

July 27, 1943.

B. LERMONT ET AL

2,325,523

METAL ROLLING AND BENDING DEVICE

Filed Feb. 8, 1943

4 Sheets-Sheet 1

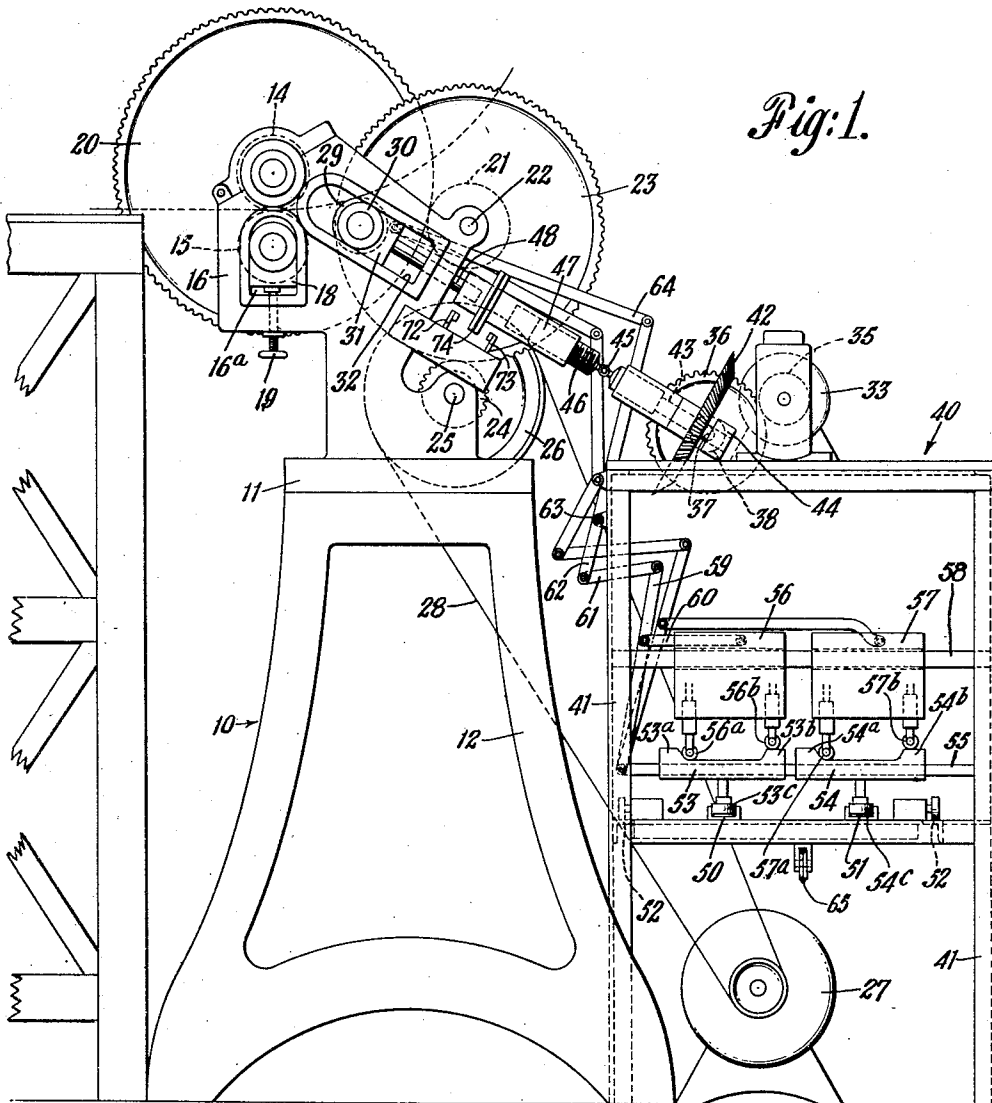


Fig. 1.

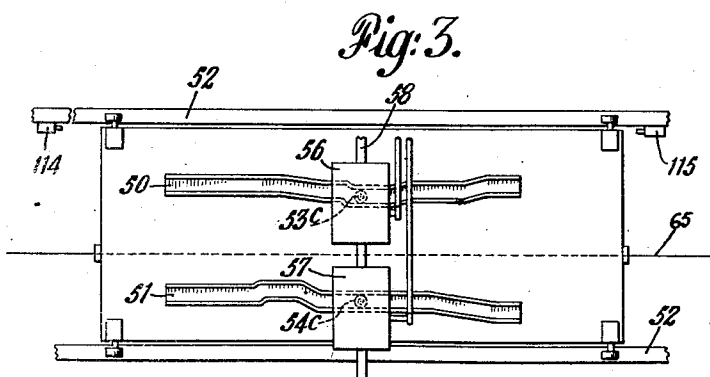


Fig. 3.

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4 Sheets-Sheet 2

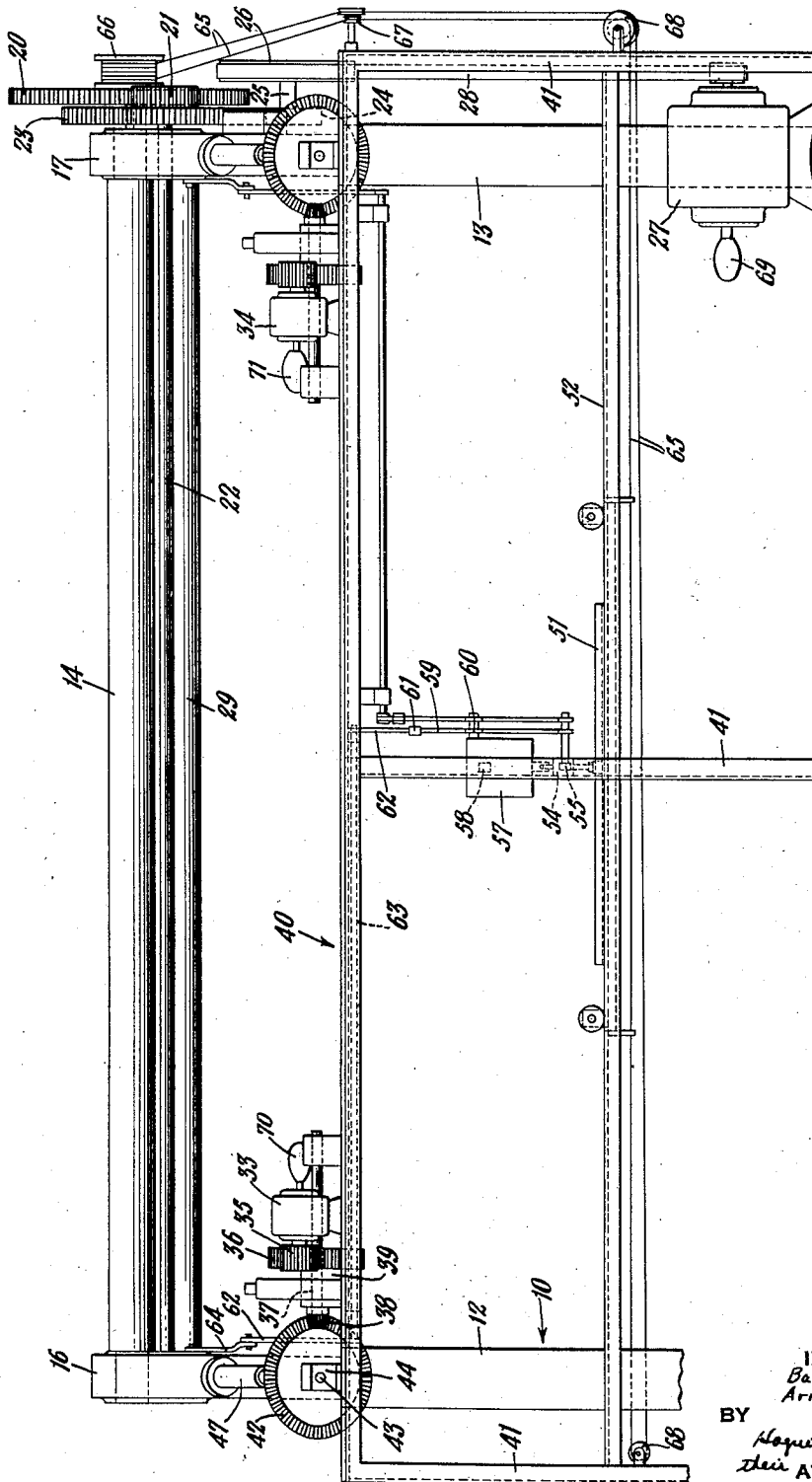


Fig. 2.

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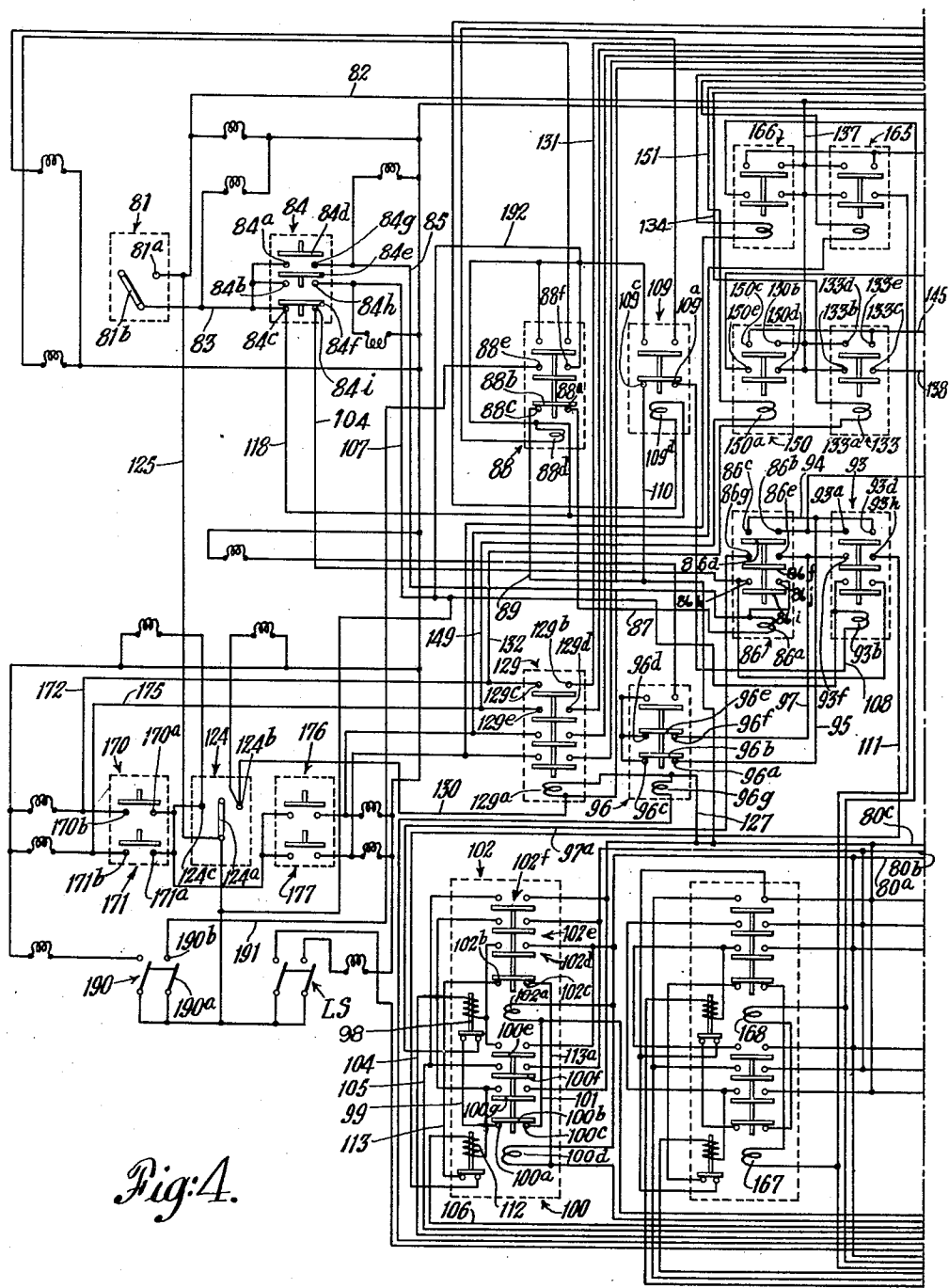
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4 Sheets-Sheet 4

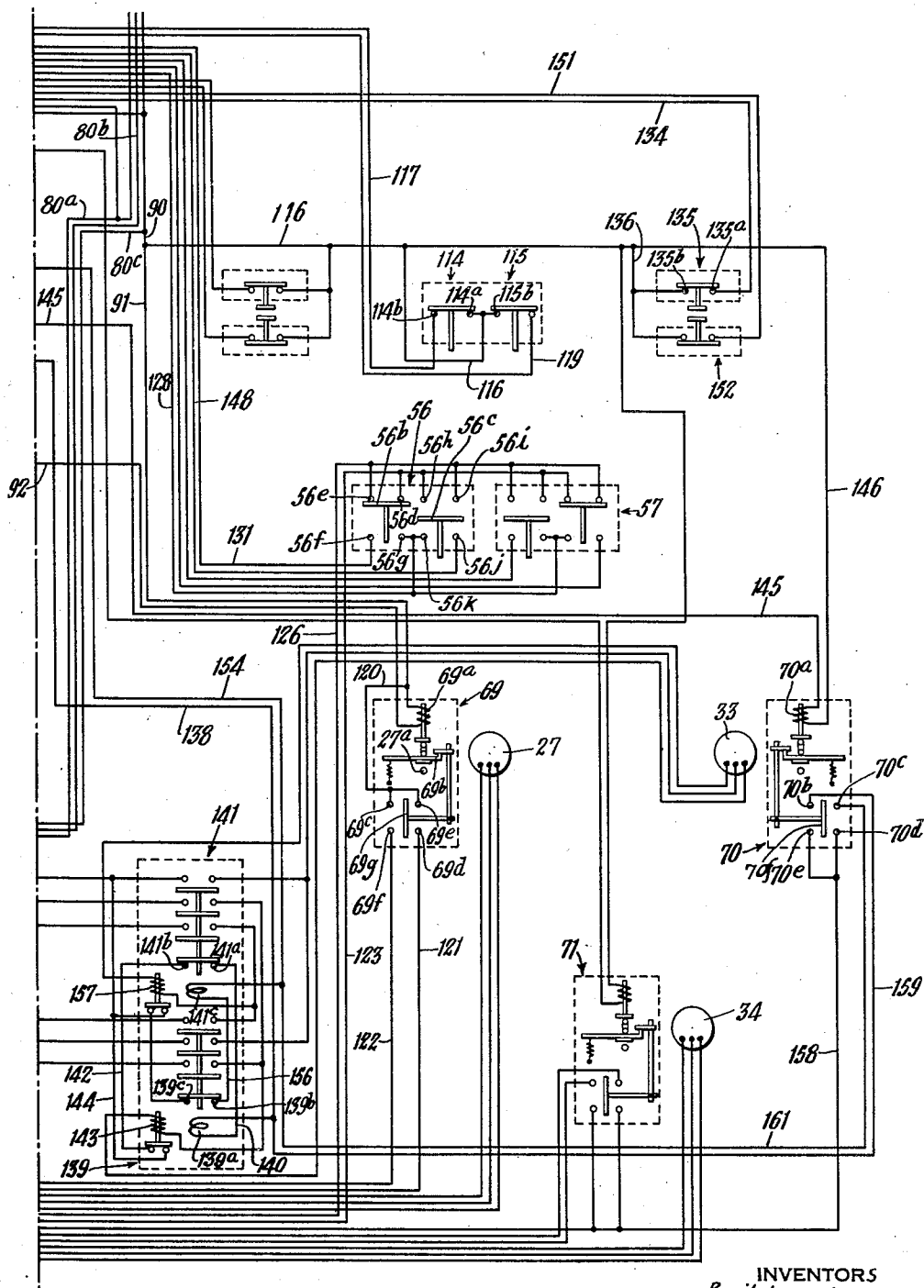


Fig. 4^a

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2,325,523

METAL ROLLING AND BENDING DEVICE

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Application February 8, 1943, Serial No. 475,098

4 Claims. (Cl. 153—54)

This invention relates to devices for shaping sheet metal and relates more particularly to devices for rolling and bending sheet metal into a wide variety of curved forms having single or multiple curvatures.

A large demand exists for sheets of metal having simple or complex curvatures for use in the manufacture of aircraft, boats, land vehicles and the like and for apparatus that is capable of producing such sheets in a minimum amount of time and at low cost. Heretofore, metal bending devices have been sharply limited as to the types of sheets that could be produced thereby, and moreover they are not adapted to be operated automatically to produce duplicate sheets having complex and varying curvatures.

An object of the present invention is to provide apparatus which is capable of rolling and bending metal sheets into a wide variety of curved forms.

Another object of the invention is to provide apparatus that can be adjusted easily to produce a wide variety of curved metal articles.

Another object of the invention is to provide apparatus that can be automatically controlled to produce metal sheets having complex curves and that can readily duplicate such curved sheets.

Other objects of the invention will become apparent from the following description of a typical form of apparatus embodying the present invention.

Apparatus of the type embodying the present invention is provided with three rolls that are engageable with a sheet of metal; two of the rolls acting to advance the sheet of metal and the third being adjustable toward and away from and angularly with respect to the other two to impart varying curvatures to the sheet. Thus, by suitably adjusting the rolls, the apparatus may be caused to shape a metal sheet into cylindrical or conical forms or substantially any combination of curved forms of the same or varying radii.

More particularly, apparatus embodying the invention may be automatically controlled to vary the relationship of the rolls and to produce complex curved sheets of identical shape. By varying the automatic controls, the shape of the sheet produced may be altered, as desired, and thereafter reproduced as often as desired. Automatic control of the movement of the adjustable roll may be effected by means of cams actuated by movement of the feed rolls and the adjustable roll so that the adjustments are always re-

lated directly to the position of the sheet being processed and the position of the adjustable roll.

For a better understanding of the present invention, reference may be had to the accompanying drawings in which:

Figure 1 is a view in side elevation of a typical form of device embodying the present invention; Figure 2 is a view in front elevation of the device;

Figure 3 is a top plan view of the cam arrangement of the device; and

Figures 4 and 4a are a schematic wiring diagram of the apparatus.

As illustrated in Figures 1 and 2, a typical form of rolling and bending apparatus in accordance with the present invention may include a base 10 consisting of a top 11 and legs 12 and 13 at opposite ends thereof for supporting the rolls of the bending device.

The rolling and bending mechanism proper may consist of a pair of rolls 14 and 15 having their axes disposed in a common vertical plane. The opposite ends of the roll 14 are journaled in the side members 16 and 17 that project upwardly and rearwardly from the top 11 of the base member 10.

The roll 15 is mounted in suitable journal blocks 18 which are slidably mounted in vertically disposed openings 16a in the side members 16 and 17 so that the spacing of the rolls 14 and 15 may be regulated to accommodate metal sheets of varying thickness. The roll 15 may be moved relatively to the roll 14 by means of screw members 19 threaded into the side plates 16 and 17 and bearing against the undersurfaces of the journal blocks 18.

The rolls 14 and 15 serve primarily to feed a sheet of metal therebetween and to grip the sheet of metal tightly as it is fed therethrough. In order to advance the sheet of metal, the roll 14 may be driven through a suitable train of gears including a large gear 20 fixed to the end of the roll 14, a small gear 21 suitably supported on a shaft 22 journaled in the side member 17 and having a second large gear 23 fixed thereto which meshes with a small gear 24 fixed to a shaft 25 journaled in the side member 17 and having a pulley 26 mounted thereon. The pulley is driven by means of a motor 27 and a belt 28.

It will be understood that the drive gearing may be varied as may be desired in order to effect a reduction between the speed of the motor and the speed of rotation of the roll 15, and that both of the rolls 14 and 15 may be driven by suitable gearing.

In order to bend the sheet of metal into the desired curved form, a third roll 29 is provided. The roll 29 is preferably journaled in semi-spherical bearing members 30 which are received in journal blocks 31 that are slidably received in elongated openings 32 in the frame members 16 and 17. The openings 32 are inclined at an acute angle with respect to the plane passing through the axes of the rolls 14 and 15 so that as the roll 29 is moved from its right hand position, as viewed in Figure 1, toward its left hand position, it will move upwardly with respect to the rolls 14 and 15. Preferably the axis of the roll 29 is movable in a plane passing through the axis of the roll 15.

When the roll 29 is in its right hand and lowermost position, the sheet of metal is forced against the upper surface of the roll 29 and is deflected upwardly to only a small extent, thereby imparting a curvature of relatively long radius to the sheet. As the roll 29 is moved to the left and upwardly, the sheet is deflected upwardly to a greater extent and thereby is curved more sharply or on a shorter radius. By adjusting the roll 29 toward and from the pair of rolls 14 and 15, the curvature of the sheet can be correspondingly varied.

The adjustment described above will cause the sheet to be curved on the same radius from edge to edge. In order to vary the radius of curvature of the sheet from edge to edge, the ends of the roll 29 may be displaced unequal distances from the rolls 14 and 15 by adjusting the slide blocks at opposite ends of the roll 29 along the slots. The semi-spherical bearings 30 prevent binding of the ends of the roll in the slide blocks 32.

While the adjustment described above can be accomplished manually, it is preferred to provide an automatic control system for regulating the position and movements of the roll 29 so that duplicate sheets of varying curvature can be produced automatically.

The apparatus for regulating the position of the roll 29, as illustrated, may consist of two reversible motors 33 and 34 supported at opposite ends of the table 40. Each of the motors 33 and 34 acts to adjust one end of the roll 29. Inasmuch as the motors and associated driving mechanism are the same for each end of the device, only one of the motors and driving mechanisms will be described herein.

The motor 33 is provided with a gear 35 which meshes with and drives a gear 36 that is supported on a shaft 37 having a bevel pinion 38 at its opposite end. The shaft 37 is journaled in a suitable bearing 39 on a table 40 disposed in front of the rolling device. The table 40 is provided with suitable supporting legs 41 and is anchored to the base 10 of the rolling device in any suitable way.

The bevel pinion 38 meshes with the bevel gear 42 that is mounted on a shaft 43 substantially coaxial with the axis of the slot 32. The shaft 43 is journaled in suitable bearings 44 supported on the table 40. The shaft 43 is coupled by a universal joint 45 to a threaded shaft 46 that is threaded into a sleeve 47 carried by a plunger 48 that is connected to the journal block 31. Thus upon rotation of the shaft 43 by the motor 33, the threaded shaft 46 is screwed into or out of the sleeve 47 advancing or retracting it, the journal block 31 and the left hand end of the roll 29.

The right hand end of the roll 29 is adjust-

able in the same manner by means of the motor 34 and associated gearing of the type described above.

While the motors may be controlled manually in order to adjust the position and angular relationship between the pair of rolls and the adjustable roll, such adjustment preferably is effected by means of a cam mechanism by means of which extremely accurate control of the operation of the motors is attained.

The cam mechanism illustrated consists of a pair of channel members 50 and 51 which are movably supported on rails 52 in the table 40. The channel members 50 and 51 are of undulatory shape in order to control the positions of two cam members 53 and 54 that actuate switches for controlling the amount of operation and direction of operation of the motors 33 and 34. The cam members 53 and 54 may consist of tubular elements slidably mounted upon a rod 55 extending transversely of the table 40 and fixed to the center pair of legs 41-41 of the table. Each of the cam members 53 and 54 is provided with cam lobes 53a, 53b and 54a, 54b at their opposite ends and have downwardly projecting rollers 53c and 54c which engage in the cams 50 and 51, respectively. Upon endwise shifting of the cams 50 and 51, the cam members 53 and 54 will be shifted endwise as the rollers 53c and 54c are deflected by undulations in the cams 50 and 51.

The cam members 53 and 54 are disposed beneath a pair of switch boxes 56 and 57 which control the motors 33 and 34, respectively. Each switch box contains a pair of double pole, double throw switches to be described later. One switch in each box 56 or 57 causes rotation of the motors 33 and 34 in a clockwise direction, while the other switches cause the motors 33 and 34 to rotate in a counterclockwise direction. The switches in box 56 are normally biased open and are actuated into one position by movement of the follower rollers 56a or 56b onto the top of one of the cam lobes 53a or 53b. The switches in switch box 57 are actuated by the rollers 57a or 57b engaging the cam lobes 54a, 54b or on the recess therebetween on the cam member 53 into another position by movement into the recesses between the lobes. Thus, the direction of rotation of the motors 33 and 34 is dependent upon the position of the cam members 53 and 54 and the extent of displacement of each end of the roll 29 is dependent upon the extent of operation of the motors 33 and 34. In order to effect accurate control of the position of the roll 29, stoppage of the motors 33 or 34 is controlled entirely by the position of the roll 29 as will now be described.

Each of the switch boxes 56 and 57 is slidably mounted upon a cross-bar 58 so that it can be moved relatively to its corresponding cam member 53 and 54. The switch boxes are moved by means of similar linkage systems. As illustrated, the system for controlling the position of the switch box 56 consists of a lever 59 pivotally connected at its lowermost end to a rear leg 41 of the table 40. A link 60 connects the switch box 56 to the lever 59. A link 61 at the upper end of the lever 59 is connected to a lever 62 that is pivotally supported adjacent its midportion at the rear of the table 40. This lever may include a supporting shaft 63 that extends from adjacent the switch box 56 to adjacent the left hand end of the table 40 as viewed in Figure 2. The upper end of the

lever 62 is connected by a link 64 to the slide block 31.

The switch box 57 is connected by a similar linkage to the slide block 31 that supports the right hand end of the shaft and is responsive to its movement.

The travel of the cams 50 and 51 is related to the movement of the sheet being processed in order to permit duplication of curvatures in successive sheets. Endwise movement of the cams 50 and 51 is accomplished by means of a cable 65 that is wound around a drum 66 on the end of the roll 14. The cable 65 is looped over suitable pulleys 67 and 68 and one flight thereof is connected to the cams 50 and 51 so that during rotation of the roll 14 the cams 50 and 51 are moved longitudinally.

The motors 27, 33 and 34 may be provided with plugging switches 69, 70 and 71 which cause the motors to stop immediately upon opening of any of the control switches. Such switches operate to reverse flow of current in the field of the motor, bringing the motor to a stop. Upon stoppage of the motor a relay cuts off the current supply so that reverse rotation of the motor will not take place. With this arrangement, extremely close control of the position of the roller 29 and operation of the motor 27 may be obtained.

In order to prevent accidental damage to the device, normally open limit switches 72, 73 may be mounted on each of the side members 16 and 17. These switches are connected in the motor circuits and when opened, deenergize the motors. The switches 72 and 73 may be opened by means of a contact ring 74 on each sleeve 47. When the contact ring 74 comes in engagement with a limit switch 72 or 73 at either end of its path of travel, the motor circuit is opened and the motor stops. If desired, limit switches 114, 115 may be used to stop the motor 27 to prevent overrun of the cams 50 and 51.

As illustrated diagrammatically in Figures 4 and 4a, the control circuit for the apparatus may be arranged to provide both manual and automatic control for the motors 27, 33 and 34, which are shown as constant speed motors.

The circuit includes a master control switch 81, having a contact 81a connected by a conductor 82 to the power line 80a of a three phase power supply. The switch blade 81b is connected by a conductor 83 to three contacts 84a, 84b and 84c of a manual control switch 84 having manually operated switch blades 84d, 84e and 84f. The switch 84 is provided further with contacts 84g, 84h and 84i. The contacts 84a and 84g and blade 84d form a normally open "forward" switch. The contacts 84b and 84h, and blade 84e form a normally open "reverse" switch and the contacts 84c, 84i and blade 84f form a "stop" switch, which is normally closed.

When the blade 84d is depressed and the master switch 81 is closed, a circuit is completed from the power supply line 80a, through conductor 82, contact 81a, blade 81b, conductor 83, contact 84a, blade 84d, contact 84g, conductor 85, solenoid 86a of relay 86, conductor 87, contact 88a of relay 88, blade 88b, contact 88c, conductor 89, to conductor 80c of the power supply lines. Passage of current through the solenoid 86a of relay 86 closes all of the normally open contacts thereof. Actuation of this relay completes a circuit for starting the motor 27 in a forward direction, as follows: Current passes from conductor 80c through conductors 90, 91 to the solenoid 69a

of the plugging switch 69, then through conductor 92 to the contacts 86b of relay 86 and the contact 93a of relay 93. Inasmuch as the contact 86b is connected to contact 86c by the now closed contact blade 86d, connection further is made to conductors 94, 95 to contact 96a of relay 96 through blade 96b, to contact 96c, then to contact 96d, blade 96e, contact 96f, conductor 97 to contact 86e, blade 86f and contact 86g, conductor 97a to the overload protector relay 98, conductor 99, contact 100a, blade 100b and contact 100c of relay 100, conductor 101 through solenoid 102a of relay 102 to the main conductor 80a, thereby actuating the relay 102 which connects the motor 27 to the lines 80a, 80b and 80c through the relay switches 102d, 102e and 102f and conductors 104, 105 and 106. At the same time the reversing shoe 69b of the plugging switch 69 is lifted out of contact with the motor shaft.

The motor 27 will continue to operate until stoppage is desired after the "forward" switch 84a, 84d and 84g is open inasmuch as the "stop" switch 84c, 84f and 84i forms a holding circuit for the solenoid 86a, as follows, main conductor 80a, switch 81, conductor 83, contact 84c, blade 84f, contact 84i, conductor 104, conductor 105, contact 86h, blade 86i, contact 86j, solenoid 86a, conductor 87, contacts 88a and 88c, conductor 89 to main conductor 80c. The solenoid 86a will remain energized until the "stop" switch is opened, thereby breaking the circuit and deenergizing solenoid 102a of the forward motor control relay 102.

For reverse operation of motor 27, a similar circuit is provided. When the main control switch 81 is closed, a circuit is completed from main conductor 80a through the switch 81. Upon actuation of "reverse" switch 84b, 84e and 84h, current flows from contact 84h, through conductor 107 to the solenoid 93b of relay 93, conductor 108, contact 109a of relay 109, contact 109c, conductor 110, conductor 89 to main conductor 80c, thereby closing relay 93. When relay 93 closes, a circuit is completed through the solenoid 69a to pick up the shoe 69b of plugging switch 69 and energize the solenoid 100d of the relay 100 to energize the motor 27 for reverse operation. This circuit is as follows from mains conductor 80c, conductors 90, 91, solenoid 69a, conductor 92, contact 93a, contact 93d, conductor 95, contact 96a, blade 96b, contacts 96c, 96d, blade 96e, contact 96f, conductor 97, contact 93f, contact 93h, conductor 111, overload protector relay 112, conductor 113, contacts 102b, contact 102c, conductor 113a, solenoid 100d to mains conductor 80a. The motor 27 is thus connected to the mains 80a, 80b and 80c through the relay switches 100e, 100f and 100g and the lines 104, 105 and 106, with the connections reversed with respect to the connection through the relay 102.

The "stop" switch 84c, 84f and 84i forms a holding circuit similar to that described above for reverse rotation of the motor 27.

If desired, the apparatus may be provided with limit switches 114 and 115 for controlling the movement of the rolls 14 and 15, the motor 27 and the movement of the cams 50 and 51.

The limit switches 114 and 115 are double contact switches that are normally open and may be moved to closed positions by cam lobes (not shown) on the cams 50, 51, or by engagement with the cams 50, 51, at opposite ends of their path of travel. The connections of the switch 114 are as follows: conductors 80c, 90, 116 to con-

tacts 114a and 115b, contact 114b, conductor 117, solenoid 109d of relay 109, conductor 118 to contact 84c, switch 81 and to mains conductor 80a. When the switch 114 is opened, therefore, the relay 109 is deenergized closing the circuit between contacts 109a and 109c and completing the circuit through the solenoid 93b of reverse relay 93. Opening the circuit between contacts 109a and 109c by closing switch 114 deenergizes the solenoid 93b and opens the circuit to motor control relay 100.

Similarly, the contact 115c of forward limit switch 115 is connected by conductor 119 through solenoid 88d of forward relay 88 to conductor 118 and contact 84c of the "stop" switch. Therefore, when the switch 115 is closed, the solenoid 88d is deenergized, opening the circuits through the relay 86 and stopping the motor 27.

In order to bring the motor 27 to an almost immediate stop, the plugging switch 69 is provided with two pairs of contacts 69c, 69d, 69e and 69f and a shiftable blade 69g that is moved by means of the shoe 69b by engagement with motor shaft 27a upon deenergization of the solenoid 69a. The contacts 69c and 69e are connected by conductor 120 to the main conductor 80c by the conductors 90 and 91. The contacts 69d and 69f are connected respectively to the solenoids 100d and 102a by the conductors 121 and 122. Inasmuch as the opposite ends of the solenoids 100b and 102a are connected to the mains conductor 80a, a circuit will be completed through one of the solenoids when the blade 69g is moved by rotation of the motor 27. This arrangement is such that the motor is reversed automatically and brought to a standstill when the blade 69g engages and then disengages the sets of contacts 69c, 69f and 69e, 69d.

The controls for the motors 33 and 34 may be either manually operated or automatic. The automatic control is obtained by means of the cam controlled switches in the switch boxes 56 and 57 as will be described now. The switch for controlling the motor 33 includes two double throw blades 56b and 56c, blade 56b cooperating with four contacts 56d, 56e, 56f and 56g. Contact 56d is connected by conductor 123 through a lag switch LS to the blade 124a of a three position switch 124 that is used to set the device for hand or automatic operation. The blade 124a also is connected by conductors 125 and 82 to mains conductor 80a. Contact 56e is connected to conductor 126, solenoid 96g of relay 96 and then by conductor 127 to mains conductor 80c, thereby actuating relay 96 when the circuit is completed through contacts 56d, 56e, and blade 56b, and switch LS is closed, to stop the motor 27, without, however, deenergizing the solenoids of the relays 86 and 93. When the switch LS is open the relay 96 is, of course, not affected by action of the switch 56.

The contacts 56h and 56i that cooperate with the blade 56c are connected to conductors 123 and 126, respectively, and act in the same manner as contacts 56d and 56e.

The contacts 56g and 56k are connected by conductor 128 to one side of the solenoid 129a of the relay 129, then to conductor 130 to contact 124b of the switch 124. The other side of the solenoid 129a is connected to the conductor 127 and to mains conductor 80c. Thus when the switch blade 124a engages contact 124b in "automatic" position, the solenoid 129a is energized and all contacts thereof are closed.

The switch contact 56f is connected by con-

ductor 131 to upper contact 129b and when the relay 129 is actuated to closed position, a circuit is completed from contact 129c through conductor 132, solenoid 133a of relay 133, conductor 134, contact 135a of normally closed limit switch 135, contact 135b and conductor 136 and 90 to mains conductor 80c. As a result, when the contacts 56f and 56g are closed, the solenoid 133a is energized, closing all of the contacts thereon. When this relay is closed, a circuit is completed from mains conductor 80a through conductors 82, 137, contacts 133b, 133c, conductor 138, relay solenoid 139a, conductor 140, contact 141a of reversing relay 141, contact 141b, conductor 142, overload protector relay 143, conductor 144 to mains conductor 80c thereby closing motor control relay 139 for motor 33 and starting the motor 33 in a forward direction. The solenoid 70a of plugging switch 70 is simultaneously energized as follows: mains 80a, conductor 127, contacts 133d, and 133e, conductor 145, solenoid 70a, conductors 146, 90 to mains 80c.

The contacts 56k and 56j are used for actuating the motor 33 in a reverse direction as follows: Contact 56k is connected to conductor 128, and to the contact 124b of switch 124 as described above so that power is supplied from conductor 80a to contact 56k. When the switch-blade 56c closes contacts 56j and 56k, power flows from 56j through conductor 148 to contact 129d, contact 129e, conductor 149 to solenoid 150a of reversing relay 150, conductor 151, normally closed limit stop switch 152, conductors 136 and 90 to mains 80c, thereby closing relay 150. When relay 150 closes, the following connections are made: mains 80a, conductor 137, contacts 150b, 150c of relay 150, conductor 145, plugging switch solenoid 70a, conductors 146, 90 to mains 80c thereby energizing the solenoid 70a. Simultaneously, the motor 33 is started in "reverse" as follows: mains 80a, conductor 137, contacts 150d and 150e, conductor 154, solenoid 141c of reversing relay 141, conductor 156, closed contacts 139b and 139c of "forward" relay 139, overload protector relay 157, conductor 144 to mains 80c thereby actuating relay 155 and connecting the motor 33 to the mains.

In order to bring the motor 33 to a quick stop, the contacts 70b, 70c, 70d and 70e of the plugging switch 70 are used in conjunction with the motor controlled shiftable contactor 70f. The contacts 70d and 70e are connected by a conductor 158 to the mains conductor 80a. Contact 70b is connected by conductor 159 to solenoid 139a, conductor 140, contacts 141a, 141b, conductor 142, overload protection relay 143 and conductor 144 to mains conductor 80c. Similarly, contact 70c is connected by conductor 161, to solenoid 141c, conductor 156, contacts 139b and 139c of motor reverse relay 139, overload protector relay 157 and conductor 144 to mains conductor 80c. The operation of plugging switch 70, therefore, is the same as that of the plugging switch 69, described above.

The operation of the motor 34 and the circuits therefor, for the cooperating plugging switch 71 and the motor control switches 57 are identical with those described for motor 33 with the exception that a different set of relays 165 and 166 are used for controlling the solenoid of the plugging switch 71 and the forward and reverse motor relays 167 and 168.

If desired, the automatic controls for the motors 33 and 34 need not be used and manual con-

trol of these motors obtained. In order to control the motors 33 and 34, additional forward and reverse switches are provided. Inasmuch as these manually actuated switches and their circuits are the same, only one set will be described, as used with the motor 33.

The "forward" switch 170 and the "reverse" switch 171 each has a contact 170a and 171a connected to contact 124c of the selector switch 124 and thus may be connected to the mains 80a through switch 124. Contact 170b of forward switch 170 is connected by conductor 172 to contact 129c and to the conductor 132, the solenoid 133a of relay 133, conductor 134, limit switch 135 and to mains 80c, thereby closing the forward control relay 133 and energizing the plugging switch solenoid 70a and the "forward" power relay 139 as described above. The relay 129 is not closed inasmuch as the switch 124 is not in "automatic" position and the connection to contact 129c is, therefore, an open circuit.

Similarly, the contact 171b is connected by conductor 175 to conductor 149, solenoid 150a of reverse control relay 150, conductor 151 to limit switch 152 and to the mains conductor 80c. Thus, when switch 171 is closed, and switch 124 is in "manual" position, the motor 33 is operated in reverse and the plugging switch solenoid 70a is energized.

Switches 176 and 177 are provided for manually controlling the motor 34 in the same way.

The device may be provided further with an automatic reversing circuit for returning the cams 50, 51 to starting position. This circuit includes a switch 190 having a blade 190a connected to the switch 124 and having a contact 190b connected through conductor 191 to contact 88e of relay 88. Opposite contact 88f is connected by the conductor 192 to conductor 107 and thus to the solenoid 93b of relay 93 so that when the relay 88 is actuated to open position by closing of the limit switch 115, the relay 93 is actuated to reverse the motor 27 and return it and the cams 50 and 51 to starting position. When the switch 190 is open, the motor 27 merely stops at limit position of the cams 50 and 51.

It will be understood that the system may be provided with suitable signalling means, such as lights, to indicate the condition of the system. Such signalling lamps are illustrated in Figure 4, but they will not be described as they are not necessary to effective functioning of the system and apparatus.

In operation, cams 50 and 51 of suitable contour are connected to the cable 65, the sheet is threaded between the rolls 14 and 15 and the roll 29 is adjusted into the desired position. The motor 27 is then started by closing switches 81 and contacts 84a and 84g and the cams 50 and 51 begin to move lengthwise of the cam table 52. With the switch 124 in "automatic" position the undulations or offset portions of the cams 50 and 51 deflect the cam member 53 and/or 54 to actuate the switches in the switch boxes 56 and/or 57 to cause the motors 33 and 34 to operate to advance or retract the roll 29. As the roller 29 moves, the linkage system between the slide blocks 32 and the switch boxes 56 and 57 are actuated to move the switch boxes relatively to the cam members 53 or 54. Depending upon the extent of the displacement of the cam members 53 and 54 by the cams 50 and 51, the motors 33 and 34 will continue to operate until all of the switches in the switch boxes 56 and 57 are open, thereby discontinuing operation of the motors 33 and 34. If the cam

members 53 or 54 are displaced to different extents, the motors 33 and 34 will operate for different lengths of time and the roller 29 may assume an angular position with respect to the rolls 14 and 15, thereby imparting a conical shape to the sheet of metal. Similarly, if the cam members 53 and 54 are displaced in the opposite direction by the cams 50 and 51, the motors 33 and 34 will be driven to displace the roller 29 toward the rollers 14 and 15, thereby imparting a sharper curvature or bend to the sheet undergoing treatment.

The limit switches cooperating with each of the motors 27, 33 and 34 prevent motion of the rolls beyond predetermined limits.

The lag switch LS is used to permit operation of the motors 33 and 34 for a large shift of the roller 29 relatively to the rolls 14 and 15 by momentarily stopping the motor 27 when the displacement of the cam members 53 and/or 54 is sufficient to close the upper contacts of the switches 56 and 57 as viewed in Figure 4 by throwing out the relay 96 and deenergizing the power control relays 100 and 102 for the motor 27. This condition remains until the switches 56 and 57 open and the motor 27 is energized again.

From the foregoing description, it will be clear that a device has been provided by means of which controlled bending of sheets of metal may be accomplished easily, that the curvature of the sheet of metal may be varied widely, that complex curvatures may be imparted to the sheet from end to end and from edge to edge under close and accurate control so that individual or duplicate sheets of widely varying shape may be readily produced.

While the preferred form of the device is disclosed herein, it will be understood that the device may be modified in a great many of its details such as, for example, in the arrangement of the specific driving mechanism for the rolls, in the mechanism for adjusting the position of the adjustable roll, and in the contour, size and shape of the cams, without departing from the invention. Therefore, the form of the invention disclosed herein should be considered as illustrative and not as limiting the scope of the following claims.

We claim:

1. A metal bending device comprising a pair of parallel driven rolls for advancing a sheet of metal, cam means movable in response to rotation of said rolls, a third roll adjacent to said pair of rolls, a means at and for moving each end of said third roll selectively toward and away from said pair of rolls to vary the spacing and angular relationship between said third roll and said pair of rolls, a separate electric motor for actuating each of said means, switch means actuated by movement of said cams, and electrical connections between said switch means and said motor for moving said third roll in response to actuation of said switches by said cams.

2. The device set forth in claim 1 comprising means for supporting said switches for movement relatively to said cams, and means mechanically connecting said switches to said third roll to displace said switches relatively to said cams in proportion to the movement of said third roll.

3. A metal bending device comprising a pair of motor driven rolls for advancing a sheet of metal, a third shiftable roll, a pair of reversible electric motors, means connecting each of said

motors to a different end of said third roll to shift the latter toward and away from said pair of rolls and angularly with respect thereto, switch means electrically connected to each of said motors for actuating said motors selectively in a forward and a reverse direction to advance and retract the ends of the third roll selectively, and cam means movable in response to rotation of said pair of rolls for actuating said switch means to adjust the third roll relatively to said pair of rolls.

4. A metal bending device comprising a pair of rolls for advancing a sheet of metal, a reversible electric motor for actuating at least one of said rolls, a third roll shiftable toward and away from said pair of rolls, a second reversible electric motor for shifting one end of said third roll, a third reversible electric motor for shifting the other end of said third roll, a first switch box mechanically connected to the end of said third roll shifted by said second motor and shiftable in response to shifting movement of said third

roll, a second shiftable switch box connected to and shiftable with the end of the third roll shifted by said third motor, a pair of switches in said first switch box, one of said switches having contacts electrically connected to said first motor for stopping the latter when closed and other contacts electrically connected to the second motor to drive the motor in forward direction, when closed, the other switch having contacts electrically connected to said first motor for stopping said first motor when closed, and other contacts for causing said second motor to operate in reverse, when closed, switches in said second switch box, connected similarly to said first motor and said third motor, movable switch actuating cams associated with said first and second switch boxes to control the operation of said motors, and cam means movable in response to movement of said pair of rolls for moving said switch actuating cams.

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