June 14, 1960 B. F. RAYNES 2,940,499

CAM CONTROLLED METAL FORMING MACHINE

Original Filed Feb. 15, 1954 2 Sheets-Sheet 1

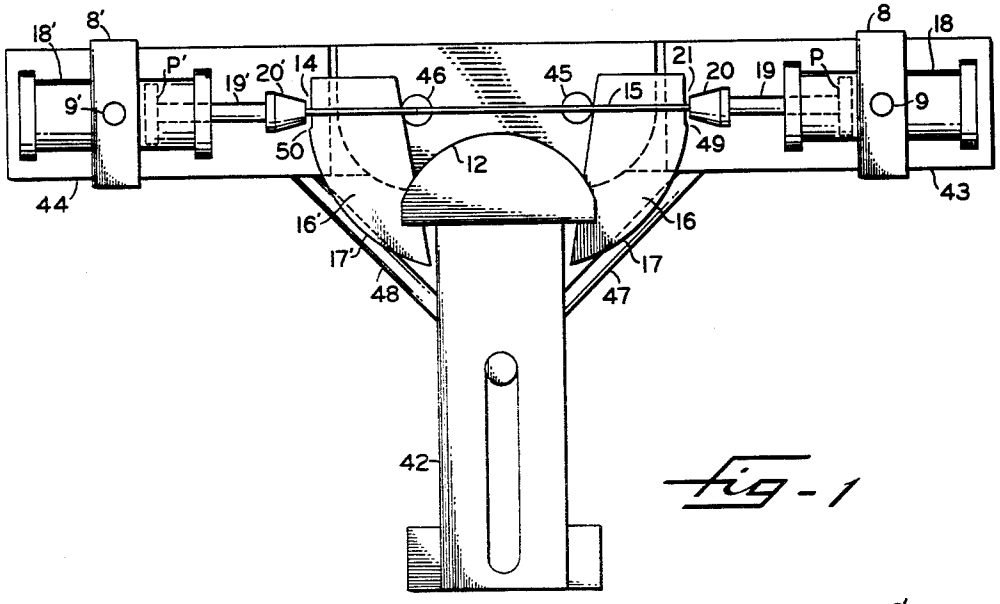


fig - 1

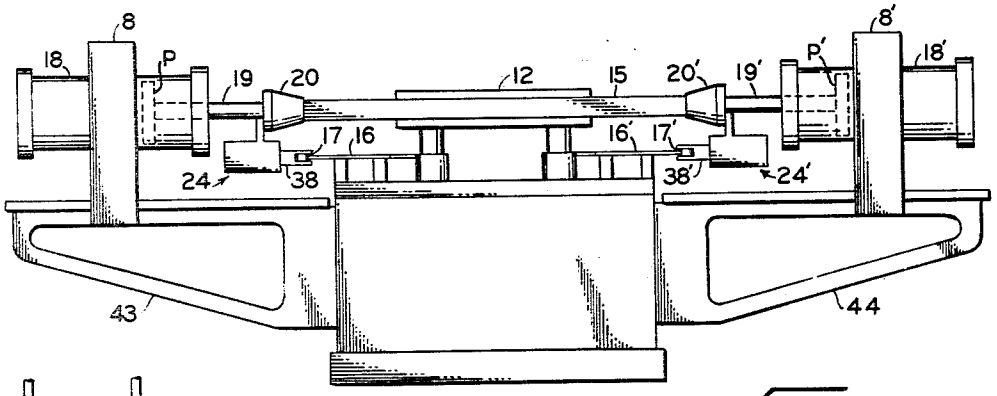


fig - 2

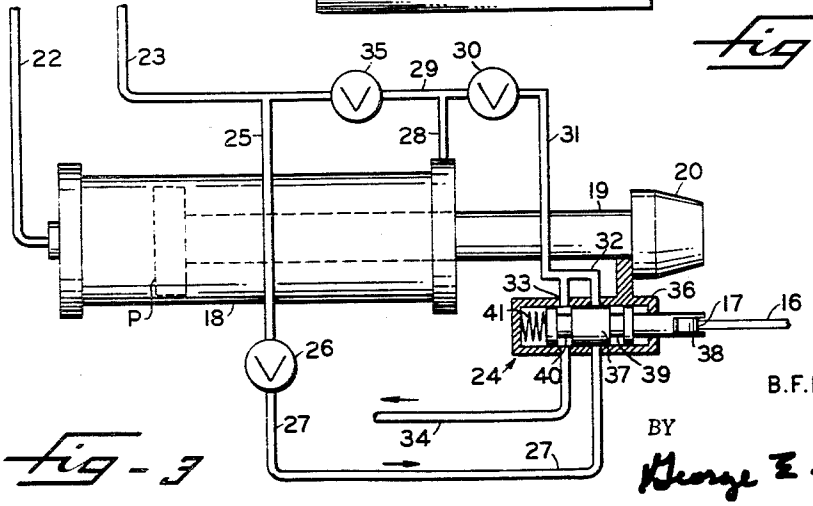


fig - 3

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CAM CONTROLLED METAL FORMING MACHINE

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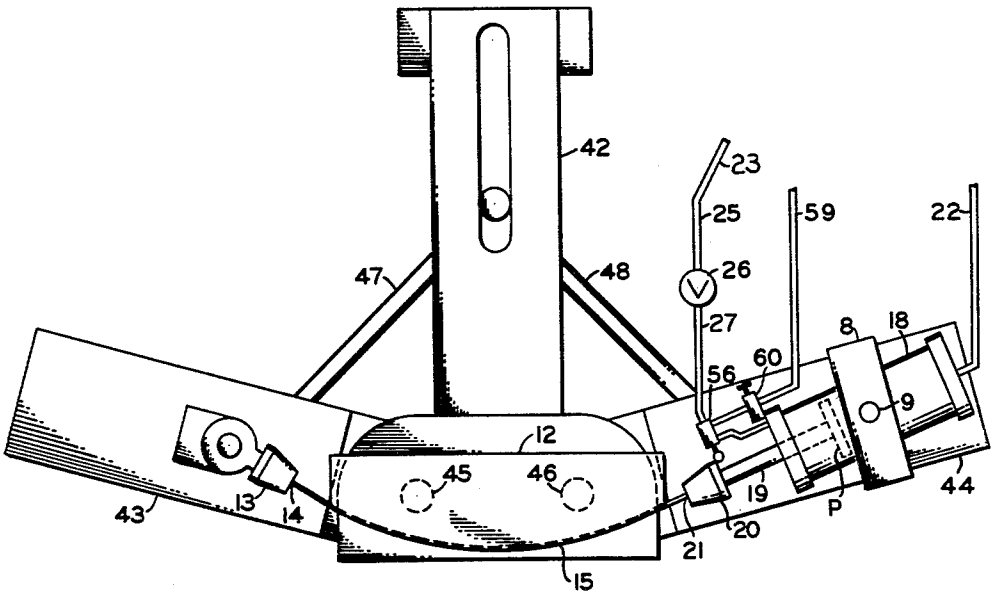


fig - 4

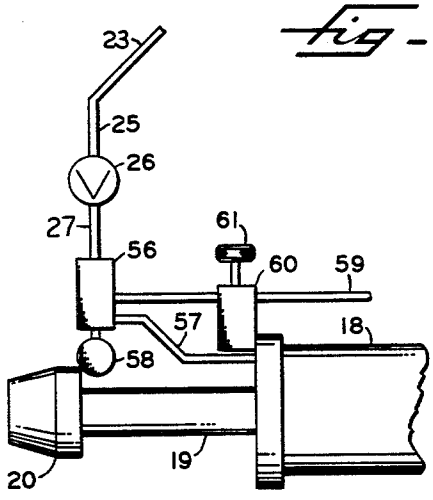


fig - 5

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CAM CONTROLLED METAL FORMING MACHINE

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Original application Feb. 15, 1954, Ser. No. 410,229. Divided and this application July 3, 1959, Ser. No. 824,855

9 Claims. (Cl. 153—32)

This invention relates to a means for accurately controlling the amount of stress applied to a workpiece while it is being formed in a metal forming machine of the type wherein the workpiece is first stressed a predetermined amount and then formed while under tension by being wrapped along the face of a forming die.

This application is a division of my application for Cam Controlled Stretch Former, Serial No. 410,229, filed February 15, 1954, now Patent No. 2,893,460.

When forming metal on a machine of the aforementioned type, it has been customary to test a sample of the material to be formed to determine the amount of tension which must be applied to the workpiece to stress it to its elastic limit. The necessary amount of tension, as determined from this test, is applied to the workpiece which is then wrapped along the face of a forming die to form it to a desired shape. In actual production practice, however, it has been found that the amount of tension required to stress a given number of workpieces of the same size and material to their elastic limits, may vary greatly. For instance, it has been found that one piece may require the application of a 40,000 pound force to stress it to its elastic limit while another piece may require as much as 60,000 pounds force to stress it to its elastic limit. In order to produce satisfactorily formed parts in a situation such as this, it would be necessary to test each workpiece to determine what tension must be applied to stress it to its elastic limit, a procedure obviously prohibitive from a cost and manufacturing standpoint. If, as an alternative, an average force is taken as a norm, as for example 50,000 pounds, it will result in some of the workpieces being greatly overstressed and others understressed, resulting in a complete lack of uniformity in the finished parts and rendering many of them useless. Also, since in many instances the yield strength and the ultimate strength of a workpiece are relatively close values, it follows that any appreciable amount of over stressing of a workpiece will result in failure of the material and ruining the workpiece.

While the amount of tension required to stress each of a number of workpieces of the same size and material to their elastic limits may vary greatly, it has been found that the elongation of each workpiece when stressed to its elastic limit, is very nearly the same. It therefore follows that by determining the amount of elongation required to stretch a hard workpiece to its elastic limit, all other workpieces of similar size and material whether in high or low tensile range of hardness may be stretched to their elastic limit by a substantially like amount of elongation despite the variation in the amount of force required by each workpiece.

It is, therefore, the primary object of my invention to provide a control means for use on a machine of the aforementioned type, to regulate the elongation of a workpiece to an amount sufficient to stress it a desired amount and to maintain a proportional amount of elongation in proportion to the length of the unformed portion of the workpiece throughout the forming operation.

A further object is to provide a control means as beforementioned which is adaptable for use on all types of forming machines in which tensile stress is applied to a workpiece while it is being formed.

A further object is to provide a control means as above described which is simple and inexpensive to manufacture and which may be quickly and easily installed on a forming machine.

These and other objects and advantages will become apparent as the description of the invention proceeds.

My invention consists primarily of a cam control which is designed to operate in conjunction with the forming die to regulate the amount of tension applied to the workpiece by the tensioning device, prior to and during the forming operation, to permit the workpiece to be elongated a distance sufficient to stress it the desired amount at all times. The shape and size of the cam is governed by the shape of the forming die with which it is used and the size and material of the workpiece to be formed.

For a better understanding of the invention, attention is directed to the accompanying drawing illustrating several preferred embodiments of the invention and in which:

Figure 1 is a top view of a forming machine employing two hydraulic tensioning devices which pivot about a stationary forming die, each of the tensioning devices being controlled by a cam mounted in a stationary position adjacent the die;

Figure 2 is a front view of the machine of Figure 1;

Figure 3 is a schematic view partly in section of a portion of the machine of Figure 1 showing its hydraulic system controlled by a cam;

Figure 4 is a top view of a forming machine wherein one end of the workpiece is held in a stationary chuck while the workpiece is drawn along the face of a stationary forming die by a tensioning device equipped with a control valve which regulates the elongation of the workpiece;

Figure 5 is a view, partly diagrammatic, illustrating the attachment of the tensioning device control valve.

With reference to Figures 1 and 2 of the drawing, the machine consists of a main body member 42 having a pair of carrier arms 43 and 44 pivotally attached thereto at pivots 45 and 46. A pair of draw bars 47 and 48 extending from arms 43 and 44 respectively are connected to a suitable power source (not shown) and provide means for swinging arms 43 and 44 about pivot points 45 and 46 toward body 42. Forming die 12 is mounted in a stationary position at the end of body 42 between and above arms 43 and 44.

A hydraulic cylinder 18 having the rod end thereof directed toward die 12 is attached to a vertical shaft 9 pivotally supported in a frame 8 attached to carrier arm 43 and contains a piston P. The piston is connected to the end of a piston rod 19 which has a chuck 20 attached to the other end thereof and adapted to grasp one end 21 of workpiece 15, and serves as a means for applying tension to workpiece 15. Oil or other fluid under pressure is supplied to the head end of cylinder 18 through a conduit 22 (Fig. 3) connected to a suitable supply tank (not shown). Fluid under pressure is supplied to the rod end of cylinder 18 by a supply pipe 23 connected to the supply source through a control valve 24 attached to chuck 20. Fluid connection is established between pipe 23 and valve 24 through pipe 25, valve 26 and pipe 27 opening into the lower side of valve 24. Fluid connection between the rod end of cylinder 18 and valve 24 is established through pipes 28 and 29, valve 30, pipe 31 and branch pipes 32 and 33 which open into the upper side

of valve 24. A fluid return pipe 34 extending from the lower side of valve 24 conveys fluid from cylinder 18 and valve 24 back to the fluid supply tank. Fluid connection between pipe 23 and the rod end of cylinder 18 may also be made through a valve 35, pipe 29 and pipe 28. A second hydraulic cylinder 18^1, identical to cylinder 18 and similarly mounted and similarly controlled as by a valve 24^1, is pivotally supported as at 9^1 in a frame 8^1 mounted on carrier arm 44 with the rod end of the cylinder directed toward die 12. Cylinder 18^1 has a piston P^1, a piston rod 19^1 and chuck 20^1 adapted to grasp the other end 14 of workpiece 15.

A cam 16 is mounted on main body member 42 adjacent the side of die 12 in a stationary position with the cam face 17 facing toward cylinder 18. A second cam 16^1 is secured in a similar manner on the opposite side of die 12 with its face 17^1 facing toward cylinder 18^1. Cam faces 17 and 17^1 are both provided with a rising contour at points 49 and 50 respectively for a purpose to be later explained.

Valves 24 and 24^1 which control the fluid in the rod end of cylinders 18 and 18^1 respectively in a manner to be later explained, are each (the primes here being omitted for the sake of brevity) comprised of a cylindrical body 36 which slidably contains a piston 37 connected to a cam follower 38. Piston 37 is provided with two fluid passing grooves 39 and 40 which are adapted, upon movement of piston 37, to connect the openings of pipes 27 and 32 and the openings of pipes 33 and 34 respectively. Grooves 39 and 40 are so spaced apart that both cannot be connected with the pipe openings simultaneously. Piston 37 is normally held in a position as shown in Figure 3 in which groove 40 connects the opening of pipe 33 with the opening of pipe 34, under the bias of a spring 41 contained in the end of valve body 36.

To operate the machine, valves 35 and 35^1 are closed, valves 30 and 30^1 opened, and fluid under pressure is directed from pipes 22 and 22^1 to the head ends of cylinders 18 and 18^1 moving pistons P and P^1 toward the rod ends of the cylinders and advancing piston rods 19 and 19^1 and chucks 20 and 20^1 toward each other until cam followers 38 and 38^1 engage cam faces 17 and 17^1 as shown in Figure 2, fluid being exhausted via grooves 40 and 40^1 of valves 24 and 24^1 and pipes 34 and 34^1. The size of cams 16 and 16^1 is such that the distance between chucks 20 and 20^1 when in this position permit ends 21 and 14 of workpiece 15 to be gripped by chucks 20 and 20^1 respectively. Valves 26 and 26^1 are then opened and fluid under pressure is directed from pipe 23 to control valves 24 and 24^1 through pipes 25 and 25^1, valves 26 and 26^1 and pipes 27 and 27^1. Power is then applied to draw bars 47 and 48 to swing arms 43 and 44 about pivots 45 and 46 toward body 42 to wrap workpiece 15 along the curved face of die 12. As the arms move, cam followers 38 and 38^1 pass along cam faces 17 and 17^1. In so doing they encounter the rise in the contours of faces 17 and 17^1 at points 49 and 50 just before workpiece 15 comes into contact with the face of the die 12. The rise in the contours forces cam followers 38 and 38^1 and pistons 37 and 37^1 outwardly a distance sufficient to cause grooves 39 and 39^1 to come into alignment with the openings of pipes 27 and 32 and 27^1 and 32^1. This permits fluid under pressure to pass through grooves 39 and 39^1 from pipes 27 and 27^1 into pipes 32 and 32^1, 31 and 31^1, through valves 30 and 30^1 and pipes 28 and 28^1 into the rod ends of cylinders 18 and 18^1 thereby moving pistons P and P^1 toward the head ends of cylinders 18 and 18^1. As pistons P and P^1 move, they cause chucks 20 and 20^1 to move away from each other and apply tension to workpiece 15, the control valves 24 and 24^1 also moving away from cam faces 17 and 17^1. This permits cam followers 38 and 38^1 to move inwardly under the bias of springs 41, thus moving grooves 39 and 39^1 out of alignment with the openings of pipes 27 and 32 and pipes 27^1 and 32^1 and stopping the admission of fluid under pressure to the rod ends of cylinders 18 and 18^1. The rising contours of cam faces 17 and 17^1 are such that they regulate valves 24 and 24^1 to admit the proper amount of fluid under pressure to cylinders 18 and 18^1 to cause pistons P and P^1 to apply sufficient tension to workpiece 15 to elongate it the desired amount. As arms 43 and 44 continue to move toward body 42, workpiece 15 engages and is wrapped along the face of die 12 to form it to the desired shape.

To prevent an increase in tension and consequent overstressing of workpiece 15 as it is wrapped around die 12 by the rotation of arms 43 and 44, it is necessary to permit pistons P and P^1, piston rods 19 and 19^1, and chucks 20 and 20^1 to move inwardly toward die 12 during the forming operation. To accomplish this the contour of each of cam faces 17 and 17^1 is such that as cam followers 38 and 38^1 pass along cams 16 and 16^1, this permits cam followers 38 and 38^1 and pistons 37 and 37^1 to move outwardly, to the right, under the bias of springs 41 and 41^1. This movement of pistons 37 and 37^1 brings grooves 40 and 40^1, or a portion thereof, into alignment with the openings of pipes 33 and 33^1 and 34 and 34^1 allowing fluid to bleed off from the rod end of cylinders 18 and 18^1 through pipes 28 and 28^1, valves 30 and 30^1, pipes 31 and 31^1, branch pipes 33 and 33^1, grooves 40 and 40^1, and pipes 34 and 34^1, permitting pistons P and P^1 to be drawn toward the rod end of cylinders 18 and 18^1. The positions of pistons 37 and 37^1 are so controlled by the contour of cam faces 17 and 17^1 that the rate at which fluid passes through grooves 40 and 40^1 is such that pistons P and P^1 are constantly in positions in relation to workpiece 15, such that workpiece 15 is continually elongated by an amount which is in direct proportion to its unformed length, throughout the forming operation.

Referring to Figures 4 and 5, the forming machine illustrated is similar in construction to that previously described and illustrated in Figures 1 and 2. It consists of a main body member 42 having a pair of carriers arms 43 and 44 pivotally attached to one end thereof to pivots 45 and 46. A pair of draw bars 47 and 48 extending from arms 43 and 44 respectively, are connected to a suitable power source (not shown) to provide means for moving arms 43 and 44 about pivot points 45 and 46 toward body 42. Forming die 12 is mounted on the end of body 42 in a stationary position between and above arms 43 and 44. A chuck 13 adapted to grip the end 14 of workpiece 15 is pivotally mounted on arm 44. A hydraulic cylinder 18 is pivotally mounted as at 9 in a frame 8 mounted on arm 43 and contains a piston P connected to a piston rod 19 to one end of which is attached a chuck 20 adapted to grip the end 21 of workpiece 15. Fluid under pressure is supplied to the head end of cylinder 18 through a pipe 22 connected to a suitable fluid supply source (not shown) and to the rod end of cylinder 18 through a pipe 23 and a control valve 56. Fluid connection is established between pipe 23 and valve 56 through pipe 25, valve 26 and pipe 27 and between valve 56 and the rod end of cylinder 18 through pipe 57. Valve 56 is of a known type which is normally opened and closed by pressure against a control lever 58. Valve 56 is adjustably supported on the end of cylinder 18 by a rod 59 slidably mounted in an opening in a bracket 60 which is secured to cylinder 18 and a lock screw 61 serves to engage rod 59 to lock it in adjusted position.

To operate this machine, fluid under pressure is directed by pipe 22 to the head end of cylinder 18 to move piston P to the rod end of the cylinder and move chuck 20 sufficiently near chuck 13 so that ends 14 and 21 of workpiece 15 may be gripped by chuck 13 and 20 respectively. Arms 43 and 44 are then simultaneously moved about pivot points 45 and 46 toward body 42 to positions which permit full contact between workpiece 15 and the face of die 12 as shown in Figure 8. Fluid under pressure is then directed to the rod end of cylinder 18 from

pipe 23 through 25, valve 26, control valve 56 and pipe 57 causing piston P to move toward the head end of cylinder 18 and retract rod 19 and chuck 20 to apply tension to workpiece 15 and stretch it. Valve 56 is set in an adjusted position so that when workpiece 15 has been elongated sufficiently to provide the proper amount of stress to force it to conform to the shape of die 12, chuck 20 will come in contact with control lever 58 and move it, thus closing valve 56 which stops the passage of fluid into cylinder 18. The movement of piston P is thus arrested when the workpiece has been elongated the proper amount.

In each form of the invention, the length of workpiece between the chucks gripping its ends, before stretching, is kept the same for all workpieces to be bent to the same shape.

The fluid used in the hydraulic systems of the above described machines is preferably a liquid such as oil and the pipes conveying the liquid to moving parts of the machines are composed of flexible material.

This invention may be embodied in other forms or carried out in other ways without departing from the spirit or essential characteristics thereof. The present embodiment of the invention is therefore to be considered as in all respects illustrative and not restrictive, the scope of the invention being indicated by the appended claims, and all changes which come within the meaning and range of equivalency of the claims are intended to be embraced therein.

Having thus described my invention, what I claim as new and useful and desire to secure by Letters Patent is:

1. A forming machine adapted to form a long workpiece to a desired curvature comprising, in combination: a main body member; a pair of carrier arms pivotally attached to said member at laterally spaced points thereon and normally extended to opposite sides of said member; means connected to one of said arms for gripping one end of said workpiece; workpiece tensioning means comprising a jaw gripping the other end of said workpiece, a fluid containing cylinder connected to the other of said arms, a piston slidable in said cylinder and connected to said jaw, and an outlet including a movable valve for releasing fluid from the rod end of said cylinder; a curved die mounted on said body member in the vicinity of said spaced points and behind the unformed workpiece; means including a pair of drawbars linked respectively to said arms for rotating the arms and drawing the same toward the sides of said member thereby to wrap said workpiece about the face of said die; and means including a curved cam mounted on said body member and constructed and arranged to control said movable valve to release fluid through said outlet at a desired rate as said arms are rotated.

2. A forming machine as in claim 1, said unformed workpiece being spaced from said die initially and said valve having means engageable by said cam as the workpiece moves to engage the face of said die for admitting fluid under pressure to the rod end of said piston in said cylinder to tension the workpiece before the same is wrapped about said face of the die.

3. A forming machine as in claim 1, said workpiece gripping means being constructed as a duplicate of said workpiece tension means and mounted on said one of the arms in the same manner as said workpiece tensioning means is mounted on said other of the arms; and a second means including a second curved cam mounted on said body member and constructed and arranged to control the movable valve of said duplicate tensioning means to release fluid through the outlet thereof as said arms are rotated.

4. A forming machine as in claim 3, said unformed workpiece being spaced from said die initially, said valves having spring urged movable control means for following the cam faces of their respective cams and for admitting or selectively releasing fluid under pressure on the rod end of the piston individual thereto in accordance with the moved position of said cam-spring urged control means, said cam faces having riser portions engageable by their respective follower means as the workpiece moves to engage the face of the die to admit said fluid pressure to tension the unformed workpiece, and said cam faces having following portions curved to control said release of the fluid pressure during wrapping of the workpiece about said die face as the arms are rotated to the sides of said body member.

5. A forming machine adapted to conform a long workpiece to a desired curvature comprising, in combination, a main body member having a pair of arms, a die having a face conforming to said curvature and mounted on said body member, means including a pair of jaws respectively gripped to the ends of the workpiece and spaced from said die for holding the unformed workpiece initially away from the die, a cylinder pivotally attached to one of said arms, a piston connected to one of said jaws and slidable in said cylinder, means connected to the other of said jaws for pivotally attaching the same to the other of said arms, means supporting said arms for rotation on said body member sufficient to bring the workpiece into contact with the die and to wrap the workpiece along said face of the die, and workpiece tensioning means including said piston and cylinder and a cam and follower therefor carried respectively by said die and said one of the jaws for resisting movement of said piston toward the die as said one of the jaws and the portion of the workpiece gripped thereby are drawn toward the die in response to movement of the workpiece into contact with the die and subsequent wrapping thereabout, said cam having a curved face and said follower being constrained by said tensioning means to contact and follow along said face of the cam as the workpiece is brought into contact with and wrapped along said face of the die, said cam face being shaped to control initial stretching of said workpiece by said tensioning means prior to contacting of the workpiece with the die, said cam face being further shaped to control continual elongation of the workpiece by said tensioning means in proportion to the length of the unwrapped portion of the workpiece as the workpiece is wrapped along the face of the die, said tensioning means including a valve carried by said one of the jaws and having a spring biased plunger movable under control of said follower to a first position for preventing release of fluid under pressure by said piston in said cylinder and to a second position for releasing said fluid from the cylinder to permit movement of the piston toward the die.

6. A forming machine adapted to conform a long workpiece to a desired curvature comprising, in combination, a main body member having a pair of swinging arms, a die having a face conforming to said curvature and supported on said body member, means including a pair of jaws respectively gripped to the ends of the workpiece and spaced from said die for holding the unformed workpiece initially away from the die, a cylinder, means for supporting said cylinder on one of said arms for rotation about a transverse axis parallel to the axis of swinging of said arms, a piston connected to one of said jaws and slidable in said cylinder, means securing the other of said jaws to the other of said arms, means for swinging said arms on said body member to bring the workpiece into contact with the die and wrap the workpiece along the face of the die, and workpiece tensioning means including said piston and cylinder and a cam and follower therefor carried respectively by said body member and said one of the jaws for resisting movement of said piston toward the die as said one of the jaws and the portion of the workpiece gripped thereby are drawn toward the die in response to movement of the workpiece into contact with the die and subsequent wrapping thereabout, said cam having a curved face and said follower being constrained by said tensioning means to contact and follow along said face of the cam as the workpiece is

brought into contact with and wrapped along said face of the die, said cam face being shaped to control initial stretching of said workpiece by said tensioning means prior to contacting of the workpiece with the die, said cam face being further shaped to control continual elongation of the workpiece by said tensioning means in proportion to the length of the unwrapped portion of the workpiece as the workpiece is wrapped along the face of the die, said tensioning means including a valve carried by said one of the jaws and having a spring biased plunger movable under control of said follower to a first position for preventing release of fluid under pressure by said piston in said cylinder and to a second position for releasing said fluid from the cylinder to permit movement of the piston toward the die.

7. A forming machine adapted to conform a long workpiece to a desired curvature comprising, in combination, a main body member having a pair of swinging arms, a die having a face conforming to said curvature and supported on said main body member, means including a pair of jaws respectively gripped to the ends of the workpiece and spaced from said die for holding the unformed workpiece initially away from the die, a cylinder, means for supporting said cylinder on one of said arms for rotation about a transverse axis parallel to the swinging axis of said arms, a piston connected to one of said jaws and slidable in said cylinder, means securing the other of said jaws to the other of said arms, means for swinging the arms to bring the workpiece into contact with the die and wrap the workpiece along said face of the die, and workpiece tensioning means including said piston and cylinder and a cam and follower therefor carried respectively by said body member and said one of the jaws for resisting movement of said piston toward the die as said one of the jaws and the portion of the workpiece gripped thereby are drawn toward the die in response to movement of the workpiece into contact with the die and subsequent wrapping thereabout, said cam having a curved face and said follower being constrained by said tensioning means to contact and follow along said face of the cam as the workpiece is brought into contact with and wrapped along said face of the die, said cam face being shaped to control initial stretching of said workpiece by said tensioning means prior to contacting of the workpiece with the die, said cam face being further shaped to control continual elongation of the workpiece by said tensioning means in proportion to the length of the unwrapped portion of the workpiece as the workpiece is wrapped along the face of the die.

8. A forming machine adapted to form a long workpiece to a desired curvature comprising, in combination, a main body member; a pair of carrier arms pivotally attached to said member at laterally spaced points thereon and normally extended to opposite sides of said member; means connected to one of said arms for gripping one end of said workpiece; a jaw gripping the other end of the workpiece; a fluid containing cylinder connected to the other of said arms; a piston slidable in said cylinder and connected to said jaw; means including a movable valve for controlling fluid pressure on said piston in said cylinder to thereby tension said workpiece; a curved die mounted on said member in the vicinity of said pivot points and behind the unformed workpiece; means including a pair of drawbars linked respectively to said arms for rotating the arms and drawing the same toward the sides of said member thereby to wrap said workpiece about the face of the die; means including a cam constructed and arranged to control said movable valve in response to predetermined tensioning of the workpiece as the same is engaged with and wrapped about the face of the die, said jaw having a surface which serves as said cam, said valve being mounted on said cylinder and having a control member engageable by said cam surface to close said valve in response to said predetermined tensioning of the workpiece, and means for adjustably supporting and positioning said valve in the path of movement of said jaw thereby to adjust said predetermined tensioning of the workpiece.

9. A forming machine adapted to form a long workpiece to a desired curvature comprising, in combination, a main body member; a pair of carrier arms pivotally attached to said member at laterally spaced points thereon and normally extended to opposite sides of said member; means connected to one of said arms for gripping one end of said workpiece; a jaw gripping the other end of the workpiece; a fluid containing cylinder connected to the other of said arms; a piston slidable in said cylinder and connected to said jaw; means including a movable valve for controlling fluid pressure on said piston in said cylinder to thereby tension said workpiece; a curved die mounted on said member in the vicinity of said pivot points and behind the unformed workpiece; means including a pair of drawbars linked respectively to said arms for rotating the arms and drawing the same toward the sides of said member thereby to wrap said workpiece about the face of the die; and means including a cam constructed and arranged to control said movable valve in response to predetermined tensioning of the workpiece as the same is engaged with and wrapped about the face of the die, said jaw having a surface which serves as said cam, said valve being mounted on said cylinder and having a control member engageable by said cam surface to close said valve in response to said predetermined tensioning of the workpiece, said valve control member being constructed to open said valve in response to a decrease in the tension of the workpiece as the same is wrapped about the face of the die.

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