March 10, 1959

D. R. KNOX ET AL

2,876,823

BENDING PAD STRUCTURE AND ASSOCIATED APPARATUS FOR BENDING TUBE

Filed June 10, 1953

7 Sheets-Sheet 1

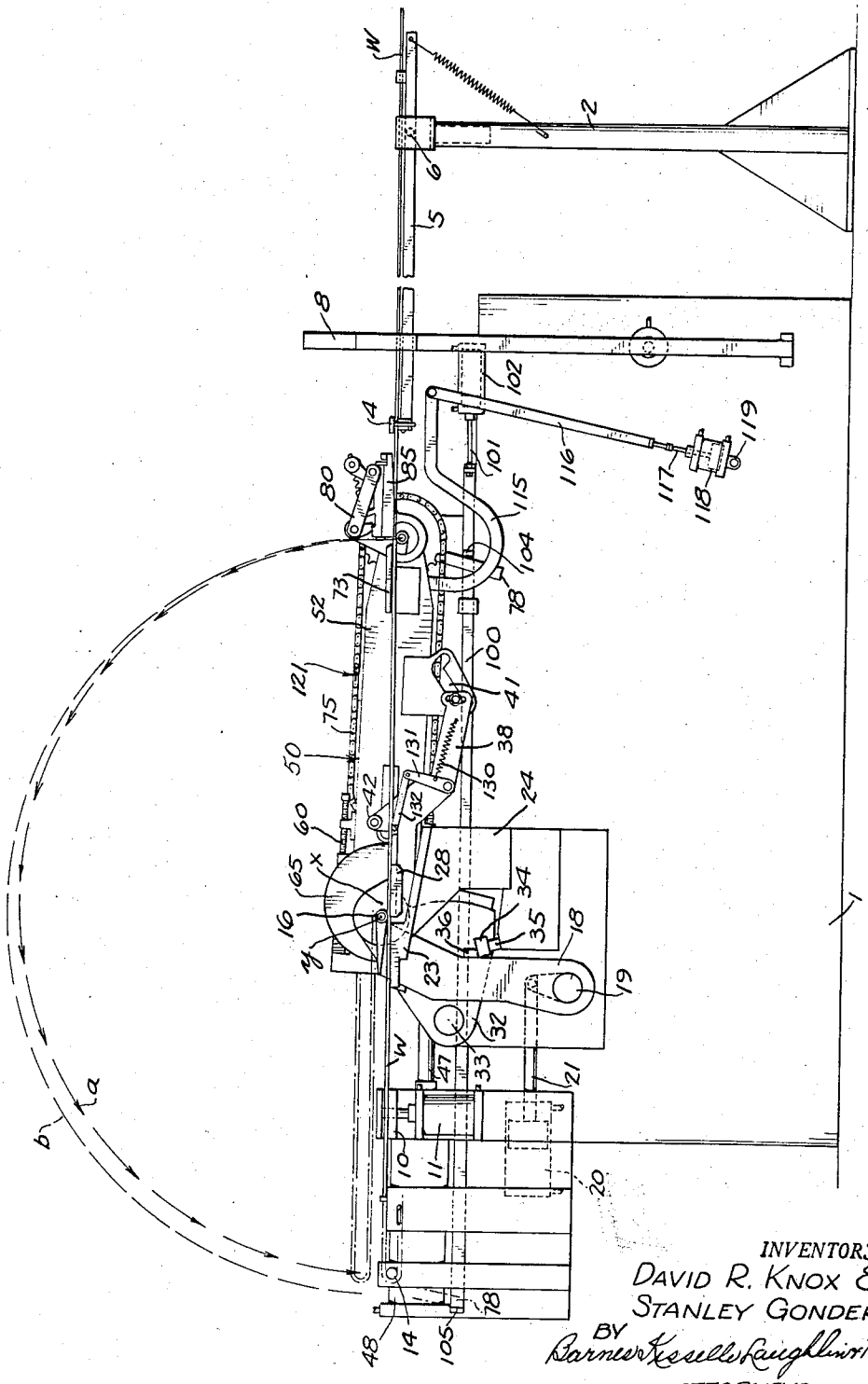


FIG. 1

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7 Sheets-Sheet 2

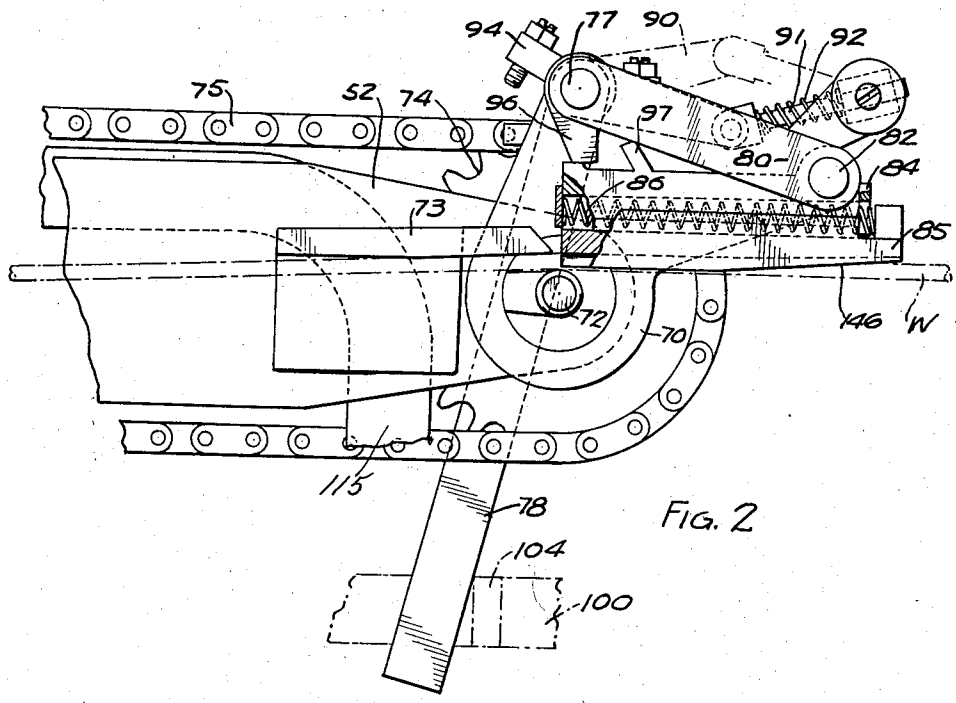


FIG. 2

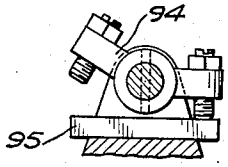


FIG. 4

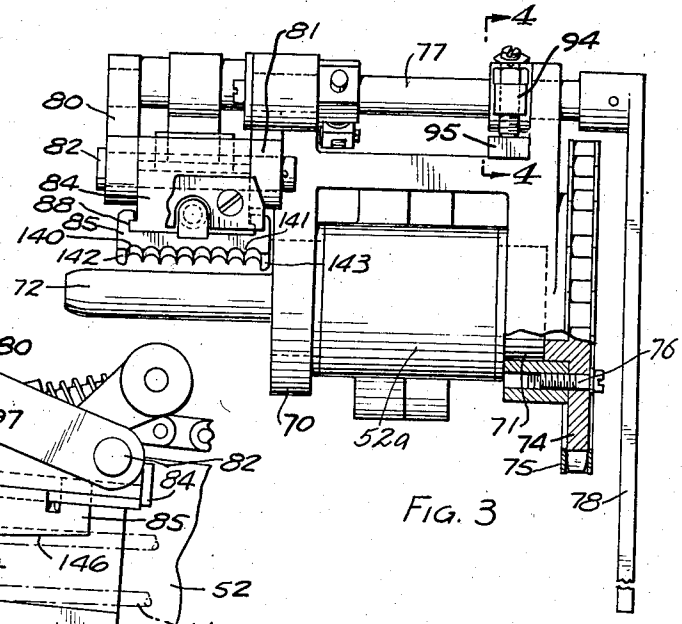


FIG. 3

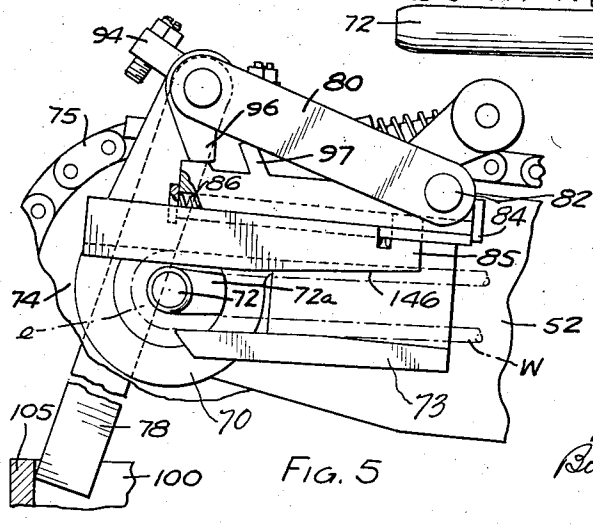


FIG. 5

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7 Sheets-Sheet 3

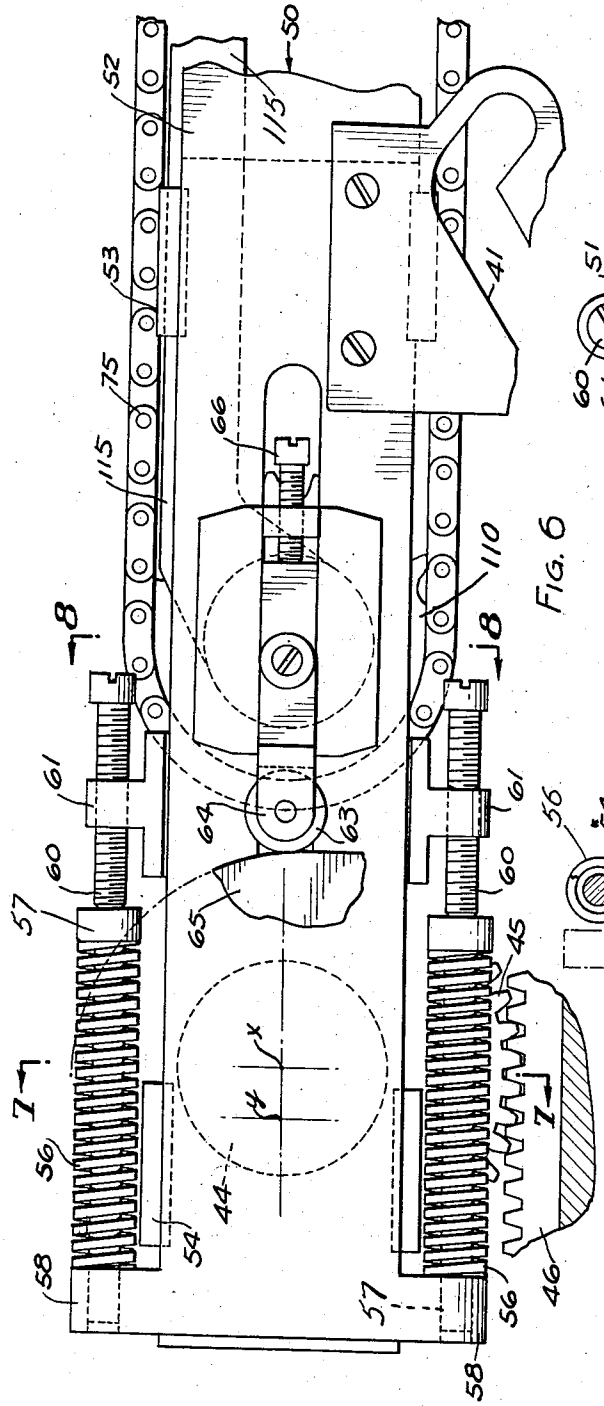


Fig. 6

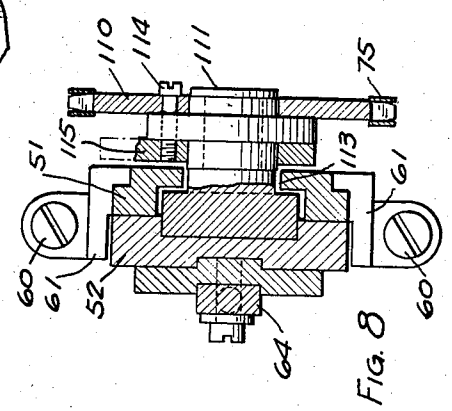


Fig. 8

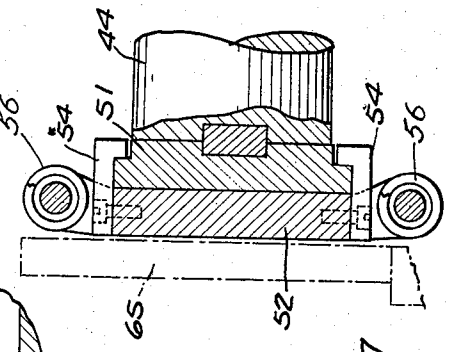


Fig. 7

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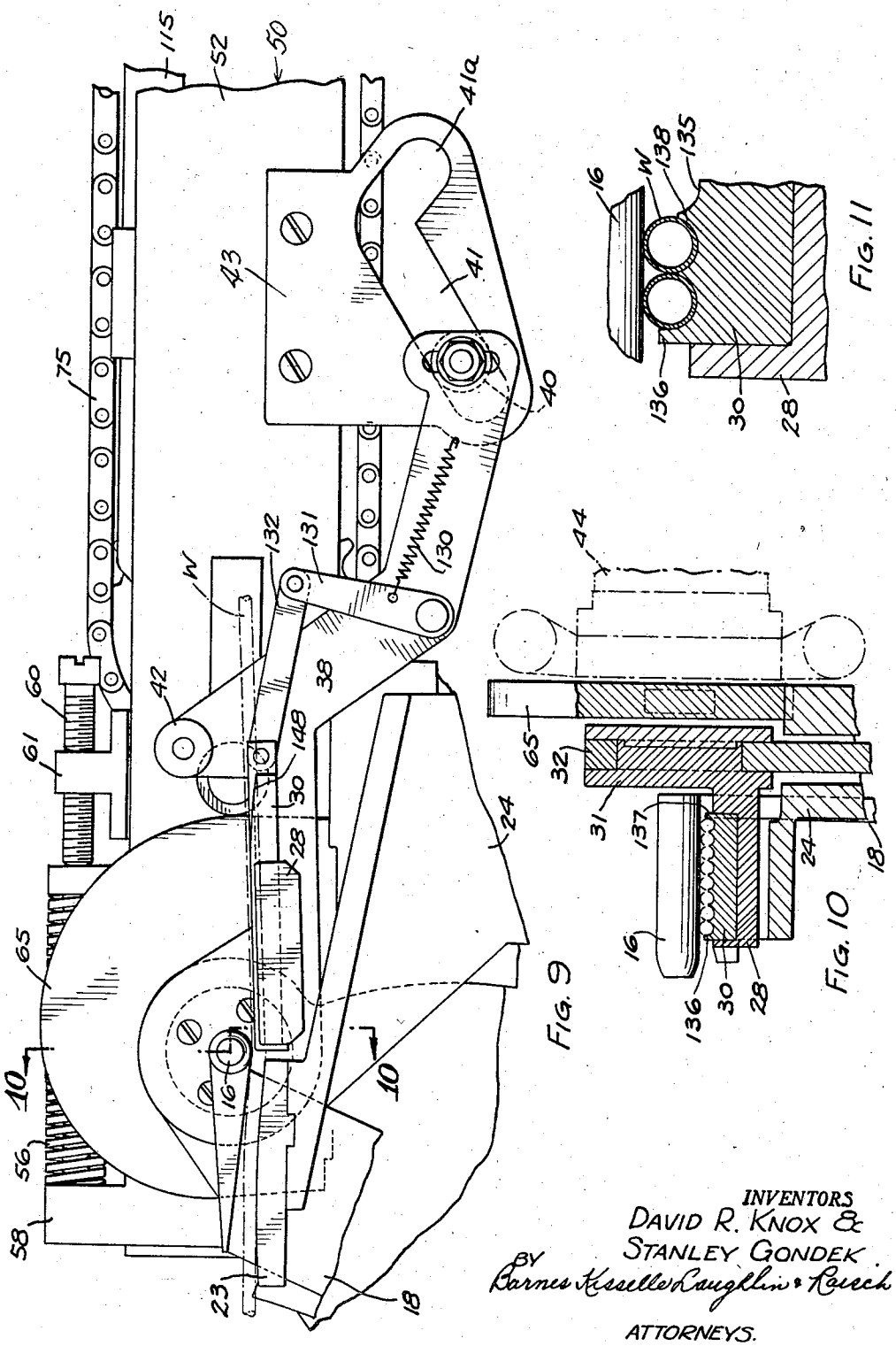


FIG. 9

FIG. 11

FIG. 10

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7 Sheets-Sheet 5

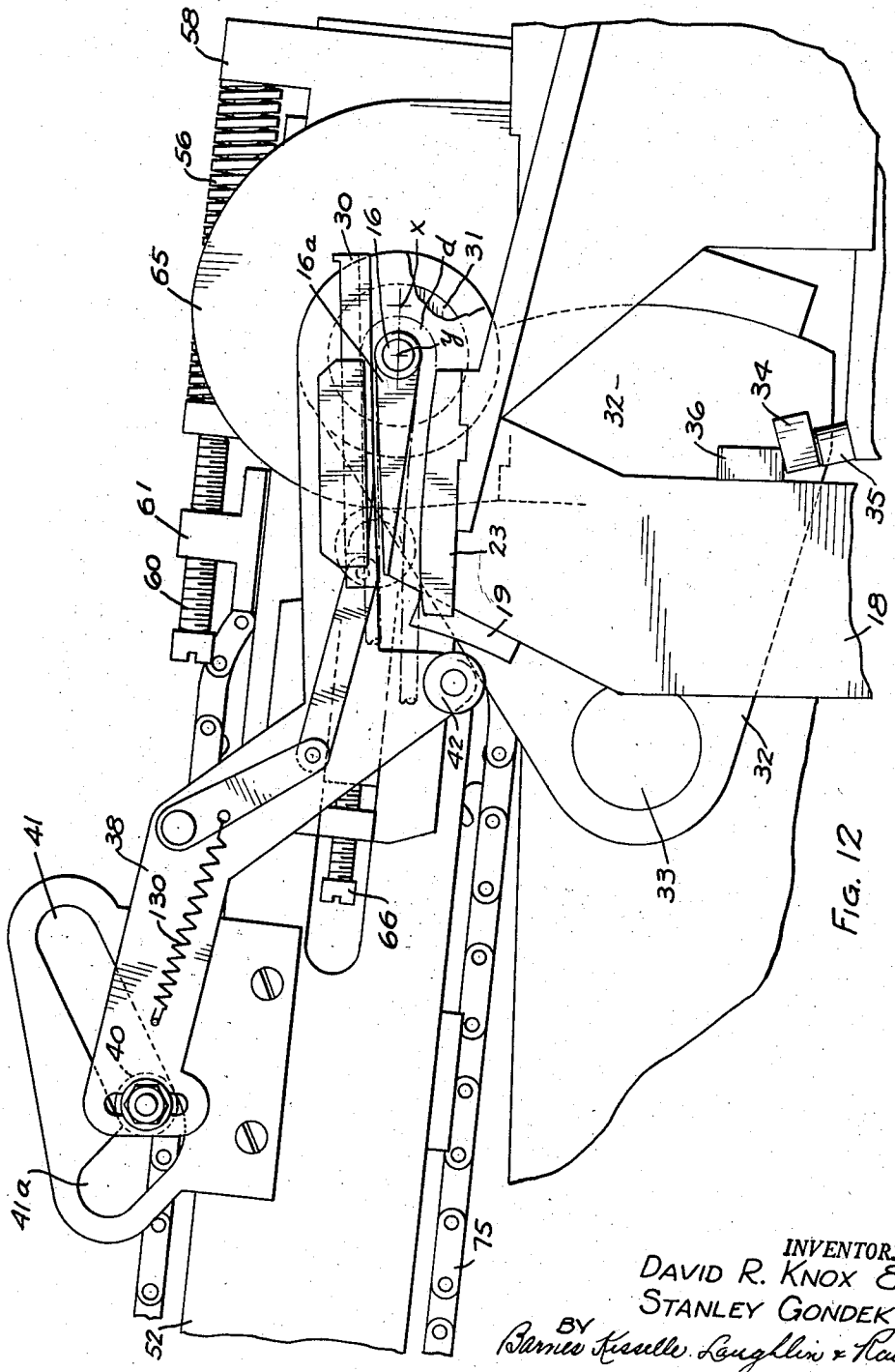


FIG. 12

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BENDING PAD STRUCTURE AND ASSOCIATED APPARATUS FOR BENDING TUBE

Filed June 10, 1953

7 Sheets-Sheet 6

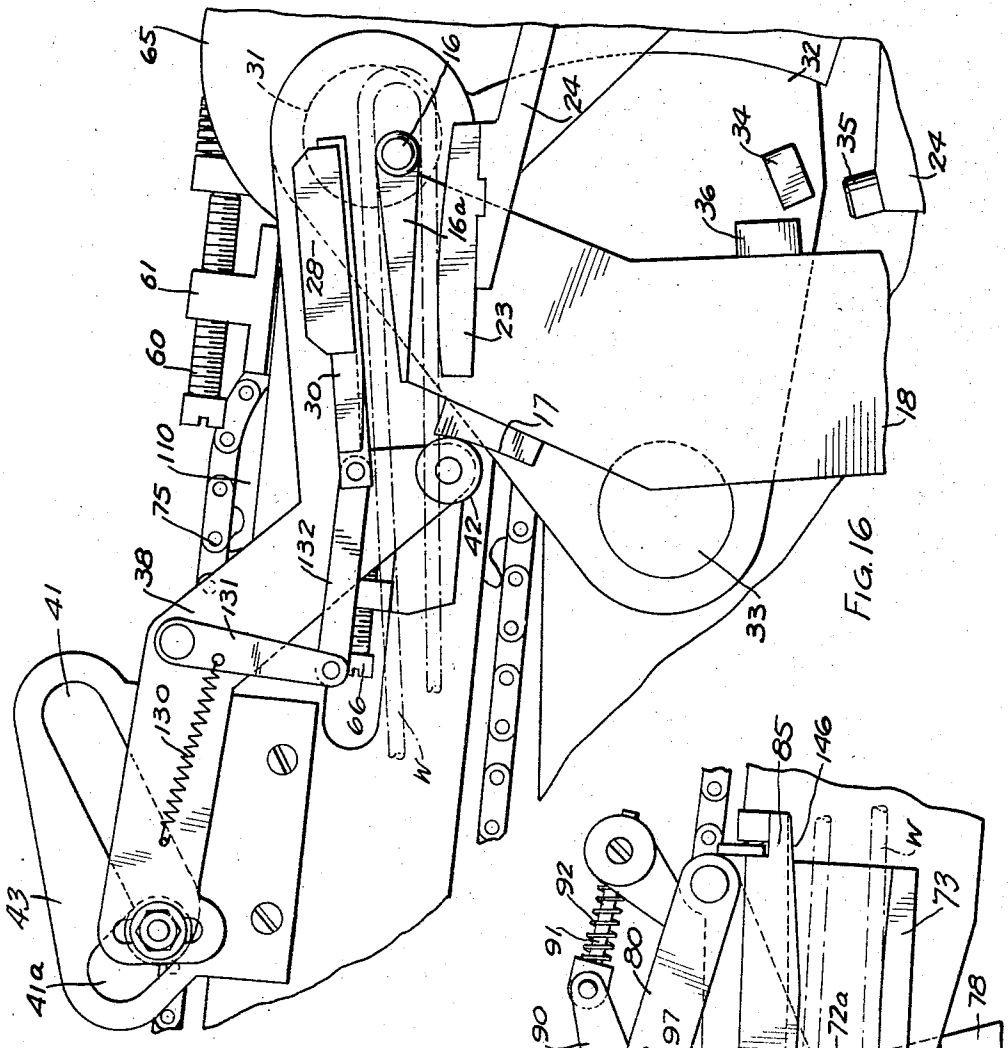


FIG. 16

FIG. 13

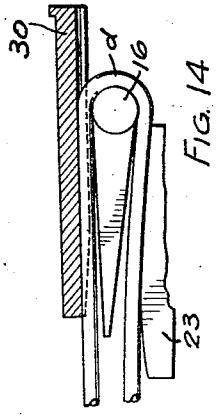


FIG. 14

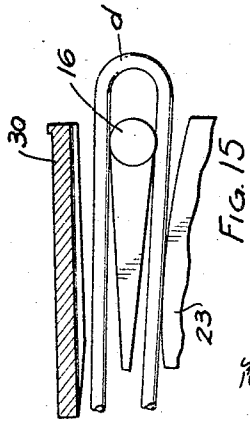


FIG. 15

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FIG. 17

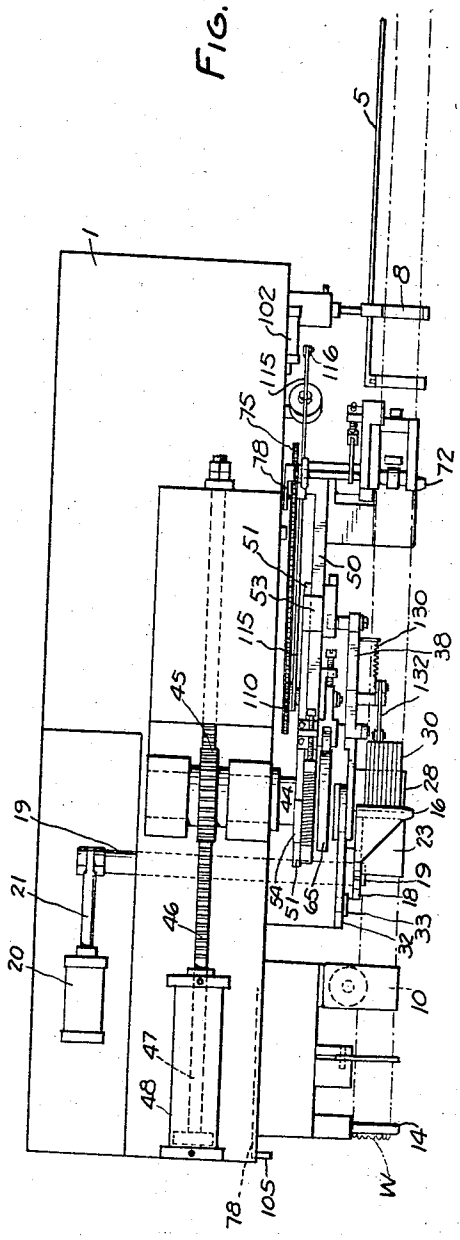


FIG. 18

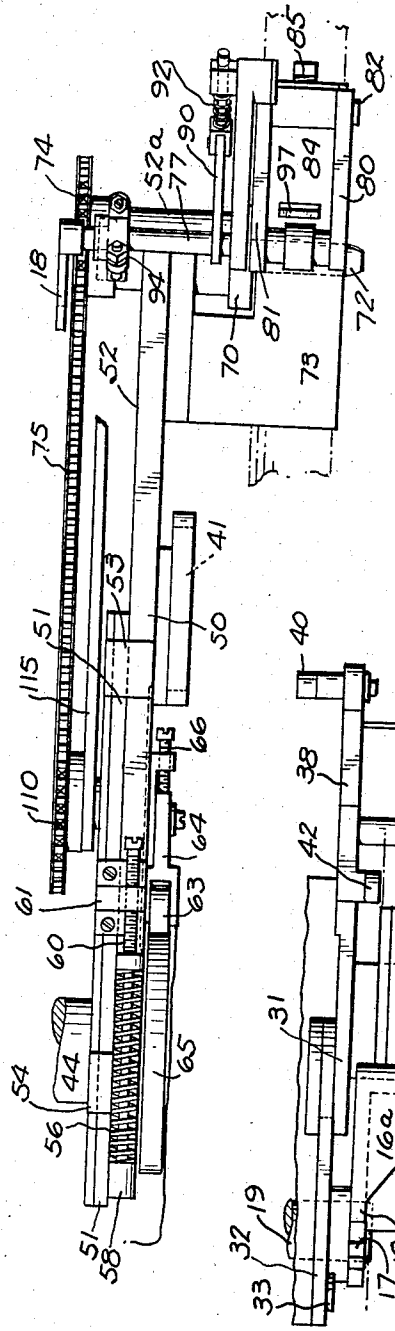


FIG. 19

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United States Patent Office 2,876,823
Patented Mar. 10, 1959

2,876,823

BENDING PAD STRUCTURE AND ASSOCIATED APPARATUS FOR BENDING TUBE

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Application June 10, 1953, Serial No. 360,751

9 Claims. (Cl. 153—46)

This invention relates to an apparatus for bending tube, and it is concerned particularly with apparatus and bending elements particularly adapted to simultaneously bend a plurality of tubes, and for supporting the tubes to prevent substantial distortion or deformation thereof during the bending operation.

While the apparatus may be employed for bending long work pieces other than tube, such, for example, as rods or the like, it is believed that the apparatus is most useful for bending tubes and, therefore, the invention will be disclosed with reference to, and the apparatus described with reference to, the bending of tubes.

There are a number of objects of the invention and one important object is the provision of apparatus and bending elements for bending tube on a short radius. In this connection, bending elements are provided for supporting a plurality of tubes so that, as they are bent on a relatively short radius, the tubes are held and supported so as to substantially prevent flattening of the tubes in cross section at the location of the bend. In this connection, the bending elements are so arranged that the several tubes support each other.

A further object is to provide bending mechanism which substantially eliminates friction on the tubes as the bending devices fashion the plurality of tubes about a bending element or arbor. A still further object of the invention is to provide articulating bending devices which are grooved for receiving the tubes, so that the grooved devices may shift into and out of engagement with the tubes to thus facilitate placing the tubes in and removing the tubes from the bending apparatus. A still further object is to provide an improved construction for accommodating the takeup in the length of the tubes due to the length which goes into or is absorbed in the bend.

In making reference to bending tube on a short radius, it is to be appreciated that the radius of the bend is relative to the diameter and wall thickness of the tube. What may be considered a small radius of bend for a relatively large diameter tube, may not necessarily be considered a short radius bend for a tube of smaller diameter. A tube with a relatively thick wall might be bent with facility on a given radius but such a radius of bend might be considered a short radius for a tube with a thinner wall. In bending the tubes, say for example, about 180°, the metal of the tube on the outside of the bend is under tension, while the metal on the inside of the tube is under compression, the terms outside and inside being used with reference to the neutral axis. These conditions tend to cause the tube to become flattened as it is bent, particularly when a tube is bent on a radius relatively short when considered in connection with the tube diameter and wall thickness. As stated above, the invention is concerned with making bends on a short radius and holding and supporting the tubes to prevent such flattening or other distortion or deformation.

The invention is particularly applicable to an apparatus for bending a plurality of tubes into serpentine form and the apparatus disclosed herein is one for bending a plurality of tubes into serpentine form. Some of the bending elements or devices, however, may be employed for bending tubes other than in serpentine form.

Fig. 1 is a front elevational view illustrating a machine constructed in accordance with the invention.

Fig. 2 is an enlarged elevational view with some parts broken away and some parts in section showing some bending elements.

Fig. 3 is a view of the mechanism shown in Fig. 2 looking from the right hand side of Fig. 2.

Fig. 4 is a detailed sectional view taken on line 4—4 of Fig. 3 showing a movement limiting device.

Fig. 5 is a view of the apparatus shown in Fig. 2 illustrating the position of parts after a bend has been made.

Fig. 6 is a generally elevational view, with some parts broken away, illustrating mechanism for accommodating takeup in the bending of the tube.

Fig. 7 is a sectional view taken substantially on line 7—7 of Fig. 6 illustrating structural features.

Fig. 8 is a sectional view taken on line 8—8 of Fig. 6 showing structural features of a swinging arm.

Fig. 9 is a general elevational view illustrating an arbor and bending device in position ready to perform a bend.

Fig. 10 is a sectional view taken on line 10—10 of Fig. 9 showing an arbor and a bending device.

Fig. 11 is an enlarged sectional view showing a bending pad applied to tubes to be bent.

Fig. 12 is a view of the apparatus shown in Fig. 9 showing the position of the parts at the end of a tube bending operation.

Fig. 13 is a view similar to Fig. 5 showing the bending mechanism on the end of the arm in open position after a bending operation.

Fig. 14 is a diagrammatic view illustrating the position of the tube, an arbor, and a bending pad at the completion of a bending operation.

Fig. 15 is a view of the apparatus shown in Fig. 14 showing the parts in open position for releasing the bent tube.

Fig. 16 is a generally elevational view of the mechanism shown in Fig. 12 showing the position of the parts after the tube is released.

Fig. 17 is a top plan view of the apparatus on approximately the same scale as Fig. 1.

Fig. 18 is a fragmentary plan view on an enlarged scale showing structure of the swinging arm.

Fig. 19 is a fragmentary plan view on an enlarged scale showing structure at the central portion of the apparatus.

The apparatus shown in Fig. 1 includes a suitable frame or base **1** with the bending mechanism mounted thereon, and the tubes which are the work pieces are shown at W. The tubes are fed to the machine from the right hand side of Fig. 1. The work pieces are supported by a support **2**, and further supported in a clip or holder **4** on an arm **5** which swings about a fulcrum **6** in turn mounted for swinging on a vertical axis on support **2** as shown. A loading device is generally illustrated at **8**. The several tubes are positioned as shown and the leading ends thereof may be engaged by a clamp **10** operated hydraulically as by means of a piston in a cylinder **11**. After the first bending operation the clamp **10** may not be used but the tubes may be held by placing a formed bend over a stud or post **14**.

The machine has a generally cylindrical arbor **16** having a tapered supporting extension **16a** mounted upon an arbor carrying arm **18** which is pivoted as at **19** and which may be operated through a swinging movement hydraulically as by means of a piston in a cylinder **20**, a piston rod **21** of which is connected to the arm **18** as shown in Figs. 1 and 17. Adjacent to and generally

under the arbor 16 is a stationary tube bending shoe or plate 23 carried by a fixed bracket 24. The tubes are placed under the arbor 16 and over the fixed shoe 23 as shown in Fig. 9.

There is a bending device for bending the tubes about the arbor, in the form of a shoe 28 with a grooved bending pad 30 thereon (Fig. 10), and the shoe has a bearing formation 31 journalled in a plate 32. This plate 32 is pivotally mounted as at 33. The plate 32 has a lug 34 thereon arranged to engage an abutment 35 carried by fixed bracket 24 (Fig. 16) and to be held against the abutment by a lug 36 on the arm 18 (Fig. 12). There is a lever arm 38 rigidly formed with the bending element 28 and its bearing portion 31, which is provided on its end with a roller 40 for operating in a closed cam slot 41 as will presently be seen, and which is also provided with a roller 42. Cam slot 41 is formed in a plate 43 secured on a swinging arm to be described in greater detail. It might be stated at this point that the lever arm 38 serves to swing the bending device 28 about the bearing 31 so that it moves about the arbor to bend the tubes.

There is a main rocker shaft 44 (Figs. 7 and 17) which may be rocked by means of a gear 45 mounted thereon and a rack 46 operated by a piston rod 47 (Fig. 1) of a piston in a hydraulic cylinder 48. This shaft carries a swinging arm generally illustrated at 50. This arm has relatively slidable parts. The base part 51 thereof is keyed to rock with the shaft 44. The slidable and extending part 52 is mounted on said base part 51 by guides 53 and 54 and acted upon by coil springs 56. The coil springs are carried by headed rods 57 slidably mounted on ears 58 at the base end of the arm member 52. Springs 56 act on ears 58 and, through the heads on rods 57, react against adjusting screws 60 mounted in brackets 61 carried by the base part 51 of the arm. The arm member 52 is provided with a roller 63 carried by a bracket 64 which may be adjustably set in position by a screw 66 and the roller engages the surface of an open faced cam 65, the purpose of which will presently appear. The arm 52 carries the plate 43 containing cam 41. It will be seen, therefore, that if the arm 50 is swung counter-clockwise, as Figs. 1 and 9 are viewed, the lever 38 is carried with the arm, and shoe 28 with its bending pad 30 is moved about its fulcrum in plate 32.

In so doing, the several tubes which are in position, as indicated in Fig. 10, are fashioned about the arbor 16. This will be described more fully later. The axis of the arm 50 is shown at x in Fig. 6, and it will be seen that this axis is removed from the working axis y of the arbor 16.

An assembly embodying a support or bracket 70 (Figs. 2, 3, 5 and 13) is pivotally mounted as at 71 (Fig. 3) on a bearing structure 52*a* at the end of arm 52 and bracket 70 carries a generally cylindrical arbor 72 and a fixed bending pad 73. Arbor 72 has a lateral supporting tapered extension 72*a*. The bracket has a sprocket 74 over which runs a chain 75. Sprocket 74 is fixed on bracket 70 by a bolted construction as at 76.

The bracket 70 carries a rocker shaft 77 with a depending actuating lever 78. Arms 80 and 81 mounted on the rocker shaft 77 support a pintle pin 82. A sub-assembly is rockably mounted on the pin 82 and it resides in a base member 84 and a bending pad 85 slidable upon the base member, there being an interposed spring 86 which reacts on the base member and acts upon the bending pad to normally urge the slide member to the right as Fig. 2 is viewed. The bending pad member is secured to the base member 84 by interengaging sliding elements shown at 88. The sub-assembly is acted upon by toggle levers 90 and 91 (Figs. 2 and 13) with an interposed spring 92. Means to limit the rocking action includes a rocker arm 94 with adjustable stops for engaging a limit stop member 95. Mounted on the rocker arm 94 on shaft 77 is a cam 96 for engaging the member 84, and the member 84 has a finger or projection 97 also for engaging the cam 96. In the position shown in Fig. 2, the bending pad is set for a bending operation. It will be noted that the cam 96 holds the bending pad sub-assembly in position against the tubes. If the lever 78 be shifted counter-clockwise, as Fig. 2 is viewed, the cam 96 strikes the finger 97 and rocks the sub-assembly about the pin 82, and the toggle levers shift to the dotted line position to hold the bending pad and the base member 84 in an elevated and inclined position relative to the arbor 72, said inclined position not being shown in Fig. 2 but appearing in Fig. 13 after completion of a bending operation.

A means for operating the lever 78 conveniently takes the form of a rod 100 (Figs. 1, 2 and 5) actuated by the piston rod 101 of a piston in a cylinder 102; the rod has an abutment 104 for engaging the lever 78. The rod 100 also has an abutment 105 for engaging the lever 78 in another position thereof as will presently appear.

Mounted on the arm 50 is a sprocket 110 over which the chain 75 operates. The sprocket is mounted on a stud 111 which passes through an opening 113 in the arm section 51 and which is secured to the arm section 52. The sprocket 110 is fixedly secured as by means of screws 114 to an actuating arm 115 (Figs. 1, 6 and 9). This actuating arm may be formed, as shown in Fig. 1, for clearance purposes and is pivotally connected to a rod 116 in turn connected to a piston rod in a hydraulic cylinder 118 pivotally mounted to the frame as at 119. The chain 75 may be equipped with a tightening screw 121 (Fig. 1) since the chain only has a slight oscillation relative to the sprockets.

The bending pad 30, for cooperation with the arbor 16, is acted upon by a spring 130 (Figs. 1, 9, 12 and 16), associated with the pad 30 by interconnected levers 131 and 132. This spring normally holds the pad 30 to the right as Fig. 9 is viewed.

It will be noted that the bending pad 30 is provided with a plurality of grooves 135, each for receiving a tube as shown in Figs. 10 and 11. The side portions of the pad 30 as shown at 136 and 137 are of sufficient extent as to project at least to, and preferably somewhat beyond the median line or neutral axis of the outermost tubes. The web portions 138 defining the individual grooves 135 are of lesser extent and do not extend to the median line of the tubes. The grooves fit the tubes as shown in Figs. 10 and 11 and, accordingly, the bending pad to be used is made precisely for use with tubes of determined diameter. The several tubes, accordingly, contact and support each other along lines lying substantially in a plane containing the neutral axes of the tubes. As shown in Fig. 10, there are eight tubes in position each lying in a groove 135.

The bending pad 85 is similarly constructed as shown in Fig. 3 the same having a plurality of grooves 140, one for each tube, with the intervening web portions 141 terminating short of a plane containing the neutral axes of the tubes and with side portions 142 and 143 which engage the outermost tubes at a plane containing their neutral axes. The pad 85, as shown in Fig. 3, is engaged with the tubes, but the pad is angularly disposed, having what may be termed a lead surface 146, as shown in Fig. 2, which results in the appearance in the illustration of Fig. 3. Similarly the bending pad 30 has a lead surface 148 (Fig. 9).

The grooves in the bending pads are formed substantially on the radii of the tubes to be received therein, and the center to center distances are substantially equal to the center to center distances of the tubes or, in other words, substantially equal to the diameter of the tubes. The intervening webs 138 and 141 extend from the lowermost part of the grooves a distance less than the radius or, in other words, terminate short of a plane containing the neutral axis of the tubes received therein. Accordingly, when several tubes are properly positioned within

the grooves they make contact with each other substantially along lines lying in a plane containing their neutral axes. The outside surfaces of the outermost tubes of both bending pads are supported by the side portions **136, 137** and **142** and **143**. Therefore, it will be seen that the tubes support each other by interengaging with each other and are held and prevented from flattening laterally as they are bent around the respective arbors.

At the beginning of a cycle of operation the swinging arm **50** is in the position as shown in Fig. 1; the bending assembly on the end of the arm is in open position, as shown in Fig. 13. In said open position, the assembly has been rocked counter-clockwise, as Fig. 13 is viewed, from the position shown in Fig. 2 and the bending pad sub-assembly has been rocked counter-clockwise, as Fig. 13 is viewed, and held elevated by the toggle levers **90** and **91**. The arbor **16** is retracted, as shown in Fig. 16. Thus, there is a clearance for shifting the tubes laterally in position over the arbor **72** and under the arbor **16**. The leading ends of the tubes may be engaged by the clamp **10** and trailing portions of the tubes by clip **4**. With the tubes thus in position, the apparatus is set for a bending operation. Oil is introduced into the cylinder **118** to rock the sprocket **110** which, through the chain **75**, rocks the assembly on the end of the arm member **52** clockwise to the position shown in Fig. 2. The rod **100** is shifted to rock the lever **78** clockwise to set the sub-assembly to the position shown in Fig. 2. Thus, the bending pad **85** is set to a pre-bend or overbend position relative to the fixed pad **73** and arbor **72**. The arbor arm **18** is shifted from the position shown in Fig. 16 to the position shown in Figs. 1 and 9, so that the tubes are caused to be engaged between the arbor and the bending pad **30**. This is also an overbend position with reference to the fixed pad **23**.

The arm **50** is now swung on its axis by cylinder motor **48**, rack **46**, and gear **45** through substantially 180°, as Fig. 1 is viewed, if a bend of 180° is desired. In this action the length of tubing being supplied to the machine and lying on the supporting arm **5** is stabilized as the arm **5** swings up about its pivot **6**. As the arm **50** swings the bending assembly on the end of the arm is held relatively fixed by means of the chain **75** and associated parts so that the bending pad **85** bends the tubes about the arbor **72**. The arm **38** with its bending pad **30** is swung about its bearing **31** by reason of its roller **40** lying in the cam slot **41**, thus causing the pad **30** to bend the tubes about the arbor **16**. The shape of the cam groove **41** is determined so as to move the pad **30** about the arbor **16** substantially at the same rate of angular movement as the bending pad **85** moves about the arbor **72**. It will be appreciated that some tube is consumed in the bend about the arbor **16**. Thus, the distance between the arbor **16** and the arbor **72** must vary. The arbor **72** must traverse a form of involute curve. The axis *x* of arm **50** is preferably located so that the radial distances from the center *x* to the involute curve at various points along the curve have substantially a minimum amount of variation. If the involute curve had a center, which it does not, it could be visualized that the center *x* is placed near the center of the involute. The springs **56** constantly urge the outer part of the arm inwardly with the rollers **63** riding on the cam **65**, the surface of which is formed to control the movement of the arbor **72** substantially along the involute curve. In other words, by a proper location of the center *x* of arm **50** the control required of the cam **65** is minimized. If the arbor **72** moved about the axis *y* of the arbor **16** on the fixed radius of the position shown in Fig. 1, it would traverse the arc *b*. However, it actually traverses a form of involute as shown by the curve *a*, due to the shape of the cam **65**. At the completion of a bend, the bending pad **30** and associated parts are substantially as illustrated in Fig. 12. It will be appreciated that during the operation just described, the arbor arm **18** through its lug **36** holds the plate **32** and the bearing **31** for the bending pad in the position shown concentric with the arbor. At the completion of a bend, the bending assembly on the end of the arm appears as shown in Fig. 5.

Now, it will be observed that two bends have been made in the tubes, one shown at *d* (Fig. 12) about the arbor **16** and one shown at *e* (Fig. 5) about the arbor **72**. The tubes are tightly engaged about the arbors, and furthermore engaged in the grooves in the sliding bending pads. Therefore, to remove the several bent tubes, the machine has to be opened and the following things take place: The bending assembly embodying the unit **70** is shifted from the position shown in Fig. 5 to the position shown in Fig. 13, this being accomplished by actuating arm **115**, rod **116**, cylinder motor **118**, chain **75**, and sprocket **74**. The rod **100** is shifted and the lug **105** engages and rocks the lever **78** to shift the pad **85** from closed position, as shown in Fig. 5, to open position as shown in Fig. 13. The arm **18** for the arbor **16** is rocked from the position shown in Fig. 12 to the position shown in Fig. 16. In this action the lug **36** shifts from locking position, as shown in Fig. 12, thus releasing the plate **32**, and the cam element **17** on arm **18** engages the roller **42** which rocks lever **38** clockwise (Fig. 16) about the axis of pivotal mounting **31**, and the plate **32** counterclockwise about its axis **33** thus raising the pivotal mounting **31** for the bending pad **30**, and the roller **40** of the arm **38** moves into the angular portion **41***a* of the cam slot to support the bending pad and hold it elevated as shown in Fig. 16. Now the several tubes may be removed by shifting the same axially relative to the arbors.

The next movement is to return the swinging arm to its starting position in which action it moves clockwise through the arcuate movement indicated in Fig. 1, and in this action the roller **42** moves off the cam **17** so that the plate **32** drops into position with the abutment **34** striking abutment **35**, thus positioning the axis of the bending pad **30** concentrically with the arbor **16**. The parts are now in their initial position ready for the several tubes to be advanced and again placed in position between the arbors and their respective bending pads.

As previously stated, it is necessary to support the tubes to prevent them from flattening; particularly when they are bent on a short radius. Therefore, the bending pads **30** and **85** are grooved as shown to lend support to each tube. Moreover, the outside tubes are supported at their median line or neutral axis and each tube contacts another along lines lying in a plane containing the neutral axis of each tube, and thus each tube obtains support from its neighbor.

Further, when the bending pads are thus grooved to support the tubes, the area of the surface to surface engagement between the bending pads and the tubes is substantially increased and this is one of the reasons why the bending pads **30** and **85** are slidably mounted on their carriers **28** and **84**. Accordingly, when the bending pads are moved about the arbors, they do not slide on the tubes. The pads **30** and **85** slide on their supports or carriers **28** and **84** against the action of the respective springs **130** and **86**. The displaced positions of the pads **30** and **84**, with respect to their carriers or supports, following a bend, are shown in Figs. 5 and 12. The pad **30** is extended against the action of the spring **130** and the pad **84** is extended against the action of the spring **86**. It might be stated that without this sliding action of the bending pads that the friction on the tubes would be so great as to distort or deform the tubes, to even pull the tubes out of the clamp and to cause metal of the tubes to be scraped off and deposited in the groove of the pads, in addition to the introduction of friction required to be overcome in the operation of the machine.

We claim:

1. In an apparatus for bending a plurality of work pieces of elongated form, such as tubes, a bending form with smooth forming surfaces, a bending pad, the bend-

ing form and the bending pad adapted to have a plurality of work pieces disposed therebetween, the bending pad having a plurality of grooves therein, one for each work piece, and adapted to engage the work pieces with a work piece in each groove, the grooves being formed to fit the individual work pieces and the pad having web portions between its grooves which terminate short of a plane containing the neutral axes of the work pieces, so that the work pieces engage and support each other along lines of contact lying substantially in said plane, side portions on the bending pad projecting at least to said plane to support the outer sides of the outermost work pieces, whereby all work pieces are supported thereby, and means for moving the bending pad relative to the bending form to bend the work pieces on the bending form.

2. In an apparatus for bending a plurality of work pieces of elongated form and circular in cross section, such as tubes, a bending form with smooth forming surfaces, a bending pad, the bending form and the bending pad adapted to have a plurality of work pieces disposed therebetween, the bending pad having a plurality of grooves therein, one for each work piece, and adapted to engage the work pieces with a work piece in each groove, each groove being formed on a radius substantially the same as the radius of the work piece received therein and the center to center distances between the grooves being substantially equal to the outside diameter of the work pieces, the grooves having a depth less than the radius of the work pieces so that the work pieces engage and support each other along lines of contact lying substantially in a plane containing their neutral axes, the pad having side portions defining the outermost grooves which project at least to a plane containing the radial centers of the grooves, to thereby engage and support the outermost faces of the two outermost work pieces, so that all work pieces support one another against flattening, and means for moving the bending pad relative to the bending form to bend the work pieces on the bending form.

3. In an apparatus for bending a plurality of like work pieces of elongated form and circular in cross section, such as tubes, an arbor, with smooth forming surfaces, a bending pad, the arbor and the bending pad adapted to have a plurality of work pieces disposed therebetween, the bending pad having a plurality of grooves therein, one for each work piece, and adapted to engage the work pieces with a work piece in each groove, the grooves being formed substantially on the radius of the work pieces and the center to center distance between the grooves being substantially equal to the diameter of the work pieces, the grooves being defined by intervening web portions of an extent less than the radius on which the grooves are formed, whereby the work pieces engage and support one another along lines of contact lying substantially in a plane containing their neutral axes, the bending pad having side portions defining the outermost grooves and said side portions having an extent at least substantially equal to the radius of the grooves, whereby to contact and support the outside surfaces of the outermost work pieces substantially in said plane, and means for causing the bending pad to move about the arbor to bend the work pieces on the arbor with the work pieces supported against flattening.

4. In an apparatus for bending a plurality of like work pieces of elongated form and circular in cross section, such as tubes, a bending form, a supporting element, the bending form and supporting element adapted to have the work pieces disposed therebetween, a forming pad mounted on the supporting element for sliding movement on the supporting element in a direction lengthwise of the work pieces, the bending pad having grooves therein, one for each work piece, and adapted to engage the work pieces with a work piece in each groove, the grooves being formed to fit the individual work pieces, the pad having web portions defining the grooves which terminate short of a plane containing the neutral axes of the work pieces so that the work pieces engage and support each other along lines of contact lying substantially in said plane, the pad having side portions defining the outermost grooves to engage and support the outside surfaces of the outermost work pieces substantially in said plane, and means for moving the supporting element relative to the bending form to cause the pad to bend the work pieces on the surface of the bending form with the pad sliding on the supporting element and engaging the work pieces in non-sliding manner.

5. The apparatus as described in claim 4 characterized in that the grooves in the bending pad are formed substantially on the radius of the work pieces and are positioned at center to center distances substantially equal to the outside diameter of the work pieces.

6. The apparatus as described in claim 4 characterized in that the grooves in the bending pad are formed substantially on the radius of the work pieces and are positioned at center to center distances substantially equal to the outside diameter of the work pieces, and further characterized in that the pad has web portions between the grooves allowing the tubes to contact each other along said lines of contact.

7. An apparatus for bending a work piece of elongated form, such as tube, into a coil of serpentine form having a succession of reverse bends comprising, a supporting frame, a first arbor mounted on the frame, an arm pivotally mounted on the frame with its pivot adjacent said arbor, a second arbor on the arm removed from the pivot thereof, a bending pad pivotally mounted adjacent the first arbor, a bending pad pivotally mounted adjacent the second arbor, the arbors and pads adapted to have a substantially straight work piece positioned between the respective arbor and pad with the work piece extending transversely of the axes of the arbors, means for holding the leading end of the work piece in fixed position, spring means for yieldably urging the second arbor radially inwardly toward the pivot of said arm, means for swinging the arm on its pivot, means for causing the bending pads to move about their respective arbors as the arm swings to bend the work piece about the two arbors, a cam device positioned adjacent the pivot of said arm, and an element connected to the second arbor and riding on said cam device as the arm swings, said cam device being formed to control the radial inward movement of the second arbor, as the arm swings, to an extent substantially corresponding to that required by the shortening of the work piece because of the wrap of the work piece about the first arbor.

8. An apparatus for bending a plurality of work pieces of elongated form, such as tubes, into a coil of serpentine form having a succession of reverse bends comprising, a supporting frame, a first arbor mounted on the frame, an arm pivotally mounted on the frame with its pivot adjacent said arbor, a second arbor on the arm removed from the pivot thereof, the arbors having smooth forming surfaces, a bending element pivotally mounted adjacent the first arbor, a bending element pivotally mounted adjacent the second arbor, the arbors and elements adapted to have a plurality of substantially straight work pieces positioned between the respective arbor and bending element and extending transversely of the axes of the arbors, a bending pad slidably mounted on each bending element and adapted to engage the work pieces, means for swinging the arm on its pivot, and means for causing the bending elements with the pads thereon to move about their respective arbors as the arm swings to thereby bend the work pieces about both arbors, with the bending pads having a non-sliding contact with the work pieces, said bending pads having a plurality of grooves, one for each work piece, of a depth and location so that the work pieces engage each other along lines of contact lying substantially in a plane containing their neutral axes, said grooves having side por-

tions which engage and support the outermost work pieces on their outer faces substantially in said plane.

9. The apparatus as described in claim 8 characterized in that the bending pad adjacent the arbor on the arm is pivotally mounted relative to said arbor, means for rocking the pad to provide clearance for insertion and removal of the work pieces, and means for rocking the pad into engagement with the work pieces and for locking the pad in said engaged position.

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