July 8, 1969 J. W. RECKARD 3,453,857

APPARATUS AND METHOD OF BENDING PIPE

Filed Oct. 21, 1966 Sheet 1 of 4

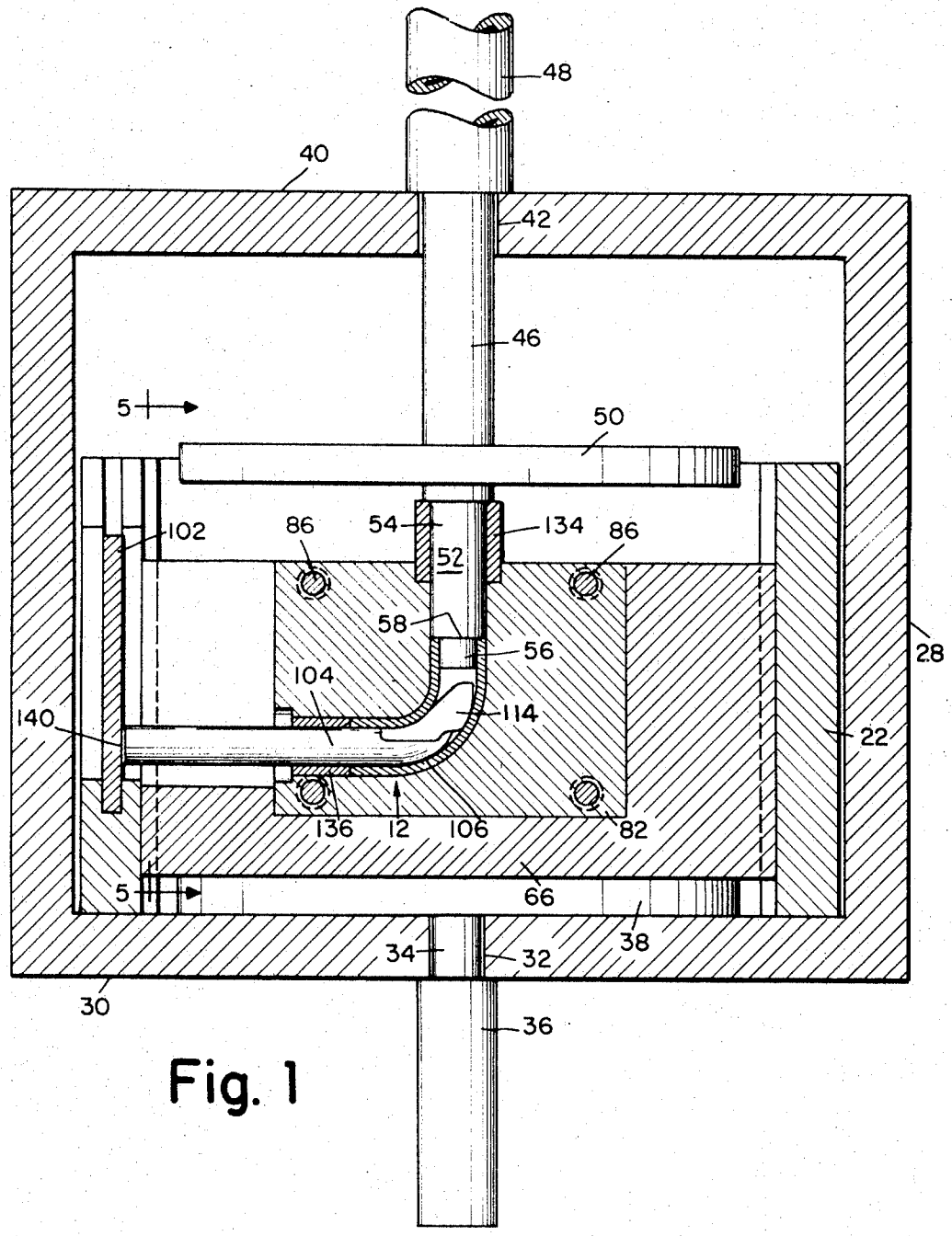


Fig. 1

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July 8, 1969 J. W. RECKARD 3,453,857

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Filed Oct. 21, 1966 Sheet 2 of 4

Fig. 2

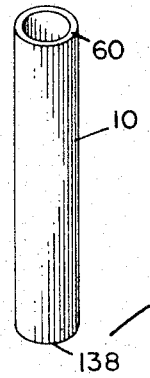


Fig. 3

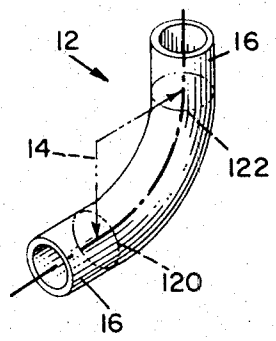


Fig. 4

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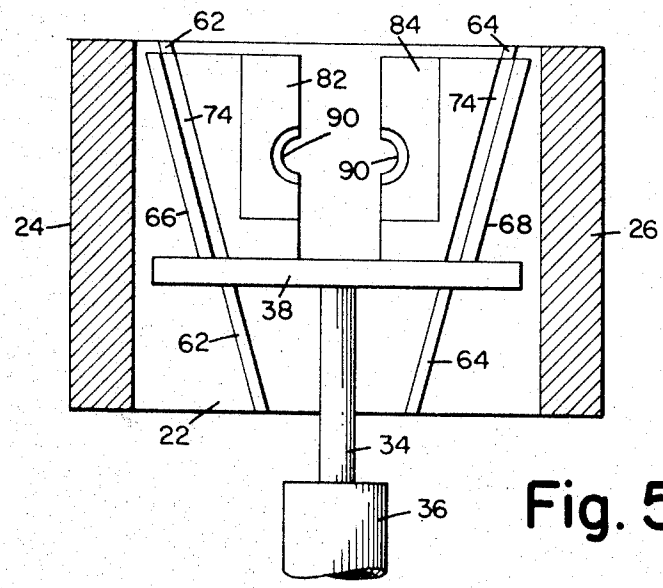


Fig. 5

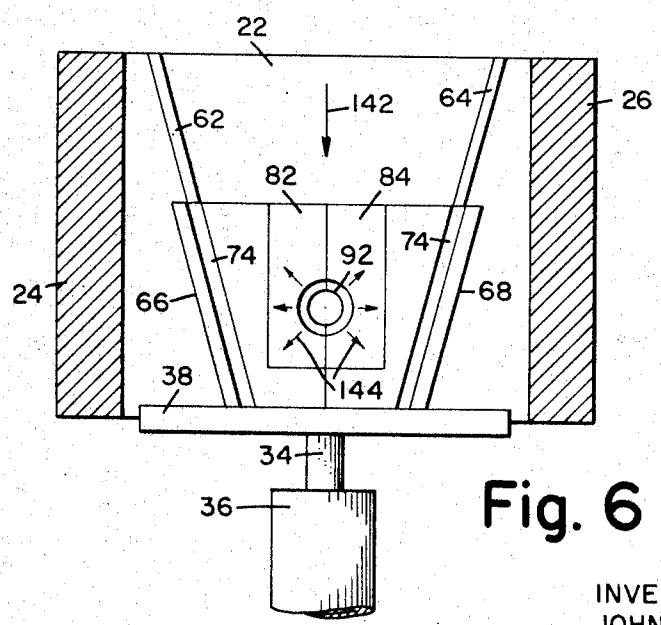


Fig. 6

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July 8, 1969 J. W. RECKARD 3,453,857

APPARATUS AND METHOD OF BENDING PIPE

Filed Oct. 21, 1966 Sheet 4 of 4

Fig.7

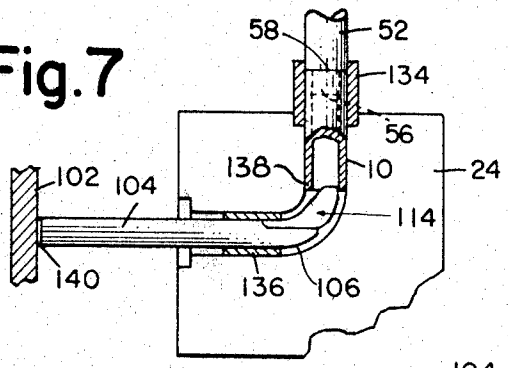
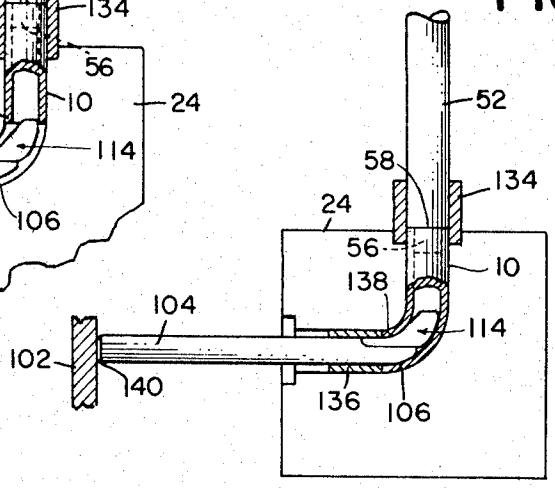


Fig.8



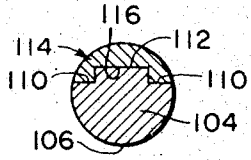


Fig. 10

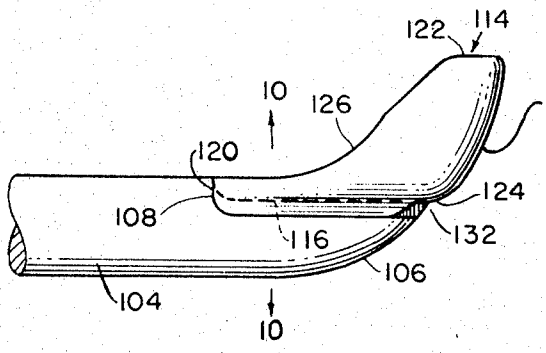


Fig. 9

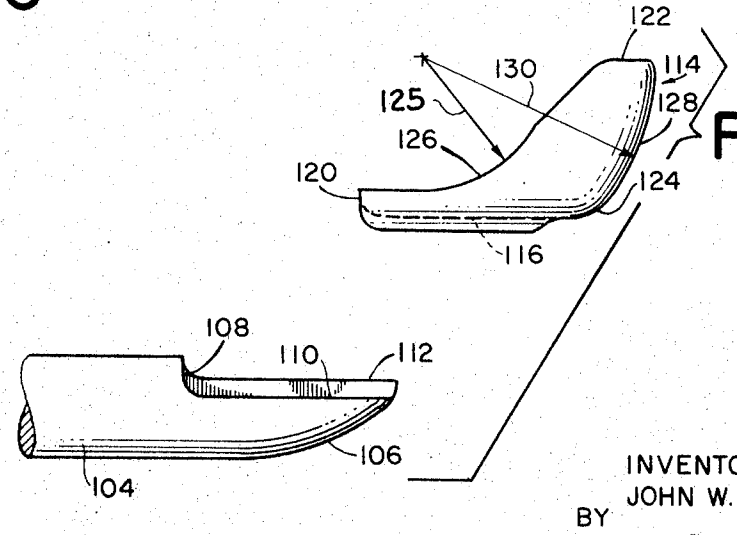


Fig. 11

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APPARATUS AND METHOD OF BENDING PIPE

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Int. Cl. B21d 9/12, 11/10

U.S. Cl. 72—357

8 Claims

ABSTRACT OF THE DISCLOSURE

A method and apparatus for the cold bending of metallic pipe into an elbow fitting wherein a force is applied upon the trailing end of a straight blank while the leading end is inserted in the tangential portion of a cavity which is bent to conform to the elbow fitting, interposing a mandrel in the other tangential portion of the cavity which has a removable end portion that extends around the bend of the cavity, and providing die halves forming the cavity which are mounted in a guide in such a manner that the radial forces developed internally in the pipe during the bending operation act to keep the die halves closed and thus prevent formation of an undesirable longitudinal seam.

This invention relates to apparatus and method of bending metallic pipe and tubing.

It is well recognized in the art that in the forming of pipe fittings, such as elbows, changes occur in the pipe wall thickness, i.e. thinning occurs along the outer bend radius wall or heel and thickening at the inner bend radius wall. For this reason the A.S.T.M. has created a specification which states that the wall thickness at any point of the fitting must not be less than 87.5% of the nominal or standard thickness of the pipe.

It is the primary object of this invention to provide an apparatus and method of bending pipe under compression without the application of a positive restraining force on the leading end of the blank which will efficiently produce a pipe fitting that meets the A.S.T.M. specification.

The bending of a pipe into an elbow with long tangents presents an additional problem, that is maintaining the integrity of the bend while a portion thereof straightens out to form one of the tangents. It is an important object of this invention to provide an apparatus and process for bending pipe under compression into an elbow with long tangents that maintains the integrity of the bend as well as the proper thickness at the heel thereof.

In the bending of pipe in which a force is applied to the trailing end of the straight blank to push it into a die cavity, internal forces develop which push the pipe radially outwardly against the wall of the cavity, often of magnitude sufficient to separate the die halves and thereby cause an undesirable longitudinal seam to be formed in the elbow. It is another object of this invention to provide an apparatus and method of bending pipe in which the die halves are provided with means whereby the aforesaid internal radial forces developed in the pipe as it is forced through the cavity tend to keep the die halves closed rather than open, thereby minimizing the possibility of producing the undesirable seam.

Another object of the invention is to provide an apparatus and method for bending pipe employing a fixed mandrel which is retained in a tangential portion of the die cavity so that the stock or work piece is forced around the mandrel, the mandrel being provided with a novel removable curved button which maintains the integrity of and prevents the collapse of the bend and at the same time

permits ready and easy removal of the mandrel from the bent pipe.

Another object of the invention is to provide an apparatus and method of bending pipe and particularly into elbows with tangential portions, which is relatively inexpensive and easy to operate.

These and other objects of the invention will become more apparent as the following description proceeds in conjunction with the accompanying drawings, wherein:

FIG. 1 is a vertical sectional view through the middle of the apparatus;

FIG. 2 is a perspective view of the straight blank or workpiece;

FIG. 3 is a perspective view of the bent elbow made from the workpiece and including tangential portions;

FIG. 4 is a group perspective view of the apparatus;

FIG. 5 is a sectional view taken on the line 5—5 of FIG .1 and showing the die halves in the open position;

FIG. 6 is a view similar to FIG. 5 showing the die halves in the closed position;

FIG. 7 is a diagrammatic view, partly in section, illustrating the first stage in the bending process;

FIG. 8 is a view similar to FIG. 7 showing an intermediate bending stage;

FIG. 9 is an enlarged elevational view of the inner end of the mandrel and illustrating the removable curved button;

FIG .10 is a sectional view taken on the line 10—10 of FIG. 9; and

FIG. 11 is a group elevational view of the button and the inner end of the mandrel.

Specific reference is now made to the drawings in which similar reference characters are used for corresponding elements throughout.

The present apparatus and method is designed to form a given length of a straight tubular blank or workpiece **10**, made of stainless steel and similar metals, into an elbow **12** of radius **14**, generally 90°. There are many applications in the process industry requiring a pipe fitting in the form of an elbow having tangential portions **16**, see FIG. 3, which extend as straight portions at substantially 90° to each other beyond the curvature of the bend as is clearly shown in FIG. 3. These tangential portions are adapted to receive flanges which will not foul when the elbow is joined to other lengths of pipe. While the present invention is capable of bending the straight blank **10** into a short elbow, it is particularly well adapted to produce an elbow with tangential portions for a purpose soon to appear.

Coming now to the apparatus itself, the same comprises a die box **18** having front and rear walls **20** and **22** and side walls **24** and **26** joining them. The member **18** is a fixed member which is retained in a press frame **28** whose lower wall **30** contains an opening **32** through which a vertically disposed ram **34** extends which is operated by a conventional hydraulic or press cylinder **36** and which mounts a conventional platen **38**. The bottom of the member **18** is either entirely opened to allow passage of the platen **38** or is an actual wall with an opening large enough to permit the vertical reciprocal movement therein of the platen **38** and the ram **34**.

Similarly, the upper horizontal wall **40** of the press frame is provided with an opening **42** through which the ram **46** extends for vertical reciprocation, which ram is operated by a conventional press cylinder **48** and which also carries at its lower end a platen **50**. The platen mounts a pilot **52**, the upper portion **54** of which is of a diameter substantially equal to the outer diameter of the workpiece **10** and which includes a reduced portion **56** at its lower end which is adapted to enter into the workpiece **10** so

that the shoulder **58** between the upper portion **54** and the lower portion **56** of the pilot will bear against the trailing end **60** of the workpiece.

The end walls **20** and **22** of the guide box **18** are each provided with vertically extending ribs **62** and **64**, which are preferably rectangular in cross section, which project inwardly of the box **18** and which converge downwardly and inwardly thereof.

A pair of die holders **66** and **68** are provided, see FIG. 4, each with end walls **70** and **72** and channels **74** and **76** therein which also converge downwardly and inwardly and are of such shape and size as to slidably receive the guide ribs **62**, **62** and **64**, **64** of the opposite end walls **20** and **22** of the die holder guide box **18**.

Each die box **66** and **68** contains an inner wall **78** which is provided with a substantially rectangular cut-out portion **80**. Dies **82** and **84** are provided in the form of rectangular blocks which fit into the cut-out portions **80** of the die holders and there removably retained by suitable bolts **86**. The inner faces **88** of the dies are provided with die cavities **90** of semi-circular cross section and of a shape to conform to that of the elbow to be made so that when the inner faces **88** of the dies meet, a cavity **92** is formed whose diameter approximates the outer diameter of the pipe or tubing and whose shape is that of the elbow desired, as shown in FIG. 3. The upper end of the semi-circular die cavity **92**, that is the end of the vertical tangential portion is provided with a semi-cylindrical enlarged opening **94** whereas a similar semi-cylindrical enlarged opening **96** is provided at the lower end of the semi-circular cavity or the end of the horizontal tangential portion. Thus, when the inner faces **88** of the dies **82** and **84** meet, not only is a die cavity **92** provided for the elbow with tangential portions to be formed, but enlarged cylindrical portions are also provided at the top and at the front side thereof.

The front wall **20** of the die box **18** is cut out as at **98** and includes a channel **100** peripherally around the cut-out portion to removably retain a gate member **102**, which gate member may be manually positioned to close off the opening **98** or automatically positioned therein if it is carried by the upper platen **50**. It will also be noted particularly from FIGS. 1, 5 and 6 that the die holders **66** and **68** rest upon the lower platen **38** so that when the platen **38** is raised by the press cylinder **36** to its uppermost position, the die holders are spread apart as shown in FIG. 5 and when the platen is lowered to its lowermost position, the inner faces **88** of the dies **82**, **84** meet to provide the die cavity **92**.

A mandrel **104** is provided which is an elongated rod whose diameter approximates the inner diameter of the pipe or tubing. One end of the mandrel is ground to provide a curved surface **106** which conforms to the radius of curvature of the heel of the bend desired in the elbow but which extends for only a portion of the overall length of the bend. Opposite to the curved portion **106** the mandrel is cut out as at **108** to provide axially extending recesses **110** forming between them a substantially flat raised tongue or land portion **112**.

Associated removably with this end of the mandrel is a button **114**. Opening through one end of the button at its undersurface is a channel-shaped groove **116** which slidably receives the tongue or land **112** of the mandrel to provide a removable but snug fit. It will be seen from FIGS. 9–11 that the mandrel and button are ground to provide certain surfaces which are essential in the bending process to retain the integrity of the bend of the elbow, i.e. prevent the collapse of the bend during formation thereof, and to permit formation of the front tangential portion **16** of the elbow without collapse of the pipe at the bend.

The formation of the surfaces will best be understood from a description of the manner in which the button **114** is made. A steel rod is first bent to the required radius **14** of the finished pipe fitting or elbow **12**. This rod is cut at the tangential points **120** and **122** shown in dotted line in FIG. 3 and become the front and rear ends of the button. The groove **116** is then machined into the front end of the button for a snug removable fit on the end of the mandrel **104**. Such a member when put into the end of the elbow fitting will not pass entirely therethrough. To effect this the heel is ground as at **124** and the lead end of the button is also contour ground so that in its final form the button can be dropped through the fitting. The grinding off of the heel and the contour grinding of the lead end of the member must be kept to a minimum to prevent the collapse of the bend of the elbow during its formation. Thus, it will be seen that the button **114** has a curved portion **126** at its lead end which conforms to the radius **125** of the inner curve of the desired elbow, an outer portion **128** on the opposite side thereof going to the trailing end of the button which conforms to a radius **130** of the outer curve or heel **118** of the bend of the elbow, a portion **124** which is ground out of the heel portion as well as additional contour grinding so that the button can be dropped through the fitting. The curved surfaces **106** and **128** together approximate the radius of the inner surface of the outer curve or heel **118** of the elbow even though the under grinding of the heel at **124** produces an interrupted or indented portion **132** when the button is assembled in place upon the end of the mandrel as shown in FIG. 9.

A die bushing **134** is provided to hold the workpiece **10** in the machine as well as a bushing **136** to hold the mandrel in place.

In use, press cylinder **36** is used to raise the platen **38** which raises and opens the die holders **66** and **68** and the dies **82** and **84** carried thereby. The mandrel **104** with the button **114** mounted on its end is slipped through the bushing **136** which is positioned and held in one of the semi-cylindrical openings at the forward end of the horizontally extending tangential portion of the die cavity **90**. The bushing **134** is slipped over the workpiece **10** and placed in the semi-cylindrical opening **94** at the top of the vertically extending tangential portion of the die cavity **90** so that the leading end **138** of the workpiece embraces the trailing end **122** of the button **114**, as shown in FIG. 7. The press cylinder **36** is then again actuated to lower the platen **38** whereupon the dies **82** and **84** are closed to form the cavity **92** whose inner wall is spaced from the outer surface of the mandrel **104** and its plug **114**. The gate **102** is then dropped into the channel **100** so that it abuts the forward end **140** of the mandrel, as seen in FIGS. 1, 7 and 8. Press cylinder **48** is then actuated whereupon the platen **50** is lowered and the pilot **52** enters the bushing **134** with the reduced portion **56** thereof entering the trailing end **60** of the workpiece **10** and the shoulder **58** bearing on the trailing end **60**. The ram pressure thus forces the workpiece into the cavity **92**. The initial stage is shown in FIG. 7. An intermediate stage is shown in FIG. 8 in which the bend in the pipe or tubing is first formed. In FIG. 1 the complete bend is shown with the forward tangential portion straightening-out, so to speak. In this action the leading end **138** of the pipe pushes the mandrel support bushing **136** forwardly toward the gate but the mandrel itself remains stationary.

As seen in FIG. 6, the press force **142** pushing the workpiece into and through the die cavity is in effect a compressive force which is applied to the trailing end **60** of the workpiece and the bend in the workpiece with the straightening-out of the forward tangential portion is effected without the application of a positive reactive force or restraint applied to the leading end of the workpiece. The reactive force on the workpiece or blank as it passes through the cavity is only the friction between the inner surface of the workpiece and the outer surface of the mandrel and the removable button, and the friction between the outer surface of the workpiece and the inner surface of the die cavity. During the bending operation,

in which the mandrel and the button act to prevent the collapse of the bend, internal forces **144** are created in a direction radially outwardly of the pipe or tubing which normally tend to open the die halves with the result that the elbow is formed with an undesirable longitudinal seam. This is prevented in the instant invention because the radial forces **144** are resolved into vectors which act to keep the die halves **82** and **84** closed because they urge the die holders **66** and **68** downwardly into the closed position by virtue of the fact that they are mounted in the guide box **18** so as to converge when closed and to diverge when opened.

When the press is raised and the dies are opened, the bent pipe is removed with the mandrel from the machine and tapped free of the mandrel, at which time the plug separates from the mandrel and remains at the bent portion of the elbow from which it falls out freely of its own accord when the elbow is inverted.

While a preferred embodiment of the invention has here been shown and described, it will be understood that skilled artisans may make minor variations without departing from the spirit of the invention and the scope of the appended claims. Thus an hydraulic cylinder can be provided to automatically withdraw the mandrel from the bent pipe and the machine can be provided with electrical controls for periodically opening and closing the dies and raising and lowering the press which acts upon the workpiece to push it through the die cavity.

I claim:

1. Apparatus for cold bending metallic pipe or tubing into an elbow fitting comprising die halves with semi-cavities therein adapted when mated to form an overall closed cavity having a bent portion and tangential extensions and conforming in shape and size to that of the elbow fitting desired, die holders mounting said dies so that said overall cavity extends in a generally vertical plane and one of said tangential extensions is horizontally disposed, means to move said die holders convergently together to form said overall cavity and divergently apart to open said overall cavity, and a mandrel including a body portion extending into said horizontally disposed tangential extension and an end portion removably mounted on said body portion and extending around said bend, the other tangential extension which is vertically disposed being adapted to receive a blank to be forced into said cavity around said mandrel.

2. The combination of claim **1** wherein said button is so shaped as to pass freely through the bent fitting but with close tolerance to the internal diameter of the fitting.

3. The combination of claim **2** wherein said button has a first surface portion with a radius substantially equal to that of the inner curve of the bend of the fitting, a second surface portion opposite to but longitudinally displaced from said first portion with a radius substantially equal to that of the outer curve of the bend of the fitting, said button having a third surface adjacent said second surface at the heel thereof which is ground down and contour surfaces elsewhere so that the button can pass freely through the bent fitting.

4. The combination of claim **1** wherein said means to move said die holders convergently together and divergently apart includes a fixed guide member, vertically extending downwardly converging interengaging ribs and channels coactive between said fixed guide member and said die holders, and means to raise and lower said die holders as a unit in said fixed guide member, said dies being mounted at the confronting faces of said die holders.

5. In an apparatus for cold bending metallic pipe or tubing into an elbow fitting, die halves with bent semi-cavities in generally vertical planes opening through the confronting faces thereof, die holders mounting said die halves, a fixed guide member, downwardly converging interengageable ribs and channels slidably mounting said die holders in said fixed guide member and means to raise and lower said die holders in said fixed guide member as a unit so that said semi-cavities close on the downstroke and open on the upstroke, the straight pipe or tubular blank being adapted to be forced through said closed cavities upon application of a force downwardly on the blank.

6. In an apparatus for cold bending of metallic pipe or tubing into an elbow fitting including a die having a cavity formed of a bend and tangential portions conforming in shape and size to that of the elbow fitting desired, one tangential portion being adapted to receive a straight pipe or tubular blank upon which a force is to be applied to push it through the cavity, a mandrel including a body portion extending through the other tangential portion of the cavity and a button removably mounted on one end of said body portion and curving around the bend of said cavity, said button being so shaped as to be able to pass freely through the bent fitting, said blank being adapted to pass between the outer surface of said mandrel and button and the inner surface of said cavity.

7. The combination of claim **6** wherein said button has a first surface portion with a radius substantially equal to that of the inner curve of the bend of the fitting, a second surface portion opposite to but longitudinally displaced from said first portion with a radius substantially equal to that of the outer curve of the bend of the fitting, the said button having a third surface adjacent said second surface at the heel thereof which is ground down and contour surfaces elsewhere so that the button can pass freely through the bent fitting.

8. A method of cold bending metallic pipe or tubing into an elbow fitting with tangential portions comprised of applying a force upon the trailing end of a straight blank of pipe or tubing while the leading end is inserted in the tangential portion of a cavity which is bent to conform in size and shape to the elbow fitting, and interposing a mandrel in the other tangential portion of said cavity having a removable end portion extending around the bend of the cavity, the applied force acting to move the blank through the cavity around the mandrel, the friction between the blank, mandrel and cavity being the sole restraining force to the movement of the blank through the cavity.

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U.S. Cl. X.R.

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