Dec. 22, 1942. A. L. PARKER ET AL 2,306,223

AUTOMATIC TUBE BENDING MACHINE

Filed March 31, 1941 11 Sheets-Sheet 1

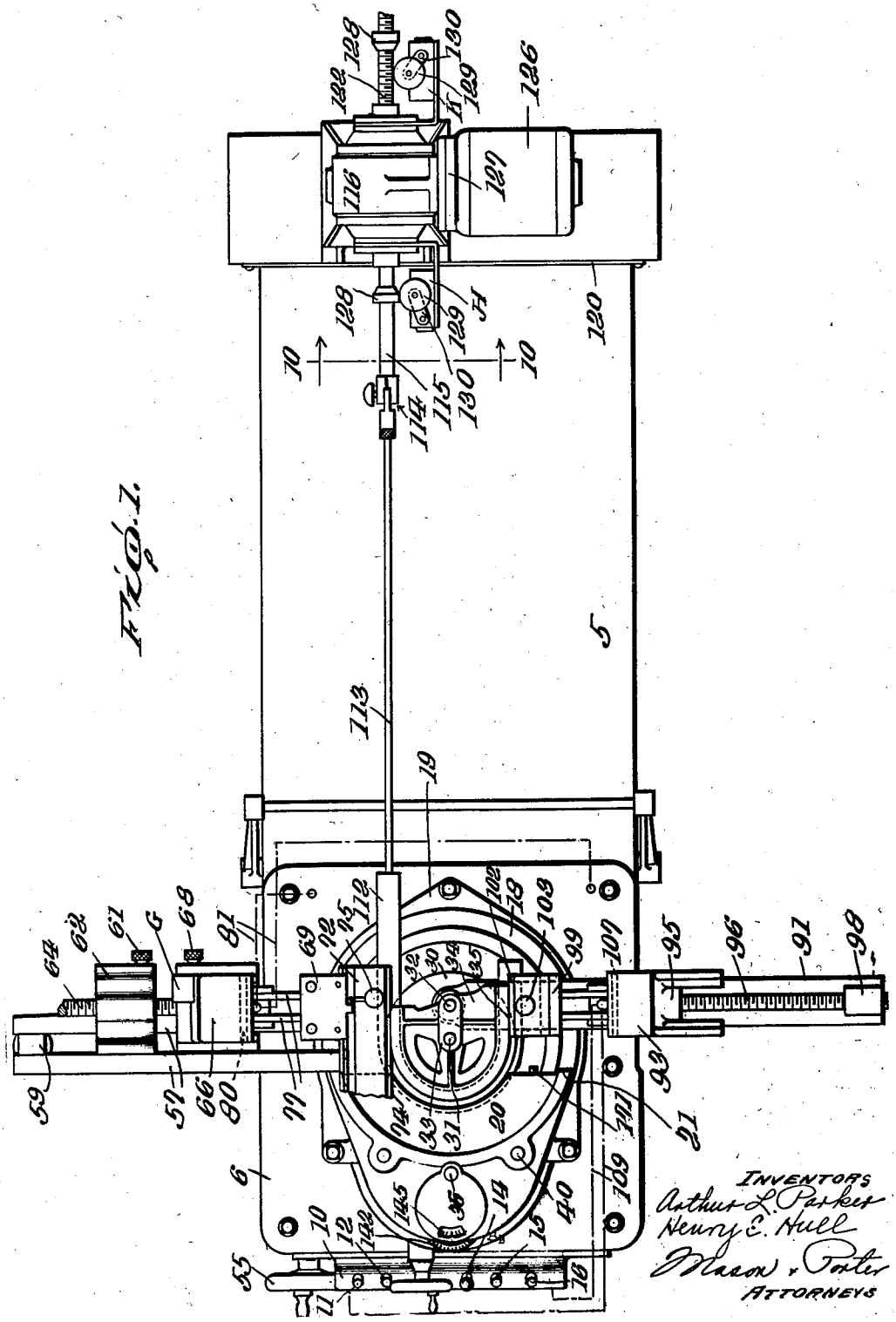


Fig. 1.

INVENTORS
Arthur L. Parker
Henry E. Hull
Mason & Porter
ATTORNEYS

Dec. 22, 1942. A. L. PARKER ET AL 2,306,223

AUTOMATIC TUBE BENDING MACHINE

Filed March 31, 1941 11 Sheets-Sheet 2

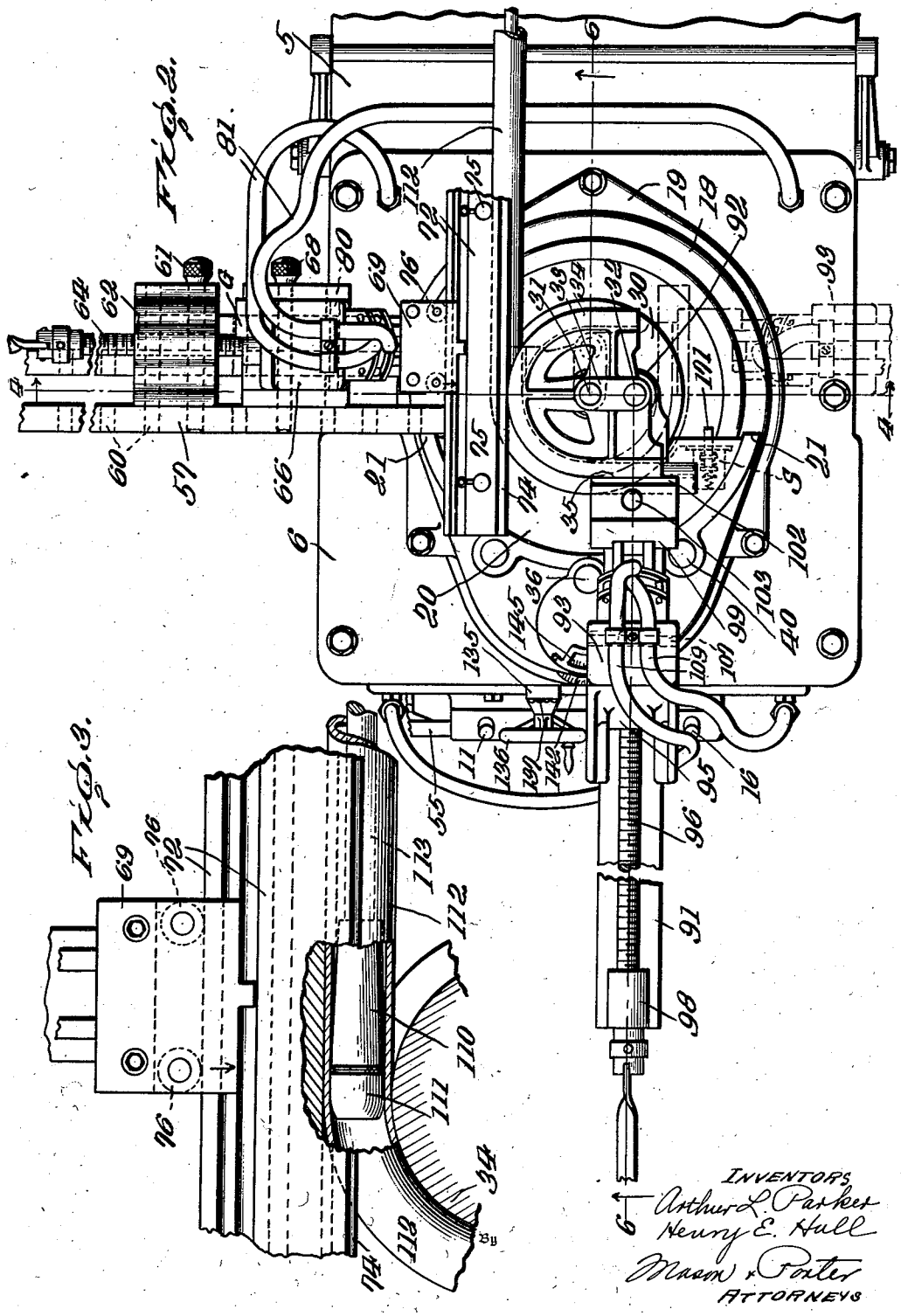


Fig. 2.

Fig. 3.

INVENTORS
Arthur L. Parker
Henry E. Hull
Mason & Porter
ATTORNEYS

Dec. 22, 1942. A. L. PARKER ET AL 2,306,223

AUTOMATIC TUBE BENDING MACHINE

Filed March 31, 1941 11 Sheets-Sheet 3

Fig. 5.

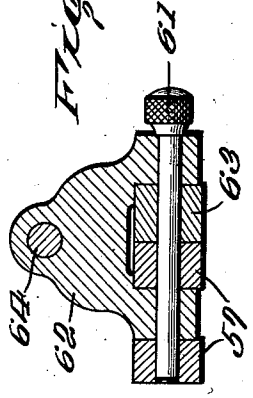


Fig. 4.

INVENTORS
A. L. Parker
H. E. Hull

By Mason & Porter
ATTORNEYS

Dec. 22, 1942. A. L. PARKER ET AL 2,306,223

AUTOMATIC TUBE BENDING MACHINE

Filed March 31, 1941 11 Sheets-Sheet 4

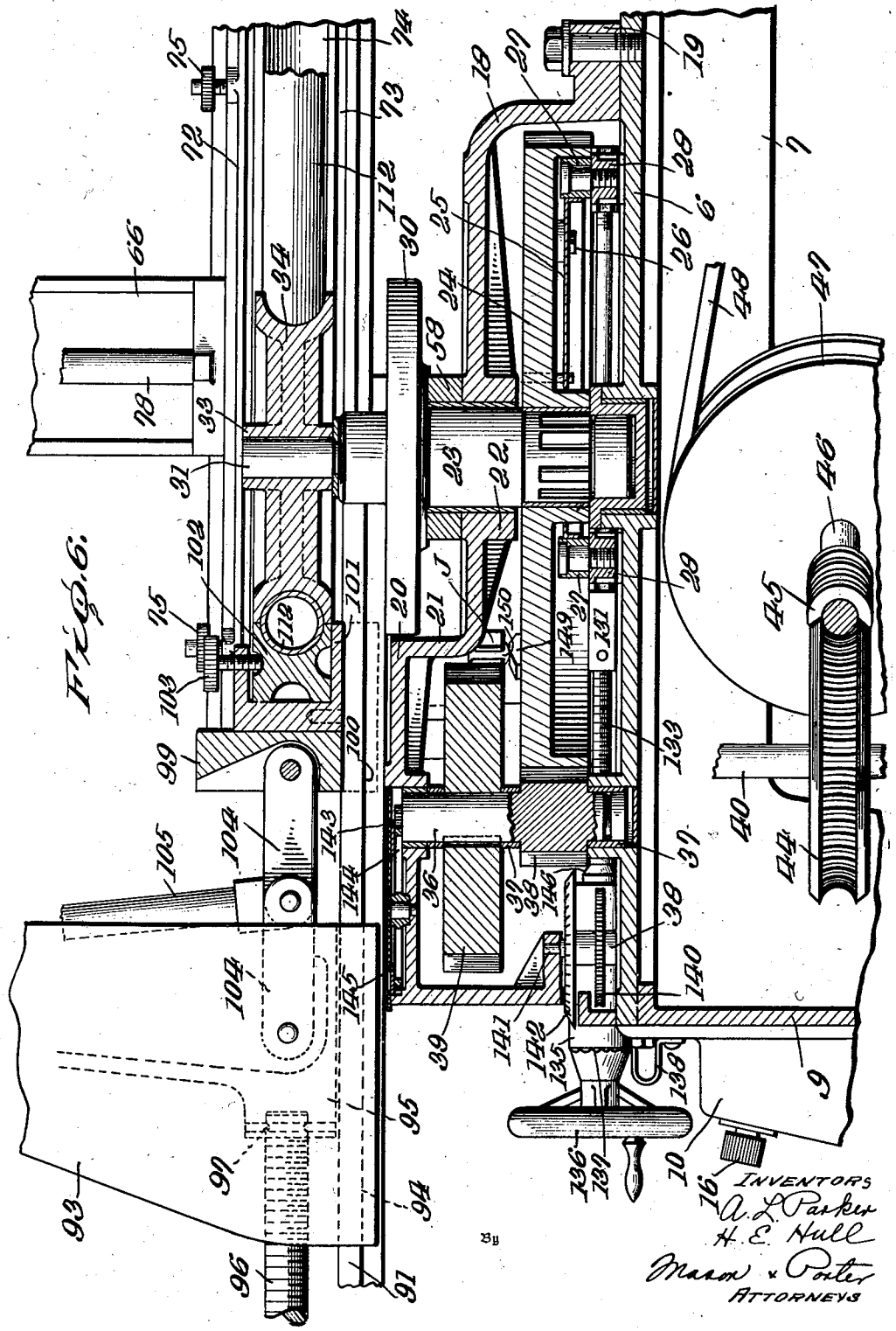


Fig. 6.

INVENTORS
A. L. Parker
H. E. Hull
By Mason & Porter
ATTORNEYS

Dec. 22, 1942. A. L. PARKER ET AL 2,306,223

AUTOMATIC TUBE BENDING MACHINE

Filed March 31, 1941 11 Sheets-Sheet 5

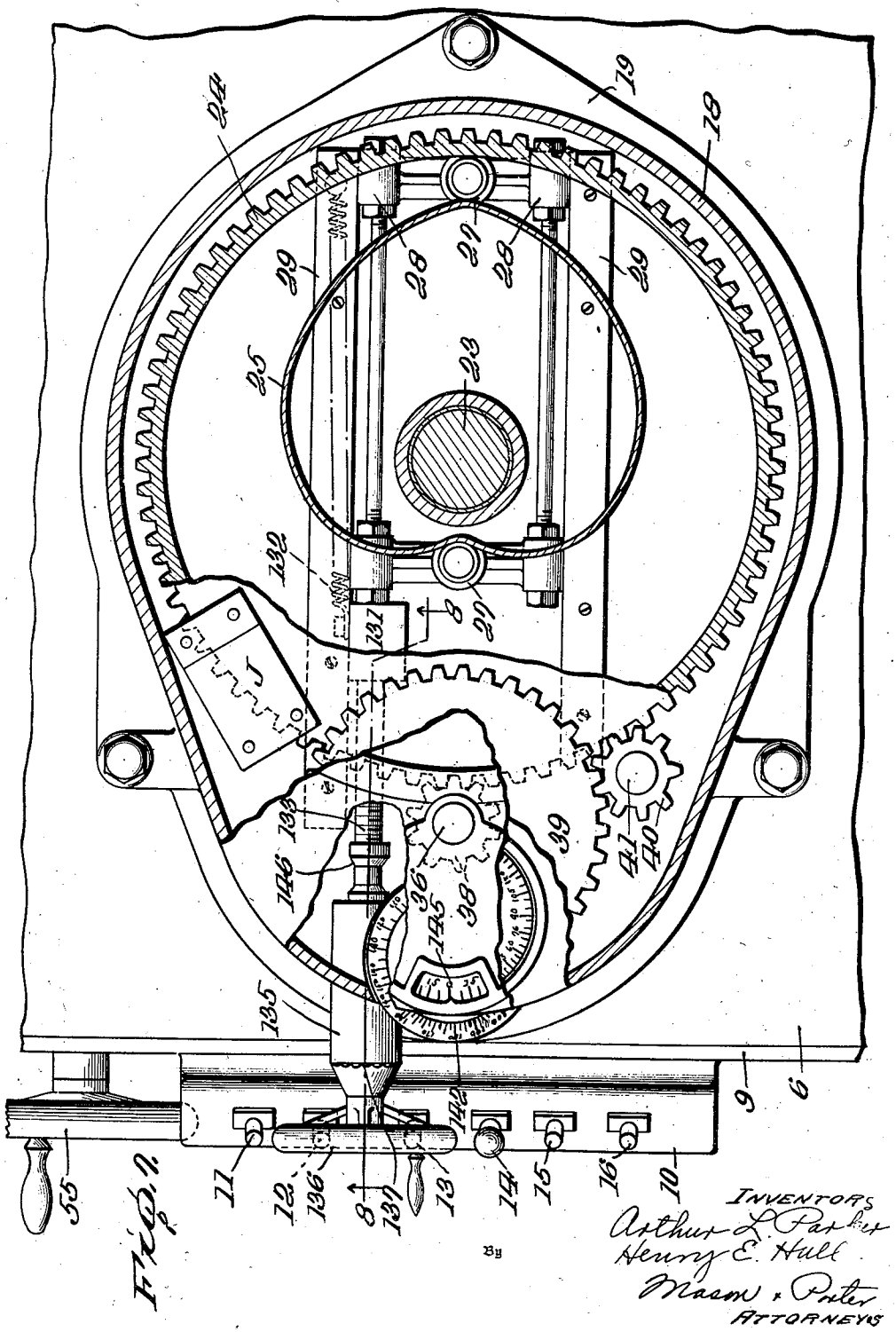


Fig. 2.

INVENTORS
Arthur L. Parker
Henry E. Hall
By Mason & Porter
ATTORNEYS

Dec. 22, 1942. A. L. PARKER ET AL 2,306,223

AUTOMATIC TUBE BENDING MACHINE

Filed March 31, 1941 11 Sheets-Sheet 6

Fig. 8.

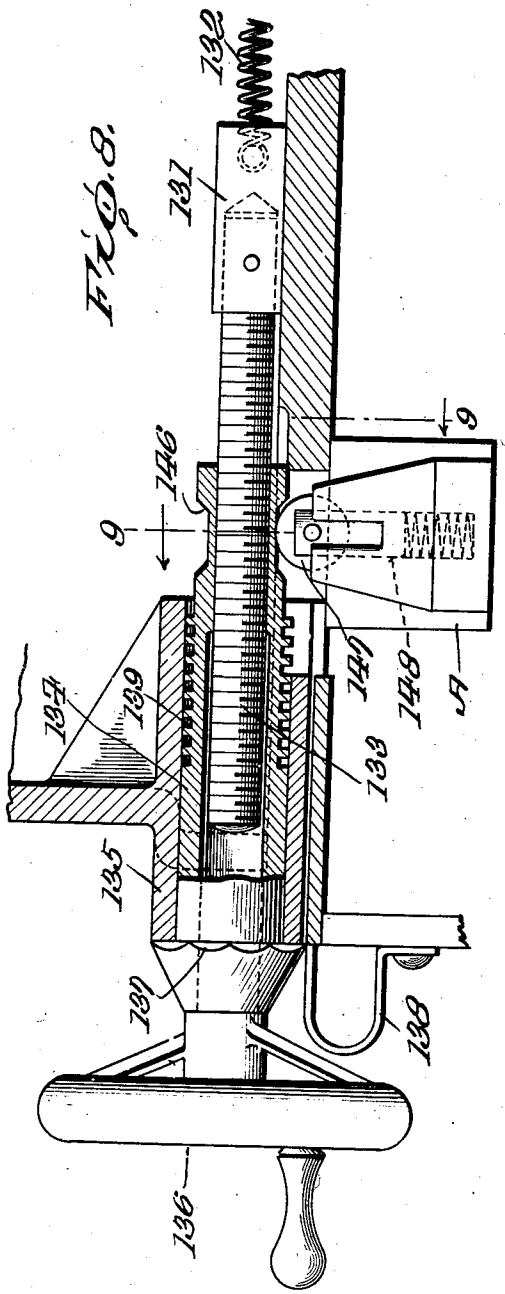
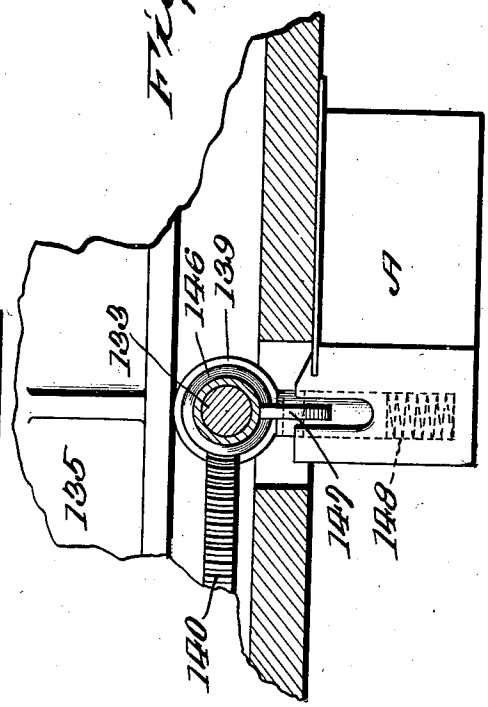


Fig. 9.



INVENTORS
Arthur L. Parker
Henry E. Hull
By Mason & Porter
ATTORNEYS

Dec. 22, 1942. A. L. PARKER ET AL 2,306,223

AUTOMATIC TUBE BENDING MACHINE

Filed March 31, 1941 11 Sheets-Sheet 7

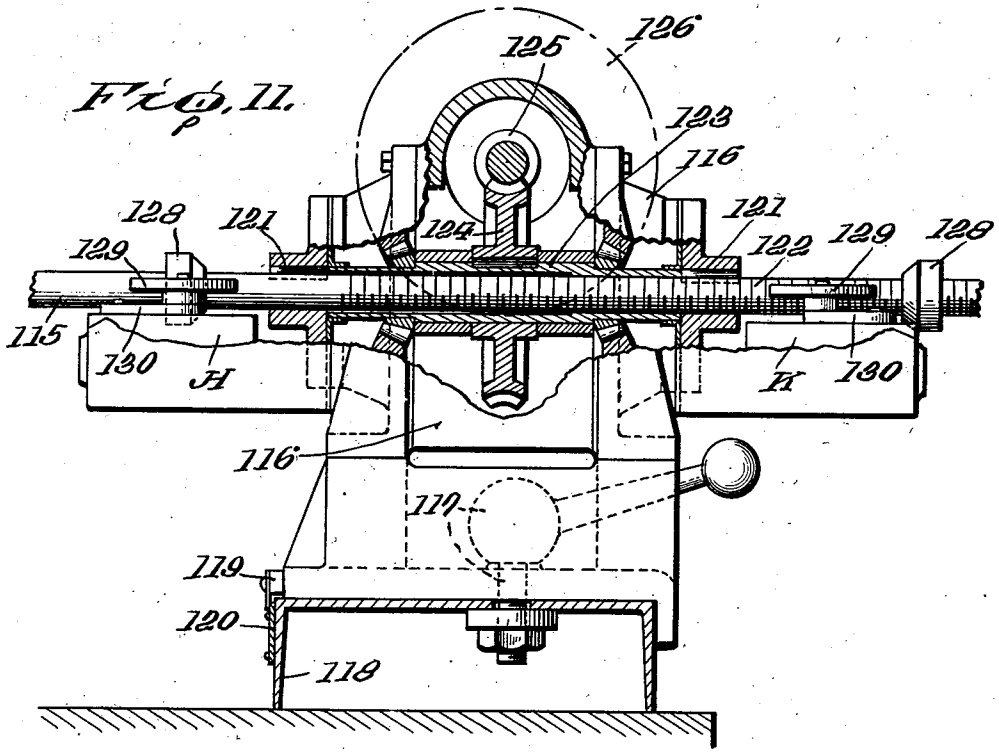


FIG. 11.

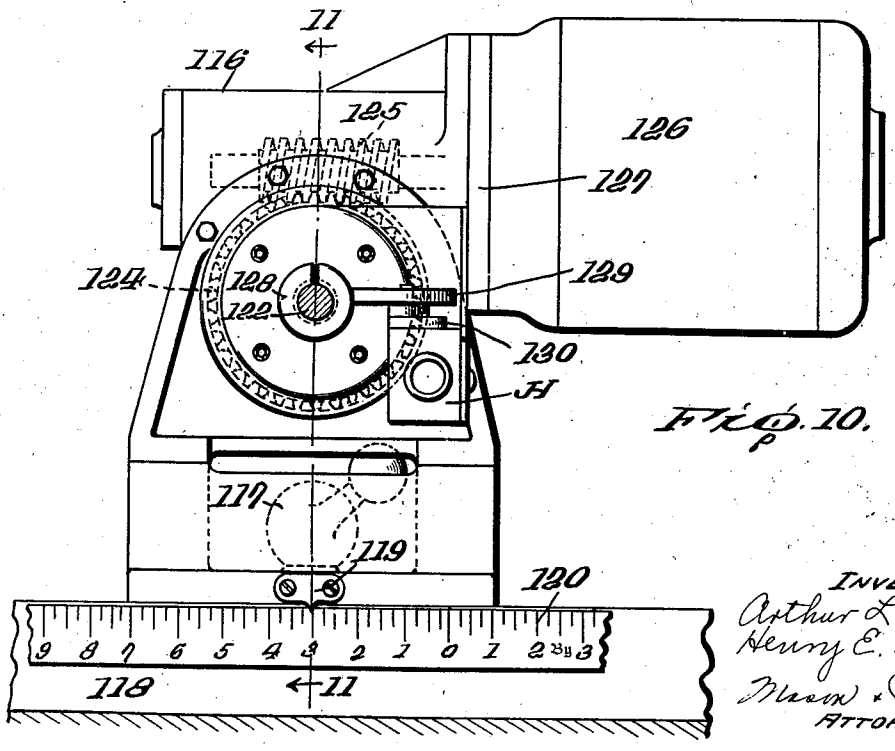


FIG. 10.

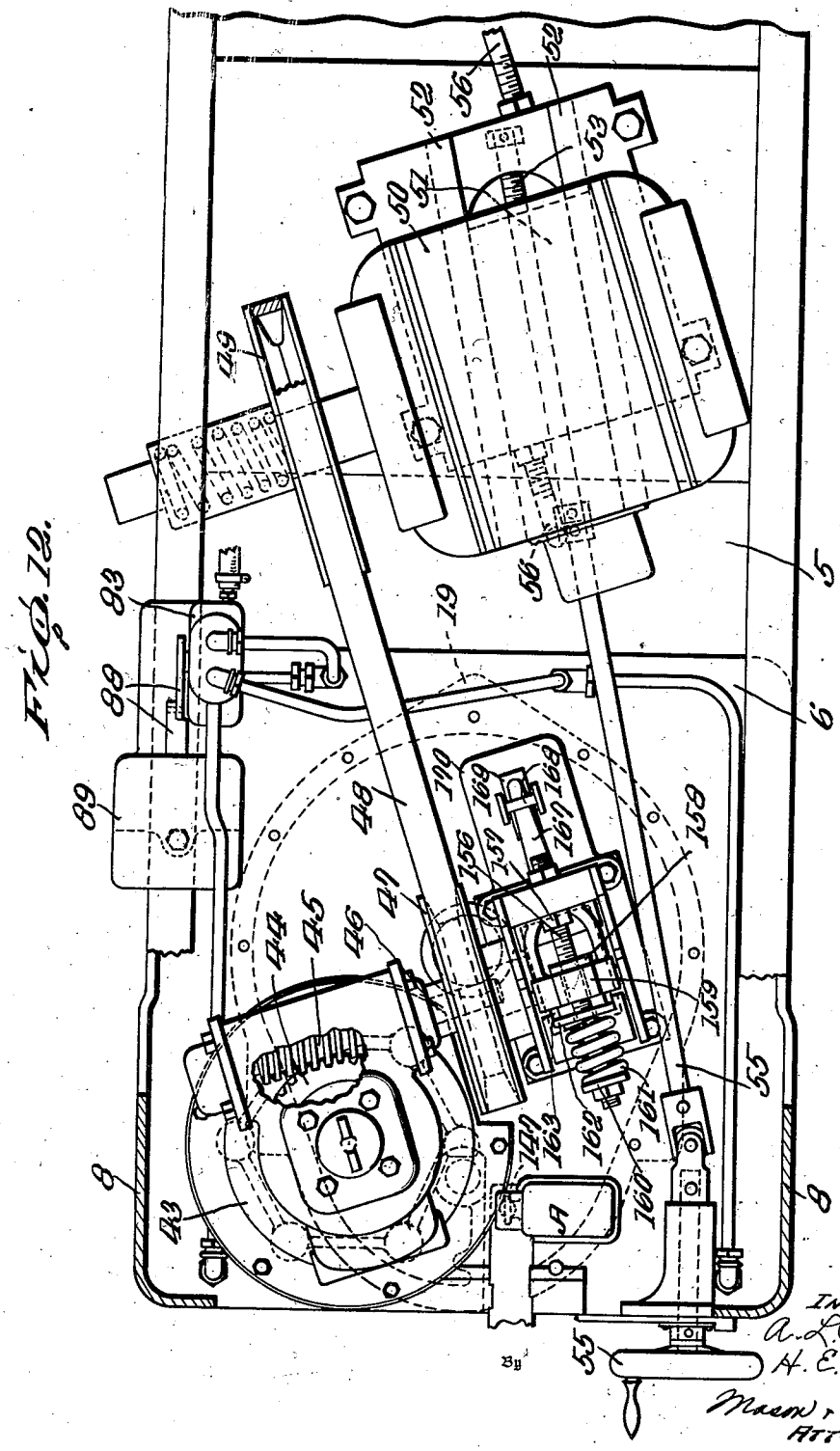
INVENTORS
Arthur L. Parker
Henry E. Hull
Mason & Porter
ATTORNEYS

Dec. 22, 1942. A. L. PARKER ET AL 2,306,223

AUTOMATIC TUBE BENDING MACHINE

Filed March 31, 1941 11 Sheets-Sheet 8

Fig. 12.



Dec. 22, 1942. A. L. PARKER ET AL 2,306,223

AUTOMATIC TUBE BENDING MACHINE

Filed March 31, 1941 11 Sheets-Sheet 9

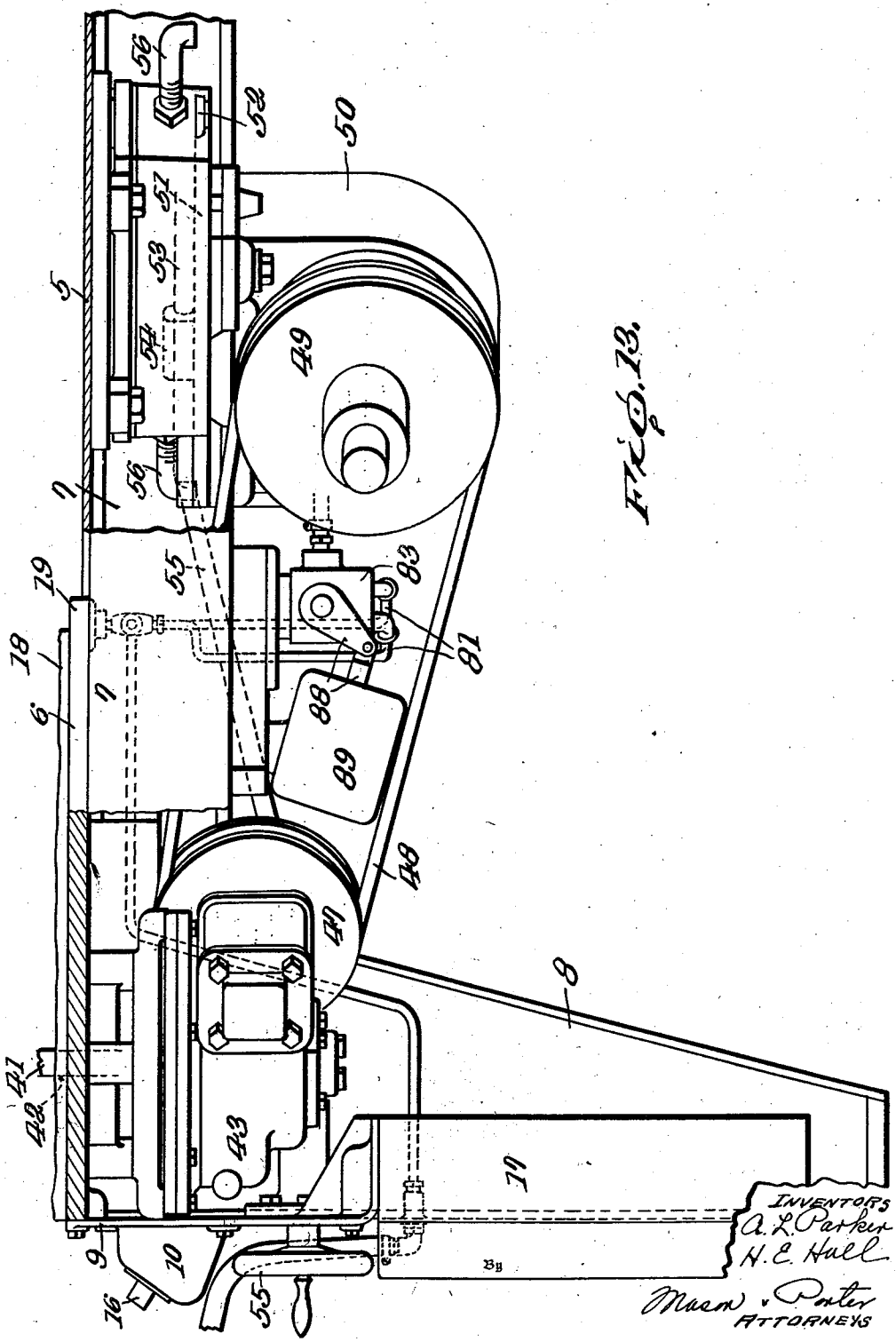


Fig. 13.

Dec. 22, 1942. A. L. PARKER ET AL 2,306,223

AUTOMATIC TUBE BENDING MACHINE

Filed March 31, 1941 11 Sheets-Sheet 10

FIG. 14.

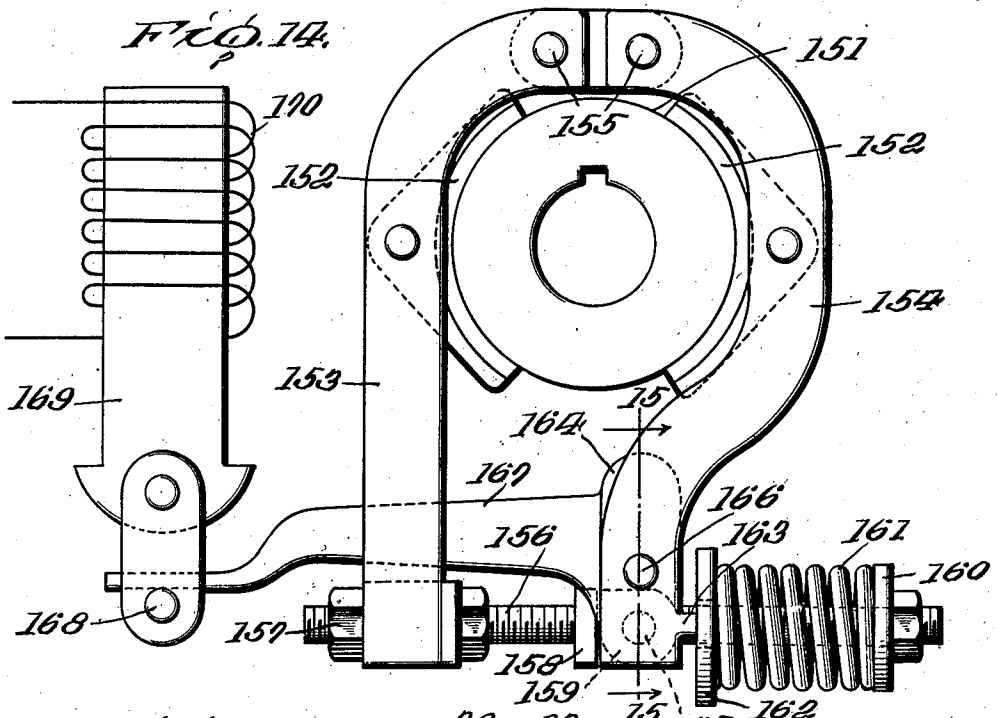


FIG. 15.

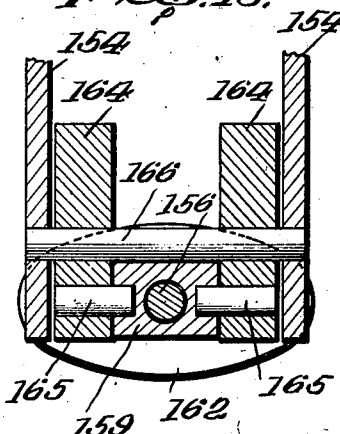
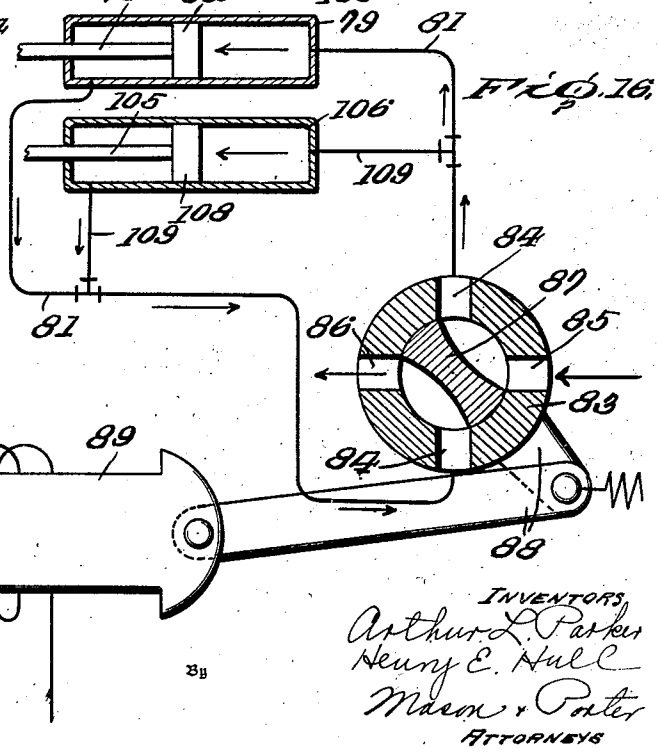


FIG. 16.

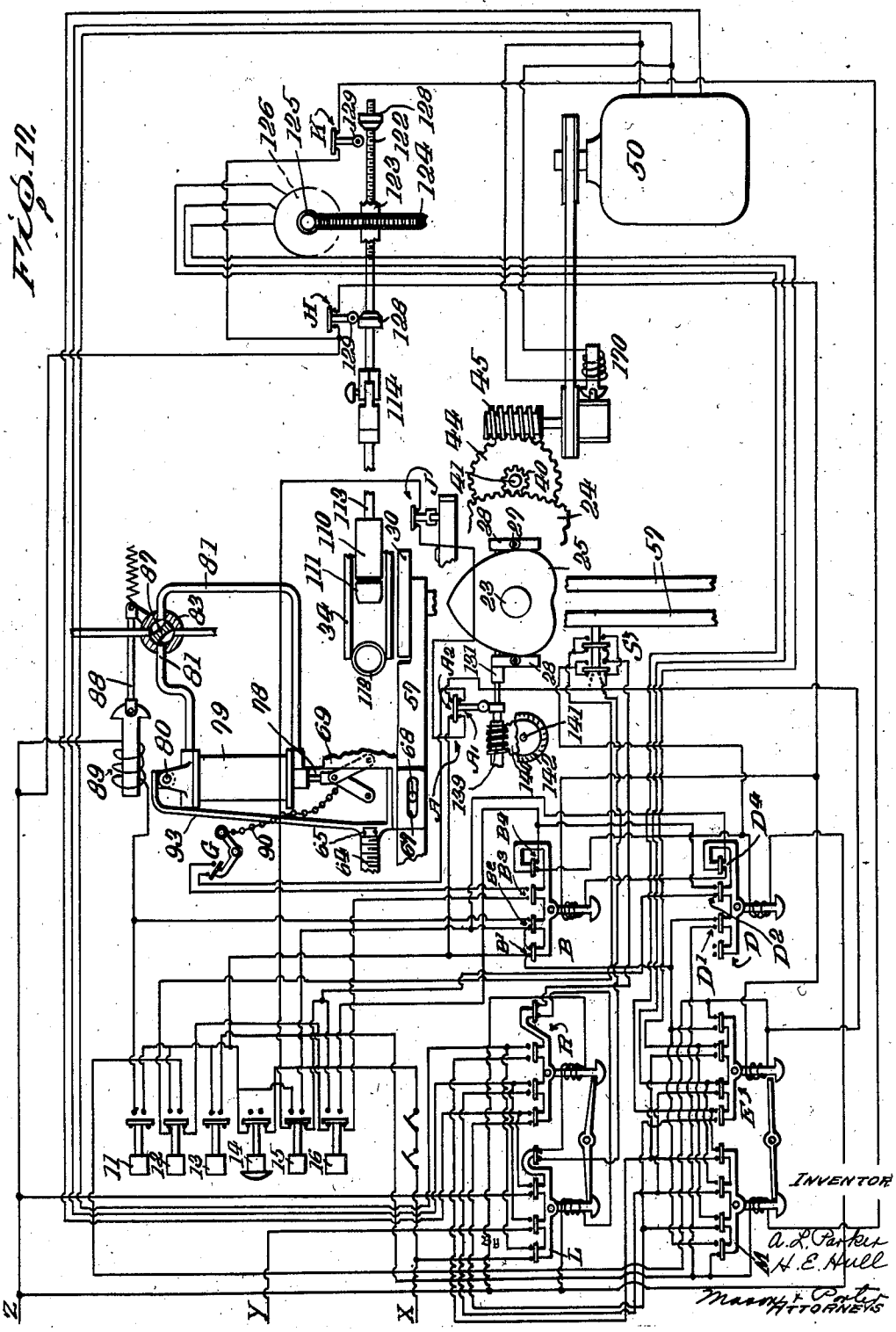


INVENTORS,
Arthur L. Parker
Henry E. Hull
By Mason & Porter
ATTORNEYS

Dec. 22, 1942. A. L. PARKER ET AL 2,306,223

AUTOMATIC TUBE BENDING MACHINE

Filed March 31, 1941 11 Sheets-Sheet 11



Patented Dec. 22, 1942 2,306,223

UNITED STATES PATENT OFFICE

2,306,223

AUTOMATIC TUBE BENDING MACHINE

Arthur L. Parker and Henry E. Hull, Cleveland, Ohio; said Hull assignor to said Parker

Application March 31, 1941, Serial No. 386,206

16 Claims. (Cl. 153—40)

The invention relates to certain new and useful improvements in tube bending machinery, particularly in tube bending machines of the character illustrated in the copending application for U. S. Letters Patent Serial No. 314,042, filed on January 16, 1940, by Arthur L. Parker and Henry E. Hull, and it primarily seeks to provide novel bending machine structures automatically operable through manually initiated bending and return cycles.

In its more detailed nature, the invention resides in providing a novel automatically operable machine structure including a bending rotor, a motor and driving connections for imparting tube bending and return movements to said rotor, a fluid actuated clamp means for clamping tubes to the rotor, a fluid actuated clamp means for clamping a slidable vise block in opposition to the tube and rotor, a tube shape retaining mandrel, a motor for projecting the mandrel to and retracting it from its effective position, rotor movement braking means, and electrical control means including a bending cycle initiating button which when pressed causes the clamping devices to clamp the tube and set the vise block, to automatically condition the rotor motor control circuit for the desired right or left bend, to start the rotor motor, and means to break the rotor motor control circuit and apply the brake means when the degree of bend intended has been completed, and also to effect retraction of the mandrel and thereafter release said clamping devices, thereby to complete a bending cycle. The control equipments also include a return button which when pressed initiates an automatically completed return cycle including replacement of the mandrel to its effective position, starting of the rotor motor in reverse or return direction and the breaking of the control circuits and the application of the rotor movement braking means upon completion of the mandrel positioning and the return to normal of said rotor.

Another object of the invention is to provide a machine of the character stated including a single solenoid operated valve which coordinates the electrical control circuits with both fluid actuated clamping means.

Another object of the invention is to provide a machine of the character stated including a novel circuit controlling switch arrangement associated with the clamping equipment so as to prevent initiation of a bending operation prior to proper clamping of the tube.

Another object of the invention is to provide a machine of the character stated including a circuit controlling switch arrangement associated with the mandrel positioning means and the bending rotor motor circuit so as to prevent initiation of a bending operation while the mandrel is retracted.

Another object of the invention is to provide a machine of the character stated including an adjustable bending rotor motor circuit controlling switch equipment effective to discontinue a bending operation when the desired degree of bending of the tube has been completed.

Another object of the invention is to provide a machine of the character stated including a novel bending rotor motor circuit controlling switch effective by engagement or non-engagement by the vise block carrying arm to condition the circuit for driving said motor one way or another according to the intended direction of bend.

Another object of the invention is to provide a machine of the character stated including a manually operable button effective when pressed and held to directly and manually control the clamp means operating valve independent of the automatic cycles.

Another object of the invention is to provide a machine of the character stated including manually operable buttons for directly controlling mandrel projection and retraction independent of the automatic cycles, and also a button which may be actuated to stop the machine at any time.

With the above and other objects in view that will hereinafter appear, the nature of the invention will be more fully understood by following the detailed description, the appended claims, and the several views illustrated in the accompanying drawings.

In the drawings:

Figure 1 is a plan view illustrating the invention, the parts being illustrated in position after completion of a bending cycle and before the start of the return cycle.

Figure 2 is an enlarged fragmentary plan view of the bending head structure, the parts being illustrated in full lines as having completed 90° of a bend, the completion of a bend such as is illustrated in Fig. 1 being indicated in dotted lines.

Figure 3 is an enlarged fragmentary plan view illustrating the cooperative relation of the mandrel and the vise slide block, parts being broken away and in section.

Figure 4 is a vertical cross-section taken substantially on the line 4—4 on Fig. 2.

Fig. 5 is a fragmentary vertical cross-section taken on the line 5—5 on Fig. 4.

Figure 6 is a vertical longitudinal section taken substantially on the line 6—6 on Fig. 2.

Figure 7 is a horizontal section taken through the plane of the heart cam in the bending head, parts being broken away and illustrated in plan view.

Figure 8 is an enlarged fragmentary longitudinal sectional view taken on the line 8—8 on Fig. 7.

Figure 9 is a detail vertical cross-section taken on the line 9—9 on Fig. 8.

Figure 10 is an enlarged fragmentary vertical cross-section taken on the line 10—10 on Fig. 1.

Figure 11 is a vertical longitudinal sectional view taken on the line 11—11 on Fig. 10, parts being broken away and shown in side elevation.

Figure 12 is an inverted plan view illustrating the positioning of the bending head driving motor, the clamp controlling valve, the bending rotor driving connections, and the braking equipment.

Figure 13 is a side elevation of the parts illustrated in Fig. 12, parts being broken away and in section.

Figure 14 is a detail end elevation of the braking equipment, the association of the controlling solenoid therewith being illustrated somewhat diagrammatically.

Figure 15 is a detail vertical cross-section taken on the line 15—15 on Fig. 14.

Figure 16 is a diagrammatic sectional view illustrating the clamp controlling valve and its connection with the clamp actuating cylinders.

Figure 17 is a diagrammatic view illustrating the circuit connections with the various machine parts.

In the example of embodiment of the invention herein disclosed, there is included a long rectangular table or supporting structure comprising a top plate 5 which is supplemented at one end by a bending head supporting plate 6, both said plates being secured upon a frame structure including sides 7 and corner standards or supporting legs 8.

An end plate 9 is supported across the front end of the machine and carries a control panel 10 equipped with six control buttons designated a "clamp" button 11, an "extractor" button 12, a "mandrel" button 13, a "stop" button 14, a "bend" button 15, and a "return" button 16, all arranged in a line across the panel in the manner best illustrated in Figs. 1, 7 and 13 of the drawings. These buttons comprise the manual controls associated with the electrical circuits and control devices which are mounted in part in the controller box 17 supported beneath the panel 10 in the position best illustrated in Fig. 13.

A bending head housing 18 is flange-secured, as at 19, upon the support plate 6 and includes a front super-structure or upward extension 20 terminating rearwardly in transversely aligned abutment walls 21.

Rearwardly of the upward extension 20, the housing 18 is equipped with a vertically disposed shaft bearing 22 for rotatably supporting a rotor shaft 23 which has a large spur gear 24 affixed to its lower end, said gear being recessed at its under surface to accommodate the positioning of a heart cam 25 which is secured to the gear as at 26.

The heart cam 25 engages fore and aft with and between rollers 27 secured to and extending upwardly from a frame 28 slidably mounted in guides 29 secured upon the support plate 6, see Figs. 4, 6 and 7 of the drawings. The purpose of the slidably mounted frame 28 will become apparent as the description progresses.

A bending rotor 30 is affixed to the upper end of the shaft 23 and carries a radius block mounting pin 31 which is disposed coaxially with the shaft 23, and a radius block driving pin 32 which projects upwardly from the rotor in eccentric relation to the axis thereof. The mounting and driving pins 31 and 32 are receivable in bearings 33 formed on selective radius blocks 34 each of which is peripherally grooved to properly engage a tube to be bent and includes a tangential extension 35 which is similarly grooved and against which a tube to be bent is clamped in a manner later to be described. It will be obvious that by clamping a tube end to the tangential extension of a radius block and imparting rotation to said block, a bend will be formed in said tube in a manner well known in this art.

For imparting the desired rotation to the bending rotor 30, there is provided a countershaft 36 which is rotatably supported, as at 37, in the head or housing and is equipped with a driving pinion 38 enmeshed in driving relation with the spur gear 24. The shaft 36 also carries a large driven gear 39 to which rotation is imparted by a pinion 40 mounted on a vertical drive shaft 41 rotatably supported, as at 42, and extended downwardly through the support plate 6 into a drive gear housing 43 secured beneath said plate in the manner best illustrated in Figs. 6, 7, 12 and 13 of the drawings.

Within the housing 43, the shaft 41 carries a worm wheel 44 to which rotation is imparted by a worm gear 45 secured upon a driver shaft 46 equipped with a pulley 47 and driven by a transmission belt 48 from any suitable variable speed, spring-pressed drive pulley 49. The driver pulley 49 is mounted on the drive shaft of the bending rotor drive motor 50, said motor being suspended from a slide 51 slidable in guides 52 supported on the table. The guides are disposed in angular relation to the plane in which the driver pulley 49 rotates, and by adjusting the position of the motor by movement of the slide, the motor can be moved to vary the spaced relation thereof with the driver pulley 47 and also laterally with respect to the transmission belt 48 so as to cause the spring-pressed halves of the pulley 49 to spread apart or come together, according to the direction in which the motor is moved, thereby to vary the speed of rotation imparted to the pulley 47.

In order to provide for the desired adjustment of the motor position, an adjuster screw 53 is provided which threads through a nut 54 fixed to the motor slide, said screw being turned through the medium of a hand wheel and suitable driving connections generally designated 55. Movement of the motor slide may be suitably limited by stops 56, see Figs. 12 and 13 of the drawings.

A vise slide block arm 57 projects radially from the rotor center and includes a mounting hub 58 which surrounds the rotor shaft 23 below the rotor in the manner illustrated in Figs. 2, 4 and 6 of the drawings. The spaced parallel bars comprising the main body of the arm 57 may be supported at their free ends against downwardly directed thrusts upon an adjustable prop 59, see Fig. 4.

The parallel bars comprising the arm 57 are apertured, as at 60, to receive a removable screw 61 which passes through the apertures and through an opening in a screw bearing 62 for the purpose of adjustably anchoring said bearing upon the arm. The screw also passes through a

spacer member 63 disposed at one side of one of the arm bars in the manner best illustrated in Fig. 5 of the drawings. The bearing member 62 is equipped with a threaded bore for receiving an adjuster screw 64 which is rotatably secured, as at 65, to a bearing standard 66 slidably supported upon the arm 57 and equipped at its base with a longitudinal slot 67 for receiving an anchoring screw 68 which passes through selected apertures 60 in said arm. Thus mounted, the standard is capable of limited adjustment back and forth along the arm 57 by manipulation of the screw 64.

A vise block 69 is slidably mounted, as at 70, on the arm 57 and is equipped with slideways 71 for a slide 72 having a shelf portion 73 on which to support a selected vise slide block 74. The selected slide blocks 74 are square in cross-section and are equipped at each face with a groove of a distinct size so as to adapt each said block for proper clamping engagement with tubes of a multiple of sizes. The selected slide block 74 may be removably secured to the supporting slide 72, as at 75, and it will be observed by reference to Figs. 2, 3 and 4 of the drawings that the slide engages anti-friction rollers 76 carried by the block 69, thereby to permit the slide and the slide block 74 to slide along in contact with the engaged tube while it is being bent and without engaging the same in abrasive contact.

Toggle links 77 are anchored respectively to the vise block 69 and the standard 66 and are pivotally connected together and to a piston rod 78 projecting from the lower end of a fluid pressure cylinder 79 which is swingably supported, as at 80, at the top of said standard. Fluid pressure lines 81 connect with the cylinder above and below the piston 82 which is reciprocable therein and connect at their other ends with a single control valve 83 having selective pressure flow ports 84, a supply port 85, and an exhaust port 86. The valve rotor 87 by which port communication selection is made is crank and link connected, as at 88, with the core of an actuating solenoid 89. It is to be understood that the valve rotor is shifted to a position for directing fluid pressure into the upper end of the cylinder 79 and causing a straightening out of the toggle links 77 each time the solenoid 89 is energized, and when this solenoid is de-energized, the valve rotor is spring returned to the toggle collapsing position, see Figs. 16 and 17.

The standard 66 carries a circuit controlling switch G connected by an actuator chain 90 with the toggle links as indicated in Figs. 4 and 17 so that the switch is closed whenever the toggle links are extended as in Fig. 4. The purpose of this switch will become apparent as the description progresses.

A clamp arm 91 is pivoted, as at 92, to swing about the driver pin 32, and a bearing standard 93 is slide guided, as at 94, on said arm. The standard includes a solid body portion 95 to which an adjustment screw 96 is rotatably anchored as at 97. The screw passes through a threaded bore in a block 98 secured upon the arm. A clamp block 99 is slidably mounted, as at 100, on the arm 91 and carries a support shelf 101 on which a clamping block 102 is secured, as at 103. Like the vise slide block 74, the clamp block 102 is square in cross-section and has each face thereof equipped with a tube engaging groove of distinct size.

Toggle links 104 are anchored respectively to the clamp block 99 and the standard 93 and are connected together and to the piston rod 105 which projects downward from a fluid pressure cylinder 106 which is pivotally supported, as at 107, at the top of the standard 103. Like the pressure cylinder 79 previously referred to, the cylinder 106 is connected at top and bottom, above and below the reciprocable piston 108, with pressure lines 109 which connect with the previously mentioned lines 81 leading to the ports 84 of the single control valve 83, see Figs. 5 and 16.

A mandrel 110 is provided and includes a shaped tip 111 which engages in the tube 112 being bent directly opposite the bending rotor, or at the bend center, thereby to support the tube internally as it is being bent and prevent flattening out thereof at the point of bend. The mandrel 110 is mounted at the free end of a mandrel rod 113 which is removably coupled, as at 114, to a vibratory mandrel positioning rod 115, see Figs. 1, 3 and 11 of the drawings. The vibratory rod 115 passes through a housing 116 which is laterally-adjustably secured, as at 117, upon a transverse beam 118 mounted upon the table top at the end of the machine remote from the bending head. The housing is equipped with a pointer 119 associated with a scale 120 mounted on the beam 118, and by provision of this equipment it is possible to accurately gage and thereby facilitate positioning of the housing 116 and the mandrel anchoring and adjusting equipment supported thereby.

The longitudinally movable or vibratory rod 115 is spline-connected with the housing 116, as at 121, so as to be held against rotation, and this rod is externally threaded, as at 122, for engagement in the internally threaded bore provided in the adjusting sleeve 123. The sleeve 123 is rotatably mounted in the housing but is held against longitudinal movement therein and is equipped with a worm wheel 124 to which rotation is imparted by a worm gear 125 secured upon the shaft of the mandrel positioning motor 126 secured, as at 127, to the housing. It will be obvious that when the motor 126 is operating, rotation will be imparted to the adjuster sleeve 123 and longitudinal movement will be imparted to the vibratory rod 115 and the mandrel attached thereto, in one direction or the other according to the direction of rotation of the reversible motor 126.

Fixed actuator cams 128 are secured in spaced relation on the rod 115 and these are engageable with the rollers 129 carried on the swingable actuator arms 130 of switch structures H and K. The switches H and K are so connected in the electrical control circuits that when the switch H is engaged by the respective cam 128 and opened, it discontinues operation of the motor 126 and retraction of the mandrel, and when the switch K is engaged by the respective cam 128 and opened, it discontinues operation of the motor 126 and projection or advancement of the mandrel.

For adjustably determining the desired angle of bend to be formed in a given tube, and for stopping the mechanism when this degree of bend has been accomplished, there has been provided a stop block 131 which is disposed in the path of movement of the slide 28 hereinbefore referred to. An anchored spring 132 constantly tends to draw the block 131 toward the slide 28 and the block is secured at the end of an externally threaded rod 133 engaged in the internally threaded bore of an adjuster sleeve 134

rotatable in a bearing 135 provided in the bender head housing in the manner best illustrated in Fig. 8. The sleeve 134 is equipped with a hand wheel 136 having flattened facets 137 engaged by a flat, position retaining spring 138 anchored to the machine frame. It will be obvious that by turning the hand wheel 136, the position of the stop block 131 can be altered at will.

The adjuster sleeve 134 is externally threaded, as at 139, and meshes with a worm wheel 140 mounted on a vertical shaft rotatably supported at 141 in the housing and equipped with a visible dial 142 settable by adjustment of the hand wheel 136 in the manner above described for displaying the degree of bend to be attained during a given bending cycle.

The shaft 36 is equipped at its upper end with a small pinion 143 which meshes with a large gear 144 carrying a visible dial 145 which can be observed during bending operations to determine the degree of bend which has been attained at any given time during the bending cycle.

The adjuster sleeve is equipped with a cam portion 146 engageable with a roller 147 carried at the upper end of the depressible actuator 148 of a control switch A connected in the electrical control circuit and effective whenever it is opened by depression of the element 148 to discontinue the bending cycle. It is to be understood that each time the frame 28 engages and longitudinally shifts the stop block 131 to signify that the desired degree of bend has been attained, circuit breaking actuation of the switch will be accomplished by engagement of the cam portion 146 with the roller 147.

A return stop cam 149 projects from the upper surface of the gear 24 and is engageable, when the bending rotor is at the zero point, with the actuator roller 150 of a return stop switch J. It is to be understood that the switch J is connected in the control circuits, and whenever it is engaged at the return of the bending rotor to the zero point, the circuit will be broken and the return movement of the parts discontinued in a manner hereinafter again referred to.

A brake drum portion 151 is provided on the rotor drive shaft 46 and is engaged by a braking equipment so as to definitely stop rotation of the rotor the instant the desired degree of bend in the tube has been completed during the bending cycle, and also at the instant that the parts are returned to the zero point in the return cycle.

The braking equipment is best illustrated in Figs. 12, 14 and 15 and includes brake shoes 152 engageable at opposite sides of the brake drum portion 151 and carried by brake arms 153 and 154 which are pivotally connected as at 155. A threaded rod 156 is secured, as at 157, to the arm equipment 153 and has an abutment collar 158 threadably adjustable thereon, said collar being opposed by a block 159 slidably mounted on said rod. The rod includes an adjustable abutment head 160, and a compression spring 161 is interposed between this head and a pressure applying disk 162 which is freely slidable on the rod and engages lugs 163 projecting from the arm equipment 154. This spring is normally effective to move the arm equipments 153 and 154 toward each other so as to apply the brake shoes 152. A brake releasing head 164 is pivoted, as at 165, to the block 159, and it is also pivoted, as at 166, at a higher point, to the arm equipment 154. A lever 167 extends from the head 164 and is engageable at 168 by the retractable core 169 of a solenoid 170.

It is to be understood that when the solenoid 170 is energized, retraction of the core thereof lifts the lever 167 and causes the pivot pin 166 to swing about the lower pivot 165 now rendered a fixed fulcrum by abutment with the collar 168, thereby causing the lugs 163 to compress the spring 161, move the arm equipments 153 and 154 apart, and relieve the braking pressure of the shoe 162.

It will be observed by reference to Figs. 2 and 17 of the drawings that one of the abutment walls 21 of the housing extension 20 carries a circuit selector switch S effective to control the making of right or left hand bends. This switch includes a spring-projected actuator plunger 171 which is engageable by the vise block arm 57 when swung to that particular side of the machine, that is, to the position opposite that illustrated in Fig. 1.

In Fig. 17 of the drawings the electrical control circuits are diagrammatically illustrated in combination with the associated parts of the machine, the association of these mechanical parts also being illustrated diagrammatically. The bender motor 50 is a 3-phase, A. C. motor, and the same is true of the mandrel positioning motor 126. The control circuits illustrated diagrammatically in Fig. 17 include the usual main power input lines X, Y and Z and the several switches which have been referred to hereinbefore, namely, the clamp switch G which permits the bending operation to start only after the tube clamping equipment has been properly set, the mandrel position controlling switches H and K, the actuation of the former of which stops movement of the mandrel when it has been projected a proper distance, and actuation of the latter of which stops movement of the mandrel after it has been retracted a proper distance, the switch S which selects the circuits for a bend in a particular direction according to the positioning of the clamp arm 57, the switch A which serves to terminate the bending operation after the intended degree of bend has been completed, and the switch J which terminates return movement of the rotor at the zero point. All of these switches have been referred to hereinbefore and are diagrammatically indicated in Fig. 17.

All of the manually actuated control buttons 11 through 16 and the connections thereof in the control circuits are indicated in Fig. 17, and it will be observed by reference to this figure that the electrical control equipments include a bending motor controller including alternately closable relays L and R, a mandrel positioning motor controller including alternately closable relays M and E, a bending controlling relay B, and a return controlling relay D, all shown at the lower left hand corner of Fig. 17.

The radius block 34 is removably and reversibly mounted on the pins 31 and 32 so that the tangential clamping face 35 thereof can be disposed to one side or the other for making right or left hand bends. For a like purpose, the arm 91 can be swung to one side or the other about the pin 32 so as to place the clamping block opposite the radius block clamping face 35, and the arm 57 can be swung to one side or the other about the rotor center so as to place the slide block opposite the point of bend. It is to be understood, of course, that when the arm 57 is positioned as shown in Figure 1 the members 62 and 67 are mounted on one of the spaced

parallel arms comprising the arm structure 57, whereas when this arm structure is swung to the opposite side of the rotor said parts 62 and 67 will be removed and mounted on the other parallel arm comprising the arm structure 57. It should also be obvious that when the arm structure 57 is swung to the opposite side of the rotor, as viewed in Figure 1, it will engage the switch button 171 and thus condition the electrical control circuit so that when the bending cycle is initiated the rotor will rotate in a clockwise direction, as viewed in Figure 1, and form a bend in a direction opposite that indicated in Figure 1. The adjustable mounting of the mandrel shown in detail in Figures 1, 10 and 11 permits placement of the mandrel to one side or the other of a line passing through the center of the rotor accordingly as the clamping face 35 is placed to one side or the other, and, as previously stated, the rotor driving motor 50 is reversible. It should be obvious, therefore, that either right or left hand bends can be made in tubes placed in this machine. It should be noted also that the scales 120, 142 and 145 are marked both directions from zero so as to facilitate placement of the parts and the observation and gaging of bending operations.

The bending cycle

Assuming a tube to be properly placed in the machine, the automatic bending cycle is started by pressing the bend button 15. This completes a circuit from power line X through the undepressed stop button 14, back through the depressed bend button 15, through normally closed contact D^4, through bend relay coil B, through the mandrel position controlling switch H to line Z. This energizes coil B which closes the normally open contacts B^1, B^2 and B^3 and opens the normally closed contact B^4. Contact B^1 maintains the circuit after the bend button 15 is released and until the end of the bending cycle. Contact B^2 allows current to flow through the solenoid 89, thus opening the clamp valve 83 and allowing fluid pressure to force the cylinder pistons downwardly, straighten out the two sets of toggle links, and apply the clamping devices. Contact B^3, switch G, and the adjustable switch A (contact A^1) operate in series to allow current to pass through the bend circuit selecting switch S for energizing either left hand or right hand bend starting coils of the relays L or R depending upon the side of the machine upon which the slide block arm 57 is located. The coil of the relay L will cause the bender motor 50 to rotate in the proper direction for making a left hand bend in the tube, or the coil of the relay R will cause reverse rotation for a right hand bend. Near the completion of the bend, contact A^2 of the switch A is forced to close, causing current from the line X to flow through the coil of the mandrel extracting relay E, and through the mandrel position controlling switch H to the line Z. The coil of the relay E being thus energized allows the contacts of this relay to close and start the mandrel positioning motor 126 for retracting the mandrel. An instant later, contact A^1 of the switch A opens, deenergizing the particular motor control coil of the relay L or R which happens to be operating at that particular time, thus shutting off the current in the leads to the bender motor 50. The breaking of the power circuit to the motor 50 also de-energizes the brake controlling solenoid 170 and, as previously described, whenever this solenoid is de-energized the braking equipment is applied to instantly stop rotation of the rotor.

The mandrel positioning motor 126 continues to run in the mandrel retracting direction until the cam on the mandrel shifting rod engages and opens the switch H. This stops the motor 126 and de-energizes the coil of the bend relay B. The contacts controlled by the relay B thus being opened, the clamp valve solenoid 89 is de-energized and this valve is spring shifted so as to effect an unclamping of the tube clamping equipments, thereby completing the bending cycle.

During the bend cycle the normally closed contact B^4 is held open by the coil of the relay B to prevent the possibility of energizing the coil of the return relay D.

The return cycle

After removing the bent tube, the return cycle is started by pressing the return button 16. This energizes the coil of the return relay D and effects a closing of the normally open contacts D^1 and D^2 and open the normally closed contact D^4. Contact D^2 maintains the circuit after the return button 16 is released until the end of the return cycle. Contact D^1 energizes the coil of the mandrel advancing relay M which causes the mandrel positioning motor 126 to rotate in the proper direction for advancing the mandrel to the bending position hereinbefore described. Simultaneously, the coil of the selected relay L or R is energized through the selector switch S previously referred to for initiating return movement of the rotor in the proper direction. This starts the bender motor 50 in a direction the reverse of that which effected the bending operation, and when the rotor has returned to the zero position, the switch J is opened, thus dropping out the relay D and the control circuit then effective in operating the bender motor 50. The mandrel positioning motor 126 is stopped at the correct position by the mandrel advance limiting switch K, the rotor motion braking equipment is applied, and the machine parts are now restored to the starting position.

The manually operable clamp button 11, the extractor button 12, and the mandrel button 13 are provided principally for testing purposes during set-ups. The clamp button 11 energizes the clamp valve solenoid directly, but when this button is utilized the clamping equipments are applied only while the button is held down. The extractor button 12 by-passes the contact A^2 of the switch A for starting the mandrel positioning motor 126 in the mandrel retracting direction. The mandrel button 13 can be utilized to manually advance the mandrel to the bend starting position. The stop button 14 can be utilized to stop the machine at any time.

It is of course to be understood that the details of structure and arrangement of parts may be variously changed and modified without departing from the spirit and scope of the invention.

What is claimed:

1. In a machine of the character described, a bending rotor; a single reversible electric motor for imparting rotation in one direction or another to said rotor; a radius block rotatable with said rotor; means for clamping a tube to said block to turn therewith, vise block clamping means for holding a vise block against the tube as it is being bent; a control circuit for controlling operation of said motor and including, means for

manually closing said circuit to initiate a bending cycle operation of said motor, means for manually closing said circuit to initiate a return cycle operation of said motor, adjustable means for automatically terminating the bending cycle when a predetermined degree of bend has been attained, and means for automatically terminating each return cycle with the rotor positioned at the zero point.

2. In a machine of the character described, a bending rotor, a single reversible electric motor for imparting rotation in one direction or another to said rotor, a radius block rotatable with said rotor, means for clamping a tube to said block to turn therewith, vise block clamping means for holding a vise block against the tube as it is being bent, means including electrical control devices for initiating a bending cycle operation of said motor, means for automatically terminating the bending cycle, and means under control of said control devices for actuating said tube and vise block clamping means to engage the tube prior to commencement of said cycle.

3. In a machine of the character described, a bending rotor, a single reversible electric motor for imparting rotation in one direction or another to said rotor, a radius block rotatable with said rotor, means for clamping a tube to said block to turn therewith, vise block clamping means for holding a vise block against the tube as it is being bent, means including electrical control devices for initiating a bending cycle operation of said motor, means for automatically terminating the bending cycle, and electrically controlled fluid pressure actuated means for actuating the tube and vise block clamping means to engage the tube necessarily prior to commencement of said cycle.

4. In a machine of the character described, a bending rotor, a single reversible electric motor for imparting rotation in one direction or another to said rotor, a radius block rotatable with said rotor, means for clamping a tube to said block to turn therewith, vise block clamping means for holding a vise block against the tube as it is being bent, means including a control circuit and electrical control devices for initiating a bending cycle operation of said motor, means for automatically terminating the bending cycle, and electrically controlled fluid pressure actuated means for actuating the tube and vise block clamping means to engage the tube prior to commencement of said cycle, said last named means comprising a normally open switch connected in the control circuit and closable as an incident to the effective actuation of said tube and vise block clamping means.

5. In a machine of the character described, a bending rotor, a single reversible electric motor for imparting rotation in one direction or another to said rotor, a radius block rotatable with said rotor, means for clamping a tube to said block to turn therewith, vise block clamping means for holding a vise block against the tube as it is being bent, means including a control circuit and electrical control devices for initiating a bending cycle operation of said motor, means for automatically terminating the bending cycle, a fluid pressure actuated means for operating each said clamping means, and a single electrically operable valve for controlling the operation of both fluid pressure actuated means and so connected in the control circuit as to be effective for setting the clamping means necessarily prior to commencement of the bending cycle and for releasing the clamping means following completion of said bending cycle.

6. In a machine of the character described, a bending rotor, a motor for imparting rotation to said rotor, a radius block rotatable with said rotor, means for clamping a tube to said block to turn therewith, vise block clamping means for holding a vise block against the tube as it is being bent, a mandrel engageable in a tube being bent at the point of bending to support the tube against flattening, means for manually initiating and automatically terminating a bending cycle operation of said motor, means for projecting the mandrel to the point of bending prior to commencement of each bending cycle and for retracting the mandrel in the tube after completion of the intended degree of bending of said tube, and control means assuring placement of the mandrel at said point of bending before a bending cycle can be initiated.

7. In a machine of the character described, a bending rotor, a motor for imparting rotation to said rotor, a radius block rotatable with said rotor, means for clamping a tube to said block to turn therewith, vise block clamping means for holding a vise block against the tube as it is being bent, a mandrel engageable in a tube being bent at the point of bending to support the tube against flattening, means for manually initiating and automatically terminating a bending cycle operation of said motor, means for projecting the mandrel to the point of bending prior to commencement of each bending cycle and for retracting the mandrel in the tube after completion of the intended degree of bending of said tube, and means preventing initiation of the bending cycle while the mandrel is in retracted position.

8. In a machine of the character described, a bending rotor, a motor for imparting rotation to said rotor, a radius block rotatable with said rotor, means for clamping a tube to said block to turn therewith, vise block clamping means for holding a vise block against the tube as it is being bent, a mandrel engageable in a tube being bent at the point of bending to support the tube against flattening, means for manually initiating and automatically terminating a bending cycle operation of said motor, means for projecting the mandrel to the point of bending prior to commencement of each bending cycle and for retracting the mandrel in the tube after completion of the intended degree of bending of said tube, said last named means including an adjuster rod to which said mandrel is connected, a captive sleeve threadably engaged with the rod, a reversible electric motor connected in driving relation with said sleeve, cam elements on said rod, and cut-out switches actuated by said cam elements for automatically stopping said reversible motor at the fully projected or fully retracted positions of said rod.

9. In a machine of the character described, a bending rotor, means for imparting rotation to the rotor, a radius block rotatable with the rotor, means for clamping a tube to said block to turn therewith, vise block clamping means for holding a vise block against the tube as it is being bent, a mandrel engageable in a tube being bent at the point of bending to support the tube against flattening, power operating means for retracting the mandrel in the tube after completion of the intended degree of bending of said tube, and means controlling operation of said bending rotor rotation imparting means so that

a bending operation cannot be initiated when the mandrel is retracted from its effective position at said point of bending.

10. In a machine of the character described, a bending rotor, a single reversible electric motor for imparting rotation in one direction or another to said rotor, a radius block rotatable with said rotor, means for clamping a tube to said block to turn therewith, vise block clamping means for holding a vise block against the tube as it is being bent, means for manually initiating a bending cycle operation of said motor, means for manually initiating a return cycle operation of said motor, adjustable means for automatically terminating the bending cycle when a predetermined degree of bend has been attained, means for automatically terminating each return cycle with the rotor positioned at the zero point, a mandrel engageable in a tube being bent at the point of bending to support the tube against flattening, and power operated means automatically operable to retract the mandrel in the bent tube after completion of the intended degree of bending of said tube and for again and automatically projecting said mandrel to the point of bending prior to commencement of another bending cycle.

11. In a machine of the character described, a bending rotor, a reversible motor for imparting rotation to said rotor clockwise or counterclockwise, a radius block rotatable with said rotor, means for clamping a tube to one side or the other of said block to turn therewith, vise block clamping means placeable at either side of the rotor for holding a vise block against the tube as it is being bent toward the right or toward the left, means for manually initiating and automatically terminating a bending cycle operation of said motor, and circuit controlling means for causing the motor to function in one direction or the other accordingly as said vise block clamping means is disposed at one side or the other of said rotor.

12. In a machine of the character described, a bending rotor, a single reversible electric motor for imparting rotation in one direction or another to said rotor, a radius block rotatable with said rotor, means for clamping a tube to one side or the other of said block to turn therewith, vise block clamping means for holding a vise block against the tube as it is being bent, means for manually initiating a bending cycle operation of said motor, means for manually initiating a return cycle operation of said motor, adjustable means for automatically terminating the bending cycle when a predetermined degree of bend has been attained, means for automatically terminating each return cycle with the rotor positioned at the zero point, said vise block clamping means being placeable at either side of the rotor thereby to oppose a tube during the making of left or right hand bends, and circuit controlling means for causing the motor to function in one direction or the other accordingly as said vise block clamping means is disposed at one side or the other of said rotor.

13. In a machine of the character described, a bending rotor, a single reversible electric motor for imparting rotation in one direction or another to said rotor, a radius block rotatable with said rotor, means for clamping a tube to said block to turn therewith, vise block clamping means for holding a vise block against the tube as it is being bent, means including electrical control devices for initiating a bending cycle operation of said motor, means for automatically terminating the bending cycle, a fluid pressure actuated means for operating each said clamping means, a single electrically operable valve for controlling the operation of each fluid pressure actuated means for setting the clamping means prior to commencement of the bending cycle and for releasing the clamping means following completion of said bending cycle, and independent manually operable control means operable at will to control operation of said valve independently of the automatically controlled cycles of operation.

14. In a machine of the character described, a bending rotor; a single reversible electric motor for imparting rotation in one direction or another to said rotor; a radius block rotatable with said rotor; means for clamping a tube to said block to turn therewith, vise block clamping means for holding a vise block against the tube as it is being bent; a control circuit for controlling operation of said motor and including, means for manually closing said circuit to initiate a bending cycle operation of said motor, means for manually closing said circuit to initiate a return cycle operation of said motor, adjustable means for automatically terminating the bending cycle when a predetermined degree of bend has been attained, means for automatically terminating each return cycle with the rotor positioned at the zero point, and independent manually operable control switch means connected in said control circuit and operable at will to stop the machine independently of the automatically controlled cycles of operation.

15. In a machine of the character described, a bending rotor, a reversible motor for imparting rotation to said rotor clockwise or counterclockwise, a radius block rotatable with said rotor, means for clamping a tube to one side or the other of said block to turn therewith, vise block clamping means placeable at either side of the rotor for holding a vise block against the tube as it is being bent toward the right or toward the left, an arm supporting said vise block clamping means and swingable about the axis of the rotor for placing the vise block clamping means at one side or the other of the rotor, means for manually initiating and automatically terminating a bending cycle operation of said motor, and circuit controlling means including a circuit conditioning switch engaged by said swingable arm for causing the motor to function in one direction or the other accordingly as said vise block clamping means is disposed at one side or the other of said rotor.

16. In a machine of the character described, a bending rotor, and clamp means for opposing a tube during bending operations and comprising a movable clamp jaw, a standard, an arm on which said standard is mounted for limited sliding movement in any one of a plurality of selective positions, screw means for moving the standard a limited distance toward or from the rotor in any one of its selective positions, toggle links pivoted together and anchored at their ends to the standard and to the clamp jaw respectively, and a fluid pressure cylinder supported on the standard and having a fluid pressure reciprocated piston therein connected with the pivotal connection of said links.

ARTHUR L. PARKER.
HENRY E. HULL.