Nov. 29, 1966 | H. VAN HARTEN | 3,287,952

BENDING MACHINE

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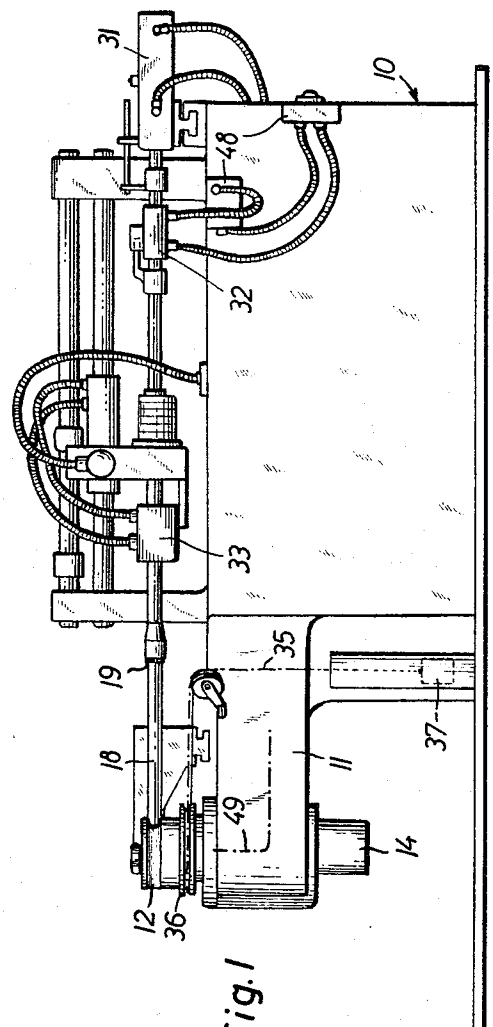

Fig. 1

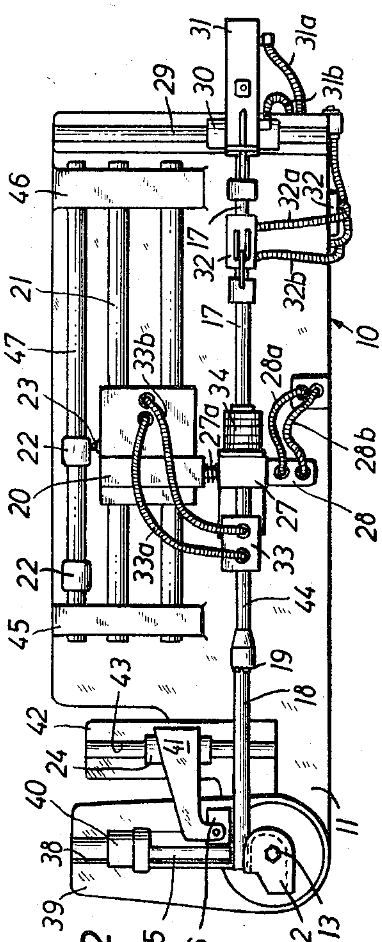

Fig. 2

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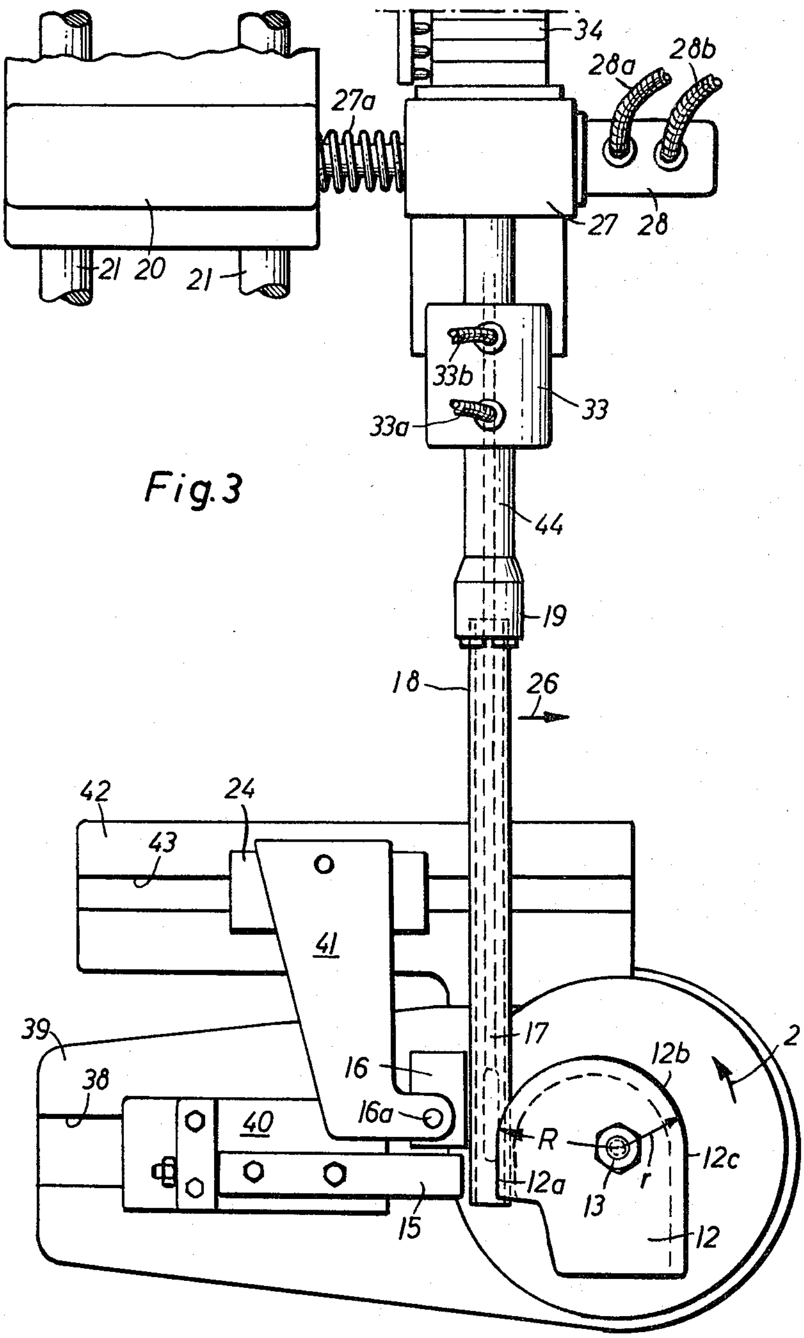

Fig. 3

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3,287,952
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The present invention relates to bending machines in general, and more particularly to a pipe bending machine. Still more particularly, the invention relates to improvements in rotary pipe bending machines wherein lengths of pipe are bent about rotary forms while the walls of pipe sections which are located just ahead of the point where bending begins receive a suitable mandrel which prevents collapsing of the pipe walls. In such machines, the pipe may but need not be held by pressure dies.

It is an important object of the invention to provide a novel form for use in rotary pipe bending machines.

Another object of the invention is to provide a novel shifting arrangement which controls movements of the mandrel in such bending machines and to construct the shifting arrangement in such a way that axial movements of the mandrel are properly synchronized with angular movements of the novel form.

A further object of the invention is to provide a shifting arrangement of the just outlined characteristics which allows the mandrel and the pipe to move in one or more directions other than axially so as to make sure that the pipe will follow the curvature of the form with utmost accuracy and that tubular stock of different gauge may be bent in the same machine.

A concomitant object of the invention is to provide a rotary bending machine for tubular stock which is capable of producing comparatively simple or more complicated bends ranging from bends which follow the periphery of a circle to bends whose curvature changes gradually or even suddenly and wherein the minimum radius of curvature may be but a small fraction of the maximum radius.

With the above objects in view, a very important feature of the invention resides in the provision of a bending machine, particularly a rotary bending machine for pipes and similar tubular workpieces, wherein the rotary form comprises a peripheral bending surface arranged to engage and to bend a workpiece in response to rotation of the form, and wherein this bending surface includes sections having different radii of curvature so that the bent portion of the pipe need not follow the periphery of a circle. The centers of curvature of all surface sections may but need not be located on the axis about which the form rotates, and the transition between such sections may but need not be gradual.

Another feature of the invention resides in the provision of a specially mounted mandrel which is movable axially to insure that the position of its leading end portion is always in proper relation to the angular position of the form.

A further feature of the invention resides in the provision of a mandrel which is movable sideways, i.e., substantially at right angles to its axis, to make sure that its tip can remain sufficiently close to the bending surface of the form.

Still another feature of the invention resides in the provision of an adjustable pressure die which insures that the form will bend only that portion of the pipe which is in actual engagement with the bending surface.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claim. The improved bending machine itself, however, both as to its construction and its mode of operation, together with additional features and advantages thereof, will be best understood upon perusal of the following detailed description of certain specific embodiments with reference to the accompanying drawings, in which:

FIG. 1 is a somewhat schematic side elevational view of an automatic pressure-die type rotary pipe bending machine which embodies the invention;

FIG. 2 is a somewhat schematic top plan view of the bending machine; and

FIG. 3 is a greatly enlarged view of a portion of the structure shown in FIG. 2.

Referring to the drawings, the bending machine comprises a fixed base **10** having a horizontal arm **11** which supports a specially configurated form **12**. The form is rotatable about the axis of a vertical shaft **13** and is driven by an electric motor **14** provided at the underside of the arm **11**. A cable **35** is fixed to a pulley **36** on the shaft **13** and to a counterweight **37** to automatically return the form **12** to the angular position of FIG. 2 or 3 when the machine completes a bending operation.

The form **12** cooperates with an elongated bar-shaped clamping die **15**, with a block-shaped or rail-shaped pressure die **16**, and with a mandrel **17**. The clamping die **15** is reciprocable radially of the shaft **13** and is guided in ways **38** provided on a horizontal carrier **39** which is rotatable with the form **12**. The slide **40** which serves to move the clamping die **15** along the ways **38** is of known design and its exact construction forms no part of this invention.

The pressure die **16** is pivotable about a vertical pin **16***a* provided at one end of an L-shaped supporting bracket **41** mounted on a second carrier **42** having horizontal ways **43** so that the die **16** may move in directions substantially at right angles to the axis of the mandrel **17**. The means for moving the bracket **41** along the ways **43** comprises a hydraulically or pneumatically operated slide **24** which may be replaced by a spring or by a package of springs.

If desired, the block-shaped die **16** may be replaced by a roller having a peripheral groove similar to the groove in the peripheral bending surface of the form **12**.

The workpiece **18** is a length of pipe which is slipped onto the leading end portion of the mandrel **17** in a direction from the left, as viewed in FIG. 2, so that its trailing end portion enters the space between the jaws of a chuck **19**. The chuck **19** is mounted on a tube **44** which surrounds the mandrel **17** and which is carried by a slide **20**. This slide is mounted on two horizontal tie rods **21** extending between two fixed platens **45**, **46** provided on the base **10** and being substantially parallel with the mandrel **17**. The pipe **18** is inserted when the dies **15** and **16** are moved away from the form **12**, and the slide **20** is then shifted to a starting position in which the leading end portion of the pipe extends slightly beyond the clamping die **15**. The slide **20** can be reciprocated by a hydraulic, pneumatic or electric motor and carries suitable control elements, here shown as limit switches **23**, which cooperate with adjustable trips **22** provided on a third tie rod **47**. The switches **23** may be connected in circuit with and then control the motor **14** so that this motor may be started, arrested or its speed adjusted in response to movement of the slide **20** toward the platen **45**.

When the pipe **18** has been moved to the position of FIGS. 2 and 3, the die **15** is caused to move toward the form **12** and to clamp the pipe to make sure that the pipe will move endwise in response to rotation of the form about the axis of the shaft **13** whereby the slide **20** follows such movement because it is connected with the pipe via chuck **19** and tube **44**. The carrier **39** also rotates about the axis of the shaft **13** to insure that the pipe **18** is bent around the peripheral bending surface of the form **12** because the pipe remains clamped between the form and the die **15**.

Before the pipe **18** begins to move in a direction to the left, as viewed in FIG. 2, the pressure die **16** is caused to engage the pipe in a zone just behind the clamping die **15**. The die **16** insures that the bending operation is carried out with requisite precision by preventing bending of that section of the pipe which is not in contact with the bending surface of the form **12**. In other words, the die **16** actually assists the mandrel **17**. When the pipe **18** is bent, the form **12** is rotated in a counterclockwise direction, see the arrow **25** in FIG. 3.

In accordance with a very important feature of the present invention, the peripheral bending surface of the form **12** does not follow the periphery of a circle. Thus, the radius of curvature R of the surface section **12***a* is substantially greater than the radius of curvature *r* in a zone between the surface sections **12***b* and **12***c* which means that, as the form **12** rotates, the freshly bent sections of the pipe **18** will move closer to the shaft **13**. In the embodiment of FIGS. 1 to 3, the radius *r* approximates about one-half of the radius R. Thus, the bent section of the pipe **18** will not resemble one-half of a circle but will resemble a more complicated curve.

Of course, and as the bending operation progresses, the pipe **18** will have to move sideways in a direction (see the arrow **26** in FIG. 3) which is substantially perpendicular to the axis of the mandrel **17**. This is due to the fact that the surface section **12***b* or **12***c* on the periphery of the form **12** is much nearer to the shaft **13** than the surface section **12***a*.

The mandrel **17** not only follows such sidewise movement of the pipe **18** but, in accordance with another important feature of my invention, also moves axially with reference to the pipe to make sure that its axial position with respect to the pipe is in proper relation to the radius of curvature of that section of the bending surface of the form **12** which is located opposite the pressure die **16**, i.e., which is in the process of deforming a fresh section of the pipe **18**.

In order to carry out such axial movement with reference to the pipe **18**, the mandrel **17** is shiftable with respect to the slide **20**. As shown in FIGS. 2 and 3, the mandrel is mounted in a head **27** which is carried by the slide **20** and which is biased by one or more helical expansion springs **27***a* tending to shift the mandrel in a direction away from the slide **20**. The bias of the spring or springs **27***a* is opposed by an adjustable arresting device **28** which may include a fluid-operated cylinder connected with flexible fluid-admitting and evacuating conduits **28***a*, **28***b* and a piston rod fixed to the slide **20**. The device **28** will arrest the mandrel **17** in a selected optimum position, for example, in a position which is best suited for introduction of a fresh length of pipe **18** when the dies **15**, **16** are spaced from the form **12**. This is of particular importance when the pipe **18** is delivered by an automatic feed mechanism, i.e., when it is necessary to keep the mandrel in a predetermined starting position to make sure that the mandrel will be properly received in the pipe.

The mandrel **17** or its supporting rod extends rearwardly and beyond the head **27** and its trailing end portion may be pivotable about a fixed vertical axis, or its trailing end portion may move sideways in and counter to the direction indicated by arrow **26**. FIG. 2 shows that the base **10** carries a support here shown as a rail **29** defining elongated horizontal ways for a slide **30** which supports the trailing end portion of the mandrel **17** so that the latter is movable sideways in directions at right angles to its axis. The position of the slide **30** may be controlled by a pneumatic or hydraulic cylinder (not shown) corresponding to the cylinder of the arresting device **28** and/or by a spring corresponding to the spring means **27***a*.

The slide **24** insures that the pressure die **16** follows the pipe **18** in the direction indicated by arrow **26**.

The means for shifting the mandrel **17** axially with reference to the pipe **18** includes a first hydraulic or pneumatic cylinder **31** which is mounted on the slide **30** and is fixed to the trailing end portion of the mandrel, and a second hydraulic or pneumatic cylinder **32**, both shown in FIGS. 1 and 2. The cylinders **31**, **32** are respectively connected with flexible conduits **31***a*, **31***b* and **32***a*, **32***b* and the system of valves **48** which control admission and evacuation of fluid through these conduits is preferably controlled by one or more cams or trips which rotate with the form **12** to make sure that all axial movements of the mandrel **17** with reference to the pipe **18** are fully synchronized with angular movements of the form. The operative connection between the form **12** and the valves **48** for the cylinders **31**, **32** may be constructed in a number of ways. This connection is indicated in FIG. 1 by a heavy phantom line **49**. If desired, the valves **48** may be controlled by suitable time lag relays, not shown. It is also possible to provide for continuous automatic changes in the axial position of the mandrel **17** with reference to the pipe **18** by driving the mandrel **17** axially with the help of a suitable auxiliary motor (not shown) whose speed is controlled in correspondence with momentary angular position of the form **12**. Such auxiliary motor also serves to return the mandrel **17** to a starting position as soon as the machine completes a bending operation. If desired, the auxiliary motor may be replaced by throttle valves mounted in conduits **31***a*, **31***b*, **32***a*, **32***b* and serving to insure that the cylinders **31**, **32** will move the mandrel **17** gradually and at a rate corresponding exactly to changes in the angular position of the form **12**. Such regulation of the speed of axial movement of the mandrel **17** will be necessary if the curvature of the form **12** changes gradually, i.e., if the zone of transition from the radius R to the radius *r* or vice versa extends along a substantial angle, as seen in the circumferential direction of the form.

In the embodiment of FIGS. 1 to 3, the cylinders **31** and **32** allow for coarse and precision adjustments in the axial position of the mandrel **17**. The cylinder **31** takes care of coarse adjustments, and the cylinder **32** thereupon effects precision adjustment in exact accordance with the momentary angular position of the form **12**. The piston of the cylinder **32** actually constitutes an element of the mandrel **17** and the trailing end of this composite mandrel is connected with the piston rod of the cylinder **31** which is reciprocable with and relative to the slide **30**.

A further cylinder **33** serves as a means to open or close the chuck **19**. This cylinder is connected with flexible conduits **33***a*, **33***b* leading to the slide **20** so that the chuck **19** may be opened or closed in a fully automatic way in dependency on the momentary position of the slide.

It will be noted that the trailing end portion of the mandrel **17** in the bending machine of FIGS. 1 to 3 is reciprocable sideways in a direction at right angles to the axis of the mandrel. This is due to the fact that the slide **30** is movable along the rail **29**. However, and as mentioned hereinabove, it is also possible to modify the bending machine in such a way that the trailing end portion of the mandrel will be pivotable about a fixed vertical axis. This could be effected by omitting the rail **29** and by providing a rigid connection between the base **10** and slide **30** or between the base **10** and cylinder **31**. Such mounting of the mandrel **17** is advisable and possible when the difference between the maximum and minimum radii of curvature of the form **12** is rather small.

The numeral **34** indicates a device which serves to rotate and to fix the mandrel **17** in selected angular positions.

The quality of the bend in a pipe or in a similar tubular body will depend to a large extent on the axial position of the mandrel with reference to the pipe, and more particularly with reference to that section of the pipe which is about to be bent by the form **12** and dies **15**, **16**. It was found that bends of optimum quality will be obtained if the mandrel advances toward the leading end portion of the pipe whenever the radius of curvature of the bend diminishes. In other words, the mandrel **17** should move in a direction to the left, as viewed in FIG. 2, when the bending operation progresses because the radius of curvature of the surface section **12*b*** is less than that of the surface section **12*a*** but exceeds the radius of curvature of the surface section **12C**. On the other hand, and if the form **12** is replaced by a form which begins to bend a pipe along a surface section with a small radius of curvature and thereupon along one or more surface sections having greater radii of curvature, the mandrel **17** will have to move in a direction to the right, as viewed in FIG. 2 or downwardly, as viwed in FIG. 3. Of course, in the course of a normal bending operation, axial movements of the mandrel **17** will be rather small, normally in the range of a few centimeters or even a few millimeters. Nevertheless, such minimal axial adjustments of the mandrel will affect very strongly the quality of the ultimate product, both as regards its appearance and its strength characteristics. For example, if the pipe is bent about a surface section with a small radius of curvature and the leading end portion of the mandrel is too far behind the bending zone, the pipe will be flat at the bend. On the other hand, and if the pipe is bent along a surface section with a large radius of curvature and the leading end portion of the mandrel extends too far into the leading end portion of the pipe, the latter is likely to burst open along the outer side of the bend.

It will be noted that the direction of axial (endwise) movement of the mandrel will depend on the configuration of the form. If the form is configurated and mounted in a manner as shown in the drawings, the mandrel **17** will move in a direction to the left, as viewed in FIG. 2. If the form **12** is replaced by a form wherein a surface section with a small radius of curvature is first to engage the workpiece, the mandrel will move in the opposite direction. If the surface section with minimum or maximum radius of curvature is located between the ends of the peripheral bending surface of the form, the mandrel will move axially back and forth to account for changes in the radius of curvature.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can,

by applying current knowledge, readily adapt it for various applications without omitting features which fairly constitute essential characteristics of the generic and specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claim.

What is claimed as new and desired to be secured by Letters Patent is:

A rotary bending machine for pipes and similar tubular workpieces, comprising a base; a vertical shaft journalled in said base; a carrier mounted on said base and rotatable about the axis of said shaft; means for rotating said carrier; a form fixed to and rotatable with said carrier about the axis of said shaft, said form having a peripheral bending surface arranged to engage and to bend a workpiece in response to rotation of said carrier and said bending surface having sections with different radii of curvature; an elongated mandrel mounted on said base and having a leading end portion arranged to extend into the workpiece which is being bent up to a point close to said bending surface; first shifting means for moving said mandrel axially in synchronism with rotary movement of said form about the axis of said shaft so that the axial position of said mandrel is correlated to the angular position of said bending surface; second shifting means for moving said mandrel horizontally and sideways in a direction substantially at right angles to the axis of the mandrel; a clamping die provided on said carrier and arranged to clamp the leading end portion of the workpiece against said bending surface during rotation of said form; a chuck surrounding a portion of said mandrel and arranged to clamp the trailing end portion of the workpiece during bending; and a slide mounted on said base for movement in the axial direction of said mandrel and supportingly connected with said chuck so that the chuck and the workpiece may move axially of the mandrel when the form rotates about the axis of said shaft.

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