

July 22, 1969

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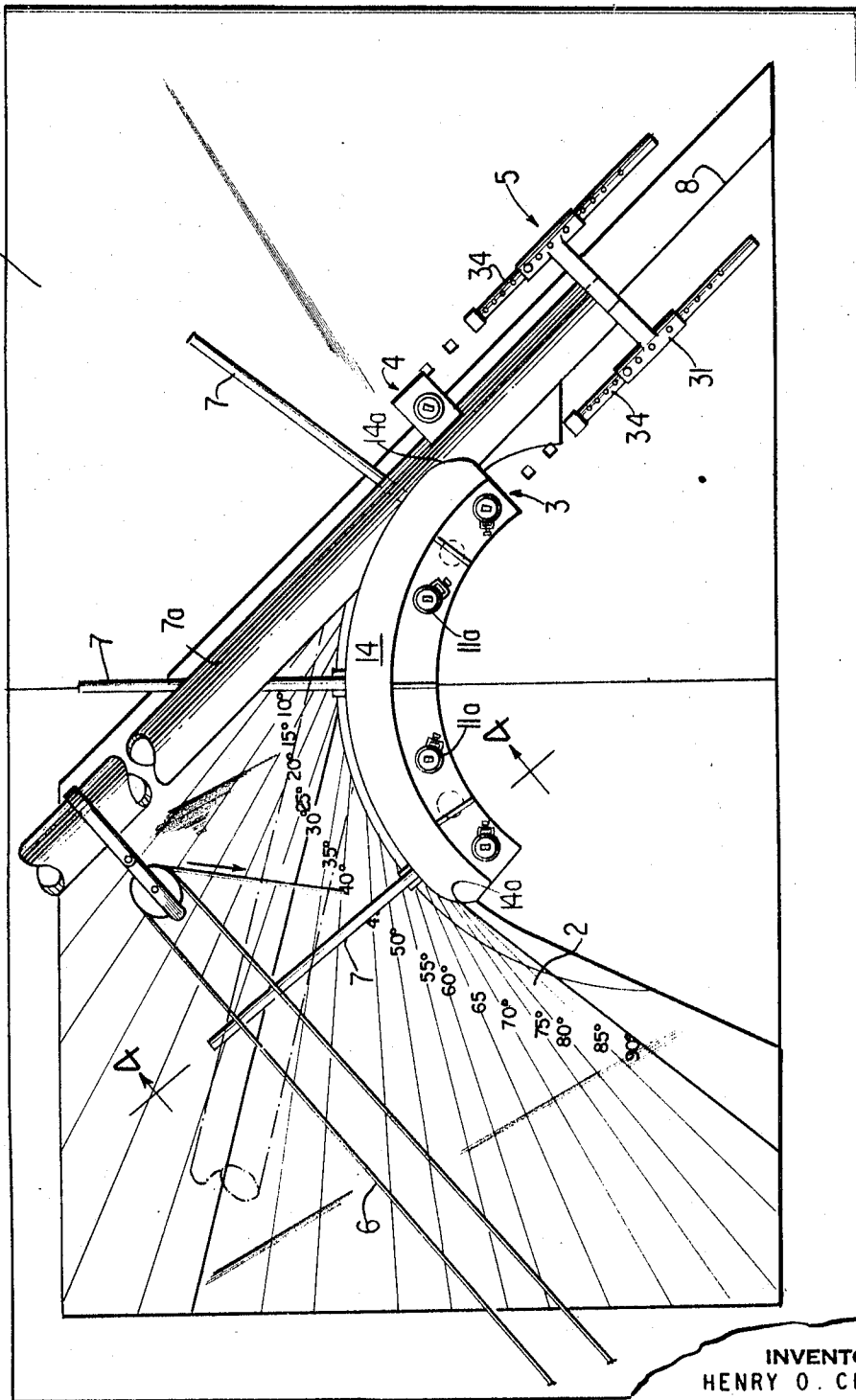
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HOT PIPE BENDING APPARATUS AND METHOD

Filed March 28, 1967

5 Sheets-Sheet 1

FIG. 1



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FIG. 2

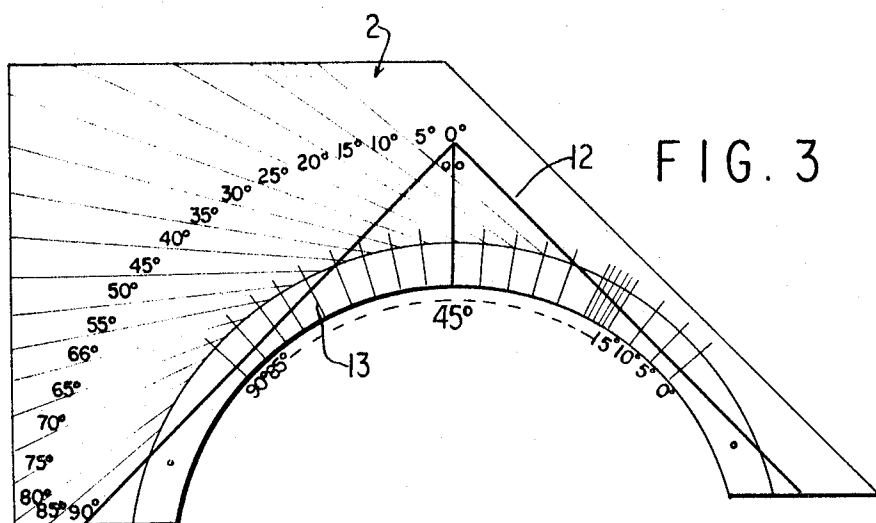
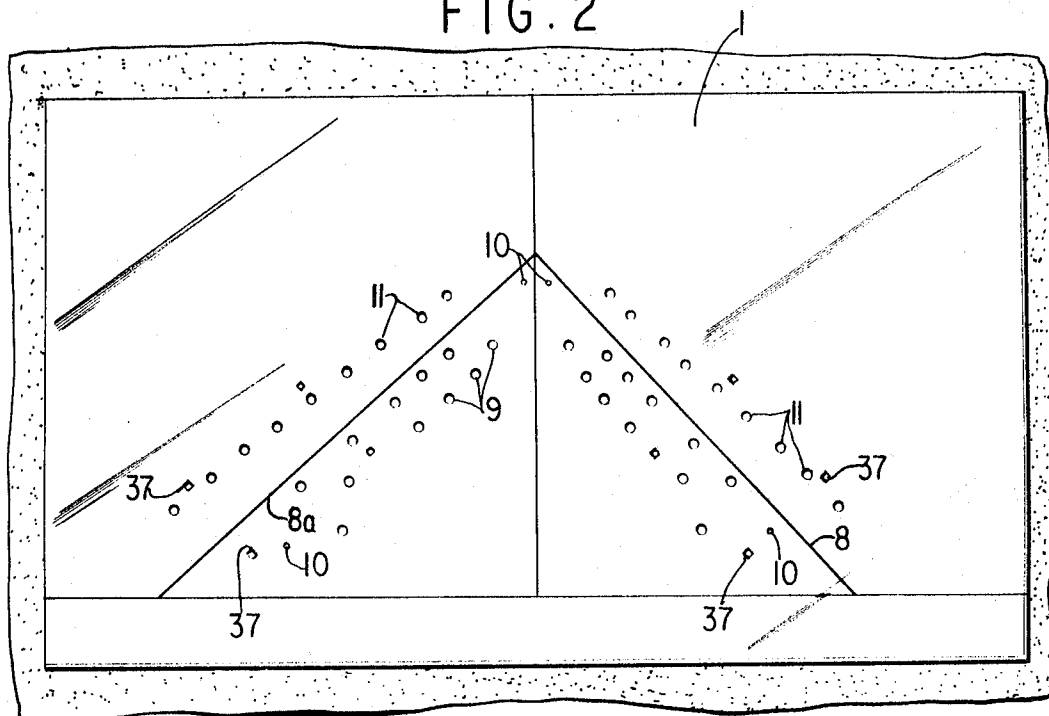


FIG. 3

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FIG. 5

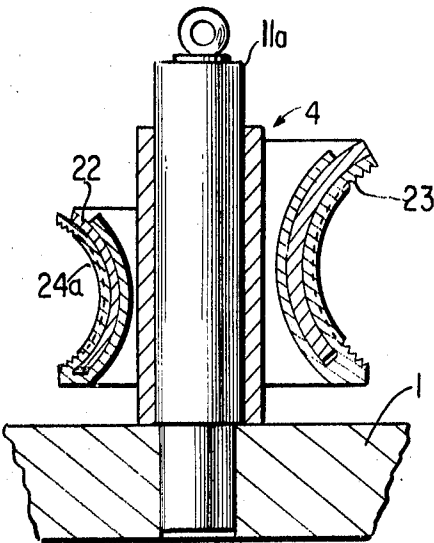


FIG. 6

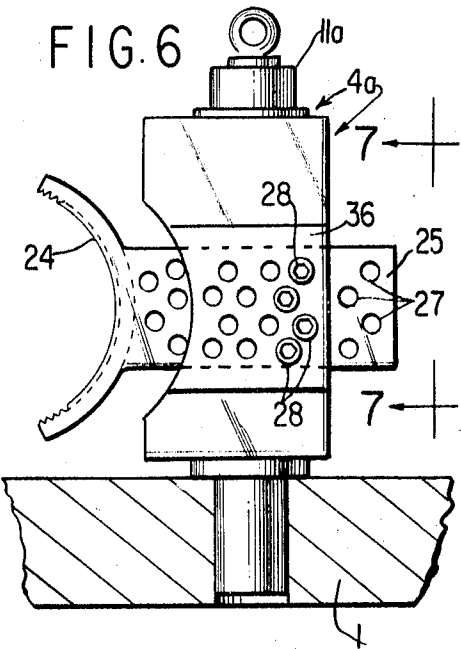
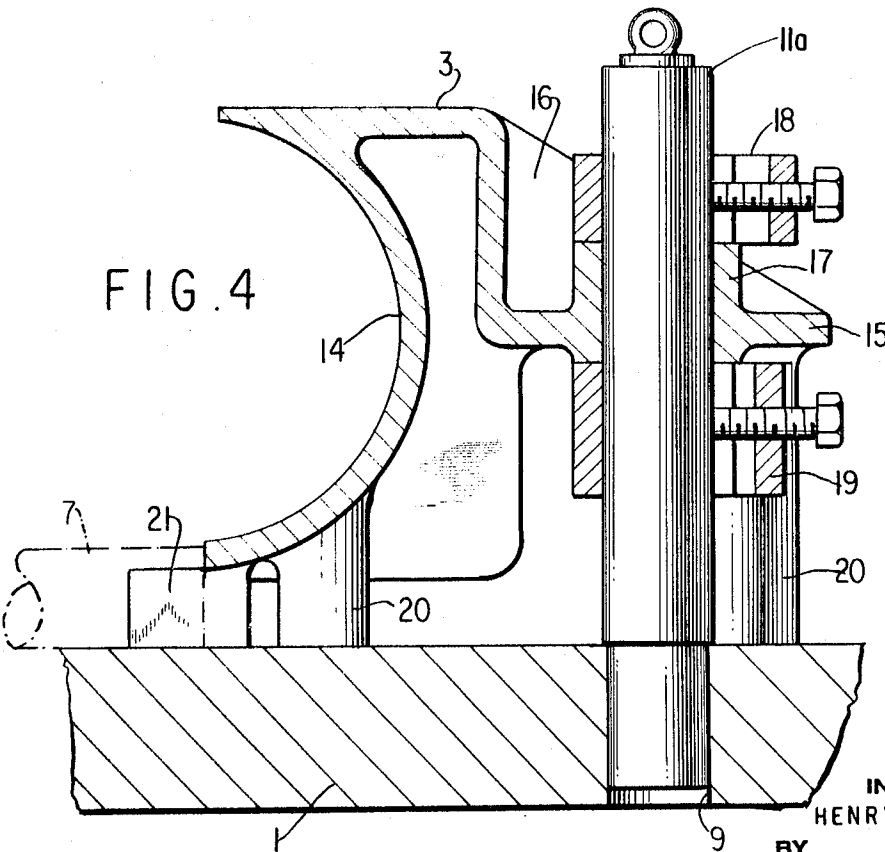


FIG. 4



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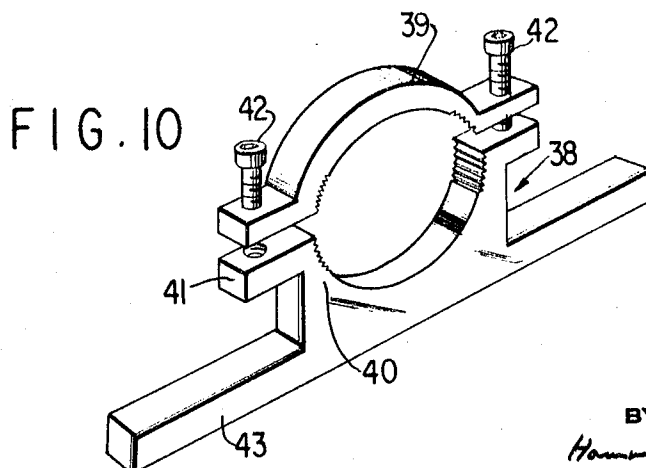
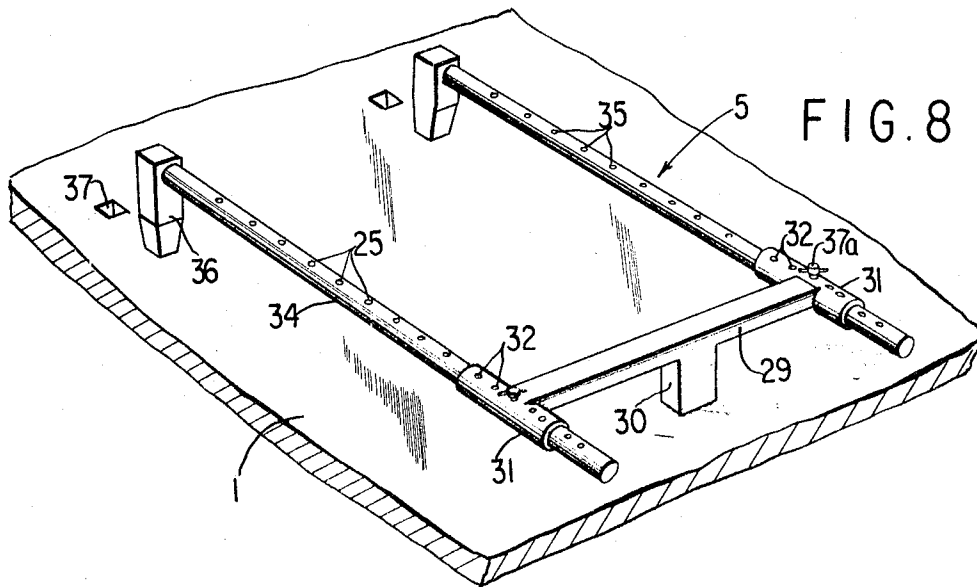
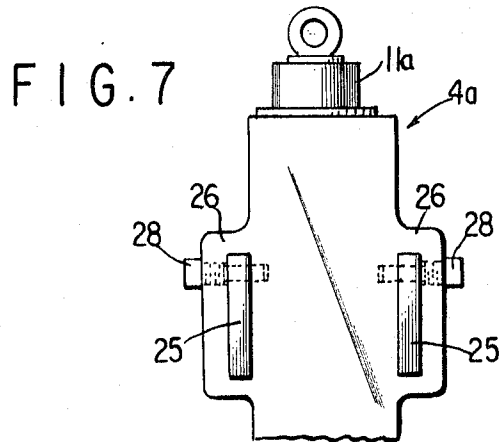
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HOT PIPE BENDING APPARATUS AND METHOD

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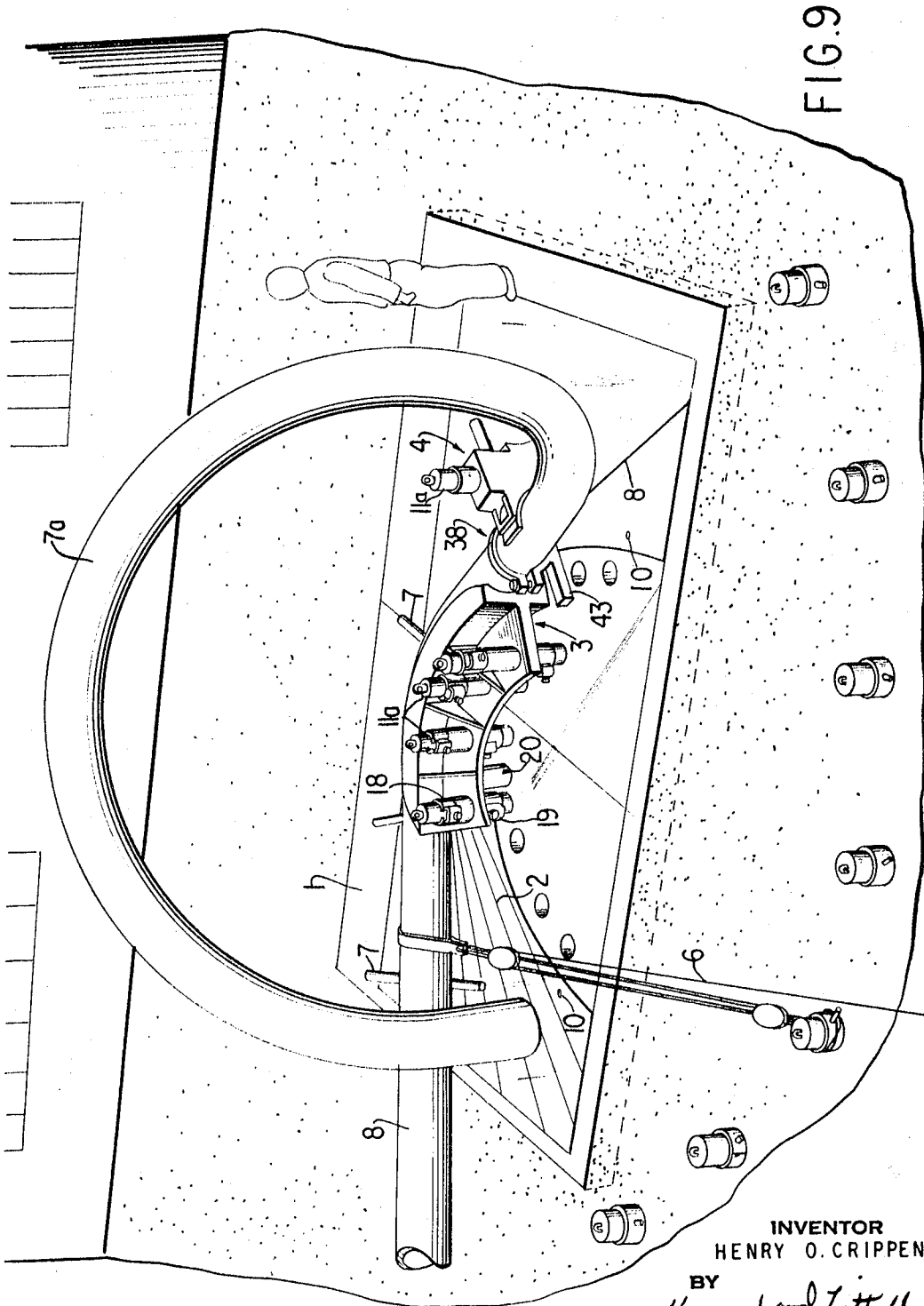
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HOT PIPE BENDING APPARATUS AND METHOD

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HOT PIPE BENDING APPARATUS AND METHOD

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12 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus for heat-bending large diameter pipe comprised of a bending block provided with guidelines forming a 90° angle, base template protractor, arced forming dies with about 180° grooved curvature face and having varying radii, means for holding one end of the pipe against the forming die during bending, means for maintaining the pipe level within the curvature face and means for applying pressure to bend the hot pipe about the die and a method of bending a hot pipe rapidly with a minimum of secondary operations and butt welding.

Prior art

Large diameter pipes are used in construction of many plants and buildings and for many installations they must be bent in specific ways in order to fit into the design conditions. Present methods of bending large diameter pipe have been costly due to the number of skilled men and the time required in the bending operation, the inaccuracy of the present system which results in waste of pipe or requires subsequent treatment by skilled personnel, and the difficulty in obtaining compound bends in a pipe. In the most common pipe-bending operations being used today, the pipe, which is filled with sand, is heated to a high temperature, i.e., 1500 to 2000° F., in a furnace and then set up on the bending table, which has a variety of holes therein. The starting end of the pipe is securely fastened and the portion of the pipe to be bent is without control of the angle of the bend and this portion rides free, resting on the bending table. The angle of the bend is controlled by the skill of the bender, by the use of a template, water and movement of the holding attachments and the angle of pulling leverage. The bending pressure is applied by a capstan with the use of several pulleys and a rope. The pulleys are held by stanchions. The rope is passed around the pulleys and connected to the pipe to be bent and the rope is then wrapped several times around the capstan. The bending pressure is started by tightening the rope around the revolving capstan and the bending pressure is relieved by releasing the rope. This operation is repeated until the desired angle of bend in the pipe is attained. During the operation of the bending, two men hold a template (usually a heavy wire bent to the desired angle of the bend) over the pipe to make certain the correct angle and radius of bend is obtained.

In addition to the men holding the template, a capstan operator and a man with a water hose are required. Water spraying of the hot pipe has two primary purposes: (1) to affect the radius of the pipe when the bend is closing in too sharply by spraying water on the outer side of the pipe to chill this portion of the pipe and stop or slow the bending in that portion, and (2) to prevent buckles in the pipe caused by the throat being too hot by spraying the inner side of the pipe with water. This operation requires not only four men and a great deal of time, but also a high degree of skill and experience. In addition, only clockwise or counterclockwise bends may be made on existing apparatus.

The said procedure has many disadvantages. One disadvantage resides in the amount of time required to perform the bend, since the pipe cools rapidly and more

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pressure is required to bend the pipe the more it cools. For example, the tensile strength of one common pipe metal at 1600° F. is 10,000 pounds per square inch, while at a temperature of 1250° F., the same metal has a tensile strength of 35,000 pounds per square inch, an increase of 3.5 times in tensile strength over a temperature drop of only 350° F. Under normal plant conditions, metal pipes will cool approximately 100° F. per minute and, therefore, the tensile strength of pipes and the pressure necessary to bend the pipes increases rapidly. If the pipe becomes too cold during the bending operation, too much pressure is required and flattening of the pipe walls occurs. Moreover, sharp or abrupt pulls on the pipe during bending thereof will cause thinning in the pipe walls which weakens the pipe. Faults caused by overbending, underbending, buckling, flattening or the like cause a high amount of rejects which increases the cost of pipe bending operations.

For proper bending, the outer side or heel of the pipe should be hotter, since the heel has to stretch and the inner side or throat of the bend only has to compress. When water is used to cool the inner side of the pipe, it will frequently cool one section of the throat of the pipe too much, which section becomes harder than the surrounding pipe sections and causes buckle. Thinning will occur due to uneven stretching and/or compression. If the throat of the pipe is unevenly cooled, the hotter portions of the throat will compress faster and cause buckles. If the far end of the pipe remains hotter than the portion of the pipe being controlled by the water, the pipe will bend farther ahead of the portion to be bent instead of following gradually the desired radius and the bend will not have the proper arc or radius.

Objects of the invention

It is an object of the invention to provide a novel apparatus for accurately and rapidly bending large diameter pipe with small crews.

It is another object of the invention to provide a novel apparatus for bending large diameter pipe without the use of water for cooling.

It is a further object of the invention to provide a novel pipe bending apparatus which may be used for different size pipes to obtain bends up to 360° with varying radii and to obtain accurate compound bends in pipe.

It is another object of the invention to provide a pipe bending apparatus in which large diameter pipes may be bent clockwise or counterclockwise.

These and other objects and advantages of the invention will become obvious from the following detailed description.

The apparatus of the invention for bending large diameter pipes is comprised of a bending block provided with two guide lines forming a 90° angle and preferably provided with a plurality of holes therein; a base template protractor resting on the bending block marked off in degrees from 0 to 90° with the 0° line coinciding with one of the guide lines on the bending block and the 90° line coinciding with the other guide line on the bending block, an arced forming die, preferably having slightly more than a 90° arc, with a 180° grooved curvature face and have a radius substantially equal to the radius of the desired pipe bend, the said die being securely centered on the bending block so that the bottom lip of the forming die curvature at each end at 90° of this curvature face meets a guide line on the base template protractor at tangential points on the base template protractor, means for holding one end of the pipe to be bent against the forming die when laid along either guide line on the base template protractor, means for keeping

the pipe level during the bending operations, and pressure applying means to bend the pipe about the die the desired number of degrees.

The bending block is a rectangular steel block which is preferably made in two pieces for handling ease during construction thereof. The said block acts as a table upon which the hot pipe is bent and is set in the floor of the bending plant and is preferably level with the plant floor. On each side of the bending block at specified distances therefrom, holes are provided in the floor of the bending plant which accommodates stanchions which can be raised or lowered to provide for the positioning of the pressure applying means at a height so that the pipe is bent in a plane parallel to the floor. The angle of the applied pressure may be varied and clockwise and counterclockwise bends may be made by the proper selection of the stanchion.

The bending block is provided with two guide lines thereon which form a true 90° angle and these two guide lines provide a reference point layout for the bending block holes and for all of the equipment that fits thereon. Preferably, the bending block has a plurality of holes arranged along the two guide lines whereby forming dies may be secured with dowel pins passing down through dowel pin sleeves provided on the form plate of the forming die and engaging the holes in the bending block. The dowel pins in the holes secure each forming die in the proper relationship to the guide lines on the base template protractor. In a preferred embodiment, the bending block has 38 of the said holes positioned with respect to the angle formed by the guide lines to accept various sized forming dies for bending pipes of 6" to 18" diameter and the holding shoes. For bending of larger diameter pipes, i.e., up to 24" diameter, additional holes may be provided.

The holes in the bending block are arranged so that the center of the hot pipe, when it is in the forming die at the start of the bending operation, lies along one of the two guide lines. The forming die must be held securely in position on the bending block so that there is no movement thereof during the bending operation. The dowel pins and holes in the bending block provide the simplest method of securing the forming die without complicated attachments. For ease of handling, the dowel pins holding the forming die may be provided with eye-hooks so that they may be removed from the holes in a simple fashion.

The base template protractor is secured on the bending block and fits around the base of the forming die. The said protractor is provided with degree lines from 0° to 90° at right angles to the radius of the forming die so that constant observation of the degree of the bend may be made during the entire bending process. The 0° line coincides with one guide line on the bending block upon which the hot pipe is laid at the start of the bending operation and the 90° line coincides with the other guide line. A second scale is preferably provided on the base plate protractor along the base of the curvature face of the forming die and coinciding with the center line of the pipe being bent and extends slightly beyond the outside diameter guide line. The 0° mark indicates the start of the bend in the pipe and the scale indicates the circular degree of the bend so that the exact position of the end of a bend can be marked on the pipe and a second bending operation may be effected, if necessary. The degree of the bend arc is the tangential point where the unbent portion of the pipe meets the forming die.

The base template protractor may also be provided with a concentric guide line about the second scale which lies just outside the diameter of the bent pipe in the forming die. This line serves for checking the outside diameter of circular bends while they are still on the bending block. Preferably, the base template protractor is provided with scales on both sides so that it has two

faces, one face used for clockwise bending and the other face used for counterclockwise bending, depending upon its position on the bending block. A base template protractor is provided for each die to be used and each base template protractor coincides exactly with the two guide lines on the bending block whether it is used for clockwise or counterclockwise bending.

To secure the base template protractor in position, the bending block and the said protractor may be provided with cooperating holes so that dowel pins can pass through the template into the bending block. The said protractor provides a means for constantly observing the degree of the pipe bend from the start of the bend to the finished angle.

The forming die is an important feature of the invention since it provides a form about which the hot pipes can be bent without buckles or wrinkles or flattening or thinning of the pipe walls. The forming die is comprised of a die body having a grooved curvature face with a peripheral arc of 180° and a diameter slightly larger than the diameter of the pipe to be bent, a form plate centered along the entire back of the die body provided with sleeves to accommodate dowel pins which pass therethrough and engage holes in the bending block. Gussets between the back of the die body and the form plate may be provided for further strengthening of the die body. When the forming die is in position on the bending block, the bottom lip of the curvature face fits concentrically with the second scale of the base template protractor. Preferably, the ends of the top lip of the curvature face are elliptically shaped so that the hot pipe to be bent may be easily inserted into the forming die along the guide line and clamped into position rapidly.

The length of the die curvature for bending 18" diameter pipe is approximately 100 degrees in circumference. The dies for bending up through 18 inch diameter pipes may be varied from 100 degrees up to 180 degrees in circumference. The center of the forming die, when it is in position, should coincide with the middle of the 90° angle formed by the two guide lines on the bending block.

The curvature face of the forming die should be slightly elevated from the bending block so that the hot pipe in the bending position is slightly elevated to allow the pressure applying means to be attached to the hot pipe while keeping the hot pipe in a level plane. The curvature face and the form plate may, therefore, be provided with pedestals for their support. To support the hot pipe during the bending operations, a plurality of riding pipes or other means of the same height as the inside bottom lip of the curvature face are provided to keep the neutral axis of the pipe parallel to the neutral axis of the forming die. The riding pipes may be accommodated in recesses under the bottom lip of the curvature face and radiate from the curvature face.

The sleeves of the form plate of the die body are slightly larger in diameter than the dowel pins which engage the holes in the bending block. To take up the play between the said sleeves and the dowel pins, shims may be used. However, it is preferred to provide the sleeves at the top and bottom thereof with adjustable collars which can be hand tightened about the dowel pins to prevent movement of the die when bending pressure is applied to the pipe.

Means are necessary to hold one end of the hot pipe to be bent against the forming die in order to sustain the back pressure occurring when the hot pipe is pulled about the forming die to affect bending of the pipe. One suitable holding means when bending pipes up to 90° is a holding shoe having at least one curvature, preferably two, curvature faces on opposite sides, which are peripherally sufficient to support the outer side of the pipe. The said curvature faces may have a peripheral arc of approximately 90° and are offset from each other so that one curvature face will normally be in position to hold 6" diameter pipe and the other curvature face will

normally be in position to hold 12" diameter pipe. To hold different size pipes, the height of the neutral axis of the curvature face can be raised by spacer rings under the holding shoe so that the axis of the curvature face will lie in the same plane as the neutral axes of the forming die and the pipe. By this means, one curvature face can be used to hold pipes having 6" to 12" diameters and the other curvature face can be used to hold pipes having 12" to 18" diameters.

The holding shoe may be held in position by a dowel pin passing through the body of the holding shoe and engaging a hole in the bending block. This arrangement allows the holding shoe to be pivoted about the dowel pin so that the curvature face may be turned aside to allow more room for insertion or removal of the pipe from the forming dies. The holding shoe is positioned so that the pipe of a specific diameter is securely held in the forming die for that diameter. If odd size pipe is to be bent, i.e., a 9" diameter pipe in a 10" diameter forming die, the curvature face of the holding shoe may be provided with a correspondingly shaped shim insert to compensate for this difference in diameter.

While the said holding shoe is completely adequate for bends up to 90° in a pipe, difficulties arise with this shoe when bends of more than 90° are being made since the bent portion of the pipe to be held after the initial bend does not lie along the 0° guide line of the primary scale of the base template protractor but is concentrically aligned with the extended outside diameter guide line on the base template protractor. For this type of bending another holding shoe having a laterally adjustable curvature face is used.

This latter modification of holding shoe is provided with an adjustable extension arm on each side of the holding shoe which supports the curvature face whereby the curvature face can be moved laterally towards the pipe so that the pipe is held in conformity with the extended outside diameter guide line on the base template protractor. The neutral axis of the curvature face is offset from the middle of the holding shoe body so that the curvature face will be in position for holding 6" diameter pipe and when the holding shoe is inverted the curvature face will be in position for holding 12" diameter pipe. The said holding shoe may be raised with spacer rings for holding larger size pipes as with the previously described holding shoe.

The extension arms are preferably provided with 36 holes and the holding shoe is preferably provided with 12 holes on each side. The said holes are arranged so that 4 holes on each extension arm will coincide with 4 holes on each side of the holding shoe in varying positions so that 4 pins may be inserted through each side of the extension arm and the holding shoe to firmly hold the curvature face in the final position.

In a preferred embodiment of the apparatus, an adjustable stop means is provided for proper positioning of pipes when they are placed in the forming die for bending up to 90°. This stop means may be an adjustable stand rack with a stop-bar which acts as a backstop called a chock set. The stop-bar of the chock set may be slidably moveable along two channel tubes to provide for a plurality of bend tangents and is capable of being securely affixed thereto in any desired position. The forward ends of the channel tubes may be attached to square pegs which fit into square holes in the bending block to hold the chock set in position. The position of the stop-bar is preadjusted to stop the end of the pipe to be bent at the computed tangent dimensions so that the heated pipe will be aligned in the proper position for the start of the bend when inserted in the apparatus with its end abutting against the stop-bar.

In order to hold the pipe properly in position when making compound bends or second bends in circular bends, a position clamp is provided to prevent rotation of the pipe during the compound bending process, or to

hold the pipe during the second bend of circular bends since the chock set is not used for these bends. This clamp may be made of two semi-circular parts which form a circular collar. Both circular parts are preferably provided with jagged teeth to clamp onto the pipe when the two parts are fastened together. The bottom semi-circular collar is provided with a base to prevent turning of both the pipe and clamp during the bending process. After the initial bend is put in the pipe, which is to have a compound bend put therein, the pipe is then put in the desired position in the forming die for the next portion of the bend. The position clamp is then placed about the pipe and firmly clamped thereto. The pipe may then be heated with the position clamp attached and re-inserted into the forming die so that the pipe can be rapidly aligned and no time for adjustment of the pipe is lost once the pipe is heated for the second portion of the compound bend. The height of the base of the position clamp should be such that the bottom semi-circular collar lies in the same plane as the inner bottom lip of the curvature face of the forming die so that the neutral axis of the pipe will be in the same plane as the neutral axis of the forming die curvature face.

The pipe bending apparatus of the invention has a wide variety of advantages, the most important of which are accurate rapid bending of pipes, whether simple, circular or compound bends or clockwise or counterclockwise or both, with a minimum of skill and number of men and equipment. The bending block provides a base for a large variety of setups for different bends. The base template protractor provides a simple means of constant observation of the angle of bend of the pipe.

The forming die due to its deep segmental curvature face provides a constant, protective support to the pipe along the entire portion of the pipe being bent thereby providing synchronization of the gradual stretching of the heel of the pipe and the compressing of the throat for proper following of the radius of the forming die. This prevents sharp abrupt pulls or bends and prevents thinning of the wall of the pipe. Since the pipe is never deviated from its bending course with the use of the forming die, the use of water on the pipe during bending is completely avoided and the disadvantages which occur with the use of water do not occur in the bending process. The forming die also extracts heat from the throat of the pipe and renders the inner side of the pipe cooler during the bending, which prevents the pipe from compressing too fast on its concave face. This coolness of the throat gives additional strength or stiffness, enabling it to resist creasing caused by the pressures put on it by the pull of the bend. This is advantageous since the heel or outer side of the pipe should be hotter during bending as it has a farther distance to travel and stretch while the throat has only to compress.

Another advantage of the apparatus of the invention is that bending may be done rapidly and little time is lost in positioning the pipe. This is important since pipes must be bent while hot and the longer the time between removal from the furnace and the completion of the bend, the more difficulties arise. The apparatus provides for an even bending pressure and the pipe follows the continued arc of the forming die which prevents the pipe from being bent sharply and prevents disruption of the compressing and stretching of the throat and heel of the bend. This lessens the chance of buckles that occur with the known methods of bending.

Referring now to the drawings:

FIG. 1 is a plan view of the pipe bending apparatus of the invention with the pipe in position for the start of the counterclockwise bend.

FIGS. 2 and 3 are plan views of the bending block and the base template protractor, respectively.

FIG. 4 is a cross-sectional view of the forming die of FIG. 1, taken along line 8—8.

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FIG. 5 is a cross-sectional view of one holding shoe used to hold the pipe in position during bending.

FIG. 6 is a side view of an adjustable holding shoe used to hold the pipe in position when performing a bend of more than 90°.

FIG. 7 is a cross-sectional view of the holding shoe of FIG. 6, taken along line 7—7.

FIG. 8 is an enlarged view of the chock set of FIG. 1.

FIG. 9 is a view of another embodiment of the pipe bending apparatus of the invention during compound bending of a large diameter pipe.

FIG. 10 is an enlarged view of the position clamp of FIG. 1.

In the embodiment illustrated in FIG. 1, the pipe bending apparatus, ready to begin a bend, is comprised of bending block 1 set in the floor of the pipe bending shop, and provided with guide lines 8 and 8a which form a true 90° angle, approximately along the center line of the bending block, a base template protractor 2, forming die 3 centered on the 90° angle, holding shoe 4, chock set 5, block and tackle 6 attached to a winch (not shown), and riding pipes 7 which keep the pipe 7a level with the inner bottom lip of the forming die.

As can be seen from FIG. 2, the bending block 1 is provided with a series of holes 9 along guide lines 8 and 8a within the angle formed thereby which engage dowel pins 11a to secure forming dies for different diameter pipes to the bending block. The bending block is also provided with smaller holes 10 which engage pins to secure base template protractor 2 thereto and with holes 11 along guide lines 8 and 8a outside the angle formed thereby to engage dowel pins to secure the holding shoe 4 in various positions for different diameter pipes.

In FIG. 3, the base template protractor is shown as provided with two sets of degree markings from 0° to 90°. On the primary set 12 of degree markings, the 0° line coincides with guide line 8 of the bending block and the 90° line coincides with guide line 8a when the base template protractor is secured to the bending block. The degree lines of this scale radiate tangentially from the forming die so that the degree of the bend in the pipe can be easily observed throughout the bending. In the secondary set 13 of degrees, the 0° mark coincides with the portion of the forming die 3 at which the bend will start and runs radially to 90° with the 45° mark coinciding with the center of the 90° angle formed by guide lines 8 and 8a. The secondary scale 13 permits a bender to determine the radial degree at which a bend has stopped when bending more than 90°. The pipe 7a may then be marked where the bend stopped, be re-heated and reinserted into the die with the mark on the pipe aligned with the 0° mark of the secondary scale for the start of a second bend.

The forming die 3 as shown in FIG. 4 is comprised of a curvature face 4 ensuring that the heated portion of the pipe will be protected, form plate 15 secured to the back of curvature face 14 and gussets 16 which provide strength to the forming die. Form plate 15 is provided with sleeves 17 through which dowel pins 11a pass and engage holes 9 in bending block 1. The top and bottom of sleeves 17 are provided with adjustable collars 18 and 19 which firmly clamp the die body in position. The curvature face 14 and form plate 15 are provided with pedestals 20 to support the forming die, and to elevate the curvature face slightly above the surface of the bending block so that the block and tackle 6 may be attached to pipe 7a during the bending without changing the plane of the bend. The top of riding pipes 7 coincides with the inner bottom lip of curvature face 14 and is held in position by brackets 21. As shown in FIG. 1, the outer edges 14a of the upper lip of curvature face 14 are elliptically shaped so that pipe 7a may be positioned directly on guide line 8 without hitting the forming die curvature face.

FIG. 5 illustrates a holding shoe 4 which can be used to bend different diameter pipes from 6" to 18" and is

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provided with two curvature faces 22 and 23 which are provided with jagged teeth to firmly grip the pipe. The arc of the said curvature faces is approximately 90°. Curvature face 22 is positioned so that the bottom lip thereof is elevated above the bending block slightly higher than the riding pipes 7 so that it may be used to hold small diameter pipes, i.e. 6" to 12", while the curvature face 23 is more elevated above the bending block to hold larger diameter pipes, i.e., 12" to 18". The neutral axis of the forming die curvature face to be used is precisely in the same plane as the neutral axes of the pipe to be bent and the curvature face of the holding shoe. To accommodate odd size pipes, i.e., 9" diameter, the curvature faces of the holding shoe may be provided with a shim 24a to take up the difference.

Holding shoe 4a of FIGS. 6 and 7 is especially useful for compound bending and in putting a second bend in a circular bend since the curvature face 24 can be moved laterally to engage the bent portion of the pipe which will not lie along guide line 8. The curvature face 24 is held on either side by extension arms 25 which slide in slots 26 of the holding shoe.

The extension arms 25 are provided with 4 rows of 9 holes, 27, while the body portion of the holding shoe is provided with 4 rows of 3 holes in each, which are arranged so that 4 holes in extension arms 25 will correspond with 4 holes in the body of the holding shoe, so that the distance between curvature face 24 and the holding shoe body can be varied in 1" increments. The extension arms are held firmly in position by pins 28 which pass through the 4 aligned holes in the extension arms and the holding shoe body.

The chock set, shown in detail in FIG. 8, is used so that the portion of the pipe where the bend is to start will be aligned with the 0° mark on the secondary scale of the base template protractor when the end of the pipe 7a is abutting against the chock set 5. The chock set is comprised of a stop-bar 29 provided with a pedestal 30 in the center thereof and with tubular collar sleeves 31 at either end thereof, which sleeves have a plurality of holes 32 drilled therethrough. Passing through each of collar sleeves 31 is an extension channel tube 34 provided with a plurality of holes 35 drilled therethrough and with a square pin at the end thereof to hold the channel tubes parallel to the bending block at the same height as the stop-bar 29. The square pins 36 engage square holes 37 in the bending block in order to hold the chock set in position. The stop-bar 29 can be moved along the length of channel tubes 34 to the desired position and secured therein by passing pins 37a through the holes in the collar sleeves and in the channel tubes.

To bend a pipe, a forming die with a curvature face of the desired radius and diameter and its base template protractor are secured to the bending block with dowel pins 11a. Holding shoe 4 is positioned on bending block 1 with its curvature face turned aside from the forming die 3. To bend a pipe up to 90° with the apparatus of the invention, the length of the arc of the bend is marked off on the pipe 7a where the bend is to begin and to end. The die 3 and base template protractor 2 for this bend radius and diameter of pipe is positioned on the bending block 1 with the inner side of the base template protractor adjoining the bottom lip of the curvature face of the forming die and the holding shoe 4 is positioned in the proper hole in the bending block 1 for the diameter of the pipe 7a. The chock set 5 is preadjusted so that the butt of the pipe 7a will abut against stop-bar 29 with the beginning of the bend marked on the pipe 7a coinciding with the 0° mark on the secondary scale 13 of the base template protractor 2. The pipe 7a is then heated to the proper temperature in a furnace and brought to the bending apparatus. The pipe is laid along guide line 8 with its butt against the stop-bar 29 of chock set 5 and holding shoe 4 is turned so that its curvature face holds the pipe firmly against the forming die when bending

pressure is applied. The block and tackle 6 is attached to the end of the pipe 7a and the winch is started to bend the pipe about the curvature face of the forming die and the desired number of degrees.

Although FIG. 1 illustrates the bend as starting from the right side of the bending block, the holding shoe 4 and chock set 5 may be located at the left side of the bending block and the bend can be made from the left side to the right side of the bending block.

FIG. 9 illustrates the apparatus of the invention putting the third bend in a compound bend in a pipe 7a. The chock set is not used since the end of the pipe does not end along guide line 8. The portion of the pipe 7a where the bend is to begin is marked on the pipe and position clamp 38 is attached to the pipe to prevent the pipe from twisting or turning during bending.

As can be seen from FIG. 10, position clamp 38 is comprised of an upper semi-circular collar 39 and a lower semi-circular collar 40 provided with lugs 41 having threaded holes so that the two halves of the clamp can be securely held together by bolts 42. The inner surfaces of the semi-circular collars are preferably jagged to ensure firm gripping of the pipe. Bottom semi-circular collar 40 is provided with a base 43 extending out on either side thereof which prevents twisting of the position clamp and pipe during bending.

Various modifications of the apparatus and method of the invention may be made without departing from the spirit or scope thereof and it is to be understood that the invention is to be limited only as defined in the appended claims.

I claim:

1. An apparatus for hot bending large pipes of at least 6" diameter comprised of a bending block provided with two guide lines forming a 90° angle; base template protractors to rest on the bending block provided with a primary scale marked off in degrees from 0 to 90° with the 0° line coinciding with one of the guide lines on the bending block and the 90° line coinciding with the other guide line on the bending block and a secondary scale with a scale from 0° to 90°, arced forming dies having approximately 180° grooved curvature faces and a radius equal to the radius of the desired pipe bend, the said die being securely centered on the bending block within the 90° angle formed by the primary scale and with the bottom lip of the forming die curvature face coinciding with the secondary scale of the base template protractor, means for holding one end of the pipe to be bent against the forming die when laid along either guide line on the base template protractor, means for keeping the pipe level with the curvature face of the forming die and pressure applying means to bend the hot pipe about the die the desired number of degrees.

2. The apparatus of claim 1 wherein the bending block is provided with a plurality of holes which cooperate with dowel pins to secure the base template protractor, the forming die and the holding means in position.

3. The apparatus of claim 1 having an adjustable stop means against which the hot pipe abuts during bending whereby the portion of the pipe where the bend starts coincides with the 0° mark on the secondary scale of the base template protractor with the pipe abutting against the said stop means.

4. The apparatus of claim 1 wherein the arc of the forming die is approximately 100°.

5. The apparatus of claim 1 wherein ends of the upper lip of the curvature face of the forming die are elliptically shaped whereby the pipe to be bent can be directly inserted between the holding means and the forming die.

6. The apparatus of claim 1 wherein the holding means is provided with at least one curvature face having an arc of approximately 90° and means for adjusting the height of the said curvature face so that the neutral axis of the curvature face will lie in the same plane as the neutral axis of different diameter pipe and forming dies.

7. The apparatus of claim 6 wherein the holding means is provided with two curvature faces on opposite sides thereof with one face being closer to the bending block than the other curvature face whereby the curvature faces will hold different diameter pipes.

8. The apparatus of claim 1 wherein the means for keeping the pipe level with the curvature face of the forming die are riding pipes radiating out from the die at a height level with the bottom lip of the forming die curvature face.

9. The apparatus of claim 1 for bending pipes more than 90° wherein the holding means is provided with a laterally adjustable curvature face having an arc of approximately 90° and means for adjusting the height of the said curvature face so that the neutral axis of the curvature face will lie in the same plane as the neutral axis of different diameter pipe and forming dies.

10. The apparatus of claim 1 provided with means for clamping the pipe whereby the pipe is held in position to prevent twisting and turning of the pipe during compound bending.

11. The method of bending large pipes of at least 6" diameter which comprises heating the pipe to the bending temperature, anchoring one end of the pipe and bending the pipe in a horizontal plane the desired number of degrees around the curvature faces of a continuous arced forming die which at the bending point extends approximately 180° around the pipe circumference and the radius of the arc is equal to the radius of the bend to be made and is spaced from the bending floor.

12. The method of claim 11 in which the pipe being bent rests upon riding supports which support the pipe spaced from the bending floor substantially the same distance the bending die is spaced from said floor.

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