Oct. 14, 1969 P. V. GREGG 3,472,056

PIPE BENDING APPARATUS AND METHOD OF BENDING

Filed Nov. 25, 1966

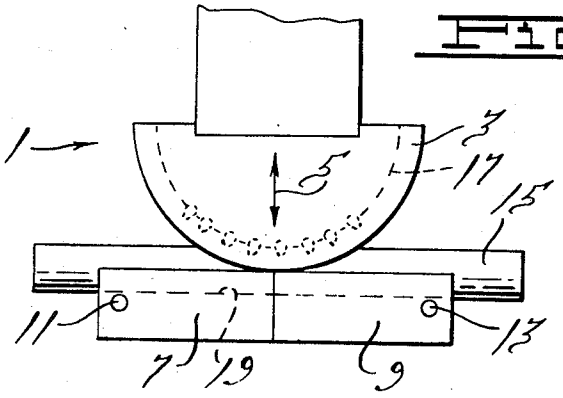

FIG. 1.

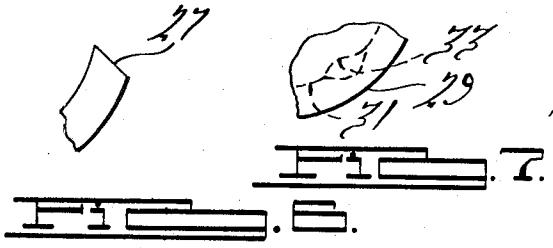

FIG. 6.

FIG. 7.

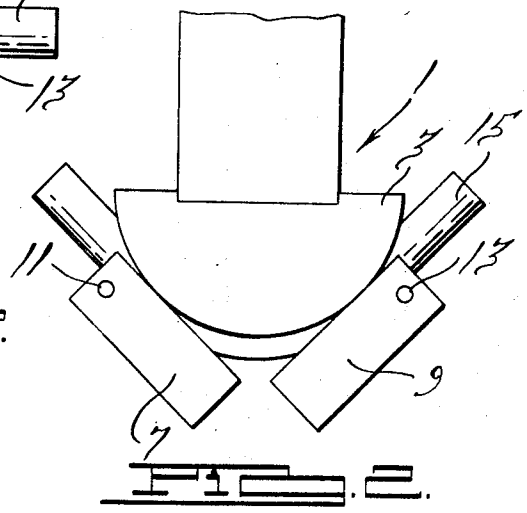

FIG. 2.

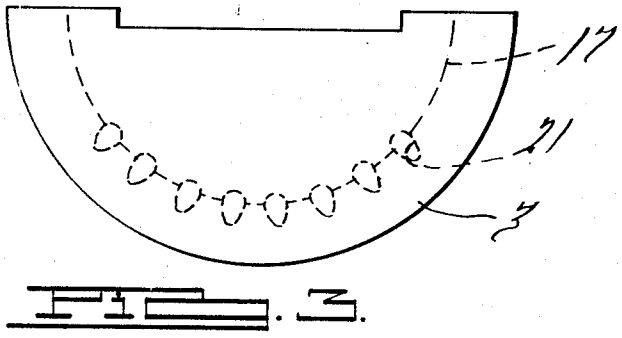

FIG. 3.

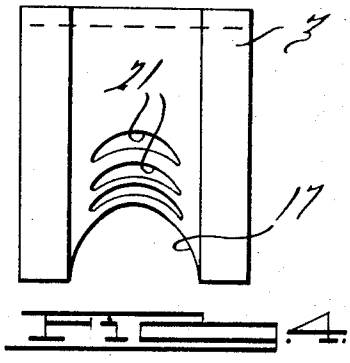

FIG. 4.

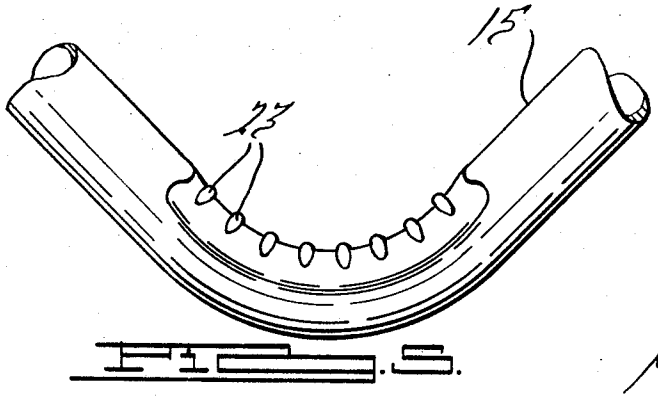

FIG. 5.

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PIPE BENDING APPARATUS AND METHOD OF BENDING

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ABSTRACT OF THE DISCLOSURE

The specification and drawings describe and illustrate preferred embodiments of apparatus and method for bending tubular articles. In the disclosed apparatus, a reciprocally supported ram die engages a tubular pipe that is supported upon a pair of pivoted wing dies and bends the pipe into a radius defined by the shape of the ram die. The ram die is provided with at least one indentation in its surface so that the material of the pipe on the inside of the bend that is stressed in compression by the bending will permanently deform into this depression and form a localized, radially deflected portion in the bent pipe. Through the use of the indented portion of the die, random surface irregularities or distortions that occur in normal bending operations are precluded. It is to be understood that the foregoing abstract of the disclosure is not to be construed in interpreting the appended claims.

Background of the invention

This invention relates to an apparatus for bending tubular articles and a method of bending tubular articles.

Often tubular articles such as pipe must be formed with a series of radically different and acute bends. The manufacture of tail and exhaust pipes for automotive vehicles is a typical example where a pipe must be formed with such a series of bends in order to enable it to fit the space allotted beneath the vehicle. When forming such pipes, accuracy of bending, quality of bending and cost are all very critical factors.

In the normal method of bending tubular articles the tubular article is positioned in engagement with an arcuate surface of the die and is bent to conform to this arcuate surface. When the pipe is thus bent, the material adjacent the die and on the inside of the bend is subject to considerable compressive stress and the material on the opposite side is subjected to tensile stress. Since automotive exhaust pipes generally have extremely thin wall sections to maintain low cost and minimum weight, it is common for the walls to collapse on the outside of the bend and wrinkle or fold on the inside of the bend during the forming operation. This is because the bending stresses exceed greatly the yield strength of the material. Although some of these detrimental effects may be avoided through the use of mandrels on the inside of the pipe, local surface blemishes, commonly known as "blisters," are formed adjacent the end of the mandrel or at locations spaced from the die. Laminated pipe also has the same defects when being bent as plain pipe bent with the assistance of a mandrel.

Summary of the invention

The method and apparatus embodying this invention have been found to permit bending of pipe, particularly laminated pipe, and relieves the compressive and tensile stresses on the inside and the outside of the bend, respectively, by causing controlled deformations of the metal of the pipe on the inside of the bend. More specifically, the method embodying this invention is particularly adapted to form an arcuate bend in a hollow tubular article and

prevent undesirable surface deformations due to the stresses produced in the material of the article by the bending. The method comprises the steps of permanently deforming the tubular article into an arcuate bend and employing the compressive stresses in the material on the inside of the bend generated by the bending to deform the material in a direction transverse to the bend and at a preselected and predetermined location.

An apparatus embodying this invention includes at least one die having a generally arcuate surface conforming to the shape of the desired bend. Transverse to the bend, the bending die is generally complementary in shape to the cross-section of the tubular article to be bent and is formed with at least one surface discontinuity in the area that contacts the pipe. This discontinuity acts to permit displacement of the metal of the pipe during bending at a controlled and preselected location.

Brief description of the drawings

FIGURE 1 is a schematic front view of a simplified bending apparatus of the type to which the present invention may be applied and shows the apparatus prior to bending of a pipe.

FIGURE 2 is a view of the apparatus shown in FIGURE 1, but shows the position of the parts after a bend has been formed in the pipe.

FIGURE 3 is an enlarged front view of the ram die shown in FIGURE 1.

FIGURE 4 is a side elevational view of the die shown in FIGURE 1.

FIGURE 5 is a side view of the bent pipe.

FIGURE 6 is a side view of the form taken by a pipe where a bend is formed near the end of the pipe by previously known methods and apparatus.

FIGURE 7 is a partial side elevational view of a ram die formed to prevent the type of pipe deformation shown in FIGURE 6.

Description of preferred embodiments of the invention

A bending apparatus **1** is provided with a ram die **3** that is supported for reciprocation in a vertical direction as shown by the arrows **5** and is operated by any suitable power source in a known manner. Supported beneath the ram die **3** are a pair of wing dies **7** and **9** that may swing about pivot points **11** and **13**. The ram die **3** and wing dies **7** and **9** have surfaces that correspond generally to the surface of the tubular article to be bent, in this case the bent article being a cylindrical thin wall pipe **15**. Thus, the ram die **3** has a channel **17** of semicircular form in cross-section taken normal to the plane of FIGURE 1. The channel **17** extends over a radius that corresponds generally to the radius about which the pipe **15** is to be bent. The radius of the surface **17** will normally be less than the desired radius of the bend to be placed in the pipe **15** to allow for spring back of the bent pipe. The wing dies **7** and **9** have semi-cylindrical surfaces **19** so that they are aligned when in their normal position (FIGURE 1). When a pipe **15** is supported on the wing dies **7** and **9**, the ram die **3** is actuated to move downwardly until it reaches the position shown in FIGURE 1. Immediately prior to the pipe **15** being bent, it will be completely engaged around its circumference by the die surfaces **17** and **19**.

To achieve a bending of the pipe **15**, the ram die **3** continues to move downward from the position shown in FIGURE 1 to the position shown in FIGURE 2. During this movement, the wing dies **7** and **9** swing about the pivot pins **11** and **13** causing the pipe **15** to be forced into engagement with the surface **17** of the ram die **3**. Thus, the pipe **15** will be bent into a radius that corresponds to the radius of the surface **17** of the ram die **3**.

During the formation of such a bend, the metal on the inside of the bend decreases in length and is placed under compression and that on the outside of the bend increases in length and is placed in tension. The tensile forces can cause flattening, collapsing and/or bursting of the tube along the outside of the bend during conventional bending. In addition, wrinkles, folds and/or blisters can occur on the inside of the bend. Blisters normally are formed when the pipe is bent with a mandrel or if laminated pipe is being bent these surface deformations occur on the surface of the outer pipe. Wrinkles and folds occur when conventional single layer-pipe is being bent without the use of a mandrel. These deformations are caused by the stresses at the respective point which stresses exceed the yield point of the metal being bent and occur at random or unpredictable positions and times.

In accordance with the present invention, the compressive stresses acting on the inside of the bend are relieved by providing for a controlled deformation of the metal on the inside of the bend at a predetermined location. This controlled deformation requires a volume of metal substantially equal to that that would be displaced by the compression of the metal during the bending.

To form the controlled, localized deformations in the pipe **15**, the surface **17** of the ram die **3** is provided with a plurality of circumferentially spaced radially inwardly extending grooves **21** that extend in planes normal to the axis of the pipe. The grooves **21** extend about 160° angularly of the surface **17**. As seen in FIGURE 4, these grooves are generally circular in planes taken parallel to the plane of the radius of the bend and decrease in radius at their peripheries. During the bending operation the metal on the inside of the pipe flows into the grooves **21** so that the bent pipe will be formed with a series of radially outwardly extending deformations or ribs **23** after it has been bent (FIGURE 5). The ribs **23** generally conform to the shape of the grooves **21** and are made up of an amount of metal equal to that displaced by the compression of the metal due to the formation of the bend.

Another type of unsatisfactory or undesirable deformation that occurs when bending pipe results when a bend is formed near the end of the pipe. The material on the inside of the bend flows and deforms the end of the pipe from a plane normal to the axis of the pipe to a plane displaced from this normal position as indicated by the reference numeral **27** in FIGURE 6. In order to maintain the straight line of 90° cutoff at the end of the bent pipe it has been common practice previously to shear off the end of the pipe after it has been bent. Although this provides the 90° end, it should be readily obvious that considerable material has been wasted. Through controlled deformation of the type previously noted, this additional forming step and wastage of material is obviated. FIGURE 7 illustrates a portion of the bending die used to form bends in the end of the pipe. In this embodiment, the bending die **29** is formed with a surface **31** that conforms to the outer periphery of the pipe to be bent and the radius about which the pipe is to be bent. Adjacent the end of the pipe, however, a localized surface deformation or relief **33** is formed in the bending die surface **31** to provide a space accommodating the end of the pipe without deforming it out of square.

It is to be understood that the foregoing description merely relates to a preferred embodiment the invention may take but that various changes and modifications may be made without departing from the spirit and scope of the invention, as defined by the appended claims.

I claim:

1. In a tube bending apparatus, a bend die, a pairof wing dies supported adjacent the bend die to cooperate with the bend die in bending a tube, said bend die having a convexly curved periphery facing said wing dies, said wing dies having aligned substantially straight peripheries facing the bend die periphery, each of said peripheries being provided with a substantially semi-circular channel and said channels defining a cross sectional space to receive a tube for bending, the channels in said wing dies being on the outside of the bend formed in the tube and each being of a substantially smooth and continuous surface along its length, the channel in the bend die being on the inside of the bend formed in the tube and having a plurality of grooves formed therein spaced from each other along the length of the channel and each extending transversely to the length of the channel, said grooves serving to form outwardly projecting stress relieving ribs on the inside of the bend of a tube by the apparatus.

2. The method of forming an arcuate bend in a hollow tubular article having substantially uniform wall thickness and preventing undesirable surface deformations due to the stresses induced in the material of the article by the bending without use of a mandrel comprising the steps of applying bending force transverse to the length of the tubular article to permanently deform the tubular article into the arcuate bend and employing the compressive stresses generated in the material on the inside of the bend by bending of the article to permanently deform the material into a plurality of angularly spaced outwardly projecting ribs extending in planes transverse to the center line of the tubular article at preselected and predetermined locations on the inner periphery only of the bend.

3. The method as set forth in claim **2** wherein the volume of the material forming the ribs is substantially equal to the amount of material displaced by compressive stresses during the formation of the bend.

4. The method as set forth in claim **2** wherein the compressive stresses generated on the inside of the bend are utilized to cause the material to flow into grooves in a die surface contacting the article on the inside of the bend, said grooves serving to form and locate said ribs.

5. In apparatus for bending a tube and having a reciprocating ram for applying bending force to a tube, a die body for attachment to and reciprocation with said ram, said die body having a convex periphery provided with a substantially semi-circular cross section channel for receiving and engaging a substantial length of a tube to be bent, said channel engaging the tube on the inside of the bend formed in the tube, said body periphery having a plurality of grooves formed therein located in the channel and spaced from each other along the length of the channel, said grooves each extending transversely to the length of the channel and along a major portion of the substantially semi-circular width of the channel and serving to form outwardly projecting stress relieving ribs on the inside of the bend of a tube bent by the die which lie in planes transverse to the axis of the tube.

References Cited

UNITED STATES PATENTS

1,197,271	10/1916	Dieckmann	72—369
2,406,838	11/1946	Kepler	72—369
361,487	4/1887	Brownson	72—382
3,240,048	3/1966	Callendar	72—369

FOREIGN PATENTS

1,167,630	4/1964	Germany.

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72—389, 476