Oct. 5, 1965 B. A. HILLS 3,209,570

CONTROL DEVICE

Filed Sept. 28, 1962 2 Sheets-Sheet 1

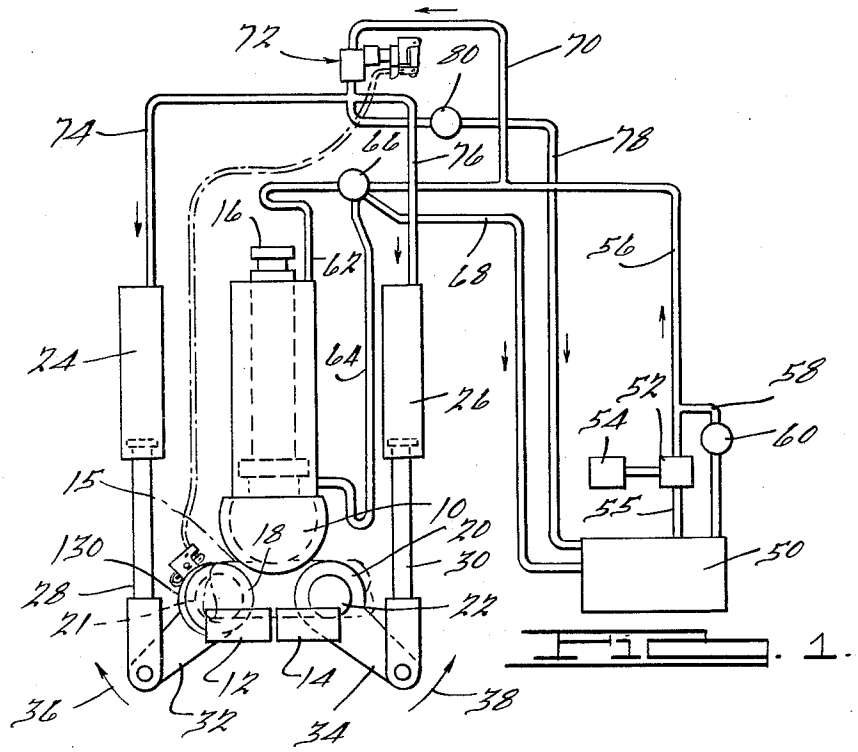


FIG. 1.

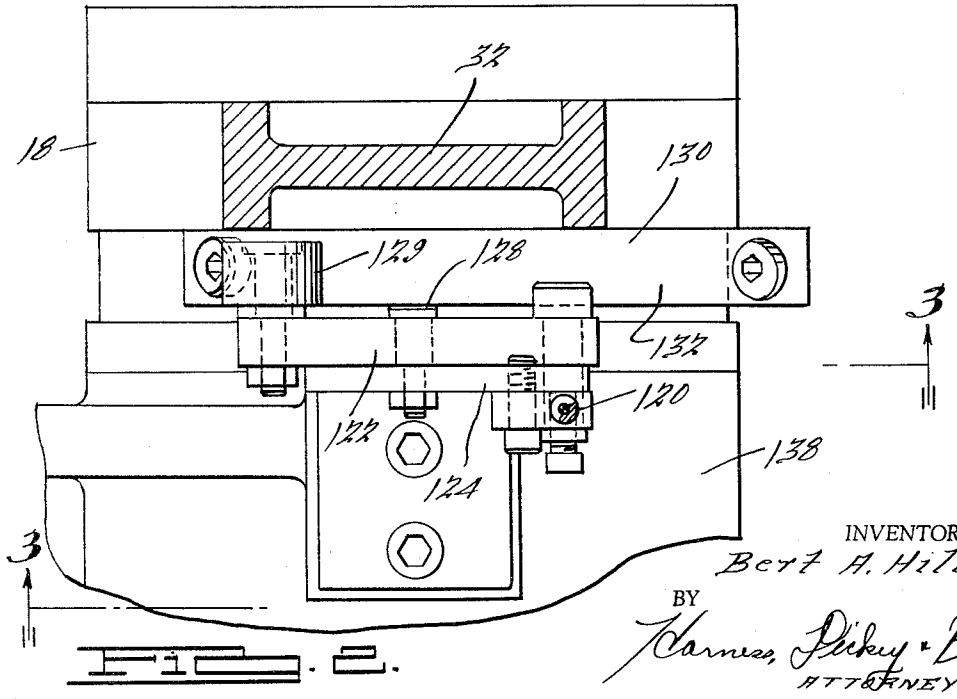


FIG. 2.

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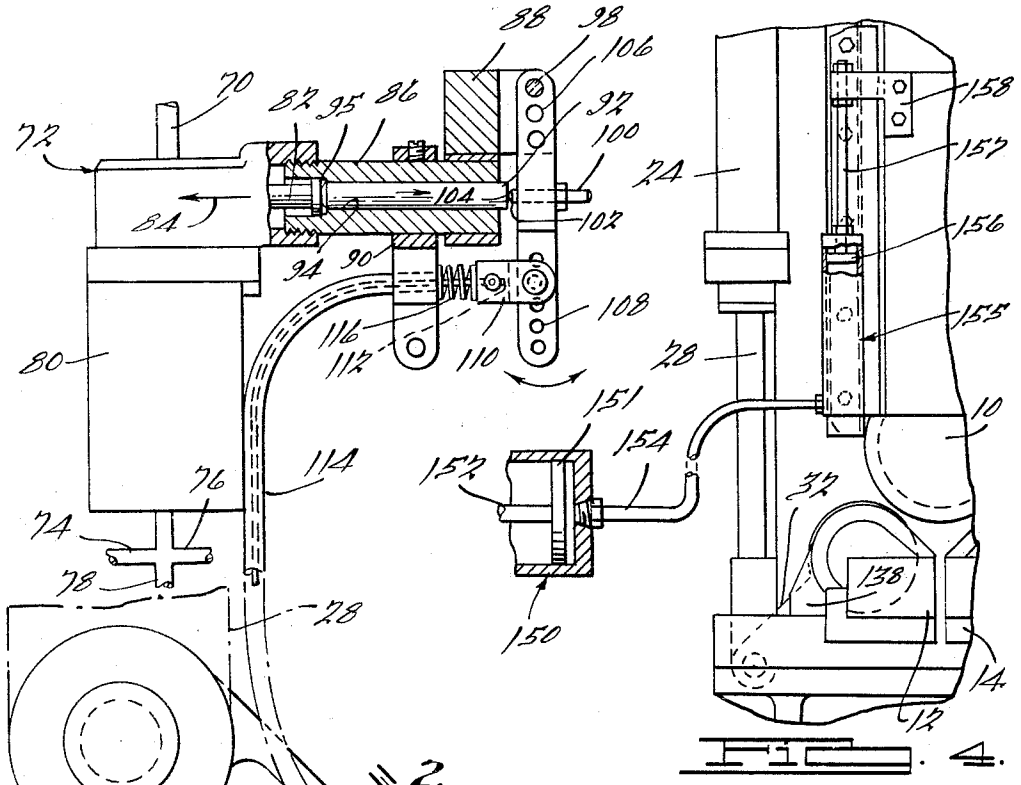


FIG. 4.

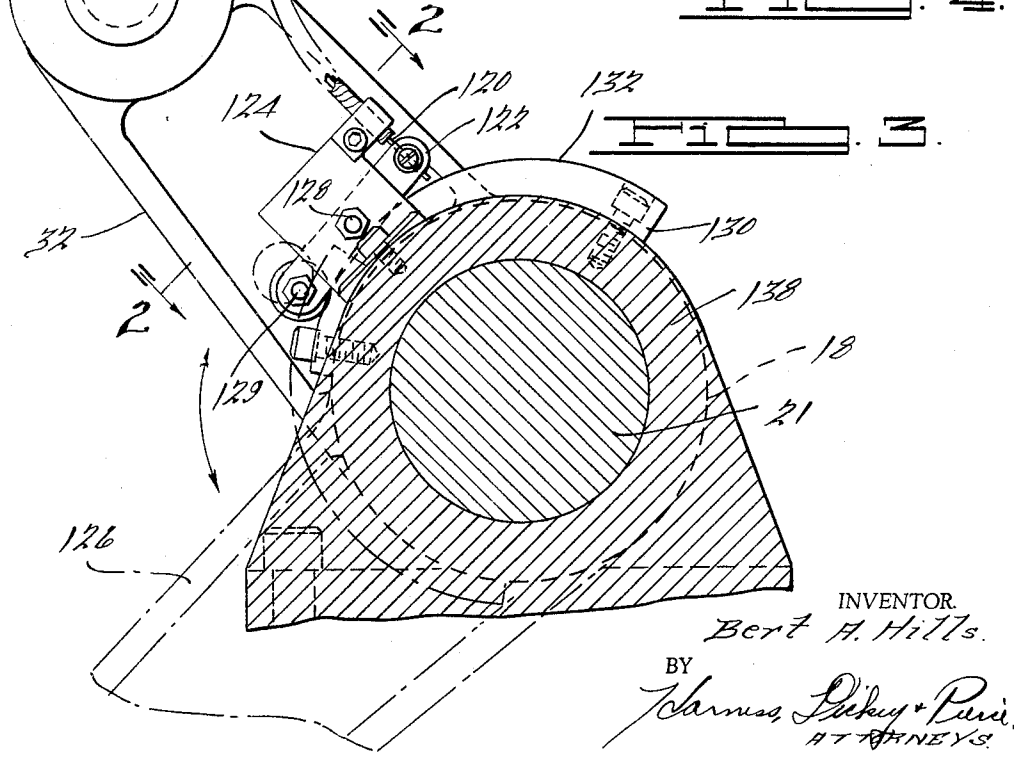


FIG. 3.

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CONTROL DEVICE

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9 Claims. (Cl. 72—21)

This invention relates to the art of bending tubes or pipes or the like and more particularly to tube bending apparatus and methods.

One type of tube bending apparatus with which the present invention is capable of being utilized comprises a reciprocably mounted bending die and associated pressure dies. Tubing to be bent is supported between the bending die and the pressure dies during a bending operation. The pressure dies are pivotally mounted for opposite swinging movement as bending pressures are exerted through the bending die. Back pressure means are associated with the pressure dies to exert back pressure through the tubing being bent. The back pressure means conventionally takes the form of fluid cylinders or the like which are connected to the pressure dies. Such apparatus is described in detail in U.S. Patent 2,887,141 issued to B. F. Bower et al., May 19, 1959, the disclosure of which is hereby incorporated herein by reference.

The primary object of the invention is to provide new and improved means of controlling back pressures during a bending operation to obtain new and improved bending results.

Another object of the invention is to provide a method of bending tubes wherein back pressures are closely controlled to attain maximum results.

The inventive principles are hereinafter disclosed in detail by reference to an illustrative embodiment of the invention as shown on the accompanying drawings wherein:

FIGURE 1 is a schematic illustration of a tube bending system incorporating the principles of the invention;

FIGURE 2 is a sectional view taken along the line 2—2 in FIGURE 3;

FIGURE 3 is an enlarged side elevational view, partly in section, of a portion of the apparatus shown in FIGURE 1; and

FIGURE 4 is a side elevational view of an alternative embodiment.

Referring now to FIG. 1, the bending system includes a bending die **10** and a pair of pressure dies **12, 14** which are adapted to cooperatively engage and support a piece of tube **15** for a bending operation. The bending die **10** is conventionally reciprocably mounted and actuable by a fluid pressure means **16**. The pressure dies **12, 14** are supported on rotatable sleeves **18, 20** which are adapted to rotate on shafts **21, 22** in opposite directions during downward movement of the pressure die **10** to obtain a wiping action of the pressure dies relative to the tube **15**. Backing pressures are applied to the pressure dies by fluid cylinders **24, 26** through connecting rods **28, 30** and fulcrum arms **32, 34** which are fixedly connected to the sleeves **18, 20**. In this manner, fluid under pressure in the cylinders **24, 26** can exert back pressures against rotative movement of the pressure dies in the directions of the arrows **36, 38**.

A fluid control system is associated with the bending mechanism and comprises a reservoir **50** and a pump **52** driven by a motor **54**. An outlet passage **55** connects the reservoir to the pump and a passage **56** is provided to convey fluid from the pump to the fluid pressure cylinders **16, 24, 26**. A bypass passage **58** having a conventional control valve **60** is provided to return fluid to the reservoir when predetermined pressures in the system are exceeded. The fluid is alternately delivered from the passage **56** to opposite sides of the cylinder **16** through passages **62, 64** by means of a 4-way valve **66**. A return passage **68** is provided to convey fluid back to the reservoir **50**. A passage **70** connects the passage **56** to the back pressure cylinders **24, 26** through a control valve **72** and passages **74, 76**. In the preferred arrangement, the valve **72** may take the form of any conventional adjustable pressure valve which is suitable for adaptation as hereinafter described. A bypass passage **78** is controlled by a relief valve **80** to return high pressure fluid to the reservoir.

Referring now to FIG. 3, the pressure control valve **72** includes an adjustable restriction or the like (not shown) which controls flow of fluid from inlet line **70** to outline lines **74, 76**. The adjustable restriction is mounted in a casing **81** and is adjustable by control means in the form of a slidably movable, normally outwardly biased, adjusting member **82**. Movement of the member **82** in the direction of the arrow **84** is adapted to vary the pressure controlling restriction in the valve and to vary the rate of flow of fluid through the valve from the passage **70**. Spring means or the like may be provided to normally bias the member **82** to the position shown in FIG. 3, which may, for example, be a position of maximum fluid flow through the valve to the cylinders **24, 26**.

In order to obtain maximum bending results, an automatic pressure adjusting means is provided to vary the back pressure exerted through the back pressure dies during the different phases of a particular bending operation. To this end, a sleeve **86** may be threadably mounted on the valve casing **80** in coaxial alignment with the member **82** and supporting a pair of brackets **88, 90**. An actuating rod extension **92** is slidably supported in a central bore **94** in the sleeve and protrudes outwardly beyond the outer end of the sleeve **86** at **95**. The inner end of the sleeve may be provided with an abutment **95** to receive the end of member **82**. A control lever is pivotally mounted at **98** on the bracket **88** and has a pin member **100** threadably mounted thereon for axial adjustment to variably position the end portion **102** which is adapted to engage the end of the extension rod **92** as indicated at **104**. The pivotally mounted support arm **96** may be provided with a plurality of adjustment holes **106, 108** to permit adjustable positioning of the pivot arm and thereby provide means of varying the length of movement of the end **106** of the pin **100** for a given amount of movement of the support arm about its pivot **98** and for varying the amount of movement of the pin end **106** for a given amount of pressure die movement as hereinafter described in detail.

A bracket **110** is fixed in one of the holes **108** and has one end **112** of a control means, such as a Bowden wire arrangement **114**, connected thereto. The bracket **90** is provided to support the Bowden wire and a cushion spring element **116** may be mounted between the bracket **90** and the bracket **110**. The other end **120** of the Bowden wire is fixedly secured to one end of a pivotally mounted lever arm **122** and is supported by a bracket member **124**. The lever arm **122** is centrally pivoted at **128** and carries a cam follower **129**, such as a roller element at the other end. A cam means, in the form of a cam block **130**, having an outer cam surface **132** is attached to the rotatable sleeve **18** and is movable therewith. The outer surface may be gradually tapered to obtain a predetermined amount of pivotal movement of the lever **122** for each degree of rotation of the pressure dies. The taper of the surface determines the amount of movement of the lever arm and the amount of adjustment of the valve **72**. The exact contour of

the cam surface will be determined by the degree of back pressure variation desired and the desired relationship of back pressure to angle of tube bend as determined by pressure die position. The relatively wide angular movement of the arm **32** between its extreme positions, shown in FIG. 3, is converted through the cam and cam follower to a relatively smaller but directly proportional movement of the control rod **82**. The sleeve **18** and arm **32** are shown to be pivotally mounted on the shaft **21** and supported in any suitable manner as by a bearing bracket **138**.

An alternative embodiment of the present invention is shown in FIGURE 4 wherein the member **82** of the valve **72** is adapted to be actuated by means of a fluid control system comprising spaced fluid motor means, one of which is actuated by movement of the bending apparatus to transmit a signal to the other resulting in corresponding movement. A slave cylinder **150** is provided with a piston **151** and a rod **152** which may be suitably connected to the pressure adjusting member **82** or to the extension rod **92**. The slave cylinder **150** is connected by a fluid passage **154** to a control cylinder **155** which may be mounted on a portion of the machine frame adjacent the bending die **10**. In the illustrative arrangement, the control cylinder piston **156** and rod **157** are adjustably connected to a movable portion of the bending apparatus comprising a bracket **158** fixed to the movable bending die **10**. Movement of the piston rod **157** and piston member **156** in the control cylinder imparts control signals to the slave cylinder through a closed fluid system. Movement of the bending die **10** is directly transmitted into corresponding linear movement of the piston rod **157** and compression of fluid in the cylinder **155** and the fluid system. Compression of the fluid is directly transmitted through the passage **154** to the slave cylinder **150** and results in a corresponding displacement of the piston **151** and the piston rod **152** resulting in variable positioning of the pressure control **82**.

In operation, a fluid such as oil or the like is drawn from the reservoir **50** by the pump **52** and delivered under pressure to the 4-way control valve **66** through the line **56**. The system may be set up to operate at a predetermined pressure by bleeding fluid through the bypass line **58** at a suitably adjusted position of the pressure relief valve **60**. The 4-way valve **66** is of conventional design and is operable to direct fluid to either the upper or lower ends of the bending die cylinder **16** through conduits **62, 64**. Downward actuation of the bending die **10** during a bending operation causes pivotal movement of the pressure dies **12, 14** against the back pressure cylinders. The passage means **70** provides a supply of fluid under pressure to the adjustable pressure control valve **72**. The amount of fluid passing through the pressure control valve **72** is dependent on the position of the pressure dies **12, 14** since the associated control means continuously adjust the valve **72** during and in direct response to movement of the pressure dies. Although only a wire control system and a fluid control system have been illustrated, other systems such as an electrical system may be equally well adaptable for use with the present invention.

I have found it desirable to provide a variable back pressure on the pressure dies during a bending operation and to vary the back pressure in accordance with the degree of rotation of the back pressure dies. In the disclosed systems, increases in the degree of bend imparted to the tubing as the bending proceeds results in variations in fluid pressure directed to the cylinders **24, 26** through the valve **72**. In this manner, the back pressure being applied to the back pressure dies **12, 14** can be maintained constant throughout a bending cycle, or can be varied throughout a bending cycle, or can be maintained constant through one portion of the bending cycle and varied throughout another portion of the bending cycle as desired.

The pressure exerted on the back pressure dies through the control arms **32, 34** and the piston rods **28, 30** is dependent on the pressure of the fluid delivered to the fluid cylinders **24, 26**. The pressure of the fluid delivered to the cylinders **24, 26** is dependent on the adjusted setting of the member **82** of the control valve **72**. In order to provide variable adjustment throughout all portions of rotation of the pressure dies, the movement of the pressure dies may be directly transmitted into corresponding movement of the member **82** of the valve. Consequently, pressure in the cylinders **24, 26** is simultaneously adjusted by varying the setting of the restriction in the pressure valve **72** as the pressure dies rotate.

The operation of the alternative embodiment shown in FIG. 4 is similar except that the pressure control valve is controlled by movement of the bending die through a hydraulic system. An electrical system might be equally well utilized. Movement of the bending die is used to obtain varying pressure valve settings by means of reciprocable movement of the piston rod **157** corresponding to movement of the bending die **10**. As the bending die **10** is moved downwardly, piston rod **157** is correspondingly moved downwardly within the cylinder **155** to exert forces through the fluid in the line **154** to the cylinder **150** which causes movement of the rod **152** directly proportional to the amount of bending die movement. The increase in pressure in the cylinder **150** results in displacement of the piston rod **152** and corresponding adjustment of the valve control rod **82** as hereinbefore described.

Since the subject invention is capable of alternative uses and may take various forms, it is intended that the appended claims be construed to include variations and changes in the illustrative designs except insofar as limited by the prior art.

What is claimed is:

1. The method of bending a tubular member comprising the steps of applying a bending pressure, applying back pressure in the area of bend, and simultaneously automatically varying the back pressure applied in the area of the bend during the bending operation in accordance with the degree of angularity of bend attained.

2. The method of bending pipe or the like, comprising the steps of applying a bending force to a bend area of the pipe, applying variable backing pressure forces in the area of bend, and automatically simultaneously varying the amount of backing pressure exerted in direct proportion to the amount of bending force applied.

3. A method of controlling a bending operation in a bending machine having a bending die and pivotally mounted pressure dies comprising the steps of applying pressure to a length of tube through said bending die, applying a corresponding backup pressure to said length of tube through said pressure dies, and automatically varying the pressure exerted through said pressure dies in direct proportion to movement of the pressure dies during the bending operation.

4. Apparatus for bending a tube or the like comprising bending die means, back pressure die means, means for actuating said bending die means to form a bend in a length of tube, back pressure means to exert variable back pressure on the length of tube in the area of bend, and automatic back pressure control means effective during a bending operation to simultaneously control the amount of pressure exerted in the area of bend on the length of tube in accordance with the position of the bending apparatus.

5. The apparatus as defined in claim **4** and wherein said back pressure control means comprises a fluid pressure system, cylinder means connected to said back pressure die means, a control valve to control the pressure of fluid in said cylinder means, and control means connecting said valve means and a movable portion of said die means to actuate said valve means in accordance with

the angular position of said die means during a bending operation.

6. The apparatus as defined in claim 5, and wherein said control means comprises a mechanical means connected at one end to said control valve and connected at the other end to a movable part of said die means.

7. The apparatus as defined in claim 6 and wherein said mechanical means comprises a wire means, one end of said wire means being connected to a pivotally supported arm, said pivotally supported arm having an adjustable pin mounted thereon, a control rod connected to said valve means, and said pin being located for engagement with said control rod to cause movement thereof in response to movement of said wire means.

8. The apparatus as defined in claim 7 and wherein the other end of said wire means is connected to a pivotally mounted lever, cam follower means provided on said lever, a cam member mounted on a portion of said die means and being movable therewith, said cam follower being engageably supported on said cam member and adapted to impart pivotal movement to said lever during movement of said die means and causing corresponding movement of said pivotally supported arm on said valve means through said wire means.

9. In tube bending apparatus for bending tubes or the

like, a movable bending die means, movable back pressure die means, cylinder means connected to said back pressure means to provide backing pressure therefor, a fluid pressure system to deliver fluid to said cylinders, a valve means controlling the delivery of fluid to said cylinders, a valve control means connected to said valve means to control the rate of flow of fluid therethrough, operating means connected to said valve control means, first fluid cylinder means connected to said operating means, second fluid cylinder means mounted on said bending apparatus, means controllably connecting said first fluid cylinder means to said second fluid cylinder means, and means connecting said bending die and said second fluid cylinder means to cause actuation thereof in response to movements of said bending die so that movement of said bending die causes corresponding movement of said valve control means by variations in pressure in said cylinder means.

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