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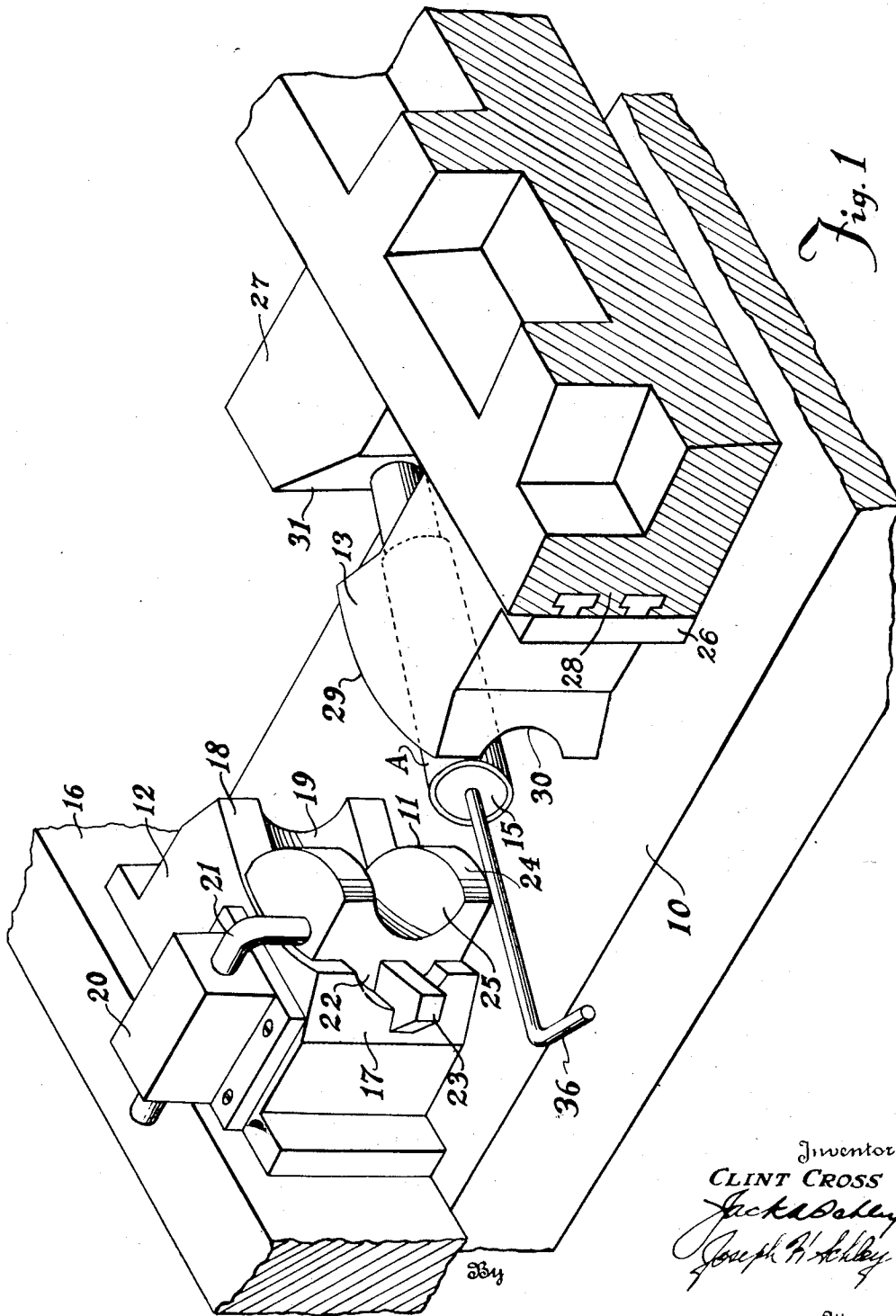
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METHOD OF AND MEANS FOR BENDING PIPES

Filed Nov. 8, 1943

5 Sheets-Sheet 1



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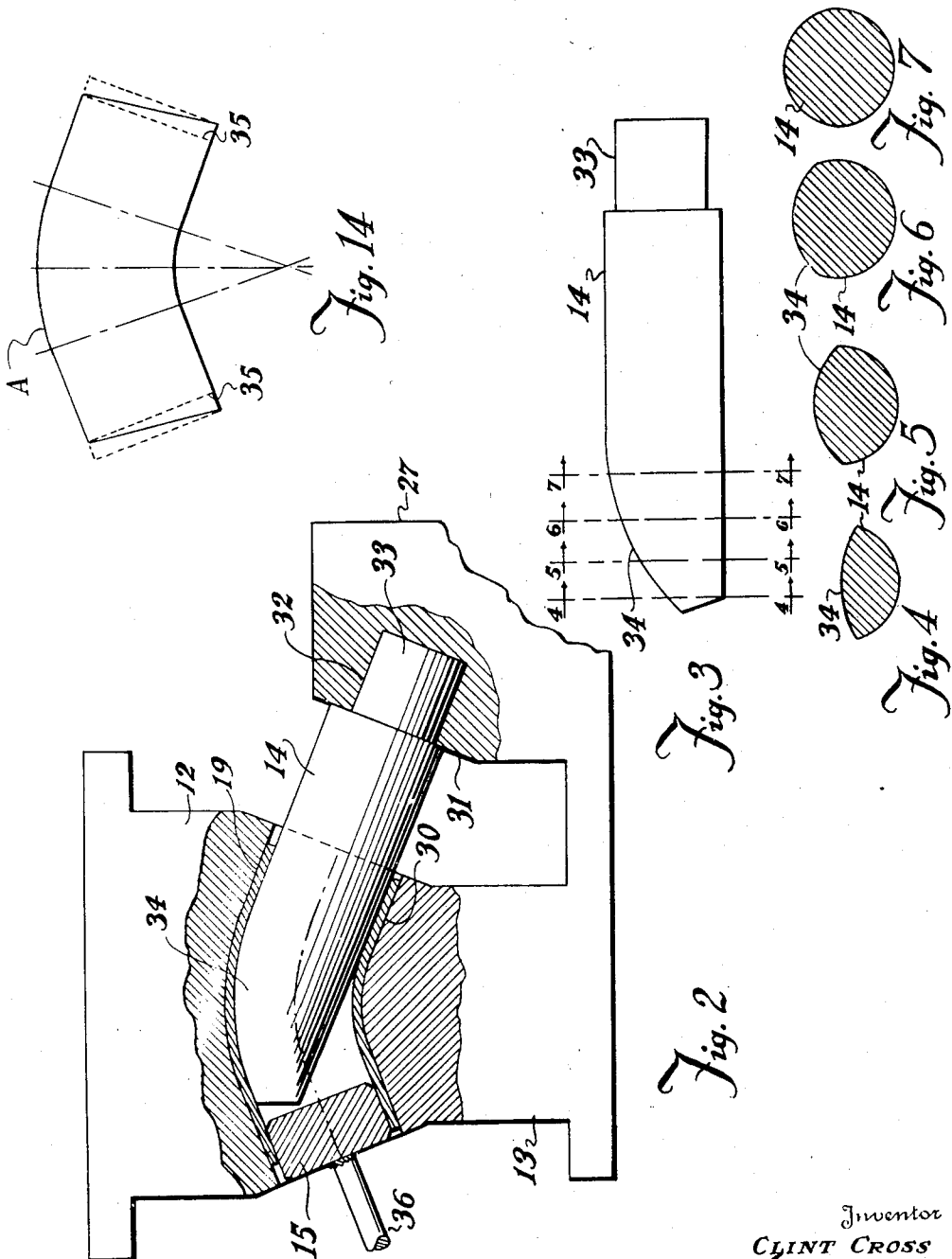
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5 Sheets-Sheet 2



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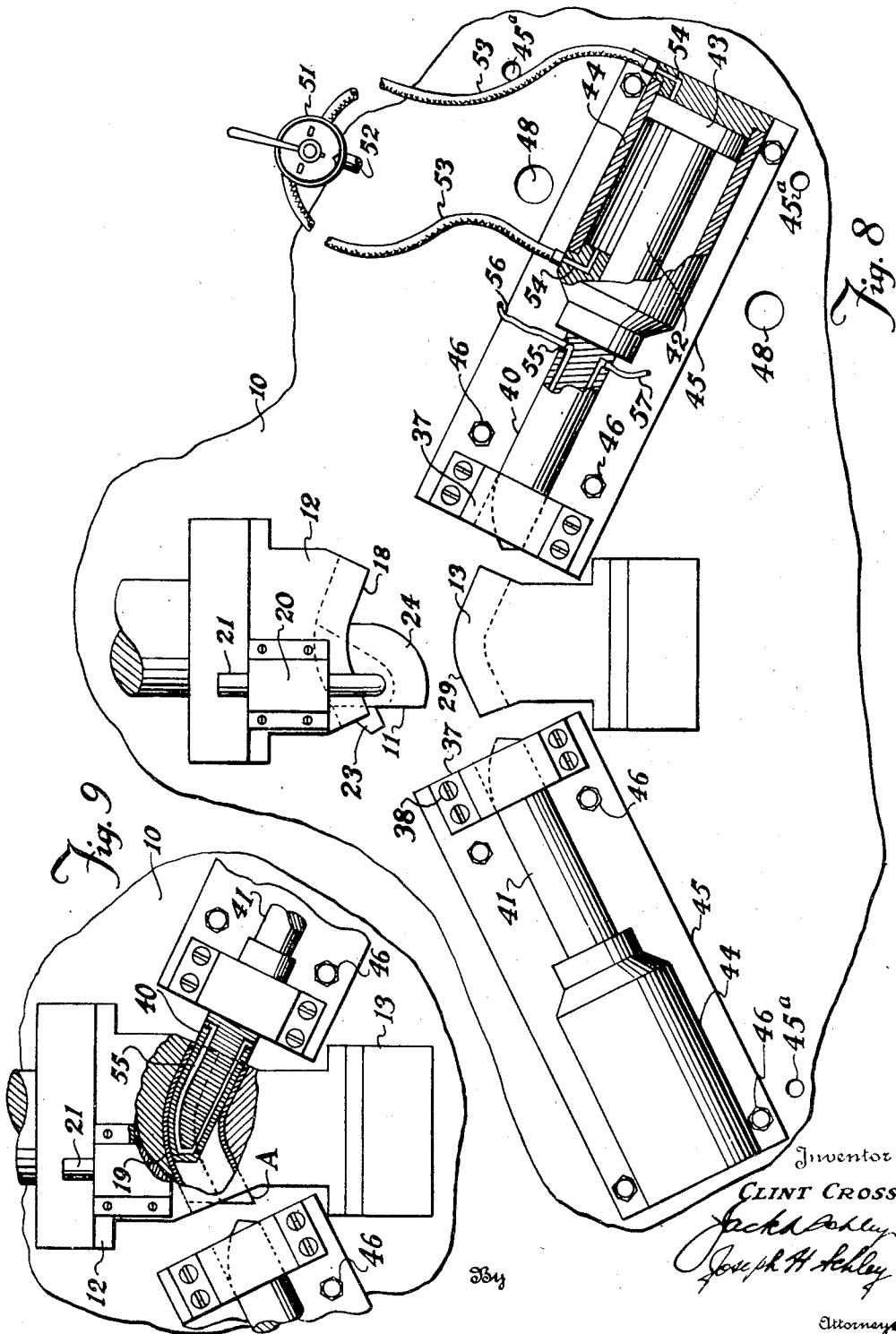
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METHOD OF AND MEANS FOR BENDING PIPES

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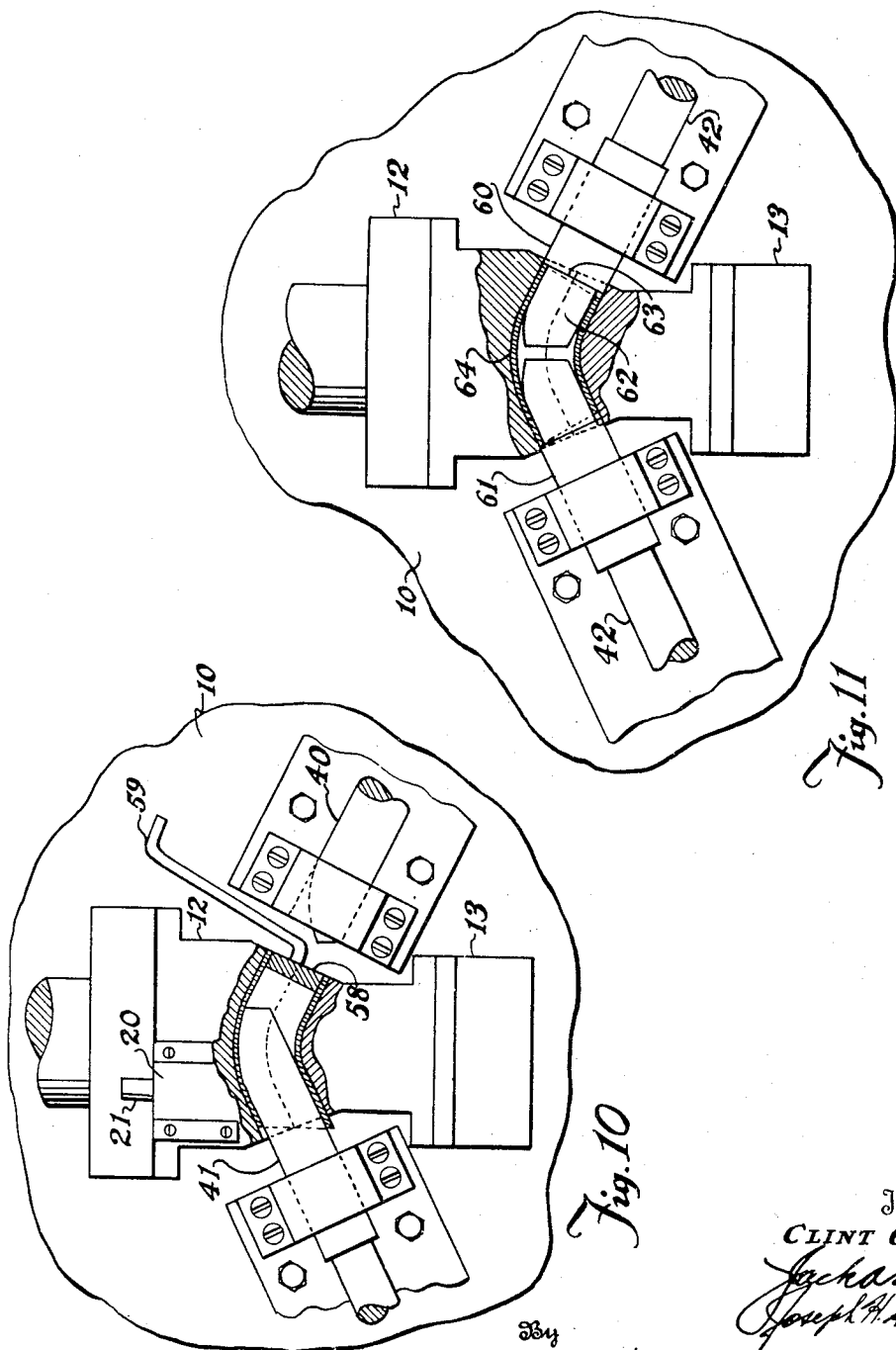
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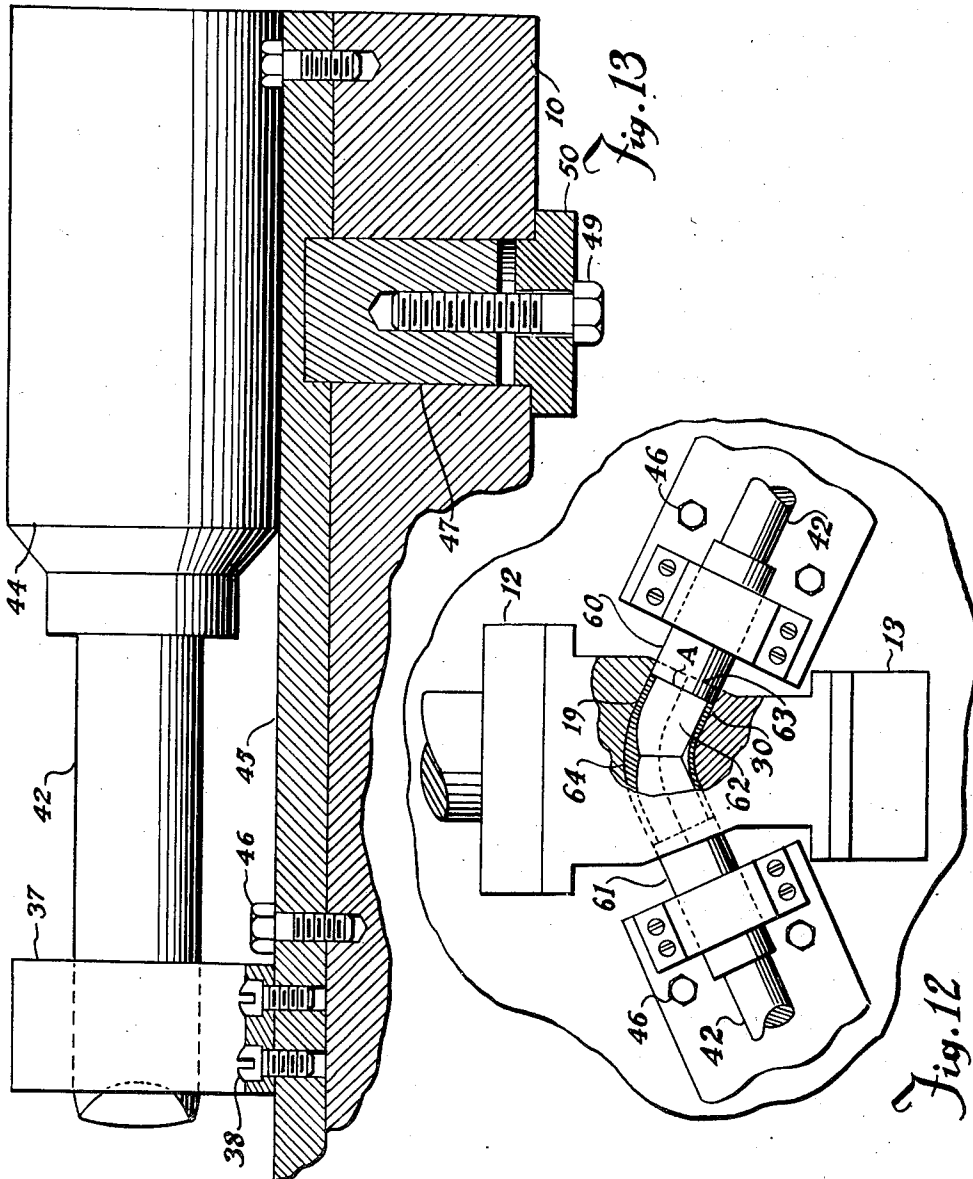
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METHOD OF AND MEANS FOR BENDING PIPES

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5 Sheets-Sheet 5



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UNITED STATES PATENT OFFICE

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METHOD OF AND MEANS FOR BENDING PIPE

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7 Claims. (Cl. 153-48)

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This invention relates to new and useful improvements in methods of and means for bending pipe.

One object of the invention is to provide an improved method whereby pipe-bends may be produced from straight lengths of pipe and the original area and wall thickness of the pipe be substantially retained, with the provision of long or short tangents at each or either end of the bend.

A particular object of the invention is to provide an improved method whereby pipe-bends may be forged with a short radius and a short or long tangent, as desired, at each or either end while retaining substantially the original wall thickness in the outer medial portion of the bend.

An important object of the invention is to provide a method, of the character described, wherein the wall which is of greatest radius is supported during the bending step and at the same time is cooled, thus assuring uniform thickness.

Still another object of the invention is to provide an improved pipe-bending or pipe-turn forming apparatus including a forming die or mandrel adapted to be inserted in the pipe and having a configuration arranged to support the wall of the pipe during the bending operation, whereby uniform flow of the metal and substantial retention of the original wall thickness is obtained.

A further object of the invention is to provide an apparatus, of the character described, having a displaceable preforming or breakdown die for starting the bend and finishing dies working in sequence with the preforming die so as to assure uniformity and continuity in the forming of the pipe-bend.

A construction designed to carry out the invention will be hereinafter described together with other features of the invention.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawings, wherein an example of the invention is shown, and wherein:

Figure 1 is an isometrical view of an apparatus constructed in accordance with the invention and shown in an open position with the preforming die in operating position,

Figure 2 is a view, partly in plan and partly in section, of portion of the apparatus showing the parts in position after the bend has been completed.

Figure 3 is an elevation of the forming die or mandrel,

Figures 4, 5, 6 and 7 are transverse, vertical,

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sectional views, taken on the lines 4-4, 5-5, 6-6 and 7-7, respectively, of Figure 3,

Figure 8 is a plan view of a modified form of apparatus in open position,

Figure 9 is a similar view, partly in plan and partly in section, showing one of the mandrels in the pipe-bend, the preforming die being omitted.

Figure 10 is a similar view, showing the other mandrel in the pipe-bend,

Figure 11 is a view, similar to Figure 10, showing mandrels for upsetting the outer medial portion of the pipe-bend,

Figure 12 is a similar view showing the upsetting mandrels in engagement and the outer medial portion of the pipe-bend upset,

Figure 13 is a longitudinal, vertical, sectional view of one of the mandrels and its cylinder, showing the mounting thereof, and

Figure 14 is an elevation of a pipe-bend, the dotted lines showing the shape after the bend is completed with the ends, after being cut, being shown in full lines.

In the drawings, the numeral 10 designates in all of the figures the bed plate of an ordinary forging or forming machine. As the invention primarily resides in the method and the bending or forming elements, any suitable device or machine may be employed.

The apparatus for performing the method in its most simple form includes a preforming breakdown die 11 and complementary forming dies 12 and 13, respectively, either of which may be stationary and either or both of which may be movable and a mandrel or support 14 (Fig. 2) for receiving the pipe to be bent, indicated by the letter A. It is desirable, and I have so illustrated, to have the breakdown die 11 movably mounted on the die 12 and to make said die 12 movable; while the die 13 is stationary. It is also preferable, in some instances, to mount a circular plug 15 in one end of the pipe A.

As shown in Figure 1, the movable die 12 is suitably fastened to a transverse reciprocable head 16 so as to be horizontally reciprocable above the bed plate 10. This head may be part of a ram, plunger or the like, and is reciprocated in the usual manner, such as by hydraulic mechanisms now being commonly employed.

The die 12 is formed with converging, upright side walls 17 to provide a reduced outer end having an upright face 18 which is transversely curved and is provided with a transverse medial sink or recess 19 substantially semi-circular in cross-section. A block housing 20 is fastened on

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top of the die 12 and a right-angular hanger 21, preferably formed from a round bar, has one leg slidably and rotatably mounted in the housing. The other leg of the hanger is fastened in the top of the breakdown die 11. A transverse medial boss 22, shaped to fit in the sink 19, is provided on the rear surface of the die 11, which surface, above and below the boss, is curved to conform to the die face 18, whereby said breakdown die is firmly supported against the movable die 12. In order to steady the breakdown die, an angular lug or hook 23 (Fig. 1) which engages over one of the upright walls 17 is formed on one side thereof. When the breakdown die 11 is not in use it may be pulled outwardly, swung upwardly and then pushed back so as to rest on top of the die 12.

The breakdown die is formed with a receding curved face 24 having a transverse medial sink or recess 25 which is substantially semi-circular in cross-section and recedes longitudinally inwardly from its outer or forward end (Fig. 1) toward its inner end. This provision is made so that initially the outer end portion of the sink 25 will receive the outer end of the pipe A and gradually make contact with the surface of the pipe, as the die 12 is moved toward the die 13, thus assuring a uniform and smooth preforming.

As is clearly shown in Figures 1 and 2, the die 13 is mounted on a transverse head 26 which also carries a mandrel block 27. The elements 13, 26 and 27 may be made integral or separately, the details being unessential. The die, block and head rest upon and are suitably fastened to a transverse breast 28 which may be adjustable, as is customary, but which is secured so as to be stationary. The outer end of the die 13 is flared, being formed with a curved face 29 and a transverse medial sink or recess 30 which is substantially semi-circular in cross-section.

The die faces 18 and 29 and the sinks 19 and 30 are all struck on concentric arcs having a common center. These arcs are designed for the particular degree of the pipe-bend desired to be made, and vary accordingly. However, the arcs are greater than the desired arc or curve of the pipe-bend so as to allow for contraction of said pipe-bend upon cooling thereof. The sinks are given such depths as to cause the faces 18 and 29 to come together when the pipe-bend is completed, at which time said pipe-bend completely and closely fills said sinks. By such an arrangement, pinching or creasing of the pipe is avoided and a smooth bend is made. Of course, the cross-sectional radius or diameter of each sink is substantially equal to the external diameter of the pipe.

By observing Figure 2, it will be noted that while the central portion of each sink 19 and 30 is curved to the degree to give the desired bend, the legs or portions, extending from each end thereof, are tangential thereto. This produces a pipe-bend or turn wherein the bend or arc is confined to the central or medial area. This is highly important, because it contributes to the forging of a short bend having a small radius as well as the maintenance of substantially uniform wall thickness.

The mandrel block 27 is formed with a vertical side face 31 disposed transversely at substantially a right angle to the longitudinal axis of the adjacent tangent of the sink 30. As is clearly shown in Figure 2, the face 31 is provided with a socket 32 for snugly receiving a reduced shank 33 formed on the inner end of the mandrel 14, which latter

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shoulders against the face 31 and is thus rigidly supported. The mandrel is thus held in position to project into and support the pipe A. The mandrel is generally cylindrical and is of a diameter substantially equal to the internal diameter of the pipe to be bent. As illustrated in detail in Figures 3 to 7, inclusive, the mandrel is provided with a curved face 34 at its outer end, which face is curved longitudinally so as to engage the inner wall of the completed pipe-bend at its medial portion opposite the sink 30. This is accomplished by the transverse contours shown in Figures 4 to 7, inclusive.

The first step of the method is the cutting of the pipe to the desired length and it is noted that the ends of the pipe are square or extend at a right angle to the longitudinal axis of said pipe. In order to facilitate handling of the pipe, the plug 15 is inserted in its outer end and is provided with an integral handle 36. When the bend is started, the pipe is suitably heated to forging temperature, as will be hereinafter explained, and the workman holding said pipe by the handle 36 telescopes it over the mandrel 14 so as to place it in the desired position relative to the stationary die 13 as shown in Figure 1. The breakdown die 11 being in place, the die 12 is moved toward the stationary die 13, whereby the outer end of the sink 25 engages the outer end portion of the pipe A. As the die 12 continues its forward movement, the contact of the sink 25 with the pipe gradually increases and thus produces a more or less rolling action as the pipe is gradually bent. Due to the outer end of the sink 25 being substantially parallel to the axis of the pipe, the engagement of said end with the outer end portion of said pipe will force the latter toward the far or outer end of the sink 30 of the stationary die. Thus, creeping or movement of the pipe upon the mandrel toward the face 31 of the block 27, which would be the result of initial engagement of the sink 19 of the die 12 with said pipe, as well as consequent off-center displacement of the bend are avoided. Also, a greater portion of the sink 25 more rapidly engages the outer end portion of the pipe so as to aid in supporting the same than would the sink 19 if it was initially engaged with said pipe, whereby distortion of the outer end portion of the pipe is held to a minimum and the formation time materially reduced. However, it is possible to eliminate the use of the breakdown die 11 by positively holding the pipe in the desired position and employing great care in the initial bending thereof, although the operating period is lengthened. It is noted that the plug 15 tends to prevent distortion of the end portion of the pipe. The prebending operation is continued until the face 24 of the die 11 engages the face 29 of the die 13. The die 12 is then retracted.

At this point in the operation, it is sometimes desirable or necessary to reheat the pipe. In this event, the plug 15 is withdrawn from the pipe which is then removed from the mandrel 14, said plug being reinserted in the same end of said pipe to facilitate handling thereof. The pipe is then again heated to forging temperature and said heated pipe is replaced in the proper position upon the mandrel. The breakdown die 11 is pulled outwardly, swung up and then pushed back so as to be supported on top of the die 12, which die is again moved toward the die 13 and into engagement with the prebent pipe. The forward movement of the die 12 is continued until

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the faces 18 and 29 engage, at which time one-half of the bend is completed.

Again, the plug is withdrawn from the pipe which is removed from the mandrel and said plug is inserted within the opposite end of said pipe. In order to bring the pipe to forging temperature, the same is placed in a suitable furnace (not shown) after which the end of said pipe opposite the plug is telescoped upon the mandrel so as to properly position the same. It is noted that the initial or prebend of the pipe will tend to assure proper positioning of the same upon the mandrel relative to the dies and that the breakdown die 11 is swung out of the way. The die 12 is then moved forwardly into engagement with the prebent pipe and this forward movement is continued until the face 18 engages the face 29. At this point, the bend is completed and the bent pipe may be removed from the mandrel in the manner hereinbefore set forth upon retraction of the die 12.

As is clearly shown in Figure 14, the completed pipe-bend has a short arc of relatively small radius and comparatively long tangents. Also, the original wall thickness is retained and especially at the outer medial portion of the pipe-bend. If desired, the axial or center arc of the pipe-bend may have a radius as small as one (1) or one and one-half ($1\frac{1}{2}$) times the nominal diameter of the pipe. It is pointed out that when the bend has a long tangent at one or both ends, such radius is virtually unobtainable by present known methods and apparatuses. Since the formation of the pipe-bend is accomplished without thinning the wall of the original pipe, the stock forming the outer end portions of said pipe-bend will flow or be forced inwardly toward the center of the outer medial portion thereof so as to shorten said outer end portions. Thus, it is necessary to cut the ends of the pipe-bend at a right angle to the axes of the tangents as shown at 35 (Fig. 14) after the forming of said pipe-bend.

The heating of the pipe, hereinbefore and hereafter referred to, may be accomplished in any suitable manner, such as by a furnace (not shown), and the forging temperature is largely determined by the type of metal or alloy from which said pipe is formed. Ordinarily, the forging temperature is between twelve hundred (1200°) and twenty-four hundred (2400°) degrees F.; however, in forging pipes of non-ferrous metals, the temperature may be much lower and may be even as low as five hundred (500°) degrees F. Also, the application of heat to the pipe may be graduated, whereby one portion of said pipe may be heated to a lesser degree than the remainder thereof. This heat gradation is especially important in connection with that portion of the pipe which is to form or which forms the outer medial portion of the pipe-bend. By holding the temperature of such pipe portion to a minimum, stretching and consequent thinning of said portion upon bending of the pipe is materially reduced without impairing the plasticity of the remainder, especially the inner medial portion, of said pipe. Thus, a substantially uniform flowing or reshaping of the aforesaid pipe remainder and the maintenance of a uniform wall thickness is greatly assisted, which wall thickness is approximately equal to the original wall thickness of the pipe.

In Figures 8 to 10, I have shown another form of apparatus for forming the pipe-bend, wherein a pair of opposed power-operated mandrels 40

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and 41 are employed. These mandrels may be operated by any suitable means, such as manual, mechanical or hydraulic, and I have chosen to illustrate a hydraulic mechanism. Each mandrel is substantially identical and is made integral with or is rigidly secured to a piston rod 42 extending forwardly from a non-rotatable piston head 43 which is reciprocally mounted within a cylinder 44. A flat, rectangular base member 45, adjustably secured to the bed plate 10, supports each cylinder and its mandrel in a plane parallel to said bed plate. The mandrels are substantially duplicates of the mandrel 14, except as to the shank 33, and have identical curved outer faces 34. A transverse guide bracket 37 is secured to one end portion of the base 45 by suitable cap screws 38 to support the outer end of each mandrel. As is clearly shown in Figure 13, the base 45 overlies the bed plate and is secured thereto by a plurality of small bolts 46. A shank or post 47 depends from the base through a complementary opening or socket 48 formed in the bed plate and has a suitable bolt 49 screw-threaded into the lower end thereof. For clamping the base to the bed plate, an annular element or washer 50 is confined upon the bolt 49 between its head and the bottom of said bed plate. If desired, a plurality of sockets 48, as well as small openings 45a for receiving the small bolts 46, may be formed in the bed plate to permit adjustment of each base in an arc relative to the dies as shown in Figure 8, the adjustment being accomplished by removing said bolts 46 and the bolt 49 and moving the base to the desired position. The details of the adjustments are immaterial and any suitable means may be used.

For operating the mandrels, a pilot valve 51 is provided for each cylinder 44 and is supplied with pressure fluid from a suitable source (not shown) by a pipe 52. This valve may be of the usual four-way type having separate connections with a pair of flexible pipes 53 leading to angular ports 54 formed in opposite ends of the cylinder, as is clearly shown in Figure 8. It is frequently desirable to cool the mandrels and this may be readily accomplished by providing an internal return duct 55 in each mandrel, the cooling fluid or medium being supplied by a hose 56 and exhausted by a similar hose 57. The duct extends around the end portion of the mandrel in close proximity to its curved face 34 as it is extremely important to chill the portion of the pipe which is to form the outer medial portion of the pipe-bend, as will be hereinafter more fully explained.

After being cut to the desired length, the pipe A is heated to the proper forging temperature and then placed upon either the mandrel 40 or the mandrel 41, one of which has been moved to its fully projected position by its respective piston 43 through manipulation of the pilot valve 51. A plug 58, similar to the plug 15 and having an integral off-set handle 59, is inserted in one end of the pipe to facilitate handling thereof and the opposite end of said pipe telescopes the projected mandrel, whereby the pipe engages and is properly positioned relative to the sink 30 of the stationary die 13. With the breakdown die 11 being in place as shown in Figure 8, the die 12 is moved toward the stationary die 13 so that the outer end of the sink 25 of said breakdown die engages the outer end portion of the pipe A. As has been hereinbefore set forth, the continued forward movement of the dies 11 and 12 will cause the contact of the sink 25 with the pipe to gradually increase and thereby gradu-

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ally bend said pipe and force its outer end portion into engagement with the outer or far end of the sink 30 of the stationary die 13. This prebending operation is continued until the face 24 of the die 11 engages the face 29 of the die 13.

The plug 58 is then removed from the outer end of the pipe and the die 12 is retracted to permit movement of the breakdown die to its non-operative position. The die 12 is again moved forwardly toward the die 13 and into engagement, with the pipe, such movement being continued until the face 18 of said die 12 engages the face 29 as shown in Figure 9. At this point in the operation, the projecting mandrel upon which the pipe is telescoped, such as mandrel 40, is retracted by rearward or inward movement of the piston 43. With the pipe firmly clamped between the sinks 19 and 30, the other mandrel 41 is ejected so as to telescope within the opposite end of the pipe as shown in Figure 10, thereby rounding out the interior of said pipe and particularly the outer end portion thereof. Manifestly, this end portion of the pipe is slightly distorted by the bending operation due to the absence of the mandrel 41, whereas the mandrel 40 has prevented distortion of the opposite end portion of said pipe. The ends of the completed pipe-bend are cut off at a right angle to the longitudinal axis of the tangents of said pipe-bend, as hereinbefore set forth.

As has been hereinbefore set forth, the mandrels are provided with ducts 55 for receiving a cooling fluid or medium and each duct passes in close proximity to the curved face 34 of its respective mandrel. Thus, the curved faces 34 are cooled and the portion of the pipe, which is contacted by said faces and which is to form the outer medial portion of the pipe-bend, is chilled so as to prevent stretching and consequent thinning of said portion during the bending operation. Due to the disposition of the inlet hose 56, it is manifest that the cooling medium will be relatively warm by the time it passes around the end of the mandrel and will have little or no effect upon the inner medial portion of the pipe-bend. Thus, the inner medial portion of the pipe is free to flow so as to be displaced or reshaped uniformly and thereby produce a pipe-bend of uniform wall thickness. Of course, the mandrels 40 and 41 could be used without being cooled, but the results would not be as satisfactory and it is very probable that the outer medial portion of the pipe-bend might be stretched and thinned. Although not illustrated, it is readily apparent that the mandrel 14 of the first form of the invention could be cooled in the same manner as the mandrels 40 and 41.

Of course, it may be necessary or desirable to reheat the pipe to forging temperature after the prebending thereof. However, it is usually possible to eliminate such heating step as well as the reheating prior to the final bending or forging operation. Thus, at least one, and possibly two, heating steps are rendered unnecessary with a consequent saving of time and expense by the apparatus shown in Figures 8 through 10. Also, it is believed that the pipe-bends formed by such apparatus would be uniform.

In order to increase the strength and wear resistance of the wall of the pipe-bend at its outer medial portion, said wall portion may be upset so as to be of greater thickness than the remainder of said wall. As is clearly shown in Figures 11 and 12, this upsetting may be accomplished by an apparatus very similar to that

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shown in Figures 8 to 10. With the exception of the mandrels, the apparatuses are substantially identical. Complementary, short mandrels 60 and 61 are substituted for the mandrels 40 and 41. The inner portion of each mandrel is enlarged in diameter to provide a reduced outer end portion or shank 62, having a diameter equal to the internal diameter of the pipe, and an annular, radial shoulder 63 substantially at the medial portion of said mandrel. It is preferable to bevel or taper the outer extremity of each outer shank 62 as shown at 64 so as to provide space to accommodate the upset portion of the bend and to eliminate any possibility of marring the interior of the pipe-bend. It is noted that the diameter of the enlarged inner portion of each mandrel is substantially equal to the external diameter of the pipe, whereby said mandrel may be inserted into the space formed by the sinks 19 and 30 when the dies 12 and 13 are closed or brought together.

After the formation of the pipe-bend, the ends thereof are cut at an angle greater than a right angle so that the outer longitudinal portion of each tangent is of greater length than and projects beyond its inner longitudinal portion. The pipe-bend is then heated to the desired forging temperature and placed in the sink 30 of the stationary die 13 and the sink 19 is brought into contact with said pipe-bend by moving the die 12 toward said die 13 until the die faces 18 and 29 are in engagement. Thus, the pipe-bend will be confined within and held in place by the coaction of the sinks 19 and 30. With the pipe-bend held firmly in position, the mandrels 60 and 61 are simultaneously projected so as to cause the outer shanks 62 thereof to enter the bore of said pipe-bend. As the projection of the mandrels progresses, the shoulders 63 will enter the space formed by the sinks 19 and 30 and engage the ends of the pipe-bend (Fig. 11). Due to the greater length of the outer longitudinal portion of the pipe-bend, the engagement of the shoulder 63 will apply pressure to said portion and thereby force the ends thereof inwardly toward its center. Thus, the outer medial portion of the pipe-bend will be upset so as to increase the thickness thereof. Any desired thickness of the upset portion may be attained up to one and one-half ($1\frac{1}{2}$) times the normal thickness of the pipe or pipe-bend.

Due to the engagement of the mandrels within the pipe-bend, there is no distortion thereof and the original wall thickness and diameters are retained with the exception of the upset portion. The inner portion of the pipe-bend is unaffected by this upsetting step, since the ends thereof are not engaged by the shoulders 63 and no pressure is applied thereto during such step. Due to the provision of the shoulders 63, the ends of the completed upset pipe-bend will be square or extend at a right angle to the longitudinal axis of the tangents of said pipe-bend. This is accomplished by the continued projection of the mandrels to their fully-extended position, whereby the shoulders are in full engagement with the ends of the pipe-bend. After the foregoing upsetting step, the mandrels are retracted so as to withdraw the same from the pipe-bend and the die 12 is returned to its original position so as to permit removal of said pipe-bend. Although not illustrated, it is manifest that the cooling illustrated in connection with Figures 8 to 10 might be employed in the upsetting step.

The foregoing description of the invention is

explanatory thereof and various changes in the size, shape and materials, as well as in the details of the illustrated construction may be made, within the scope of the appended claims, without departing from the spirit of the invention.

What I claim and desire to secure by Letters Patent is:

1. The method of forming pipe bends with tangential ends which includes, heating a suitable right line length of pipe, then rigidly and immovably supporting one end and a medial portion of the pipe interiorly and exteriorly while the opposite end of the pipe and a medial portion of the pipe are unsupported, then preliminarily bending the unsupported end of the pipe while immovably and rigidly supporting said pipe, and then completing the bending of the pipe by pressing the entire bend between arcuate surfaces having the curvature of the completed bend and maintaining the inside wall of the bend of substantially uniform thickness.

2. An apparatus for forming pipe bends including, a support, a stationary rigid die mounted upon the support and having a sink provided with an outwardly directed arcuate medial portion and end portions tangential thereto, a die mounted on the support to move toward and engage the stationary die and having a sink provided with an inwardly directed arcuate medial portion and end portions tangential thereto, said dies having complementary engaging faces, a mandrel carried by the support mounted to telescope the pipe to be bent and having a curved face conforming to the arcuate medial portion of the sink of the movable die and extending approximately the entire length of the said die curvature, and means for moving said movable die toward and from the stationary die while the mandrel is stationary.

3. An apparatus for forming pipe bends including, co-acting die members having sinks each formed with a medial curved section and end portions tangential thereto and shaped to the contour of a completed pipe bend of substantially uniform wall thickness, a mandrel adapted to be inserted in a length of pipe to be bent and having at its insertable end a face curved longitudinally and transversely for forming the entire outer bend of the pipe, means for rigidly supporting one of the dies, means for supporting the mandrel in longitudinal alinement with one of the tangential ends of the sink of the rigid die, said mandrel being positioned to telescope one end of a pipe to be bent and to support said pipe end in the aligned die sink, and means to move the other die into engagement with the rigid die to bend the pipe and confine it in the die sinks.

4. An apparatus as set forth in claim 3 and a

removable plug for insertion in the unsupported end of the pipe.

5. An apparatus as set forth in claim 3 and a break-down die removably mounted on the movable die to overhang one end of the sink thereof.

6. An apparatus as set forth in claim 3, and a second plunger having a face curved complementary to the face of the first named plunger, means for withdrawing the first named plunger from the bent pipe, and means for moving the second mandrel into the bent pipe after the first named mandrel has been withdrawn.

7. An apparatus for forming pipe bends including, a mandrel having a face curved transversely and longitudinally to support the entire outer bend of a pipe bend having tangential ends, and a pair of dies having complementary sinks provided with medial portions curved concentrically to the curved face of the mandrel adapted to be moved together to bend a pipe supported at its medial and one end portion on said mandrel.

CLINT CROSS.

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