April 6, 1943. R. CONNOR 2,316,049

MACHINE FOR BENDING PIPES AND THE LIKE

Filed Dec. 7, 1940 2 Sheets-Sheet 1

Fig. 1.

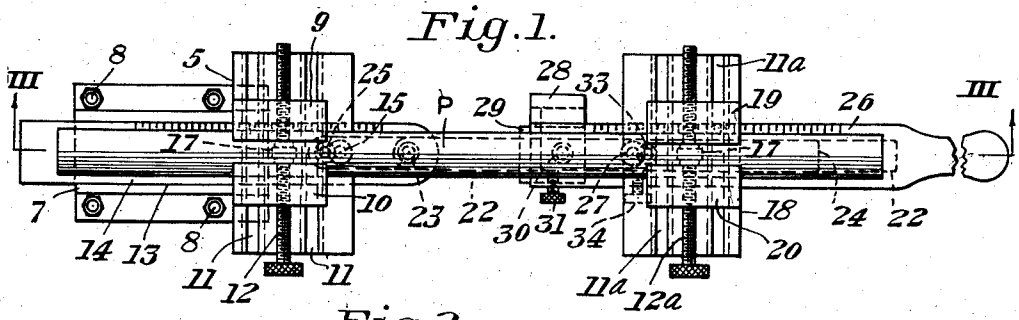


Fig. 2.

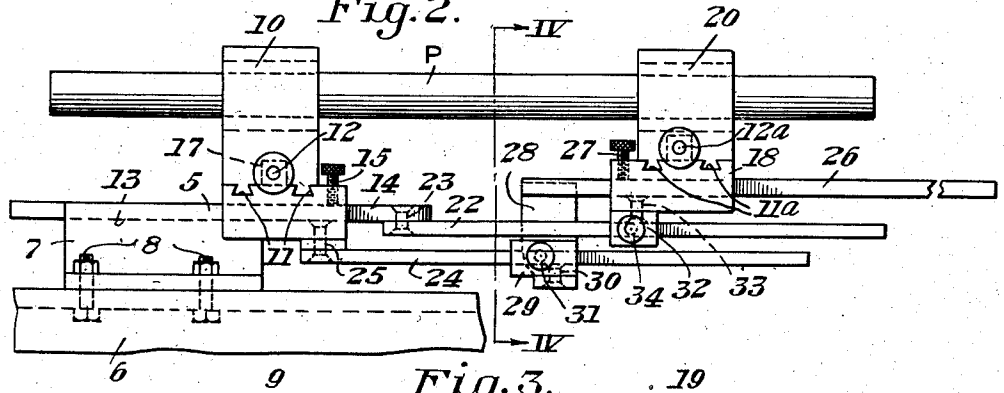


Fig. 3.

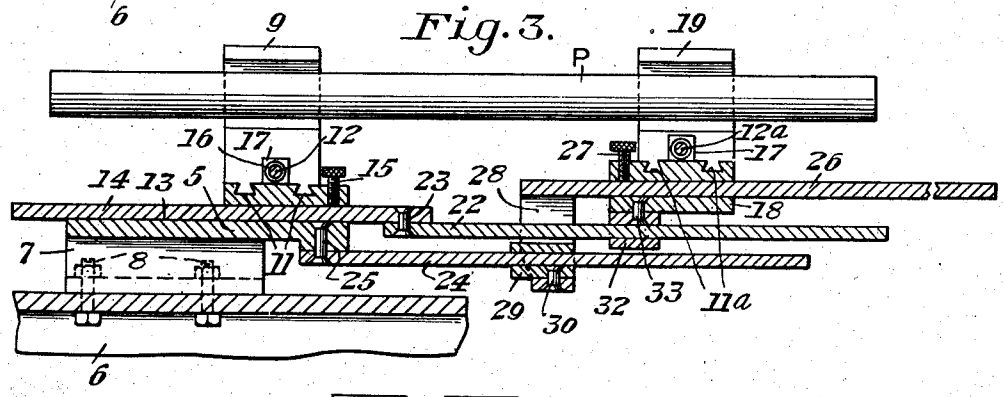
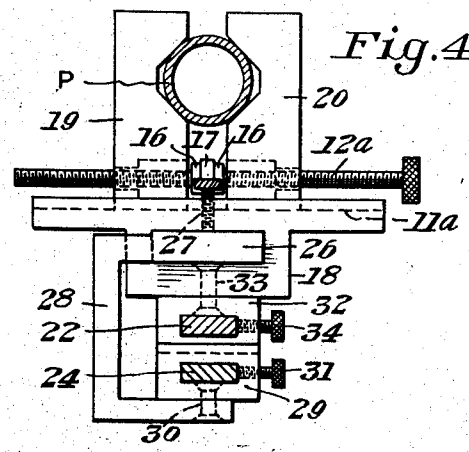


Fig. 4.



INVENTOR
Richard Connor
W. G. Doolittle
Attorney

April 6, 1943. R. CONNOR 2,316,049

MACHINE FOR BENDING PIPES AND THE LIKE

Filed Dec. 7, 1940 2 Sheets-Sheet 2

Fig. 6.

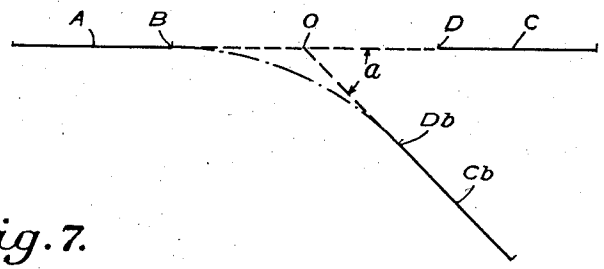


Fig. 7.

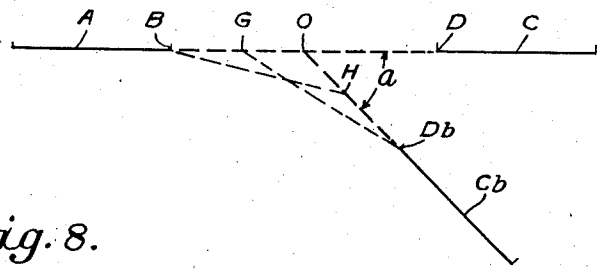


Fig. 8.

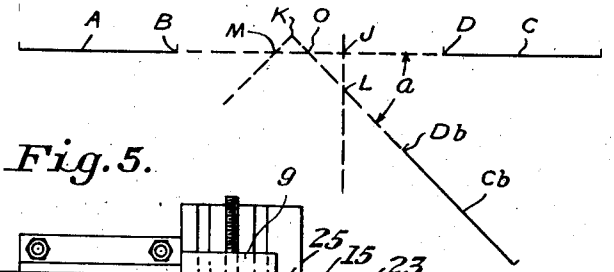
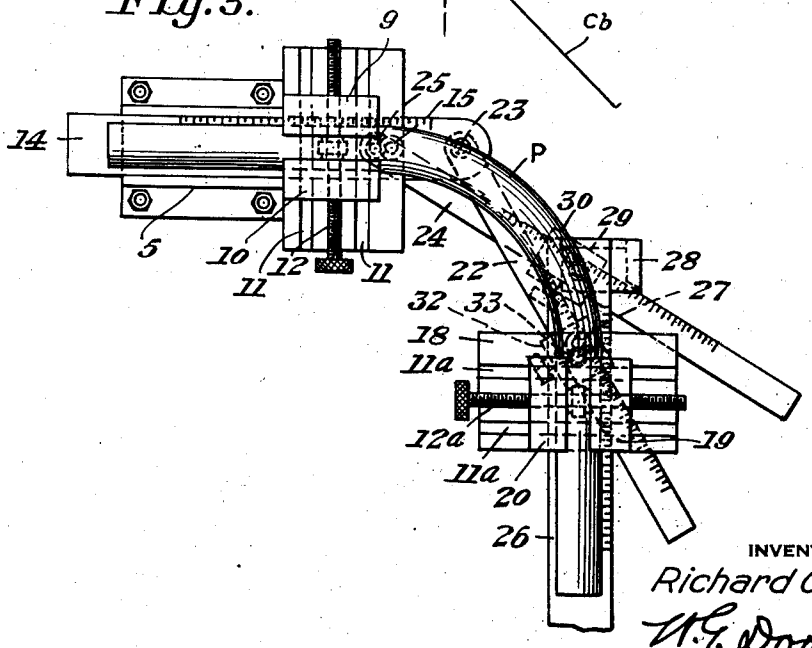


Fig. 5.



INVENTOR
Richard Connor
W. G. Dooliale
Attorney

Patented Apr. 6, 1943 2,316,049

UNITED STATES PATENT OFFICE

2,316,049

MACHINE FOR BENDING PIPES AND THE LIKE

Richard Connor, Steubenville, Ohio

Application December 7, 1940, Serial No. 368,985

9 Claims. (Cl. 153—39)

This invention relates to the art of bending pipes, tubes, rods and other shapes, and particularly to a new and improved apparatus that may be advantageously employed in practicing the method of bending contemplated by my invention.

A fundamental and characteristic feature of my invention resides in the discovery that, if the portions of material which are to lie adjacent to and become the tangents of the final bend are forced throughout the bending operation to maintain the same relative position to one another that they would, if the material were to uniformly change its shape from that of the original straight line to that of the desired arc of a circle, with the total length of arc remaining constant, and the radius of curvature at any instant being uniform throughout the length of the arc, then the material entering the bend will change its shape in the same manner, namely,—with constant length of curvature throughout the bending process and with uniform radius of curvature at any one instant.

My invention contemplates a new apparatus whereby the article to be bent is caused to change its shape from a straight line to the desired arc of a circle with constant length of arc throughout the bending operation and a uniform radius of curvature throughout the length of the arc at any one time, and without the employment of a form, die, or blocking shaped to the desired curvature. By following this procedure it facilitates the control of the dimensions of the bend and decreases to a minimum the tendency of the cross-section of the material to change in shape.

My invention further contemplates grasping and contacting the member to be bent only along the tangents of the curve of the arc to be formed, leaving the member or article free of engagement or contact with anything between the said tangent points, and, while thus held, performing a continuous bending operation.

Other objects of the present invention are; to provide in combination with means for supporting and holding the article to be bent into a predetermined curve, means and arrangement of parts for effecting a continuous bending action or operation throughout the bending of the pipes, etc., of various sizes and of various radii of curvature, without the necessity of the use of forms or dies or the necessity of inter-changing any of the parts entering into the apparatus.

In the accompanying drawings, which illustrate apparatus for carrying out my method of manufacture and diagrammatically illustrating the steps followed in practicing my method:

Fig. 1 is a plan view of apparatus embodying my invention;

Fig. 2, a side elevational view;

Fig. 3, a longitudinal sectional view taken on line III—III of Fig. 1;

Fig. 4, a horizontal sectional view taken on line IV—IV of Fig. 2;

Fig. 5, a plan view showing the position of the parts after the completion of bending of a pipe; and

Figs. 6, 7 and 8, diagrammatic views illustrating the methods followed in practicing my invention.

Referring first to the diagrammatic views, Figs. 6, 7 and 8:

In Fig. 6, A represents the line of the tangent here considered as fixed, and B designates the point of tangency between this tangent A and the arc to be formed. C represents the tangent here considered as moving while the material is in its original straight condition, and D the point of tangency between this tangent and the arc to be formed. C*b* and D*b* are successive positions of C and D respectively. Point O is the point of intersection of tangents A and C*b* prolonged.

If the arc between B and D*b* is to remain constant in length throughout the bending operation, and of uniform radius of curvature throughout its length at any instant during the operation, then it can be shown mathematically that distances B—O and O—D*b* will be equal to one another, and both equal in magnitude to

$$\frac{90\times\tan a/2}{a}$$

times the radius of the curve at a deflection of ninety degrees, where a is the angle of deflection represented by D—O—D*b*.

In Fig. 7, A, B, C, D, C*b*, D*b*, O, and a represent points, lines and values, corresponding to those indicated in Fig. 6. Point D*b* moves about point G, a point on tangent A prolonged, at a fixed distance from it. Point H is a point on tangent C*b* prolonged, moving about point B at a fixed distance from it. Then if distances B—G and D*b*—H are both equal to 0.4094 times the radius of a desired arc with a deflection of ninety degrees, and distances B—H and D*b*—G are both equal to 1.1614 times that same radius, distances B—O and D*b*—O will be equal to one another, and both equal in magnitude to

$$\left(0.2047+\frac{\sqrt{2.53+0.1676\times\cos a}}{2\sqrt{1+\cos a}}\right)$$

multiplied by the radius at a deflection of ninety degrees. If this equation is solved for various values of a between zero and ninety degrees, it

will be observed that the results obtained will be approximately the same as those found from the equation developed for Fig. 6.

In Fig. 8, A, B, C, D, C*b*, D*b*, O, and *a* again represent points, lines, and values corresponding to those indicated by them in Fig. 6. Point L is a point on tangent C*b* prolonged, which moves along a line perpendicular to tangent A and passing through point J, a point on tangent A prolonged. Point K is a point on tangent C*b* prolonged, moving so that a line passing through it, and perpendicular to tangent C*b*, will always pass through point M, a point on tangent A prolonged. Then if distances B—J and D*b*—K are both equal to the radius of an arc with a total deflection of ninety degrees, and distances B—M and D*b*—L are both equal to 0.5708 times that same radius, then distances B—O and D*b*O will be equal to one another and equal in magnitude to

$$\frac{1+0.5708\times\cos a}{1+\cos a}$$

multiplied by the radius of an arc with a deflection of ninety degrees. If this equation is solved for various values of *a* between zero and ninety degrees, it will be observed that the results obtained will be approximately the same as those found from the equation developed for Fig. 6.

Referring now to the apparatus shown by Figs. 1–5 these figures illustrate a structure embodying my invention.

As illustrated and as preferred, 5 designates a fixed bed structure or base designed to be supported upon suitable means as a bench or table 6. The bed 5 has a flanged depending portion 7 which is adapted to be secured to the table or bench by means of bolts 8 or other suitable means. Mounted on the bed 5 is a pair of adjustable article clamping jaws 9—10, each jaw at its lower end being formed to provide a dovetail connection with the base.

The bed is grooved transversely across its upper face to form guide-ways 11 to receive the dovetail construction of the article clamping or gripping-jaws. These jaws 9—10 are adapted to be moved in the guide-ways by means of a screw 12 anchored to the bed and designed to cooperate with threaded openings in the jaws; said screw has right and left-hand threads for effecting movements of the jaws towards and away from each other to open and closed positions. The bed is also provided with a slot 13 extending lengthwise of the bed and which is adapted to receive a slidable element 14 constituting an adjustable tangent arm; this element is provided with graduated scale markings and may be locked in the desired position by a set screw 15. Screw 12 is prevented from moving transversely of the bed or base by the employment of set collars 16, fastened to the screw and which are adapted to bear against a lug 17, said lug being attached to the grooved base and having a hole therein through which the screw passes.

Spaced from the bed structure 5 and designed to be movable towards and away from the stationary bed for adjustment of the device to the desired length of arc, and also mounted to swing to effect the desired motion of the moving tangent, is a movable bed or base structure 18. This movable bed carries a pair of jaws 19—20 mounted on and adjustable on the bed by means of a screw 12*a* having the right and left-hand threads and associated collars and a lug similar to the construction heretofore described in connection with the movable jaws carried by the fixed bed 5. In this structure a similar dove-tail connection between the lower end of the jaws and grooves or guide-ways 11*a* is employed.

Projecting forwardly from the movable bed 18 and connected near the outer end of element 14 is an adjustable bar or arm 22. This arm is connected to tangent element 14 by means of a pin 23 about which the arm 22 is free to swing with respect to the element 14. 24 designates a second adjustable bar or arm connected with the bed 5 by means of a pin 25 about which the arm is free to swing relatively to the bed 5, said pin 25 being located directly below and in line with the edges of jaws 9—10 positioned nearest to the bend to be made.

The movable bed 18 has an opening through which passes a tangent arm or lever 26, said lever 26 being free to slide in said opening when a clamping screw 27 is loosened, and held firmly in position when the clamping screw is tightened. At the end of the tangent arm 26, nearest to the bend to be made, and mounted thereon by means of a bracket extension 28, depending from arm 26, I provide a block 29 formed with an opening therein to receive the arm 24, said block being connected to bracket 28 by means of a pin 30, about which it is free to swing with respect to the arm 26. It will be understood that arm 24 is free to slide through the opening in the block 29 when a clamping screw 31 is loosened, and that said lever 24 is, after adjustment, firmly attached to the block by the said screw 31.

Secured to the under side of the movable bed 18 is a block 32, this block being connected to, and about which it is free to swing with respect to bed 18, by a pin 33. This pin 33 is located directly below and in line with the edges of the jaws 19—20 nearest to the bend to be made. Arm 22 is adjustable with respect to block 32, the block having an opening therein to receive the arm, said arm being adapted to be securely connected to the block and loosened therefrom by means of a screw 34.

It will be noted that the pins 23, 25, 30 and 33 are all located so as to be on the center line of the pipe P, or other article to be bent, when the said pipe etc. is in its original straight condition. Arms 14 and 26 and arms 22 and 24 are all provided with graduations to facilitate the setting of the various clamping screws to suit the desired length of bend to be made.

In the practice of my method in which apparatus of the character illustrated and described is employed, the several clamping screws 15, 27, 31 and 34 are adjusted to permit the desired positioning of the parts and cooperating elements to effect the predetermined bending action desired.

The desired position of the parts may be readily effected by sliding element 14 through the opening in bed 5 until the distance between pins 23 and 25 is equal to 0.4094 times the desired radius of bend at a deflection of ninety degrees, as indicated by the graduations on the fixed tangent arm 14, and then tightening screw 15 to securely maintain element 14 in fixed position. Afterwards, slide bed 18 together with block 32 along the arm 22 until the distance between pins 23 and 33 is equal to 1.1614 times the desired radius of bend at a deflection of ninety degrees, this being indicated by the graduations on arm 22, and tighten screw 34 securely.

When the clamps composed of jaws 9—10, and 19—20, respectively, are alined with one another

to receive a straight pipe, etc., the distance between their nearer edges will now be equal to the total length of arc of the bend to be made, or 1.5708 times the desired radius of bend at a deflection of ninety degrees. Now slide tangent arm or lever 26 through the opening in bed 18 until the distance between pins 30 and 33 is equal to the distance between pins 23 and 25. This movement will also make the distance between pins 25 and 30 equal to the distance between pins 23 and 33. Tighten screws 27 and 31 after which the apparatus is ready to receive the object to be bent.

Place the pipe, tube or other article between the jaws and tighten these clamps securely by turning the screws 12 and 12a. Application of a sufficient force, either manual or mechanical, at the far end of the lever 26 will create a bending moment in the material to be bent, and the plurality of arms hereinabove described will force the material positioned between the clamps to bend into the desired arc, while free and out of contact with any parts.

For bends of less than ninety degrees deflection, the settings of the effective lengths of the arms will be made accordingly. For example, if a bend is to be made with a radius of twelve inches and a deflection of forty five degrees, make the same settings as would be made for a bend with a radius of six inches and a deflection of ninety degrees, and stop the bending operation or action when a deflection of forty five degrees is reached.

It will also be noted that the pipe or other article being bent under my method is entirely free of contact or engagement with any part or element between the predetermined tangent points of the final bend throughout the continuous bending operation or action. The desired shaping of the arc is achieved by the tendency of the material to follow the path of least resistance to the applied bending moment, under the controlled action of the tangent arms in cooperation with the arms 22 and 24.

Attention is particularly called to the fact that with the use of an apparatus of the character illustrated and described, once the proper settings are made, nothing further is necessary to be done to control the radius of the final bend. Furthermore, the distance from one end of the pipe, etc., to the intersection with the tangent of the other end in the finished bend is definitely and accurately controlled, a feature, so far as I am aware, not embodied in any prior bending apparatus.

Another advantage is that the material will assume a smooth and even curve without flat spots and with a minimum of distortion of its cross section. A still further advantage is the simplicity with which the apparatus can be adjusted to obtain any desired radius of bend within the limits for which it is designed.

While I have illustrated and described a simple and efficient apparatus for bending pipe and the like, various changes and modifications in the apparatus may be made, thus, the power for operating may be furnished by the pull of a cable or the apparatus may be powered by means of a jack or piston associated therewith.

What I claim is:

1. In a pipe or the like bending apparatus, spaced apart clamping means for gripping and holding a straight member to be bent only along the portions of material that are to become the tangents of the curve of the arc to be formed, and linkage means cooperating with and pivoted to both of the clamping means free of contact with said member throughout the distance between said clamping means and guiding the clamping means into the relative motion they would have were the material entering the bend to bend with constant length of arc throughout the bending operation and with a uniform radius of curvature throughout the length of the arc at any instant regardless of any reaction developed by the member being bent.

2. In a pipe or the like bending apparatus, spaced apart clamping means for gripping and holding a straight member to be bent only along the portions of material that are to become the tangents of the curve of the arc to be formed, and means cooperating with and pivoted to each of the clamping means and free of contact with said member throughout the distance between said clamping means for controlling the motion of the clamping means so that, regardless of any reaction developed by the member being bent, they will be forced throughout the bending of the member to so move that the length of a circular arc tangent to each at the nearer member contacting extremity will remain constant.

3. In a pipe or the like bending apparatus, spaced apart clamping means for gripping and holding a straight member to be bent only along the portions of material that are to become the tangents of the curve of the arc to be formed, and means comprising a plurality of parts each pivoted to both clamping means cooperating with the clamping means and free of contact with said member throughout the distance between said clamping means for maintaining the clamping means, independently of the distortion of the member being bent, in the same relative positions they would have if the member bent with constant length of arc and uniform radius of curvature at any instant, whereby to impart to the member a continuous predetermined bend formed without the use of dies and the like.

4. In a pipe or the like bending apparatus, spaced apart clamping means for gripping and holding the member only at the tangent points of the curve of the arc to be formed, and means cooperating with the clamping means and free of contact with said member throughout the distance between said clamping means for effecting a bending with constant length of arc throughout the bending operation and with a uniform radius of curvature throughout the length of the arc at any instant, said cooperating means including an adjustable arm projecting from one clamping means and an adjustable arm projecting from the other clamping means, and two adjustable arms being each pivotally connected to the two projecting arms.

5. In a pipe or the like bending apparatus, means for effecting the bending of a member with constant length of arc throughout the bending operation and with a uniform radius of curvature throughout the length of the arc at any instant including, a fixed bed, pipe clamping means adjustably mounted on the fixed bed, a movable bed spaced from the fixed bed, pipe clamping means adjustably mounted on the movable bed, a plurality of arms interposed between the two beds, including an adjustable arm projecting from the fixed bed, an adjustable arm projecting from the movable bed, said arms being pivotally connected to each other, a second arm projecting from the movable bed and pivotally connected with the fixed bed, means pivoting the second arm to the movable bed, and an operating lever associated with the movable bed.

6. In a pipe or the like bending apparatus, means for effecting the bending of a member with constant length of arc throughout the bending operation and with a uniform radius of curvature throughout the length of the arc at any instant including, a fixed bed, pipe clamping means adjustably mounted on the fixed bed, a movable bed spaced from the fixed bed and pivoted to swing about the fixed bed, pipe clamping means adjustably mounted on the movable bed for engaging the article to be bent, a plurality of arms interposed between the two beds including a fixed arm, projecting from each bed, another arm pivoted to each bed and also pivoted to the opposing projecting arm, and an operating lever associated with the movable bed.

7. In a bending apparatus for pipe and like members, first and second beds, a clamp on each of said beds for rigid engagement with said member in spaced apart relation, an arm pivoted to the first bed, an arm pivoted to the second bed, a tangent element carried by each bed, and means pivoting each of said arms to the opposing tangent element.

8. In a bending apparatus, means for clamping engagement with a pipe or like member, means spaced from the first means for clamping engagement with said member, an arm pivoted to the first means on an axis passing through the inner terminals of the zones at which the first means clamps the member, an arm pivoted to the second means on an axis passing through the inner terminal of the zone at which the second means engages the member, means between said axes pivoting the first arm to the second means, and means between said axes pivoting the second arm to the first means.

9. In a pipe or the like bending apparatus, spaced apart clamping means for gripping and holding the member only along the portions of material that are to become the tangents of the curve of the arc to be formed, and means cooperating with the clamping means and free of contact with said member throughout the distance between said clamping means for effecting a bending with constant length of arc throughout the bending operation and with a uniform radius of curvature throughout the length of the arc at any instant, said cooperating means being designed to maintain two properly selected points on one tangent or its prolongation at constant distances from two corresponding points on the other tangent or its prolongation.

RICHARD CONNOR.