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METHOD OF BENDING AND APPARATUS THEREFOR

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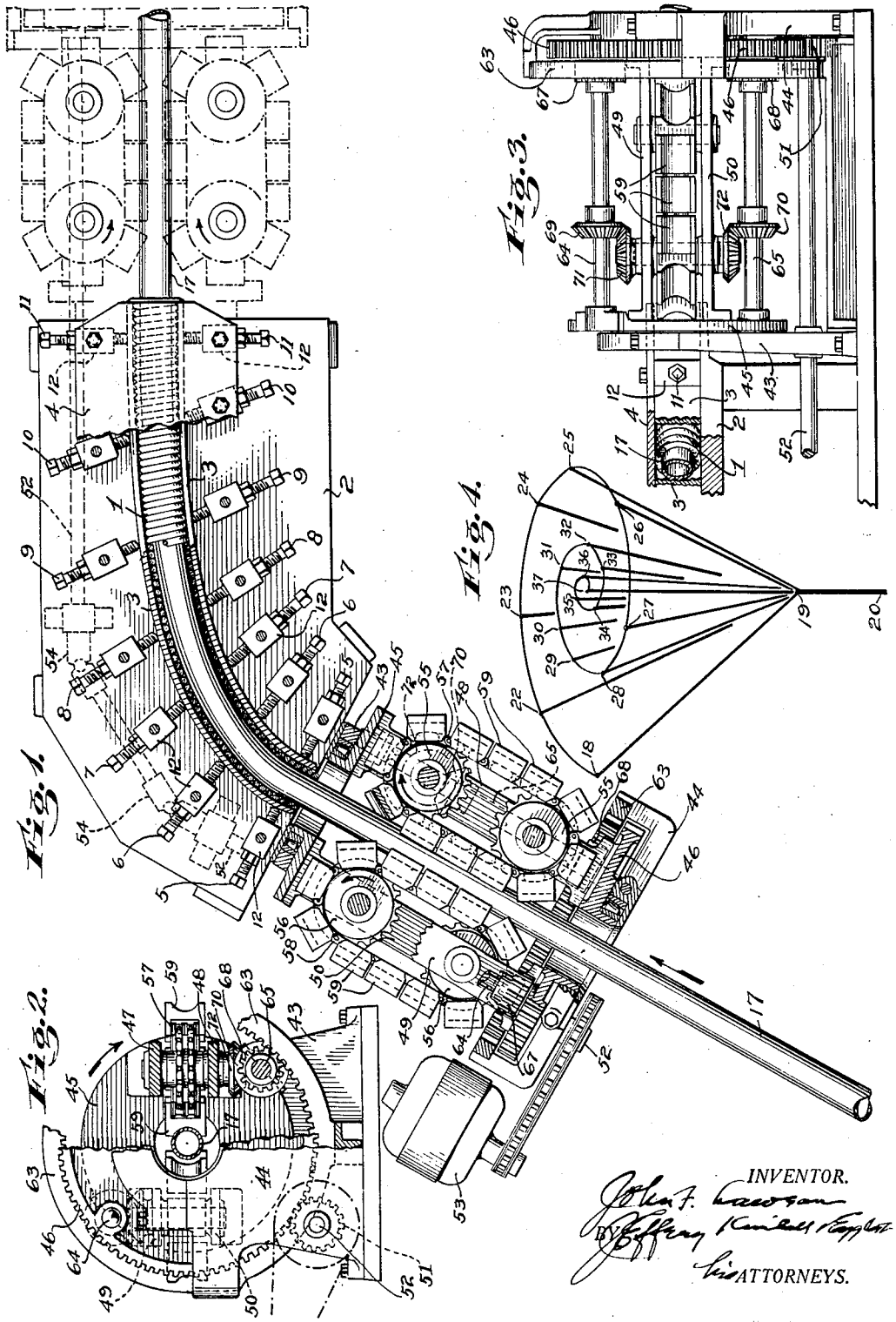

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

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METHOD OF BENDING AND APPARATUS THEREFOR

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This invention relates to bending pipe, tubing, solid bars, wire and the like; more particularly to bending such articles to straight; and still more particularly to straightening lengths of such articles which, without abrupt bends anywhere, depart somewhat as a whole from a right line. The invention includes both a method and an apparatus.

The invention is intended for metal pipe and tubing especially, but is applicable also to bars, wire and other articles of the same general kind, as above indicated. For brevity, the terms "articles" and "elongated articles" are employed hereinafter to indicate all articles of this kind.

According to the method of the invention, each and every short length, and preferably each and every infinitesimally short length, of the article to be treated, is bent systematically in substantially or quite every direction, one of the bends (it may be the first one, so far as final result is concerned) being made, preferably, at least on such a short radius that the elastic limit of the metal is exceeded (so that the length would have a permanent set were nothing further done with it) and the remaining bends being made on radii of various greater lengths, usually of successively greater lengths, until the final desired form, say the straight, is reached. From another aspect, the method of the invention consists of bending each short or elemental length of article or article wall spirally, as it may be called, in the manner hereinafter described.

Basically the apparatus of the invention may consist of any piece, structure or apparatus providing an elongated smoothly-curving curved guideway or path of various lengths of radii of curvature, the shortest of which exceeds, at least preferably, the elastic limit of the article to be treated, and which path terminates and blends into, say, a straight exit portion, through which the elongated article can be passed while being rotated, and which piece or structure constrains the article against local bending except on such radii as are prescribed by the method of the invention. Preferably mechanism for pushing the elongated articles through the guideway or path is provided at the entrance end of the piece, structure or apparatus, and another mechanism to pull the article through the guideway or path is provided at the exit end of the guide-way providing piece, structure or apparatus, these mechanisms also serving to rotate the article in passing.

These and other features of the invention appear in the accompanying drawing and the following description of the matters there illustrated.

In this drawing, Fig. 1 is a plan view, partly in section, of a machine embodying the invention. Fig. 2 is an end elevation, partly in section, of the article-pushing mechanism, and also of the article-pulling mechanism, of Fig. 1. Fig. 3 is a side elevation of one of those mechanisms. Fig. 4 is an illustrative diagram referred to hereinafter.

While the method of the invention is not limited to any particular apparatus, this method may be understood from the apparatus illustrated in the drawing which I have devised for carrying it out. The elongated curved guideway or path for the article is outlined by a metal helix 1, the turns of which are placed substantially as close together as possible. Internally, the diameter of the helix is only a little greater than the external diameter of the article, say 17, to be treated. Such a helix is a preferred device for outlining the guideway or path, since it bears on the article at many closely-spaced points and thus is well adapted to prevent bending of the article anywhere on a radius other than the respective local radius of curvature of the guideway. To hold the helix in the desired shape for the path, the helix may rest against a base plate 2, be provided at its sides with two flexible plates 3 placed at right angles to the base plate 2, and be held down to the base plate by a cover plate 4 placed parallel with the base plate 2. The two plates 2 and 4 may be permanently placed with respect to each other. Preferably however the side plates 3 are held between a series of threaded bolts 5, 6, 7, 8, 9, 10 and 11, which are provided in such numbers as may be necessary to confine these plates and the helix to the desired curved path and which may be mounted in brackets 12 permanently fastened between the lower and upper plates 2 and 4; by means of the bolts the curvature of the path may be adjusted from time to time, for example to suit the particular metal of the articles used with it. To set up the machine for say the length of tubing 17, I first take a short piece of this tubing or a piece of similar tubing made from the same metal, and by bending the piece on successively shorter radii of curvature, I find the radius of curvature, or, say, about the longest radius of curvature, which, when the tubing is bent on it, gives the piece a permanent set. That is to say, I first find a radius of curvature, and usually about the longest radius of curvature, which exceeds the elastic limit of the article to be treated. I then so set the threaded bolts, say 5 and 6, as to curve this end of the helix 1 to this radius which ex-

ceeds the elastic limit of the article 17. It being desired to straighten this tube 17 for example, that is to say, the tube being somewhat bent it being desired to straighten it accurately, the threaded bolts at the opposite end of the helix, say 10 and 11, are so set as to bring the axis of this portion of the helix 11 into a straight or right line for at least a short distance. The intermediate bolts, say 7, 8 and 9, are then so adjusted as to cause the axis of the helix to follow a smooth curve from the entrance end of short radius of curvature to, and to blend substantially tangentially into, its straight portion; in other words, I so adjust the intermediate bolts that the radii of curvature of the curved portion of the helix axis increase gradually and successively from the bolts 5 or 6 to about the bolts 11, or perhaps to a point somewhat farther back toward the bolts 10, and at this point cause the helix axis to blend tangentially into its straight part. Preferably the curve of the curved portion of the path is a parabola. To straighten then say the tubes 17, it is only necessary to force the tube through the path of guideway provided by the helix 1 and simultaneously rotate the tube a suitable number of times as it passes through, as may be found by trial. The direction of rotation, that is to say whether clockwise or counter-clock-wise, is immaterial; however it seems to be somewhat easier to force a tube 17 through the pathway when rotating it in a direction contrary to the screw-thread-effect provided by the turns of the helix. The path may be lubricated as desired or found necessary.

It will be observed that passing a tube 17 through such a path while rotating the tube, causes each and every infinitesimally short length or element of the tube to be bent repeatedly and systematically in every direction, the bend near the entrance, near the bolts 5, being made on such a short radius of curvature that the elastic limit of the metal is exceeded, and the remaining bends being made on radii of successively greater lengths until the straight portion of the path is reached near its exit. Fig. 4 represents diagrammatically the treatment which each and every such short length undergoes in passing through such a guideway as 1 while being rotated. In one respect the operation described with reference to Fig. 4 differs from the operation described with reference to Fig. 1. That is to say, in Fig. 1 the guideway or path-providing parts mounted on the base plate 2 neither rotate as a whole nor move longitudinally, but as a whole these parts are stationary and the tube 17 is moved through the guideway and at the same time is rotated within it; in Fig. 4, to the contrary, in which only an infinitesimally short length (18—19—20) of a whole tube is shown, this short length is treated as held against rotation and longitudinal movement while, as it were, the guideway is assumed to be passed over this short length of tube and at the same time rotated about this short length. The actual bending of the short length and the effect on it, is the same in both cases. Assuming (what is probably not the fact) that the bending of each element is concentrated at one point 19 in it, then the line 18, 19, 20 may be taken as representing an infinitesimally short length or longitudinal element of the wall of the tube, while occupying, say, a position about opposite the bolts 5. The element is here bent on a short radius of curvature, as represented in Fig. 4 by the relative sharpness of the angle 18, 19, 20. This is the first or a preliminary step in the operations. Next, one end of the length or element, say the end 18—19, is moved about, relative to the other end 19—20, in the manner illustrated in the diagrammatic figure; that is to say, relative to 20 the end 18 is forced to travel along a spiral, as from point 18 to point 22, to 23, to 24, and so on until the finish point 37 is reached, the latter being, in the present instance, the center of the spiral, and in the center line of the part 19—20 extended representing that the element 18—19—20, at the conclusion of the operations on it, is straight. Each and every infinitesimally short length of the tube being bent in exactly the same manner, it is evident that the tube as a whole will have a uniform lengthwise shape at the finish of the operation. In effect, every infinitesimally short length of tube passed through the device of Fig. 1 is bent in this manner and this systematic bending is the preferred method of the invention.

The mechanisms illustrated at the lower left of Fig. 1 and outlined at the upper right, are mechanisms for pushing and pulling the articles through the guideway or path 1, and simultaneously rotating them. The description of one will serve as a description of the other also, the two being alike. In fixed spaced brackets 43 and 44 are journaled two annular heads 45 and 46 which, in conjunction with the parallel bars 47, 48, 49 and 50 joining the heads, constitute a rotating frame. The external periphery of head 46 is toothed for driving by a gear 51 on shaft 52, which may be driven, for example, by an electric motor 53 directly, or through an extension of the shaft and universal joints 54 in the manner of the puller mechanism at the upper right of Fig. 1. The bars 47 and 48 carry a pair of belt sprockets 55 and likewise the bars 49 and 50 carry a pair of belt sprockets 56; each pair of sprockets carries a chain belt 57 or 58 to which are attached article (tube) grippers 59 suitably recessed to grab the article, e. g. the tube 17. An internal gear 63 is fixed to one of the brackets. Shafts 64 and 65 carried by the frame heads 45 and 46, are provided with gears 67 and 68 respectively, meshing with internal gear 63 for driving thereby as the frame is rotated; through their miter gears 69 and 70 and the miter gears 71 and 72 on shafts of sprockets 55 and 56 these shafts 64 and 65 drive the sprockets 55 and 56 and thereby the belts 57. It will be observed therefore that the motor 53 will rotate the frames of the tube pushing mechanism (at the lower left of Fig. 1) and the tube pulling mechanism (at the upper right) and thereby the tube, and simultaneously, the motor driving in the proper direction, will rotate the sprockets 55 and 56 in the various directions indicated by the arrows on the sprockets and thereby cause the two mechanisms to simultaneously push and pull the tube through the guideway in the direction indicated by the arrow adjacent the tube.

It will be understood however that the invention is not limited to the details illustrated and described, except as appears hereinafter in the claims.

I claim:

1. Apparatus for bending elongated articles, comprising means providing an elongated curved path for the article and bearing on the article at such closely spaced points thereon as to confine the article to such smoothly-curving path without permitting local bending of the article on a radius materially shorter than the respective local ra-

dius of curvature of the path, the radius of curvature of said path at one point exceeding the elastic limit of the article and the radii of curvature of said curved path at one side of said point being of greater lengths and of lengths successively greater than each other, and mechanism for pushing an elongated article through said means, in the direction of from said point of radius exceeding the elastic limit to the portion of the curve of longer radii, and for simultaneously rotating the article within said means.

2. Apparatus for bending elongated articles, comprising means providing an elongated curved path for the article and bearing on the article at such closely spaced points thereon as to confine the article to such smoothly-curving path without permitting local bending of the article on a radius materially shorter than the respective local radius of curvature of the path, the radius of curvature of said path, at one point exceeding the elastic limit of the article and the radii of curvature of said curved path at one side of said point being of greater lengths and of lengths successively greater than each other, and mechanism for pulling an elongated article through said means, in the direction of from said point of radius exceeding the elastic limit to the portion of the curve of longer radii, and for simultaneously rotating the article within said means.

3. Apparatus for bending elongated articles, comprising means providing an elongated curved path for the article and bearing on the article at such closely spaced points thereon as to confine the article to such smoothly-curving path without permitting local bending of the article on a radius materially shorter than the respective local radius of curvature of the path, the radius of curvature of said path at one point exceeding the elastic limit of the article and the radii of curvature of said curved path at one side of said point being of greater lengths and of lengths successively greater than each other, and mechanism for pulling and mechanism for pushing an elongated article through said means, in the direction of from said point of radius exceeding the elastic limit to the portion of the curve of longer radii, and for simultaneously rotating the article within said means.

4. The method of treating articles of the kind described for the purposes described, which consists in bending each short length of the article on a radius exceeding the elastic limit of the article and thereafter repeatedly bending the same short length of the article in various directions to successively lesser degrees.

5. The method of straightening an elongated article, which consists in bending each substantially-infinitesimally short length of the article on a radius exceeding the elastic limit of the article and thereafter repeatedly bending the same in various directions to successively lesser degrees until the straight condition is reached.

6. Apparatus for bending elongated articles, comprising means for confining the article to a substantially parabolic path and means for causing relative rotational and longitudinal movement between said confining means and the elongated article.

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