTER.