The present invention relates to a plate-bending roll for steel plates and the like hereinafter referred to as the workpiece. More particularly the present invention relates to a device for shaping and controlling processes for the plating, i.e., automatically manufacturing cylindrical or tubular bodies of a cross-sectional shape composed of more than two continuous arcs.

ABSTRACT OF THE DISCLOSURE

What is characterized by the present invention lies with the fact that the automatic control system for the delivery amount of a worked piece and the elevation amount of the bending rolls is effected by means of a limit switch group for starting the delivery rolls as well as the bending rolls which are provided so as to work successively following up (synchronously with) the movement of the delivery rolls and the bending rolls and so as to freely regulate the operational periods; and that the setting of each curvature in conformity with the cross section of a worked piece may be carried out by freely regulating the operational periods of the said limit switch group.

Other features of the present invention reside in that: the said automatic control system for the delivery amount of a worked piece and the elevational amount of the bending rolls is further provided with a group of limit switches for starting the drive source of the bending rolls variable of the operational positions (periods) so as to follow up the delivery of the worked piece and successively operate; further provision is made in such a manner that a group of limit switches for controlling the elevation of the bending rolls variable of the operational positions (periods) is operated synchronously with the elevation of the bending rolls; by these provisions, the elevational control of the bending rolls that have been so arranged as to be driven from the drive source through a stepless speed-change gear may be carried out, and thus a specified shape of worked pieces may be automatically formed by determining the curvature of each arc of a cross sectional shape composed of one or more continuous arcs.

Another feature of the present invention is found to lie in the mechanism that the elevation as well as the end bending of the front roll used solely for the end bending of worked pieces may be automatically carried out, and, after the end bending is completely finished, the end bending work thenceforth may automatically set out.

Now, as regards the foregoing numerous features of the present invention, preferred exemplary embodiments of the same will be illustrated in details with reference to the drawings, in which:

FIG. 1 is a partial schematic view of the apparatus for the bending of a workpiece into an elliptical formation showing a preferred example of the present invention;

FIG. 2 and FIG. 3 are illustrative views of the bending of a work piece by the present apparatus;

FIG. 4 is a partial plan view showing a modified form of the automatic control system for operation of the present invention;

FIG. 5 is an enlarged detail view taken on the line V—V of FIG. 4; and

FIG. 6 is an illustrative view showing the relationship between the rolls and the limit switches of the system of FIG. 4.

The object of the present invention will be clearly understood from the following detailed disclosure with reference to the appended drawings, in which:

In FIG. 1 the delivery rolls for the work piece 3 consist of the upper roll 1 and the lower roll 2. The said rolls 1 and 2 rotate in opposite directions and at the same peripheral velocity upon being driven by a gear group housed within the housing 4. Thus the work piece 3 is moved when the device is operated.

The rear roll 5 so arranged, as is shown in FIGS. 2 and 3, that it elevates up and down in the direction of the straight line A—B forming a specified angle to the straight line A—A and that front roll 6, used solely for the end bending operation for the work piece 3, elevate in the
direction of the straight line C-C forming a specified angle against the straight line A-A and is fitted on the opposite side of said rear roll 5. 7 is the elevation shaft of rear roll 5 and has one end secured to the rear roll 5 and its other end supported by the elevator 8. Said shaft 7 is driven by the driving shaft 11 connected through the stepless speed-change gear 10 to the drive source 9, and is elevated in the direction of the straight line A-B. The driving shaft 11 is provided with the screw portion 12, which in threaded engagement with the cam 15 for operating the upper-limit switch 13 and the lower-limit switch 14 of the rear roll 5. Said cam 15 is provided with a guide piece (not shown in the drawings) so that it may move along the axial direction of the driving shaft 11 upon the rotation of said driving shaft. The said upper and lower-limit switches 13 and 14 are mounted on the adjusting screw shaft 16 for changing their positions in relation with the position of said cam 15 so as to freely regulate the upper-limit or lower-limit operation positions or periods respectively, thus making it possible to provide any kind of shaping of the work piece such as elliptical forms and the like.

17 and 18 are limited switches for starting upward the rear-roll elevation drive source 9 and 19 and 20 are limit switches for starting downward the elevator driven by the rear-roll elevation drive source 9. These limit switches have been mounted on the adjusting screw shaft 21 and 22 so as to have the respective operational positions or periods freely adjustable and further have been arranged in parallel with the screw shaft 24 of the cam 23 for operating said limit switch group. Both ends of the rotation shaft 24 are connected by way of the clutches 25 and 26, respectively, with the driving shaft 27 extending from the housing 4 and with the transmission shaft 29 of the drive source 28 for the zero-point return of the cam 23.

Further, 30 is the drive source for the front roll 6 through the elevator 32 and the advancing shaft 31 which has one end fixed to the front roll 6 and is driven by the driving shaft 34 from the said drive source 30 through the gear box 33 or this may be a stepless speed-change gear. Said driving shaft 34 is provided with the screw portion 35, which is in threaded engagement with the cam 38 for the operation of starting of the front roll as well as the operation of the control limit switches 36 and 37 of the delivery rolls 1 and 2, and said limit switches are mounted on the adjusting screw shaft 39 so as to make their respective positions variable relative to the positions of the cam 38. In addition, the cam 38 has been constrained by a guide piece (not shown in the drawings) so as to move along the axial direction of the driving shaft 34.

40 is a limit switch which is for simultaneously carrying out the descent step of the front roll 6 and is devised so as to operate according to the specified delivery rate of work piece 3 and the stopping of the upper and lower delivery rolls 1 and 2 and also the throw-in of the clutch 25. 40a is a projection on the workpiece for operating the limit switch 40a and is secured to the position corresponding to the end-bending length on one side of the work piece 3.

Now, the operational steps will be described for the shaping of a tubular material having an approximate-elliptical cross section by a device in accordance with the present invention:

In the first place the limit switches 13, 14, 17, 18, 19, 20, 36, 37, and 40 must have been adjusted to positions where a specified cross-sectional form of work piece will be shaped. An edge of a work piece 3 is placed by hydraulic means or some other mechanism (not shown) between the delivery rolls 1 and 2 in a securely pinched condition, and the drive source 30 of the front roll 6 is started by a push-button control so as to begin the bending work. Then, as the front roll 6 starts to elevate and operates to bend the work piece as is shown in FIG. 3, and it stops elevating when the cam 38 shifts as the driving shaft 34 rotates, so that the limit switch 36 is placed in action, and at the same time the upper and lower delivery rolls 1 and 2 are operated so that the work piece 3 will be also being bent. And when the projection 40b puts the limit switch 40a into action, the delivery rolls 1 and 2 come to a stop and the end-bending work thus come to an end.

Whereas, when the front roll 6 starts to descent at the same time the delivery rolls 1 and 2 come to a stop and the cam 38 and the limit switch 37 in action, the front roll 6 will come to a stop and also the rotation shaft 24 will start to rotate starting the upper and lower delivery rolls 1 and 2 at the same time the clutch 25 is thrown in, and by the said starting will advance of the process into the succeeding main stage; and in addition, the clutch 26 is operated in use of the cam 23 which as the rotation shaft 24 rotates, so as to activate the limit switch 17 and will start the drive source 9 so as to elevate the rear roll 5. At this instant the workpiece 3 is delivered while also being bent, and the smooth shaping thereof may be achieved on the connection of the greater-diameter portion and the smaller-diameter portion of an approximate ellipse. The cam 15 will then move rightward as the driving shaft 12 rotates and said cam 15 will put the limit switch 13 in action, when the rear roll 5 comes to a stop and arcs of a certain curvature are shaped in account of the delivery of the workpiece 3 by the rotation of the delivery rolls 1 and 2.

The cam 23 thenceforward puts the limit switch 19 in action, when a reverse starting of the drive source 9 is carried out and the rear roll 5 starts to lower, so that the formation of a next connection of the smaller-diameter portion and the greater-diameter portion begins. Then, when the cam 23 rotates and its descent upon operation of the limit switch 14 by the movement of the cam 15 to the left. For forming the connection turns in the shaping of an arciform portion of a certain curvature; the limit switch 18 is activated by the cam 23 so as to start the elevation of the rear roll 5 and again a next arciform shaping of the connection of the greater diameter and the smaller diameter comes into effect; the cam 15 again shifts to the right so as to put the limit switch 13 in action, when the rear roll 5 comes to a stop and the shaping of a next arc of a certain curvature takes its turn; the cam 23 activates the limit switch 20 so that the rear roll 5 again is lowered, then the shaping of the last arciform connection of the smaller diameter and the greater diameter is effected. When the cam 15 shifts to the left and the limit switch 14 is activated, the shaping of the last arc of a certain curvature is carried out by delivery of the workpiece 3 so as to complete the shaping so as to move along the axial direction of the driving shaft 34.

In this way, each stage of the process is finished automatically and any specified cross-sectional shape is obtainable subsequent to the starting of the bending process of elliptical formation primarily by means of push-button control.

Furthermore, the end-bending work of any desired curvature may be possible, automatically and reliably, if and when the setting of the respective operational positions of the limit switches 36, 37, and 40 has been preliminarily carried out by end-bending dimension, and the like in accordance with the cross-sectional curvature of the workpiece. Consequently it is needless to say that the device of the present invention is fitted to what is described above in the case of the three rolls and the upper and lower delivery rolls and the rear roll in the case the end-bending operation is carried out by a different machine used exclusively therefor, and it is as well possible that the front roll 6 can be manually operated as has been conventionally done, even by a bending machine composed of four rolls, so that there is that a wide range of use of the present invention.

In the present invention, moreover, it is possible to
choose an elevational velocity of the bending rolls freely and steplessly so that smooth curved surfaces may be shaped without giving rise to a collapsed portion by virtue of having a stepless speed-change gear interposed between the driving shaft and the drive source of the elevator for the bending rolls that is the front roll and rear roll.

Now the second embodiment of the present invention will be described in reference to FIGS. 4, 5 and 6 as follows:

The delivery rolls for the workpiece 3 is entirely similar to that of the foregoing embodiment. That is to say the upper roll 1 and the lower roll 2 are so arranged that the rotational force is transmitted by a gear group located within the housing 4 and they rotate mutually in the opposite directions and at the same peripheral velocity so that the workpiece 3 may be conveyed. The bending roll 5b is also so arranged as to elevate in the direction of the straight line A—A forming a specific angle to the straight line A—A as shown in FIG. 6 and is moved and controlled by a hydraulic means or the like so that workpiece may be bent into a cylinder or pipe of a specified cross-sectional shape. It is so devised that the rotational control of the upper roll 1 and the control of the speed of the delivery of the workpiece 3 is carried out by means of the roll-driving control device 41, and the control of elevation of the bending roll 5b is as well carried out through said control device 41 by controlling a hydraulic circuit (not shown in the drawings) for driving the bending roll 5b.

The aforementioned control device 41 is so composed that the limit switches 47, 48, 49, and 50 are activated by means of the cans 43, 44, 45 and 46 having a specified shape and secured to the cam shaft 42.

The limit switches 47, 48, 49 and 50, furthermore, are so arranged that they are respectively secured to the larger bevel gears 51, 52, 53, and 54 and can be adjustable to the zero-point adjustment of the automatic control system is carried out. Thereafter the restriction handles 59—62 are rotated and thereby the operational position of each of the limit switches 47—50 is set so as to correspond to the arc circumference of the curved surface of a specific cross-sectional workpiece with the home point of each of the cans 43—46 as reference. Further the rotation number of the cam shaft 42 is regulated by means of the stepless speed-change gear 70 and the operational positions of the limit switches 63—66 are also regulated and thus the setting for a specified cross-sectional shape is finished. Further, the speed of rotation of the rolls 1 and 2, the work piece 3 is delivered forth onto the bending roll 5b as far as the required distance when the cam 43 puts the limit switch 47 in action so as to make the rolls 1 and 2 stop or lower in speed, so that the bending roll 5b starts to elevate and it will come to a stop after, for instance, the limit switch 65 has been activated. A curved surface, one arc, of the work piece 3 will be formed during this process. With the stop of the bending roll 5b, the rolls 1 and 2 come into an ordinary delivery speed from the halt or lower-speed condition to carry out the delivery of the work piece 3, activating successive limit switches 48—50 and 64—66, thus ending in the completion of the bending process.

By virtue of the aforementioned operation, any finished shape of the cross-section of work pieces 3, such as true circle, approximate ellipse and the like, even any profile consisting of continuous arcs, may be preferred and determined freely by properly setting the operational positions of the limit switches of any desired number provided for specified respective objectives and further by regulating the rotation speed of the cam shaft 42 through the stepless speed-change gear 70. Accordingly, cylinders or pipes of any desired cross-sectional shapes may be formed automatically by setting, as the foregoing description has said, the shapes of cross-section preliminarily.

Such being the present invention, the operation of the present device is capable of manufacturing, automatically, articles with high precision having exact and smooth curved surfaces with any cross-sectional shape composed of continuous arcs. Said device as a whole being simple and low in cost and almost free from trouble and therefore very economical, so that it will contribute tremendously to the reduction of production costs, to say nothing of its working efficiency, and thus much can be expected from its availability.

We claim:
1. In a plate-bending roll for steel plates and the like comprising a pair of superposed workpiece delivery rolls, means for rotating said rolls in opposite directions, a front roll, a rear roll, means for moving said front and rear rolls each on a straight line having a specified angle to the straight line connecting both axes of said delivery rolls, a workpiece end-bending control device characterized by an elevating shaft supporting said front roll, an elevator for elevating said elevating shaft, a driven shaft for operating said elevator and having a threaded portion, a cam in threaded engagement with said driven shaft threaded portion, adjustable limit switches controlling said rotating means and said driven shaft for elevating and stopping said front roll and starting said delivery rolls, further adjustable limit switches also controlling said rotating means and said driven shaft for elevating and stopping said front roll and starting said delivery rolls, further adjustable limit switches being arranged so as to be activated upon the moving of said cam along said driven shaft upon the rotation of said driven shaft, and limit switches positioned alongside the workpiece for temporarily stopping the rotating means for said delivery rolls, and arranged as to be activated according to any set initial portion of the workpiece.

2. A plate-bending roll for steel plates and the like.
comprising a pair of superposed workpiece delivery rolls, means for rotating said rolls in opposite directions, bending rolls, means for elevating said bending rolls each on a straight line having a specified angle to the straight line connecting the both axes of the said delivery rolls, adjustable means for automatically controlling the initial amount of delivery of the workpiece as well as the amount of elevation of the bending rolls, and automatically carrying out a specified series of bending operations on the workpiece, by presetting the desired curvature of each of the one or more continuous arcs, by relating amount of delivery of the workpiece to said amount of elevation.

3. In a plate-bending roll for steel plates and the like so devised as to automatically carry out specified bending of a workpiece by controlling the delivery amount of the workpiece and the amount of elevation of bending rolls, an automatic control system for carrying out this operation comprising a pair of superposed workpiece delivery rolls, means for rotating said rolls in opposite directions, bending rolls, means for elevating said bending rolls on a straight line having a desired angle to the straight line connecting both axes of said delivery rolls, a limit switch group for controlling said delivery rolls and said bending rolls adjustably mounted so as to have their respective operational positions freely adjustable, said limit switch group being arranged so as to be successively activated synchronously with the movement of said delivery rolls, and determining the curvature of each arc of a cross section, composed of one or more continuous arcs of the workpiece by regulating the operational positions of said limit switch group.

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