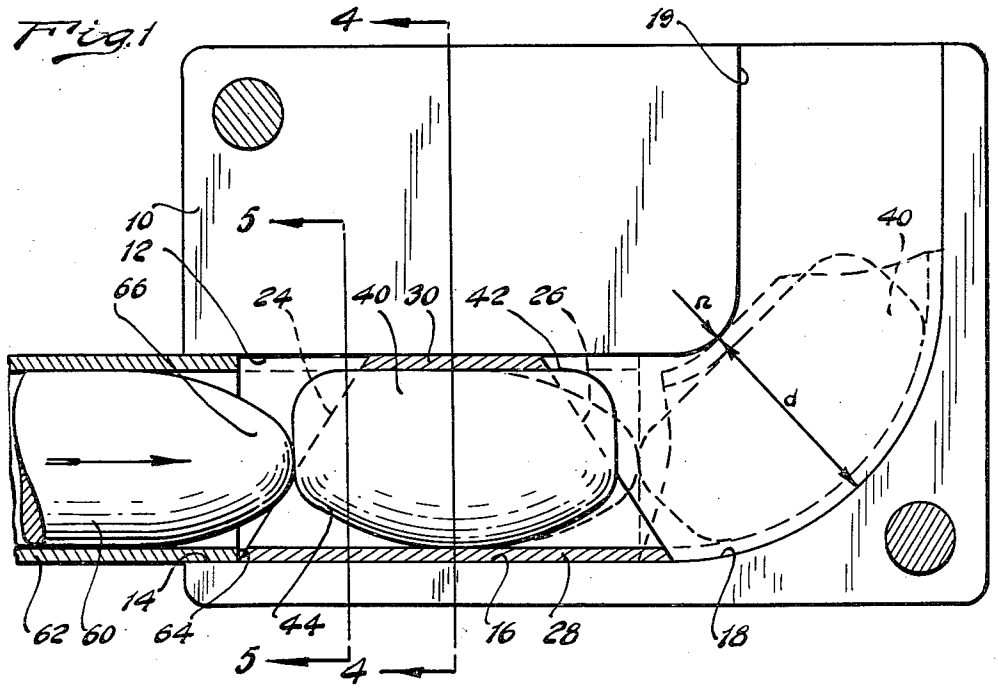
Nov. 12, 1963 J. D. STALTER 3,110,341

METHOD AND APPARATUS FOR MAKING ELBOWS BY FORCING TUBULAR STOCK THROUGH A DIE

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Fig. 1



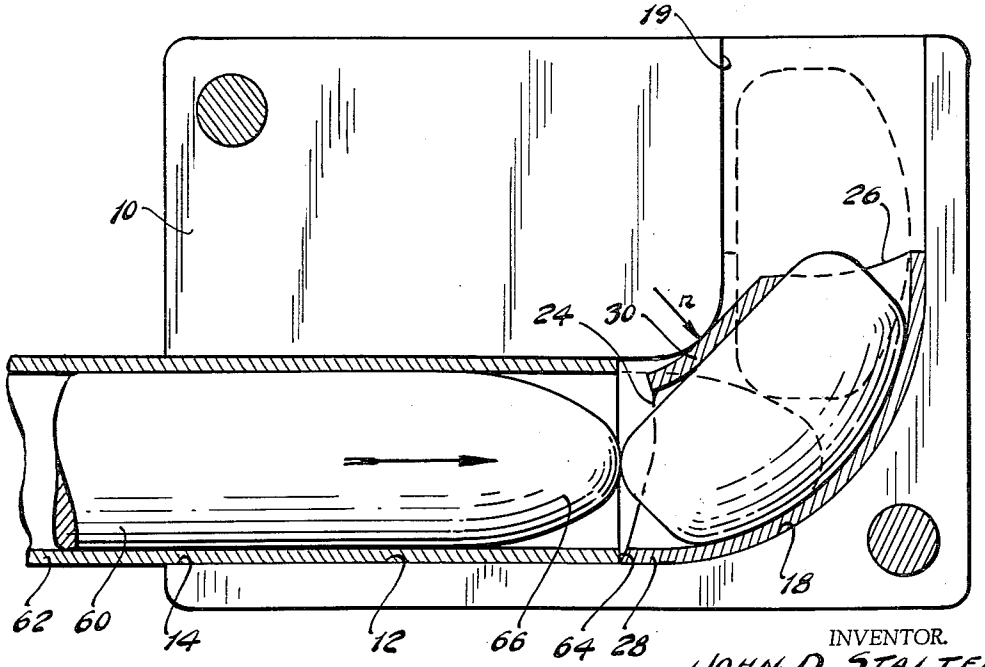


Fig. 2

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Fig. 3

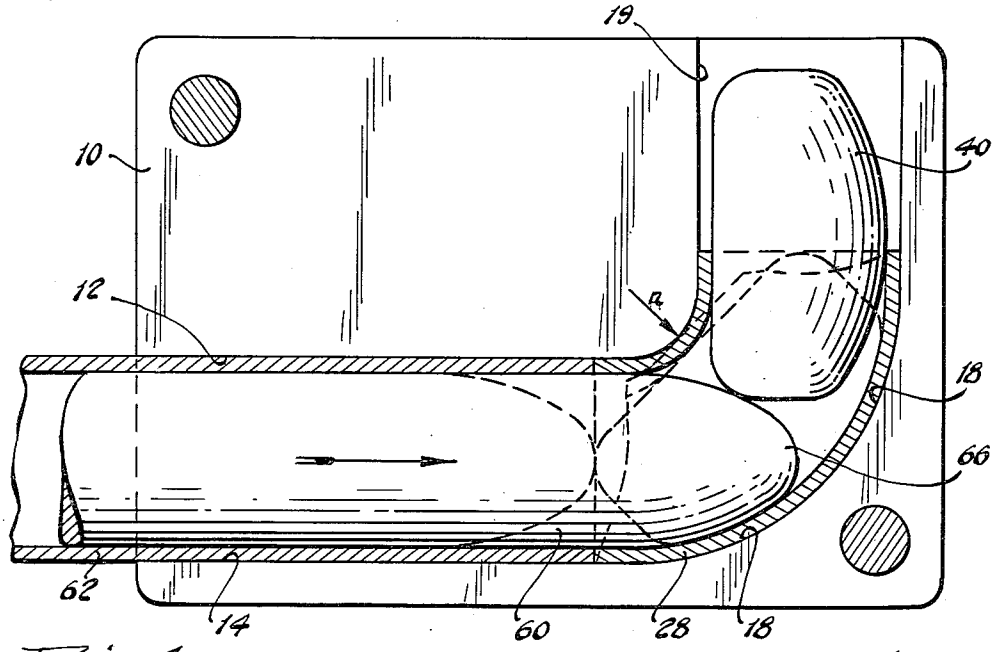


Fig. 4

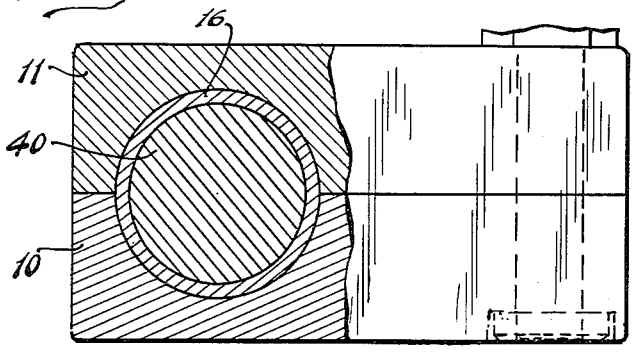
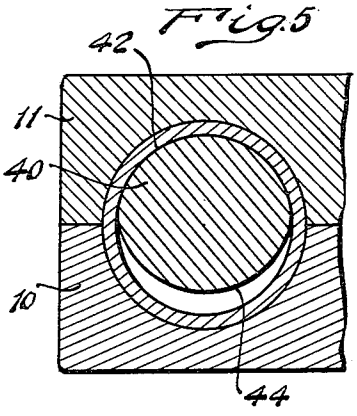


Fig. 5



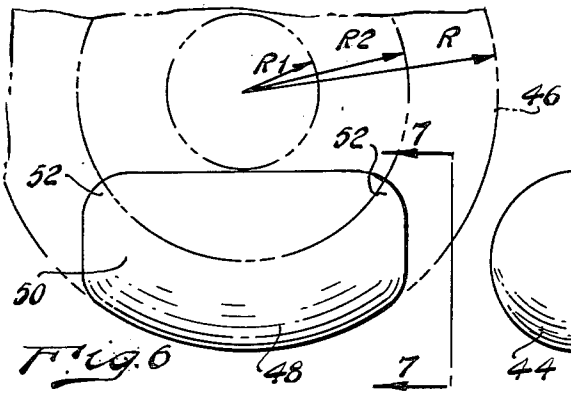
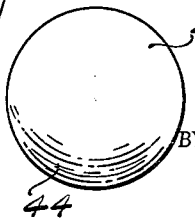


Fig. 6

Fig. 7



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3,110,341

METHOD AND APPARATUS FOR MAKING ELBOWS BY FORCING TUBULAR STOCK THROUGH A DIE

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9 Claims. (Cl. 153—32)

This invention relates to a method and apparatus for making tubular elbows and elbow fittings and more particularly to the mandrel which is used in shaping the elbows.

The prior art discloses many different ways of making elbows of relatively large or small radii. As an example, in making elbows of relatively large radii, a tubular blank without internal support is forced through the curved channel of a forming die. Such a method, however, is limited in its use and application at the point where wrinkling and undesirable deformation of the metal begins to occur as the radius of curvature, in relation to inter alia, the diameter of the desired elbow, is decreased.

When making elbows of shorter or smaller radii in relation to diameter, it is the general proposition to give the tube or blank internal support so as to maintain its internal diameter at or substantially at its desired finish internal diameter while the blank is being bent by movement through the curved channel of a forming die. As an example, the prior art has provided internal support for the extruded leg or posterior portion of the blank through supporting mandrels for the purpose of resisting the tendency of the material to collapse inwardly upon being forced to take the small radius turn. Another internal support has been provided by filling the blank with more or less plastic or liquid material such as lead, sand, resin, tar or water and/or by causing sizing balls to move within the blank or piece while the blank is being bent.

In the methods previously provided where an internal support has been provided to resist the tendency of the walls of the blank or elbow to collapse inwardly or to wrinkle, there has been concomitant limitations, namely, that resistance to the formation of wrinkles has built up, ofttimes greatly or excessively, an increased resistance to forcing the work around the corner or bend of the forming channel. The effect of the internal support which requires the greater force to move the blank through the die is not limited merely to requiring greater working efforts to bring about the formation of the elbow, but along with the greater working effort follows the greater stress and working of the metal of the blank as well as a tendency to thicken certain wall portions and/or thin out other portions and to expand the walls whereby to increase the frictional load between the outer surface of the blank and the channel of the die.

Certain of the prior art internal supports which were used for the formation of the elbows were impractical in many cases resulting in waste of time, excessive wear or injury to the die, mandrels, tools and machines used to do the work, as well as reductions in the speed of production and increases in cost.

It is an object of the present invention to provide an improved method of forming elbow fittings which has eliminated the difficulties mentioned previously by providing a simple process which is economical, practicable, highly desirable for production and satisfactory in operation.

Another object of the present invention is to provide a method of forming a long or short radius elbow fitting of high uniform strength, quality and equal wall thickness.

Still another object of the present invention is to provide a method of making long or short radius elbows in which the walls of the blank and elbow are substantially

relieved of deleterious stresses and strains during the formation of the bend thereof and more particularly during the formation of the bend in the elbow during the step of forcing the blank through a curved channel of a forming die.

A further object of the present invention is to provide a method and apparatus which provides a substantially uniform wall thickness in and throughout the parts of the elbow formed according to this invention.

A further object of the present invention is to provide a novel method of forming elbows which can be carried out with a minimum of power for forcing the blank through the die and/or working the material from an initial straight tubular form to a finished short radius elbow form.

A still further object of the present invention is to provide a method of forming an elbow from straight tubular stock which comprises placing the stock in a die having an elbow-shaped passage including an arcuate bend, providing in the interior of the tubular stock a solid mandrel which has a pair of external smooth peripheral surfaces on opposite sides thereof, one surface being cylindrical and the other surface convex, with the cylindrical surface in surface engagement with the stock which corresponds to the inside of the bend and the convex surface in line contact with the stock which corresponds to the outside of the bend, forcibly moving the stock and mandrel so as to push the stock into the arcuate bend of the die and move the material of the stock at the outside of the bend into surface engagement with the convex surface of the mandrel, and thereafter forcing the mandrel through the stock to shape the material at the inside of the bend.

A still further object of the present invention is to provide a novel mandrel comprising a substantially solid body having a longitudinally extending axis, said body being symmetrical with respect to a plane which is perpendicular to the aforesaid axis midway between its ends, the periphery of the body extending around the aforesaid axis containing a pair of smooth surfaces at opposite sides thereof, one of the surfaces being cylindrical and having its principal axis coinciding with the aforesaid longitudinally extending axis and the other of the surfaces being convex and having a longitudinal radius of curvature measured from an axis which is spaced from and perpendicular to the aforesaid longitudinally extending axis and which is more than twice the radius of the cylindrical surface, and having a radius of transverse curvature equal to the radius of the cylindrical surface.

Another object of the present invention is to provide a method of making a mandrel comprising the steps of taking an elongated segment of a solid torus of normal circular cross section with the segment having a depth at its transverse center section equal to the difference between the outside and inside radius of the torus, and shaping the inside surface thereof to circular form by a turning operation in which the segment is rotated about a center line tangent to the mean radius of the torus.

Other objects and features of the invention will become apparent as the description proceeds, especially when taken in conjunction with the accompanying drawings, illustrating a preferred embodiment of the invention, wherein:

FIGURE 1 shows in longitudinal cross section a tubular blank or tube positioned in an initial position in one of a pair of split forming dies through which the blank is to be forced to give it its elbow form.

FIGURE 2 is a view similar to FIGURE 1 showing the blank in cross section in an advanced position in its movement in the channel of the forming die.

FIGURE 3 is a view similar to FIGURE 2 showing the blank formed to the desired configuration of the bend

of the forming ide and a plunger advanced to a position to shape the trailing end of the elbow and to move the mandrel out of the blank so as to shape the leading end of the elbow.

FIGURE 4 is a sectional view taken on line 4—4 of FIGURE 1.

FIGURE 5 is a sectional view taken on line 5—5 of FIGURE 1 showing in particular the intersection of a pair of smooth peripheral surfaces provided on the novel mandrel.

FIGURE 6 illustrates the manner in which the mandrel is made from a segment of a torus.

FIGURE 7 is an end view of the mandrel looking in the direction of arrows 7—7 of FIGURE 6.

The present invention including the method, apparatus and mandrel is applicable in making both long and short radius elbow fittings, as well as radiused fittings which have straight tubular portions at the ends which are tangent to the curved portions of the fittings.

The present method and apparatus may be used with many types of malleable and ductile metals such as hard or soft copper, low carbon steel, stainless steel and aluminum alloys as are commonly employed in commercial tubular stock. It is sufficient to state at this time, without trying to state all the different kinds of metal or the range of sizes or relations of wall thicknesses to diameter in different metals with which the present invention may be advantageously practiced, it has been observed that while tubes or blanks of excessively soft metals and/or large diameters and/or thin walls require less effort to bend, the apparent advantage may tend to be more than offset when some or all of these characteristics admit of excessive thickening, wrinkling, or other undesirable effects in the workpiece. The converse follows with excessively hard materials, small diameters and/or thick walls. With these limitations in mind, I have provided a method and apparatus which includes novel means for controlling the wrinking in the leading leg and the trailing leg of the elbow.

Referring now to FIGURE 1, there is illustrated diagrammatically the half die **10** of a split pair of forming dies, the parting plane of which is in the plane of the drawings. The half dies **10** and **11**, as shown in FIGURE 4, are open in a known way to receive the blank or tube, closed to form the forming channel of circular cross section, held closed during the forming operation and finally open to permit removal of the piece after it has been formed. The channel **12** of the forming dies **10** and **11** has a straight cylindrical entering section **14** long enough to receive the tubular blank or tube **16**, a bend **18** with inside radius *r* and diameter *d*, the latter being equal to the diameter of the entering section **14** and the straight cylindrical forming section **19** which has its axis as shown at 90 degrees to the axis of the entering section **14**.

As shown in FIGURE 1, the tubular blank **16** has beveled ends **24** and **26** dimensioned to provide the necessary stock to preserve substantially the same wall thickness in the completed elbow as in the completed stock. The long side **28** of the tubular blank **16** corresponds to the outside radius of the elbow and provides the necessary excess stock to prevent excessive thinning of the wall section of the elbow. The short side **30** of the tubular blank corresponds to the inside radius of the elbow.

Part of the invention includes a double-ended mandrel **40** which has a longitudinally extending axis which is coincidental with the longitudinal axis of the tubular blank **16** and which is symmetrical with respect to a plane which is perpendicular to the aforesaid axis midway between its ends. The mandrel **40** is substantially solid and the outer periphery surrounding the axis is composed of a pair of smooth surfaces **42** and **44** at opposite sides thereof which generally intersect, as is best illustrated in FIGURE 5. One of the smooth surfaces **42** is cylindrical and has its principal axis coinciding with the longitudinally extending axis of the mandrel **40**. The other peripheral surface **44** is convex and has a longitudinal radius of curvature which is measured from an axis which is spaced from the aforementioned longitudinally extending axis and located outwardly from the cylindrical surface **42** in such a manner that the axis of the convex surface is perpendicular to the longitudinally extending axis. The longitudinal radius of curvature is more than twice the radius of the cylindrical surface. The convex surface **44** also has a radius of transverse curvature equal to the radius of the cylindrical surface **42**.

The mandrel **40**, as shown in FIGURE 6, is formed as an elongated segment **48** of a solid torus **46** of normal circular cross section. The torus **46** has an outside radius R, an inside radius R_1, and a mean radius R_2. The inside surface of the segment **48** is shaped to cylindrical form by a turning operation in which the elongated segment **48** is rotated about a center line **50** which is tangent to the means radius R_2 of the solid torus **46**. All of the corners **52** of the segment **48** are then rounded to form the mandrel **40**.

An essential feature of the invention is in the form of the mandrel **40** which, at its radially outer side, has convex surfaces which form a part of the torus **46** and which, at its inner side, has cylindrical surfaces concentric with the axis **50** tangent to the circular center line of the torus **46**. With this shape, the mandrel **40** will fit without intereference either into the straight cylindrical tube **16** or into an arcuately curved tube having the same radius of curvature as the torus **46**.

It should be observed that when the mandrel **40** is fitted within the straight tube **16**, contact on the radially outer side of the mandrel **40** is a curved line and at the radially inner side is full surface contact. When the tube **16** is curved to the radius of the torus **46**, contact between the mandrel **40** and the inner surface of the tube **16** changes to a condition in which the radially outer inner surface of the tube is in full area contact with the radially outer surface of the mandrel **40** and the radially inner surface at the inner side of the tube **16** has contact with the mandrel **40** only in a curved line as is best illustrated in FIGURE 3.

In operation, the mandrel **40** is inserted into the central portion of the tube or blank **16**. A ram or ironing mandrel **60** and a sleeve **62** are mounted opposite the entering section **14** of the dies **10** and **11** and are connected with and actuated by means such as a hydraulic cylinder, not shown. Upon actuating the cylinder, the ironing mandrel **60** and sleeve **62** are moved to the right, as viewed in FIGURES 1 and 2, under appropriate controls, not shown, so as to push the mandrel **40** and tube **16** through the curved die.

The ironing mandrel **60** is movable with or relative to the sleeve **62**. Initially, the end **64** of the sleeve **62** abuts the opposite end of the tube **16** as shown in FIGURE 1. At such a time, the rounded nose **66** of the mandrel **60** abuts the end of the mandrel **40**. The sleeve **62** has substantially the same wall thickness as the tube **16** and the resulting elbow.

Upon actuation of the sleeve **62** and mandrel **60**, the tube **16** and mandrel **40** are moved to the right into the curved portion or bend **18** of the passage as is shown in FIGURE 2. As a result, the tube **16** assumes an elbow shape although the inner wall portion **30** of the tube **16** is not shaped to the inside of the bend **18**. However, for reasons not fully understood, the basic new result is that the inner and outer wall surfaces of the elbow have substantially the same thickness.

It should be observed in FIGURE 2 that the inner leading side of the blank **16** tends to continue in a straight line rather than to turn the corner, whereas the outer leading side of the blank is forced around the curved outer wall of the curved die and has substantially swung through an arc of about 90 degrees. At both ends of the elbow,

the wall of the blank 16 adjacent the inner curve of the bend 18 is spaced from the wall of the die. Another operation is required to form both ends of the elbow.

Finally, the elbow is completed by moving the mandrel 60 to the right, as viewed in FIGURE 3, with the sleeve 62 remaining stationary. The rounded nose 66 of the mandrel 60 enters the trailing end of the elbow so as to shape the inside surface of the tube 16 at the trailing end while simultaneously moving or pushing the mandrel 40 out of the leading end of the elbow. As a result, the rounded nose 66 and the mandrel 40 expand and iron out the material at the trailing end and leading end respectively to form the intended finished and external diameters of the legs of the elbow. With such an arrangement, both ends of the elbow are finished simultaneously.

In the event a different type of mandrel or ram 60 is used, the ram moves the mandrel 40 out of the leading end or leg of the elbow completing that end to the required diameter. Thereafter, the mandrel 40 is reinserted and pushed through the elbow in the opposite direction and out the trailing end or leg to finish the trailing end of the elbow.

Alternatively, the mandrel 40 may be moved out of the elbow by pushing balls through the elbow, at least one of which has a diameter equal to the required internal diameter of the elbow.

The various operations of this invention are carried out with cold metal and at high speed. This invention may be advantageously practiced either by direct manual control of the movements of the mandrel 60 and sleeve 62 or by appropriately correlated automatic or semi-automatic mechanisms and controls which can be adjusted to the practice of this invention.

When the blank has assumed the position shown in FIGURE 3, it remains merely to open the dies 10 and 11 and remove the elbowed piece. Thereafter, by appropriate steps known and practiced in the art, the respective ends of the elbowed piece may be treated by way of enlargement or other trimming or sizing to form appropriate sockets to receive tubes in capillary or other bonded joints or otherwise treated appropriately for the purposes for which the elbows are intended to be used.

The drawings and the foregoing specification constitute a description of the improved method and apparatus for making elbows by forcing tubular stock through a die in such full, clear, concise and exact terms as to enable any person skilled in the art to practice the invention, the scope of which is indicated by the appended claims.

What I claim as my invention is:

1. The method of forming an elbow from straight tubular stock which comprises placing the stock in a die having an elbow-shaped passage including an arcuate bend, providing in the interior of the tubular stock a solid mandrel of normal circular cross section which has a pair of external smooth peripheral surfaces at opposite sides thereof, one surface being cylindrical and the other surface being longitudinally and transversely convex, with the cylindrical surface adjacent the side of the stock corresponding to the inside of the bend, forcibly moving the stock and mandrel so as to push the stock into the bend to shape the material at the outside of the bend to conform to the convex surface of the mandrel, and thereafter forcing the mandrel through the stock to shape material at the inside of the bend.

2. The method of forming an elbow from straight tubular stock which comprises placing the stock in a die having an elbow-shaped passage including an arcuate bend, providing in the interior of the tubular stock a solid mandrel of normal circular cross section which has a pair of external smooth peripheral surfaces at opposite sides thereof, one surface being cylindrical and the other surface being longitudinally and transversely convex, with the cylindrical surface adjacent the side of the stock corresponding to the inside of the bend, forcibly moving the

stock and mandrel in one direction so as to push the stock into the bend to shape the material at the outside of the bend to conform to the convex surface of the mandrel, and thereafter forcing the mandrel in said one direction through the stock to shape material on the leading end thereof at the inside of the bend.

3. The method of forming an elbow from straight tubular stock which comprises placing the stock in a die having an elbow-shaped passage including an arcuate bend, providing in the interior of the tubular stock a solid mandrel of normal circular cross section with has a pair of external smooth peripheral surfaces at opposite sides thereof, one surface being cylindrical and the other surface being longitudinally and transversely convex, with the cylindrical surface adjacent the side of the stock corresponding to the inside of the bend, forcibly moving the stock and mandrel in one direction so as to push the stock into the bend to shape the material at the outside of the bend to conform to the convex surface of the mandrel, and thereafter forcing the mandrel in said one direction through the stock to shape material on the leading end thereof at the inside of the bend, and thereafter reinserting the mandrel into the tubular stock and forcibly moving the mandrel in the opposite direction to shape material at the trailing end of the stock to the inside of the bend.

4. The method of forming an elbow from straight tubular stock which comprises placing the stock in a die having an elbow-shaped passage including an arcuate bend, providing in the interior of the tubular stock a solid mandrel of normal circular cross section which has a pair of external smooth peripheral surfaces at opposite sides thereof, one surface being cylindrical and the other surface being longitudinally and transversely convex, with the cylindrical surface adjacent the side of the stock corresponding to the inside of the bend, forcibly moving the stock and mandrel in one direction so as to push the stock into the bend to shape the material at the outside of the bend to conform to the convex surface of the mandrel, and thereafter forcing the mandrel in said one direction through the stock with a crown-shaped tool so as to move the mandrel through the stock to shape material at the leading end of the stock and to shape the material at the trailing end of the stock with the crown-shaped tool.

5. The method of bending a cylindrical tubular metal blank so as to form a right-angled elbow comprising the steps of placing the blank in a die having an elbow-shaped passage including an arcuate bend of 90 degrees, providing a mandrel within the interior of said blank, said mandrel having a pair of intersecting smooth peripheral surfaces, one of which is cylindrical and the other longitudinally and transversely convex, with the cylindrical surface in surface engagement with the material corresponding to the inside of the bend and the convex surface engaging in line contact a portion of the material corresponding to the outside of the bend, and forcing the blank and mandrel through the passage so as to move the outside side of the blank into surface engagement with the aforesaid convex surface of the mandrel, and thereafter forcing the mandrel out the leading end of the blank to shape the material at the inside thereof to the inside of the bend.

6. The method of bending a cylindrical tubular metal blank so as to form a right-angled elbow comprising the steps of placing the blank in a die having an elbow-shaped passage including an arcuate bend of 90 degrees, providing a mandrel within the interior of said blank, said mandrel having a pair of intersecting smooth peripheral surfaces, one of which is cylindrical and the other longitudinally and transversely convex, with the cylindrical surface in surface engagement with the material corresponding to the inside of the bend and the convex surface engaging in line contact a portion of the material corresponding to the outside of the bend, and forcing the blank and mandrel through the passage so as to move the outside side of the blank into surface engagement with the

aforesaid convex surface of the mandrel, and thereafter forcing the mandrel out the leading end of the blank to shape the material at the inside thereof to the inside of the bend while simultaneously shaping the trailing end of the blank with a crown-shaped tool.

7. Apparatus for forming elbows from tubular open-ended blanks comprising a die having an elongated passage extending therethrough, said passage consisting of two angularly related straight end portions and a curved intermediate portion connecting said end portions, a pair of concentrically mounted members movable into one straight end portion of said passage, one of said members being located within the interior of the other of said members, said one member having an end portion dimensioned to fit within a tubular blank which in turn fits within said passage, a mandrel mounted in the interior of said tubular element and having a pair of smooth peripheral surfaces at opposite sides thereof, one of which is cylindrical and the other longitudinally and transversely convex, with the cylindrical surface in surface engagement with the side of the blank corresponding to the inside of the curved intermediate portion and the convex surface in line contact with a portion of the material corresponding to the outside of the bend, said one member having an end portion in engagement with said mandrel and said other member having an end surface which is adapted to engage the blank, and means for actuating said members so as to advance said mandrel and blank into the curved intermediate portion of said passage so as to shape and move the material at the outside of the curved intermediate portion into surface engagement with the convex surface of the mandrel.

8. Apparatus for forming elbows from tubular open-ended blanks comprising a die having an elongated passage extending therethrough, said passage consisting of two angularly related straight end portions and a curved intermediate portion connecting said end portions, a pair of concentrically mounted members movable into one straight end portion of said passage, one of said members being located within the interior of the other of said members, said one member having an end portion dimensioned to fit within a tubular blank which in turn fits within said passage, a mandrel mounted in the interior of said tubular element and having a pair of smooth peripheral surfaces at opposite sides thereof, one of which is cylindrical and the other longitudinally and transversely convex, with the cylindrical surface in surface engagement with the side of the blank corresponding to the inside of the curved intermediate portion and the convex surface in line contact with a portion of the material corresponding to the outside of the bend, said one member having an end portion in engagement with said mandrel and said other member having an end surface which is adapted to engage the blank, and means for actuating said members so as to simultaneously advance said mandrel and blank into the curved intermediate portion of said passage so as to shape and move the material at the outside of the curved intermediate portion into surface engagement with the convex surface of the mandrel.

9. Apparatus for forming elbows from tubular open-ended blanks comprising a die having an elongated passage extending therethrough, said passage consisting of two angularly related straight end portions and a curved intermediate portion connecting said end portions, a pair of concentrically mounted members movable into one straight end portion of said passage, one of said members having an end portion dimensioned to fit within a tubular blank which in turn fits within said passage, a mandrel mounted in the interior of said tubular element and having a pair of smooth peripheral surfaces at opposite sides thereof, one of which is cylindrical and the other longitudinally and transversely convex, with the cylindrical surface in surface engagement with the side of the blank corresponding to the inside of the curved intermediate portion and the convex surface in line contact with a portion of the material corresponding to the outside of the bend, said one member having an end portion in engagement with said mandrel and said other member having an end surface which is adapted to engage the blank, means for actuating said members so as to advance said mandrel and blank into the curved intermediate portion of said passage so as to shape and move the material at the outside of the curved intermediate portion into surface engagement with the convex surface of the mandrel, and means for advancing said one member independently of said other member so as to force said mandrel out the leading end of the blank.

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