April 27, 1948. H. E. COLWELL 2,440,599

BENDING MACHINE

Filed June 16, 1944 5 Sheets-Sheet 1

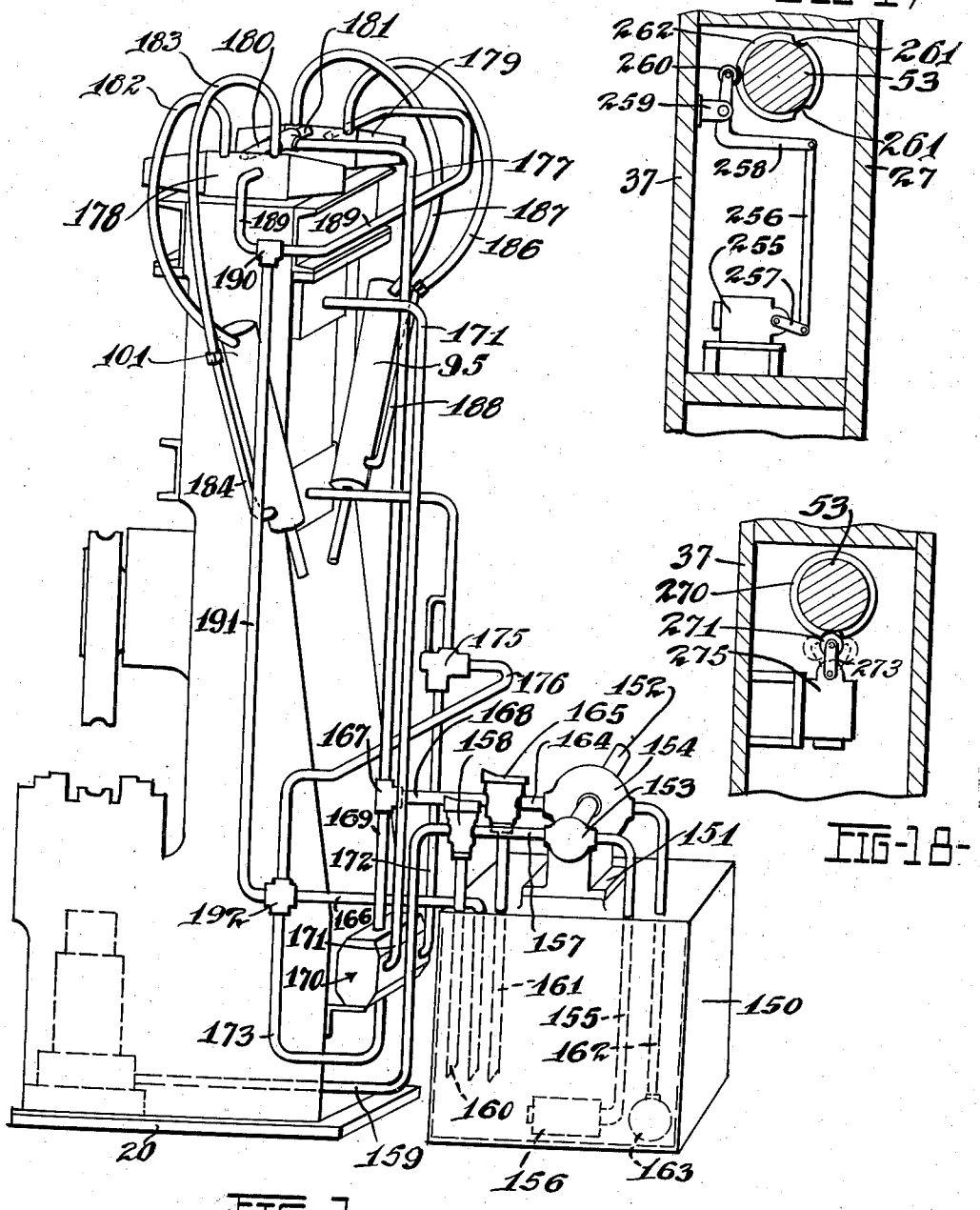

FIG-1-

FIG-17-

FIG-18-

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BENDING MACHINE

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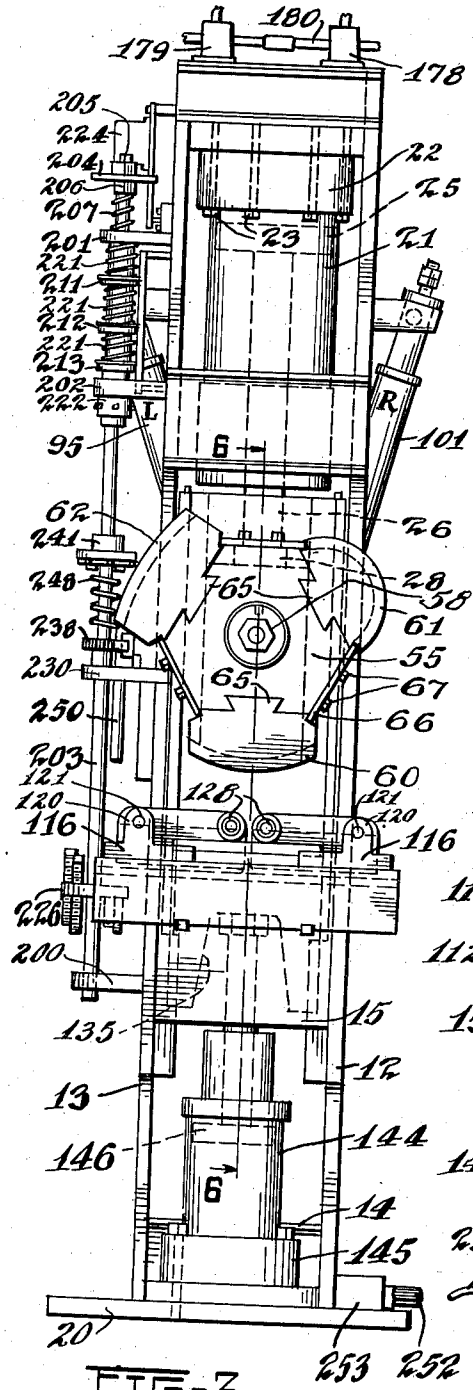

FIG-3-

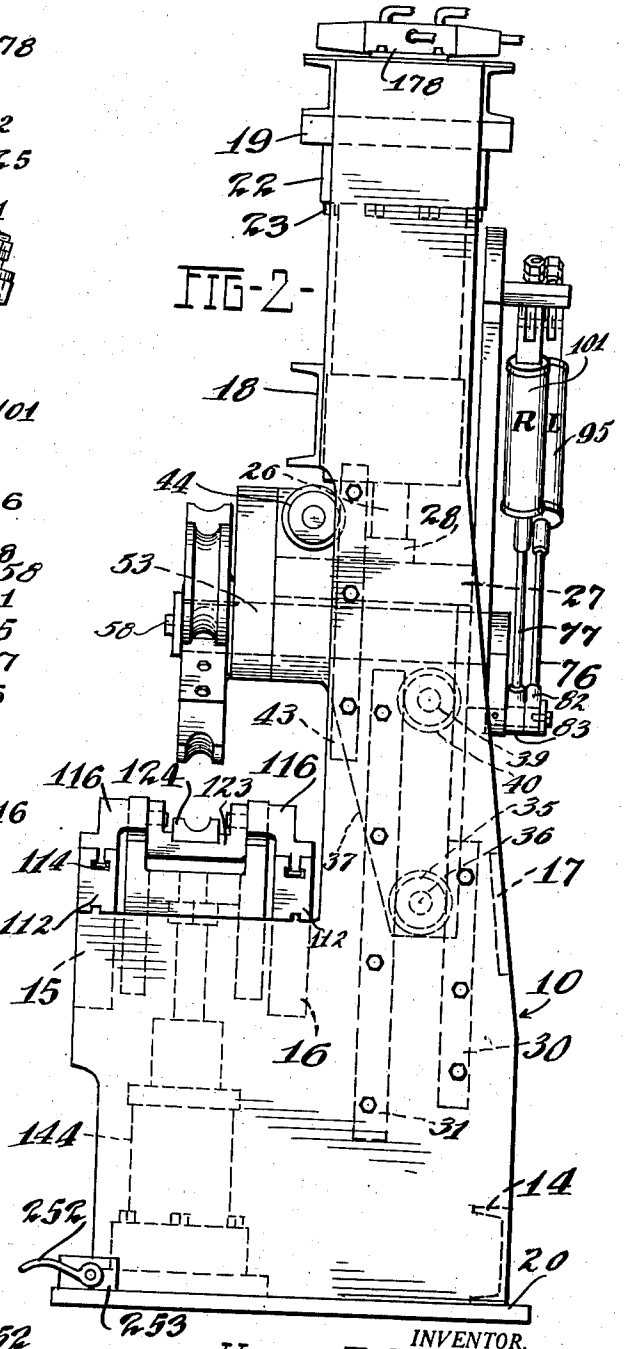

FIG-2-

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BENDING MACHINE

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FIG-5.

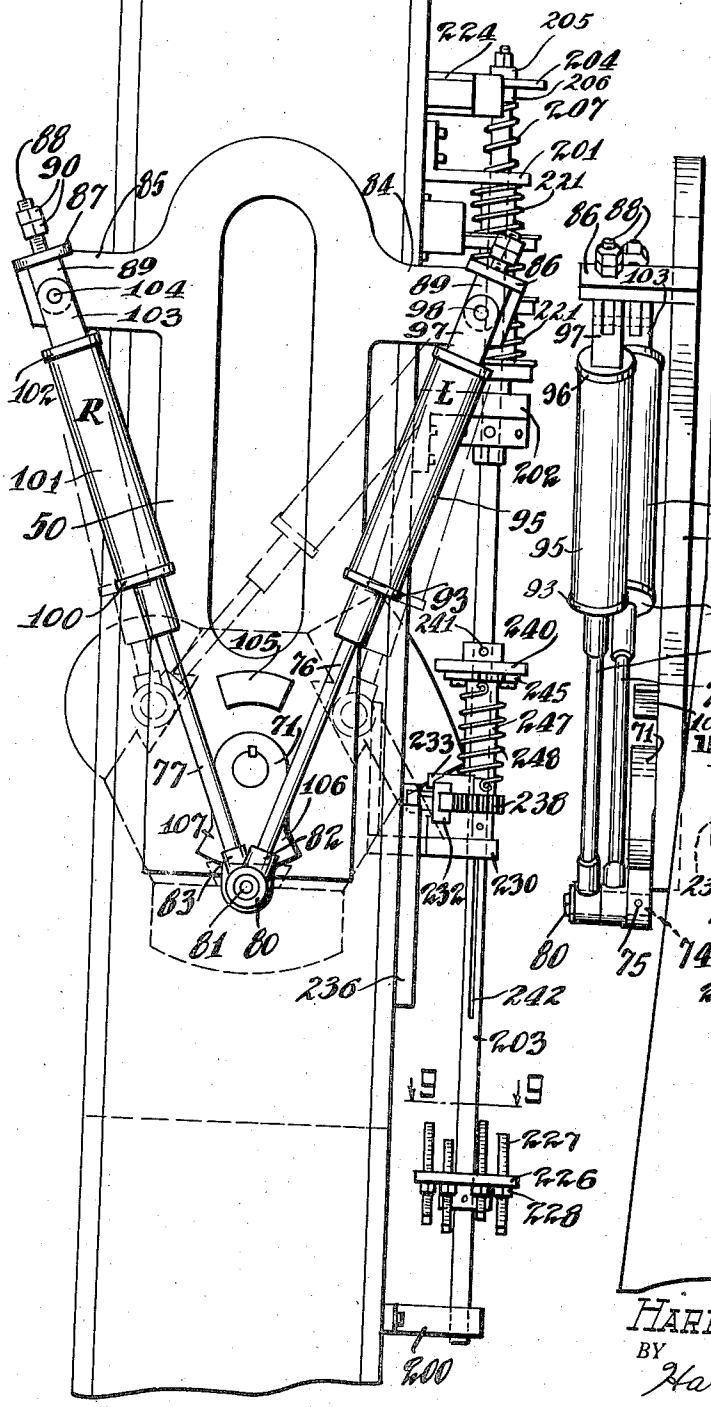
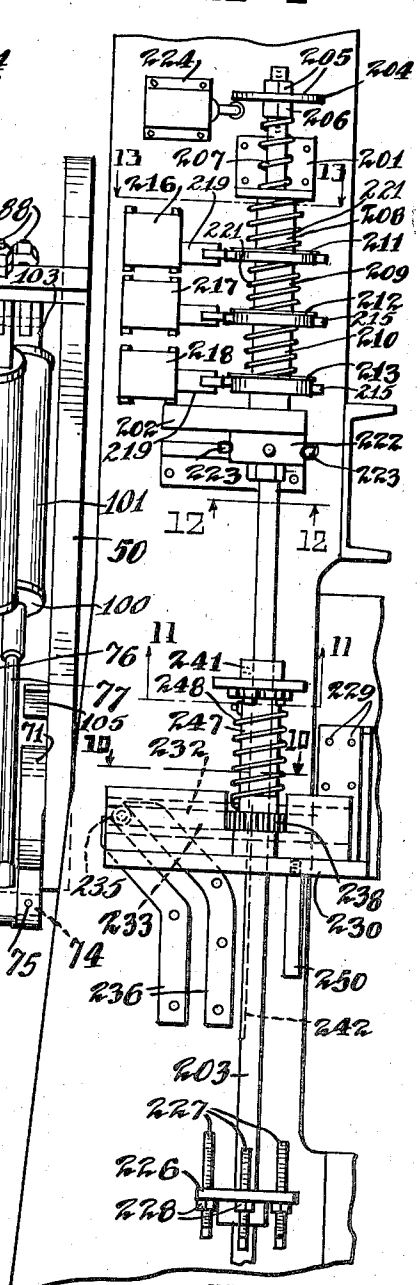


FIG-4.



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BENDING MACHINE

Filed June 16, 1944 5 Sheets-Sheet 4

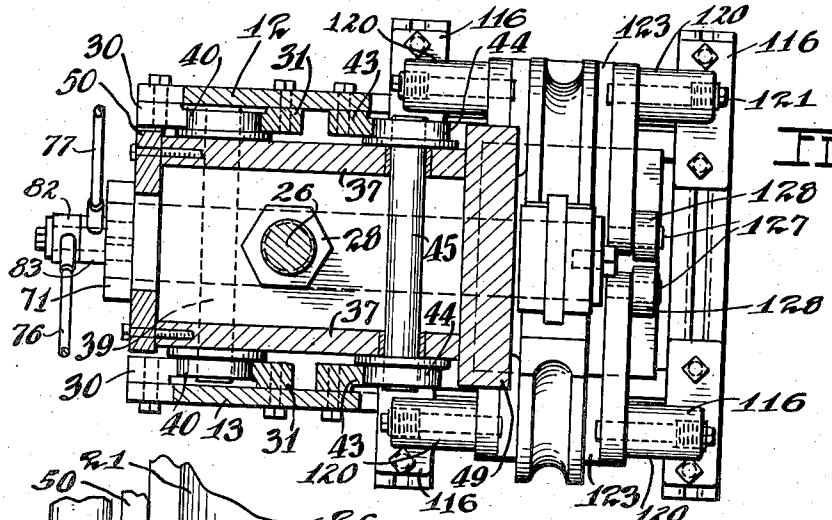

FIG-7-

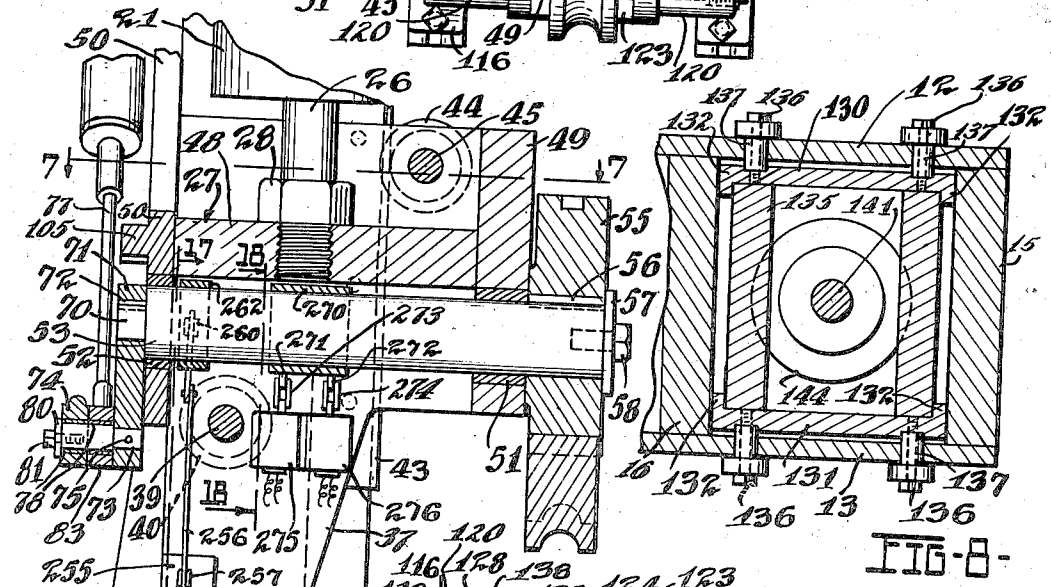

FIG-8-

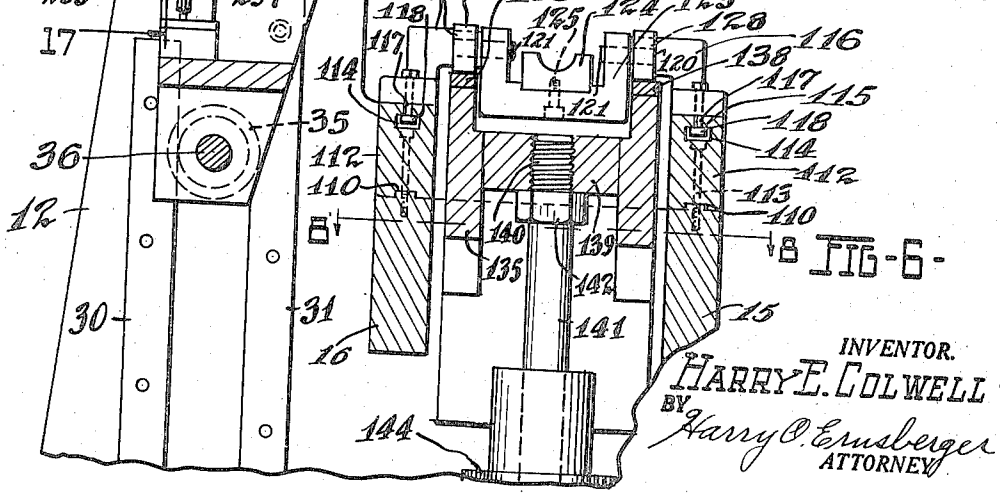

FIG-6-

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BENDING MACHINE

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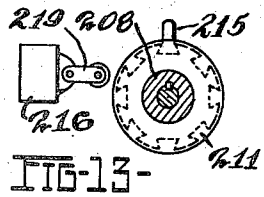

FIG-13-

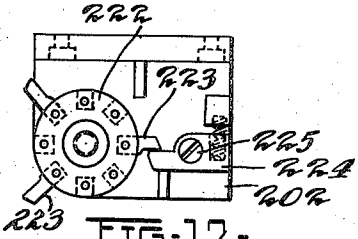

FIG-12-

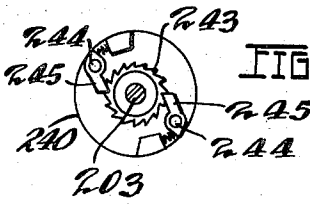

FIG-11-

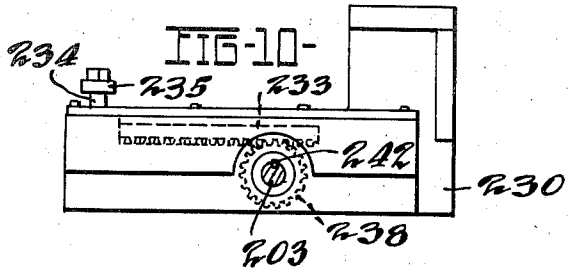

FIG-10-

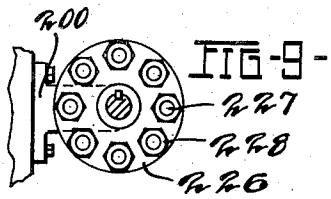

FIG-9-

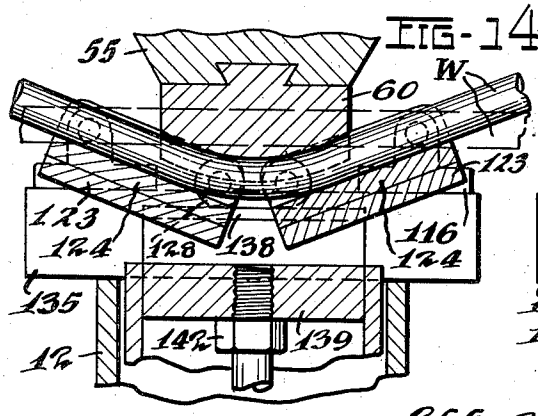

FIG-14-

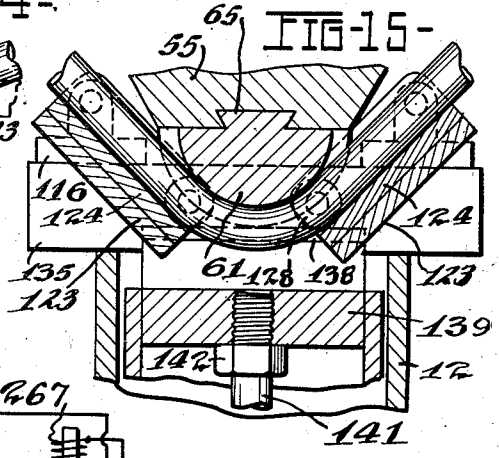

FIG-15-

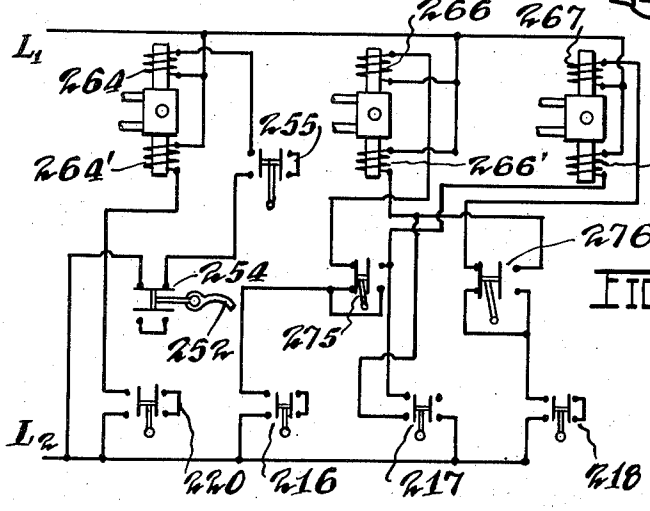

FIG-16-

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Patented Apr. 27, 1948

2,440,599

UNITED STATES PATENT OFFICE

2,440,599

BENDING MACHINE

Harry E. Colwell, Toledo, Ohio, assignor to The A P Parts Corporation, Toledo, Ohio, a corporation of Ohio

Application June 16, 1944, Serial No. 540,660

12 Claims. (Cl. 153—48)

1

This invention relates to bending machine and apparatus and more especially to apparatus for performing work upon or configurating metal articles.

The invention contemplates the provision of a machine especially adapted for performing successive operations upon work and particularly for impressing bends or predetermined configurations into the work.

An object of the invention resides in the provision of a machine tool embodying means for selectively impressing a plurality of configurations in work wherein each successive configuration may be of a different contour.

Another object of the invention embraces a machine of this character which is semi-automatic in its operation and embodying automatic means for indexing or successively positioning a plurality of tools into operative relationship for performing successive operations upon the work.

Another object is the provision of a hydraulically actuated, electrically controlled apparatus embodying a plurality of bending dies for impressing bends in rods, tubing shafting or the like wherein successive bends in each piece of work are of different configuration.

Still another object is the provision of apparatus including a supporting head associated with a reciprocating ram and which is adapted to be equipped with a plurality of tools or dies, the head being arranged to be progressively moved to predetermined positions for successively bringing the tools or dies into position to perform bending operations upon the work and arranged whereby the dies are positioned to permit free movement of the work adjacent the bent portions without the same impinging upon parts of the apparatus.

Further objects and advantages are within the scope of this invention such as relate to the arrangement, operation and function of the related elements of the structure, to various details of construction and to combinations of parts, elements per se, and to economies of manufacture and numerous other features as will be apparent from a consideration of the specification and drawing of a form of the invention, which may be preferred, in which:

Figure 1 is an elevational view of the apparatus particularly illustrating in semi-diagrammatic form the hydraulic system utilized in actuating component elements of the mechanism;

Figure 2 is a side elevational view of the apparatus;

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Figure 3 is a front elevational view of the apparatus shown in Figure 2;

Figure 4 is a side elevational view of a portion of the apparatus;

Figure 5 is a rear elevational view of the apparatus illustrated in Figure 4;

Figure 6 is a vertical sectional view taken substantially on the line 6—6 of Figure 3;

Figure 7 is a horizontal sectional view taken substantially on the line 7—7 of Figure 6;

Figure 8 is a horizontal sectional view taken substantially on line 8—8 of Figure 6;

Figure 9 is a detail sectional view taken substantially on the line 9—9 of Figure 5;

Figure 10 is a detail sectional view taken substantially on the line 10—10 of figure 4;

Figure 11 is a detail sectional view taken on the line 11—11 of Figure 4;

Figure 12 is a detail sectional view taken substantially on the line 12—12 of Figure 4;

Figure 13 is a detail sectional view taken substantially on the line 13—13 of Figure 4;

Figure 14 is fragmentary sectional view showing one position of the work supporting means at the completion of a bending operation in which a shallow bend is impressed in the work;

Figure 15 is a view similar to Figure 14 showing the position of the work and supporting means therefor at the completion of a bending operation in which a bending die of different configuration is utilized;

Figure 16 is a diagrammatic view of the electrical circuits and control devices for initiating and controlling movement of component elements of the mechanism;

Figure 17 is a fragmentary detail sectional view taken substantially on the line 17—17 of Figure 6;

Figure 18 is a fragmentary detail sectional view taken substantially on the line 18—18 of Figure 6.

While I have illustrated the apparatus of my invention as particularly adapted for performing bending operations on thin wall tubing of a character utilized especially for tail or exhaust pipes in an exhaust system of an internal combustion engine, it is to be understood I contemplate the use of the principles of my invention for performing work operations wherever the same may be found to have utility.

Referring to the drawings in detail, the apparatus is inclusive of a frame structure 10 formed with two spaced vertically arranged plates 12 and 13 joined together by transversely extending members 14, 15, 16, 17, 18 and a sub-

stantially rectangular plate 19, all of said members and plate being welded to the uprights 12 and 13. The plate 19 of the top portion of the frame supports a cylinder 21, the latter being provided with a head portion 22 secured to the plate by means of bolts 23. Slidably mounted within the cylinder 21 is a piston 25 to which is secured a rod 26, the latter being threaded into a ram or member 27 locked in adjusted relation thereto by means of a nut 28.

Secured to the opposing interior walls of the frame plates 12 and 13 are the bars or strips 30 and 31, disposed in pairs and arranged in vertical parallel relationship forming guides or ways for flanged rollers 35, the latter being journaled for rotation upon end portions of a shaft 36 supported adjacent the lower extremities of plates 37 forming component parts of the ram 27. Positioned above shaft 36 is a second shaft 39 carried by plates 37, and journaled upon the end portions of shaft 39 are flanged rollers 40 which engage and are adapted to travel along bars or guides 31, as shown in Figure 6. Also secured to the inner walls of the frame plates 12 and 13 are vertically disposed bars 43 adapted to form guides for flanged rollers 44 journaled upon end portions of shaft 45, the latter also being carried by the spaced plates 37 as shown in Figure 7. By means of the bars or tracks 30, 31, 43 and flanged rollers 35, 40 and 44, the ram or member 27 and elements carried thereby are arranged for relative movement in a vertical direction under the influence of fluid pressure exerted against the piston 25, in a manner to be hereinafter described.

A horizontally extending plate portion 48 of the ram 27 is welded or otherwise secured to vertically disposed plates or members 49 and 50, the latter having aligned openings accommodating bearings or bushings 51 and 52 in which is journaled a shaft or arbor 53, a portion of the shaft 53 projecting forwardly of the plate 49 and supporting a member 55 as shown in Figure 6. The member 55 is snugly fitted upon the shaft 53, being held in place by means of a key 56 and a washer 57 secured to the shaft by means of a bolt 58. The shaft 53 and member 55 form a tool supporting means or holder and which is arranged for rotative movement relative to the ram 27 for a purpose to be hereinafter explained.

I have illustrated the embodiment of the invention as especially adapted for making successive bends of the same or different contour in thin-walled tubing, the work performing implements or bending dies for such purpose being carried by the tool supporting member 55. While any number of differently configurated tools or dies may be carried upon the tool or die holder, I have shown an arrangement for mounting three bending tools or dies 60, 61 and 62, each having a working face of different contour. The periphery of the tool support 55 is generally of hexagonal shape, three of the facets thereof having grooves or ways to snugly accommodate tangs 65 carried by each of the dies for properly positioning the same in the holder. The alternate facets disposed between the die engaging facets are adapted to receive plates 66, the extremities of which engage abutments formed on the dies for securely clamping and retaining the latter on the support 55. The plates 66 are retained in position by means of screws 67.

It should be noted that in the embodiment illustrated, the central axes of the three dies are radially equally spaced i. e. 120° apart. The present invention is inclusive of means for indexing or shifting the tool or die supporting means to move the dies successively into operative position to perform bending operations. To this end, the shaft 53 is journaled for rotation in the bearings 51 and 52, the rear extremity of the shaft being formed with a tenon 70 upon which is mounted an arm 71 held in place by means of a key 72. The arm is provided with an opening to snugly receive the tenon portion 73 of a journal pin or shaft 74 which is held in place by means of a pin 75. A pair of upwardly extending rods 76 and 77 are threaded into members 82 and 83, the latter being bored to receive bearing bushings 78 adapted to fit on journal pin 74, members 82 and 83 and their bearings being retained in proper relation by a disc or washer 80 secured by means of a screw 81 to the journal pin 74.

The rear plate 50 forming a component of the ram 27 extends upwardly as shown in Figure 5 and is provided with laterally extending arms 84 and 85 to which are welded the rearwardly projecting members 86 and 87. Each of members 86 and 87 is formed with an opening to accommodate the threaded tenons 88 of members 89, the latter being secured in place by lock nuts 90.

Rod 76 extends a stuffing gland formed on a head 93 and is secured to a piston slidably disposed in a cylinder 95. The rear end of the cylinder is closed by means of a plate 96 formed with a bifurcated projection 97, the furcations and member 86 being bored to receive a pin 98, which forms a pivotal support for the cylinder 95. Similarly the rod 77 extends through a head 100 into a cylinder 101, a piston 99 in said cylinder being secured to the end of rod 77. The rear end of the cylinder is closed by a plate 102 having a bifurcated projection 103 of the same configuration as projection 97, and is pivotally connected to member 89 by means of a pivot pin 104. An abutment 105 is associated with the vertically disposed plate 50 forms stop means engageable with surfaces 106 and 107 of arm 71 when the arm 71, shaft 53 and bending die holder 55 are moved under the influence of fluid pressure acting on the pistons in cylinders 95 and 101 in a manner to be hereinafter explained.

The machine frame 10 is formed with forwardly extending portions which are joined together by transversely extending members 15 and 16. The upper faces of members 15 and 16 are formed with tongues 110 which fit into grooves formed in the lower faces of members 112 which are secured to members 15 and 16 by means of screws 113. The bars or members 112 are provided at their upper portions with longitudinally extending slots 114 of T shape in cross section as shown in Figure 6. The upper surfaces of bars 112 are formed with transverse serrations. The bars 112 form a support for members 116, the latter also having serrated lower surfaces mating with the serrated faces of bars 112, the serrations serving to position members 116 in adjusted position. Members 116 are provided with projections 117 slidably fitting the restricted throats of slots 114 and are securely held in adjusted position by means of bolts 118. The members 116 have upwardly and laterally extending integral bosses 120 which are bored and threaded to receive pintles or shafts 121. Positioned between members 116 are U-shaped chairs or bolsters 123, each bolster 123 being pivotally supported by a pair of shafts 121 mounted in members 116. Each of the bolsters 123 is formed with a centrally arranged recess adapted to receive and support a die or work support 124 secured in position by

means of screws 125. The adjacent portions of the bolsters 123 are formed with threaded openings to receive pins 127 upon which are revolubly journaled rollers 128.

Positioned adjacent frame plates 12 and 13 are plates 130 and 131 which are each formed with vertically arranged flanges 132. The inner surfaces of plates 130, 131 and the flanges 132 form ways or tracks for guiding a head 135 slidably engageable therewth. Plates 130 and 131 are provided with threaded openings to receive bolts 136, the latter being threaded into bushings 137. The exterior surfaces of bushings 137 are threaded into openings in frame plates 12 and 13. By adjusting the bolts 136 and threaded bushings 137, the relative position of guide plates 130 and 131 may be varied to obtain the proper sliding fit for the head 135.

The upper portions of the head 135 are provided with hardened steel bars 138 which are engaged by rollers 128. The head 135 is formed with a central web portion 139, having a threaded opening to receive the threaded extremity 140 of a piston rod 141, and locked together by means of a nut 142. The rod 141 extends into a cylinder 144 and is connected to a piston 146 disposed therein. The cylinder 144 is secured to a member 145, the latter being mounted upon a plate 20 forming the base of the machine. A pipe 159 is connected to the cylinder beneath the piston and admits fluid to the cylinder for hydraulically supporting the head 135 which is adapted to be moved downwardly during bending operations.

Particular reference is made to Figure 1 illustrating the hydraulic system for causing the functioning of various movements of the mechanism of my invention. Positioned adjacent the apparatus is a reservoir or tank 150 adapted to contain a supply of oil or other suitable actuating fluid. Mounted upon a cover 151 of the reservoir 150 is a pair of fluid pumps 153 and 154 preferably of the rotary type and of different sizes or capacities, pump 153 being of the lesser capacity. The pump 153 is provided with an inlet pipe 155 extending into the reservoir, the lower end of pipe being equipped with a filter or strainer 156. The pump 153 is provided with an exit or outlet 157 and is connected to a sequence valve 158, the latter being connected by a tube 159 to the lower end of the cylinder 144 and a return connection 160 leading into the reservoir 150. The sequence valve 158 is of the spring loaded type whereby excessive pressure in the cylinder 144 permits fluid to be returned from cylinder 155 to the reservoir 150 through the return pipe 160.

The pump 154 is provided with an inlet pipe 162 extending into the reservoir 150, the lower end of the pipe being fitted with a filter 163. The outlet pipe 164 of the pump is connected to a sequence valve 165 provided with a fluid return pipe 161 leading into reservoir 150. The sequence valve 165 is connected to a T-shaped fitting 167 by means of a connection 168, a pipe 169 leading from fitting 167 to an electrically controlled, solenoid actuated valve means contained within housing 170. The valve means in housing 170 is connected to the upper and lower portions of the cylinder 21 by means of pipes 171 and 172, for the transmission of fluid pressure alternately through said pipes to cause vertical reciprocatory movement of the piston or ram 25 contained within the cylinder 21. A pipe 173 is connected to the valve means in housing 170 through which fluid may be returned to the reservoir 150. A

branch pipe 176 is in communication with pipe 173 and a pressure relief valve interposed in pipe 172 to relieve the fluid pressure beneath the piston 25 when it has reached its uppermost position.

Connected to the fitting 167 is a pipe 177 for conveying fluid pressure from the pump 154 to an electrically controlled, solenoid actuated valve means contained within each of casings 178 and 179 mounted upon a platform provided at the upper extremity of the frame 10, the pipe 177 dividing into branches 180 and 181 leading to the valve means. Valve means in casing 178 is connected by a tube 182 to the upper end of cylinder 101 while tube 183 connects the valve means with the lower portion of cylinder 101, the tubes 182 and 183 being flexible to accommodate movement of the cylinder 101 during indexing operations.

The valve means contained within casing 179 is connected to the upper end of cylinder 95 by means of a flexible tube 186 and to the lower end of said cylinder by means of the flexible tube 187. The valve means contained within the casings 178 and 179 are connected together by means of tubes 189, a T-shaped fitting 190 being interposed between the tubes 189 which is connected by means of a pipe 191 to a four way fitting or cross 192 connected to a return pipe 166 extending into the reservoir 150.

The control arrangement of my invention involves intercalation of electrical and mechanical devices for accomplishing the indexing and work performing functions of the apparatus in which the operator, by manual or foot actuated means initiates the cycle of operations. Secured to the frame plate 13 of the machine or press are the brackets 200, 201 and 202 which are bored with aligned openings adapted to receive a vertically positioned shaft or member 203 arranged for relative rotary movement, and for slidable movement in a direction parallel with the movement of member 27. The upper end of the shaft or rod 203 is threaded to receive a disc 204, the same being adjustable on the rod and adapted to be locked in adjusted position by means of nuts 205 and 206. Positioned between the bracket 201 and nut 206 is an expansive coil spring 207 surrounding the rod 203. Disposed upon the rod 203 between brackets 201 and 202 are three similarly shaped members 208, 209 and 210 arranged one above the other. Each of these members is formed with an enlarged disc-like portion or cam plate 211, 212, and 213 respectively, each portion being formed to support a plurality of radially projecting lugs or cams 215 which are adapted to actuate snap switches designated 216, 217 and 218, the switches being provided with arms 219 arranged in the loci of the cams carried by discs 211, 212 and 213. Expansive coil springs 221 are interposed between the disc-like portions of members 208, 209, and 210 to absorb any lost motion between said members and to maintain them in proper relationship.

Positioned upon and fixed to the shaft 203 beneath the bracket 202 is a disc 222 having a plurality of radially disposed openings adapted to receive stop members or lugs 223, the number depending upon the number of work operations or bends to be performed on or impressed in the work to complete a cycle of operations. Pivotally supported upon a pintle 225 carried by bracket 202 is a pawl 224 which is arranged for cooperation with the stop members 223 on the disc 222 for successively positioning the control shaft 203 after the completion of each bending operation.

Fixedly secured upon the lower portion of the

shaft 203 is disc 226 having a plurality of radially spaced threaded openings arranged in parallelism with the shaft 203, these openings receiving a series of abutments or bolts 227 providing adjustable means for limiting the downward movement of the ram and bending dies or tools carried thereby so as to predetermine the depth of each bend or limit the travel of the tool for successive work performing operations. The bolts 227 are adapted to be locked in adjusted position by means of nuts 228.

Secured by means of screws 229 to the vertically reciprocable ram 27 is a laterally extending bracket or member 230. The member is provided with a horizontaly disposed recess in which is slidably fitted a carriage 232, a horizontally disposed toothed member or rack 233 being secured to the carriage. The carriage 232 supports at its outer end a pin or shaft 234 upon which is journaled a roller 235. Secured to the frame of the machine is a pair of angularly shaped bars or strips 236 as shown in Figure 4 arranged in spaced relation forming guide surfaces or ways to accommodate the roller 235 and control the horizontal movement of the carriage 232 and rack 233.

The bracket 230 is provided with an opening through which the shaft 203 extends, the bracket also having an arcuate recess to accommodate a spur gear 238 journaled for rotation on shaft 203 and in mesh with the teeth in the rack 233. Mounted upon shaft 203 above the gear 238 is a disc-like member 240 provided with the threaded member 241 forming a key extending into a keyway 242 formed in the shaft 203, the member 240 being loosely fitted on shaft so as to be slidable there along and rotatable with the shaft through the medium of the key 241. Also journaled upon shaft 203 adjacent member 240 is a ratchet wheel 243, and pivotally supported on pins 244 carried by member 240 is a pair of diametrically disposed, spring pressed pawls or ratchets 245 adapted for cooperation with ratchet wheel 243 providing a one way or overrunning clutch means for causing rotation of shaft 203 in one direction only for purposes to be hereinafter explained. Positioned between gear 238 and ratchet wheel 243 is a spacing collar 247 and surrounding the collar 247 is a coil spring 248 having its upper and lower ends connected respectively to the ratchet wheel 243 and the gear 238. The bracket 230 is provided with a depending pin or abutment 250 which is adapted to successively engage the abutment screws carried by member 226 secured to the shaft upon downward movement of the bracket 230. The longitudinal movement of the rack 232 at each downward movement of the ram 27 caused by the angularity of ways 236 cooperating with the roller 235 slightly exceeds the circumference of shaft 203, and therefore could effect a complete rotation of the shaft if desirable, although in actual operation, the shaft rotates through successive radial distances, each less than a complete revolution.

The electrical apparatus and control for the hydraulic means is illustrated diagrammatically in Figure 16, and switch means shown on other figures of the drawings. The operator of the machine initiates each work or bending operation by depressing a foot treadle 252 carried by a box 253 housing a switch 254 illustrated in figure 16. The switch 254 is connected in a circuit with a switch 255, the latter being a safety switch for the purpose of preventing operation of the hydraulic mechanism until one of the bending dies is in proper working position. The mechanism associated with the switch 255 is illustrated in Figure 17 and includes a link 256, connected one end to the switch arm 257 and the other end connected to one arm of a bell crank 258 pivotally supported upon a projection 259 formed upon the ram 27. The extremity of the other arm of the bell crank 258 carries a roller 260 arranged to cooperate with recesses 261 formed in a collar 262 secured to the die holder supporting shaft 53. When roller 260 engages in one of the recesses 261, the switch 255 is in closed circuit position and one of the tools or dies is in proper work performing position. Under these conditions, the actuation of the treadle operated switch 254 will initiate operation of solenoid 264 for actuating the valve means contained within housing 170 to control flow of fluid to the cylinder 21.

Solenoid mechanism 266, 266', and 267, 267' contained in housings 178 and 179 actuate the valves for controlling fluid flow to the die indexing cylinders 95 and 101.

Secured on the shaft 53 is a sleeve or collar 270, the ends of the sleeve being formed for cooperation with rollers 271 and 272 carried on switch arms 273 and 274 forming parts of switches 275 and 276. The portions of collar 270 cooperating with the rollers 271 and 272 are so configurated that both switches are in closed position only in the position shown in Figure 18. In this position of shaft 53, the die 60 is in work performing position, and the indexing mechanism in the position shown in Figure 5. In the event that the die 60 is not moved into its proper work performing position under the influence of the hydraulic means, switches 275 or 276 perform the function of actuating the hydraulic means, until the die 60 is in a central position. This is accomplished when rollers 271 and 272 rest in aligned positions as shown in Figure 18.

It is to be understood that the apparatus of my invention is susceptible of use in performing work operations of varying character and I have illustrated the arrangement wherein three bending dies of different contour may be sequentially employed to make one or more bends per each die, the number of individual bending operations in a cycle of the machine being determined by the number of stops or lugs 223 carried by the disc 222. The stops 223 are made removable so that the machine may be utilized for attaining varying members of work performing or bending operations in a cycle. In describing the operation of the machine, a three operational cycle will be explained, i. e. one bending operation for each of the bending dies 60, 61 and 62.

In the first instance, a motor (not shown) connected to shaft 152 is energized to drive the fluid pumps 153 and 154. These pumps are supplied with oil or other suitable fluid from the reservoir 150 by means of the inlet pipes 155 and 162. The operator then places a length of thin walled pipe or tubing W upon the work supporting dies 124 carried by the pivotally mounted cradles 123. The operator then depresses the treadle 252, closing the master switch 254. Assuming that the bending die 60 is in a working position as illustrated in Figure 3 and is to be utilized to produce the first bend in the tube W, the roller 260 carried by bell crank 258 (see Figure 17) is received in one of the recesses 261 in collar 262 which condition positions switch 255 so that an electric circuit is completed through switches 254 and 255 to energize the solenoid 264 and actuate valve mechanism in housing 170 to connect the

fluid feed pipe 169 with the pipe 171 to convey oil under pressure from pump 154 to the cylinder 21 above the piston 25. The fluid pressure acting on piston 25 drives the same downwardly together with the ram 27 and the dies and support. The die 60 engages the tube W causing downward pressure on the tube, and as a bend is formed therein, the fluid pressure in cylinder 144 beneath the piston 146, set up through the medium of pump 153 being less than that in tube 171, is overcome and the parts associated with the work support move downwardly to the position illustrated in Figure 14. The ram 27, die 60 and associated parts move downwardly until the pin 250 contacts one of the screws 227 in alignment therewith, which engagement moves the shaft 203 and parts carried thereby downwardly causing the lower surface of disc 204 into engagement with arm 214 adapted to close the switch 220 contained within housing 224 secured to the machine frame. The closing of switch 220 energizes solenoid 264' actuating valve means in housing 170 disconnecting fluid pressure to the pipe 171 and connecting the fluid pressure to the pipe 172 to convey oil to cylinder 21 beneath the piston 25 to cause the latter and parts carried thereby to move upwardly. When the solenoid 264' actuates the valve means, it connects the pipe 171 with the return pipe 173 to permit the oil above the piston 25 to return to the reservoir 150 through tube 166. As the shaft 203 was moved downwardly by engagement of pin 250 with one of the abutment screws 227, the lug 223, in engagement with pawl 226 is moved out of contact therewith. During downward movement of shaft 203, the roller 235, guided by ways 236, moves the rack 233 horizontally, rotating gear 238 and unwinding coil spring 248. Movement of the spring 248 is not then communicated to shaft 203 by reason of the locking action of pawls 245 in engagement with the ratchet wheel 243. During the upward movement of ram 27, the roller 235, under the influence of ways 236, retracts rack 233 and permits counter clockwise rotation of gear 238 (as viewed in Figure 10), winding up the spring 248, the tension acting gradually to rotate the shaft 203 until the next succeeding lug 223 engages pawl 226 to re-position the shaft. The shaft 203 is moved to its initial uppermost position under the influence of spring 207 at the initial upward movement of the ram 27 so that a lug 223 will be in position to engage the pawl 226 when the shaft is rotated. During rotation of shaft 203, a projection or cam 221' on disc 211 engages the lever 216' on switch 216 to complete a circuit to solenoid 266 to actuate hydraulic valve means in housing 179 causing oil to flow under pressure through feed lines 177, 181 and 187 into the lower end of cylinder 95 to force the piston upwardly, thus rotating shaft 53 and die holder 55 to bring the die 61 into operative position, the pipe 186 communicating with a fluid return line 182, so that oil above the piston in cylinder 95 is returned to the reservoir 150. The operator moves the work W along the work supporting dies 124 into position to effect the second bend in the work by means of the bending die 61. Treadle 252 is again depressed to actuate switch 254 and through switch 255, which has been reset by engagement of roller 260 (see Figure 17) engaging in another of the recesses 261 in collar 262, to energize solenoid 264, actuating the hydraulic control valves in housing 170 directing fluid above piston 25 in cylinder 21 and causing downward

movement of the ram 27. This movement brings the die 61 into engagement with the work, forming a bend therein as illustrated in Figure 15. Downward movement of the ram 27 brings the pin 250 into engagement with another abutment 227 adjusted to effect the proper depth of bend to be made in the work. Shaft 203 is again molded downwardly until switch 220 in housing 224 is actuated by disc 204 to reverse the flow of oil into the cylinder 21 resulting in return movement of the ram 27. The shaft 203 and associated mechanism repeat the cycle of operations as above set forth in connection with the bending operation accomplished by die 60. On this cycle, however, a projection on cam disc 213 actuates switch 218, energizing solenoid 267 controlling valves so as to direct oil into cylinder 101 so as to rotate shaft 53 bringing die 62 in operative position to perform a bending operation. After the work is re-positioned for the third bend, the treadle 252 is depressed and the ram 27 moved downwardly through the electrically controlled hydraulic valves in the manner above explained.

During the completion of the third cycle of operations, the projection on disc 212 actuates switch 217 energizing a solenoid 266' controlling a valve so that fluid pressure acts on the piston in cylinder 101 to bring die 60 approximately to central position as in Figure 3. The switches 275 and 276 are intercalated so as to alternately actuate the solenoids controlling the valves until equal fluid pressure above the pistons in the indexing cylinders 95 and 101, thus retaining the die 60 in central position by equalized pressure in said cylinders.

It should be noted that an "unloader" or pressure relief valve 175 is interposed in the pipe 172 leading to the lower end of cylinder 21 so that an excess of fluid pressure is prevented from building up beneath the piston which might damage the machine, the valve 175 permitting oil to return to the reservoir 150.

It is to be understood that while I have shown and described a form of the invention for making three successive bends of different radii, a number or series of bends of each type may be made by merely employing the required number of stops 223 and the required number of projections on cam discs 211, 212 and 213 coupled with their proper adjustment for proper sequence of operations of the electrically controlled, solenoid actuated fluid regulating valves.

By the utilization of the apparatus of my invention wherein the bending dies are positioned in front of the ram, many bends of variant angularity and depth may be made in a piece of work without portions of the work striking parts of the machine.

I claim:

1. Apparatus of the character disclosed comprising in combination a frame; a member arranged for reciprocatory movement associated with said frame; hydraulic means for reciprocating said member; an arbor supported upon said member and adapted for movement relative thereto; a plurality of work performing tools carried by said arbor; electrically actuated means for indexing said arbor to selectively move said tools into work performing position; a work supporting means associated with said frame; and hydraulic cushioning means for said work supporting means whereby the latter is adapted to be moved under the influence of one of said tools engaging the work.

2. Apparatus of the character disclosed com-

prising in combination a frame; a vertically reciprocable member associated with said frame; a plurality of ways associated with said frame; a plurality of rollers journaled on said member and arranged for movement along said ways; hydraulic means for reciprocating said member; an arbor revolubly supported upon said member; a plurality of bending dies carried by said arbor; electrically actuated means for rotating said arbor to selectively move said dies into work performing position; and an hydraulically cushioned work supporting means associated with said frame and adapted for cooperating with said bending dies during bending operations.

3. Apparatus of the character disclosed comprising in combination a frame; a vertically reciprocable member associated with said frame; a plurality of ways associated with said frame; a plurality of rollers journaled on said member and arranged for movement along said ways; hydraulic means for reciprocating said member; an arbor revolubly supported upon said member; a plurality of bending dies carried by said arbor; electrically actuated means for rotating said arbor to selectively move said dies into work performing position; a work supporting means mounted on said frame, and hydraulic cushioning means associated with said work supporting means whereby the latter may be moved under the influence of one of said dies engaging the work.

4. Apparatus of the character disclosed in combination a frame; a member reciprocably mounted on said frame; hydraulic means for reciprocating said member; electrically energized means for controlling said hydraulic means; an arbor mounted upon said member and arranged for rotary movement independently thereof; a plurality of bending dies mounted upon said arbor; hydraulically actuated means for moving said arbor to selectively move said dies into operative position; and electrically energized means for controlling said hydraulic means for reciprocating said member and rotating said arbor.

5. Apparatus of the character disclosed in combination, a frame; a ram mounted upon said frame; hydraulic means for reciprocating said ram; an arbor journaled on said ram and arranged for revoluble movement relative to said ram; electrically energized means for controlling said ram actuating hydraulic means; a plurality of work performing elements associated with said arbor; hydraulic means for rotating said arbor to selectively move said work performing elements into operative position, and electrically energized means set into action by movement of said ram for initiating the operation of said arbor rotating hydraulic means.

6. Apparatus of the character disclosed in combination a frame having a plurality of vertically arranged ways; a reciprocable member; a plurality of rollers journaled on said member and engageable with said ways for guiding said reciprocable member; hydraulic means for reciprocating said member; electrically energized means for controlling said hydraulic means; an arbor mounted upon said member and arranged for rotary movement independently thereof; a plurality of bending dies associated with said arbor; hydraulically actuated means for rotating said arbor to selectively move said dies into operative position; electrically energized means for controlling said hydraulic means; a work supporting means associated with said frame; and hydraulic cushioning means for normally maintaining said work supporting means in work supporting position.

7. Apparatus of the character disclosed in combination, a frame; a ram mounted thereon; a cylinder carried on said frame; a piston in said cylinder connected to said ram; means for injecting fluid under pressure into said cylinder for causing reciprocation of said ram and piston; a member supported on said ram and arranged for movement relative to said ram; work performing elements associated with said member; a cylinder mounted upon said ram; a piston in said last mentioned cylinder; a rod connecting said last mentioned piston with said member; and means for injecting fluid under pressure into said last mentioned cylinder to cause movement of said member relative to said ram to shift the positions of said work performing elements; and means for controlling the flow of fluid to both said cylinders.

8. A bending machine of the character disclosed, in combination, a frame having a plurality of vertically arranged ways; a reciprocable member; a plurality of rollers journaled on said member and engageable with said ways for guiding said reciprocable member; hydraulic means for reciprocating said member; a horizontally disposed arbor journaled upon said member and arranged for rotary movement independently of said member; a die holder fixed to said arbor and disposed laterally of said reciprocable member; a plurality of bending dies carried upon said die holder; hydraulically actuated means for rotating said arbor to selectively move said dies into operative position; means controlled by movement of said reciprocable member for initiating the operation of the hydraulic means for rotating the arbor; a relatively movable work supporting means associated with said frame; and hydraulic cushioning means for maintaining said work supporting means normally in work supporting position.

9. Apparatus of the character disclosed comprising in combination, a frame; a ram reciprocably supported upon said frame; a die supporting member movable with said ram and capable of independent rotary movement; a plurality of bending dies carried by said member; hydraulic means for causing rotation of said die supporting member to selectively move said dies into work performing position; hydraulic means for reciprocating said ram; and electrically energized means for controlling the operation of both said hydraulic means.

10. In a tube bending machine, in combination, a frame having vertically disposed ways; a ram adapted to traverse said ways; hydraulic means for reciprocating said ram; an arbor journaled upon said ram and revolvable about an axis angularly disposed to the locus of reciprocation of said ram; a plurality of tube bending dies carried by said arbor; electrically actuated means for rotating said arbor to selectively bring said bending dies into work performing position; a tube engaging hydraulically supported means associated with said frame; said tube engaging means being arranged to move with the tube when a bend is being formed in the tube by one of said dies.

11. A bending machine comprising in combination; a frame formed with a plurality of ways; a ram reciprocable along said ways; hydraulic means for actuating said ram; an arbor journaled upon said ram and revolvable about an

axis disposed at an angle with respect to the path of movement of said ram; a plurality of tube bending dies carried by said arbor; a control rod; means set into operation by movement of said ram for actuating said rod; switching means associated with said rod and arranged to be actuated by relative movement thereof for controlling the rotation of said arbor to selectively move said dies into tube bending position; a tube supporting means, and hydraulically cushioning means associated with said tube supporting means.

12. A tube bending machine comprising in combination; a frame; a plurality of vertically disposed ways carried by the frame; a ram movable along said ways; an arbor disposed for revolvable movement about an axis substantially at right angles to the locus of movement of said ram; a plurality of tube bending dies carried by said arbor; a control rod arranged for movement in an axis parallel with the movement of said ram; means associated with said ram for rotating said control rod; means for shifting said arbor to selectively move said dies into tube bending position; electric circuit closing devices associated with said control rod for initiating and controlling the operating of said arbor shifting means, and hydraulic cushioning means adapted to support a tube during bending operations; said hydraulically supported means being adapted for relative movement under the influence of pressure exerted by said ram during bending operations.

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