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METHOD AND APPARATUS FOR FORMING PRESSES

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The present invention relates to forming presses of the flexible diaphragm type and to a method of operation thereof and more particularly the invention relates to a press having a forming cycle, including a high energy pressure impulse to reproduce in a workplace fine detail such as embossed designs on the forming die.

It is an object of this invention to provide a flexible diaphragm forming press capable of reproducing finer detail in a workplace than has been possible heretofore.

It is a further object of this invention to provide a method and apparatus for producing a deep draw with exceptional reproduction of the detail of the drawing die.

It is also an object of this invention to provide a method of operation of a flexible diaphragm forming press for reproducing the fine detail of a die.

Yet another object of this invention is to provide a high pressure impulse producing mechanism in a forming press of the flexible diaphragm type.

Other objects and advantages of the present invention should be readily apparent by reference to the following specification, considered in conjunction with the accompanying drawings forming a part thereof, and it is to be understood that any modifications may be made to the exact structural details there shown and described, within the scope of the appended claims, without departing from or exceeding the spirit of the invention.

In its preferred form the press of this invention incorporates a sudden high energy release device in the fluid chamber which backs up the flexible diaphragm. The press is operated through a cycle which includes moving the diaphragm into contact with a work blank, pressurizing the fluid backing up the diaphragm, pushing a die into the work blank and diaphragm, and finally very quickly raising the pressure of the fluid to a level several times the normal forming pressure for a very brief instant when the die has reached its full depth in the work blank. The sudden release of energy which produces the practically instantaneous fluid pressure wave in the preferred embodiment is an arc discharge device having its electrodes immersed in the fluid in proximity to the diaphragm and work blank at the end of the drawing stroke of the die.

A clear understanding of the construction and operation of the invention can be obtained from the following detailed description in which reference is made to the attached drawings wherein:

FIG. 1 is a partial section view of a diaphragm forming press and includes a schematic showing of the hydraulic operating circuit.

FIG. 2 is a simplified showing of the electrical portion of the press of FIG. 1 which operates to produce a pressure increase of brief duration in the machine by producing a pressure wave that is propagated through the fluid filled cavity therein.

The machine shown in FIG. 1 is comprised of a base member 10 from which columns 12, 14 extend to support a beam 16 across their top. A bolster block 18 is fixedly supported on the base 10 and a draw ring 20 is attached to the top thereof. The base 10 has a cylinder 22 in which a piston 24 is slidable received therein comprise motors to effect movement of the ram 20. Each of the pistons 36, 38 has a rigid piston rod 40, 42, respectively, extending therefrom to the beam 16 where they are securely attached. Since the rods 40, 42 are attached to the beam 16, the selected irrigation of fluid under pressure to the cylinders 32, 34 above or below the pistons 36, 38 will effect movement of the ram 20. The ram 30 has a cavity 44 therein which is closed by a flexible rubber diaphragm 46 retained therein by a ring 47 and the cavity 44 is normally filled with hydraulic fluid.

In operation of the machine to form a workpiece 48 in accordance with the shape of the die 28, the workpiece 48 is laid on top of the draw ring 20 over the opening 50 therein through which the die 28 and stake 26 move. The stake 26 is retracted at this time with the die 28 below the top surface of the draw ring 20. The workpiece 48 is in the shape of a flat disc or an incompletely formed shape prior to the drawing or forming operation herein. At this same time the ram 30 is lifted up to provide access to the draw ring 20. After the workpiece 48 is in place on the draw ring 20 over the die 28, the ram 30 is lowered to the position shown and the diaphragm 46 then contacts the workpiece 48 on one side. The fluid pressure in the cavity 44 is raised to a high level and thereafter the stake 26 is raised to push the die 28 into the workpiece 48 and the diaphragm 46 yields due to its flexibility and elasticity to allow for movement of the workpiece 48 and die 28 into the cavity 44 as shown in FIG. 1.

The described operation is performed by the hydraulic circuit shown in FIG. 1. A valve 52 is shown connected to the cylinders 32, 34 for effecting movement of the ram 30 toward and away from the draw ring 20 on which the workpiece 48 is received. A plunger 54 in the valve 52 is positionable by a lever actuator 56 in one or the other of two positions. In the position shown, the plunger 54 is positionable to connect a pressure fluid line 58 to an operating line 60 that is in communication with the cylinders 32, 34 below the pistons 36, 38. Fluid under pressure is supplied to the line 58 from a reservoir 62 by a pump 64. At this same time, a low pressure return line 66 to the reservoir is connected to a second operating line 68 through the valve 52 around its plunger 54 and the line 68 connects with the cylinders 32, 34 above the pistons 36, 38. Since the rods 40, 42 are fixed in position, the resulting pressure differential forces the ram 30 downward and holds it against the draw ring 20.

A high pressure control valve 70 having a plunger 72 slidable therein to one or the other of two positions controls the connection of fluid under relatively high pressure to the cavity 44 in the ram 30. The plunger 72 is also shown shiftable by a lever operator 74. A high pressure supply pump 75 is connected to a line 76 that is connected at one end to the valve 20 and at the other end to a pressure regulating valve 78 that is adjustable to determine the maximum pressure in the line 76. With the plunger 72 as shown, the line 76 connects to a supply line 80 which connects directly to the cavity 44 and therefore the cavity 44 is pressurized in accordance with the adjustment of the valve 78 at this time when the plunger 72 is shifted rightward in the valve 70 as shown. A low pressure line 82 is also connected to the valve 70 and extends to a source of low pressure represented by a pump 84 that is supplied from a reservoir 86. The high pressure pump 74 also draws. The low pressure line 82 is connected to the cavity 44 when the plunger 72 is in its leftward position as when the ram 30 is raised.
and it serves only to maintain the cavity 44 full of fluid during the interval between forming operations since it is pressurized to only a few pounds above atmospheric pressure.

A two position valve 88, similar to the valve 52 operates to connect fluid under pressure to the cylinder 22 to raise and lower the stake 26 and die 28. A plunger 90 in the valve, when positioned as shown, effects the connection of fluid under pressure from the line 58 to an operating line 92 that connects to the bottom of the cylinder 22 while the return line 66 is connected through the valve 88 to another operating line 94 that connects to the top of the cylinder 22. Thus the piston 24 is raised to lift the stake 26 and die 28 into the cavity 44 to form the workpiece 48. The valve plunger 90 is shown to be shifted by a lever actuator 96 similar to those operating the valves 52, 70. These simplified levers 56, 74 and 96 are shown for illustration only and in actual practice they can be automatically cycled solenoid type operators, the manner of connection and operation of these being well known in the machinery art.

In some forming operations it is advantageous to raise the pressure in the cavity 44 to progressively higher levels during the entry of the die 28 into the cavity 44. Therefore, the valve 78 is shown adjustable by rotation of an angularly adjustable cam 98 having a spiral surface thereon and which acts to move a plunger 100 to increase the compression of a spring 102 in the valve 78 to cause the pressure in the line 66 to be maintained at a higher level. Fluid in the cavity 44 displaced by the entry of the die 28 is forced out through the line 80 and is flown off through the pressure control valve 78.

A bushing 104 extends through the ram 30 and into the cavity 44 and has included therein a pair of electrodes 106, 108 held in the bushing 104 by an insulating potting compound. A pair of electrical leads 110, 112 connect to the electrodes 106, 108 to supply a high current surge of electrical energy to produce a momentary arc between the electrodes 106, 108 in the cavity 44 after the die 28 has been inserted to full depth in the cavity 44. The arc causes ionization of a portion of the dielectric hydraulic fluid therein which tends to displace a portion of the fluid due to the expansion of the ionized fluid and therefore produces a momentary rise in pressure in the form of a shock which is propagated rapidly through the remaining fluid to impinge upon the surfaces surrounding the fluid. The shock wave diminishes in intensity as it propagates through the fluid medium and therefore the electrodes 106, 108 are positioned in the cavity 44 such that they are in close proximity to the dielectric 46 at the workpiece 48. The shock wave, as it strikes the diaphragm is several times higher than the highest pressure produced in the cavity 44 by the fluid supplied from the pump 75. Therefore the extreme pressure forces the diaphragm 46 and workpiece 48 into the fine spaces 114 of the die 28 to shape the workpiece in close conformity therewith. For best results, the detailed pattern on the die which causes the spaces 114 should be vented to atmosphere to prevent the formation of air pockets which would compress and prevent accurate reproduction of design and which would accentuate a spring back of the workpiece 48 after the extreme high pressure is no longer present. The venting can be achieved, for example, by interdrilling of the die 28.

An electrical operating apparatus is shown in FIG. 2 to be connected to the electrodes 106, 108 in the machine. The high current energy surge is applied to the conductors 110, 112 by a bank of capacitors 116 connected in parallel. The capacitors 116 have the ability to store a great amount of electrical energy which is suddenly released to the conductors 110, 112 for transmission to the electrodes 106, 108 by the closing of a switch 118 in the conductor 110. The capacitors 116 are charged when the switch 118 is open and a switch 120 is closed to complete a circuit through the conductors 110, 112 to a direct current power source 122 that includes a direct current power amplifier of any well known type and a rectifier circuit to convert alternating current from a source 124 to direct current prior to the amplification. The charge switch 120 is opened before the discharge switch 118 is closed after recharge of the capacitors 116. While the switches 118, 120 can be considered as manually operable for purposes of this disclosure, it is within the skill of the art to provide automatically operated ones in their place in a fully automated machine.

While the invention has been described in connection with one possible form or embodiment thereof, it is to be understood that the present disclosure is illustrative rather than restrictive and that changes and modifications may be resorted to without departing from the spirit of the invention or the scope of the claims which follow.

What is claimed is:

1. A press for drawing a workpiece to a predetermined shape comprising in combination:
   (a) a draw ring adapted to receive the workpiece thereon,
   (b) a ram member having a cavity therein,
   (c) means for holding said ram member above said draw ring and including means for moving said ram member between a retracted position and an advanced position wherein said ram member contacts said workpiece,
   (d) a flexible diaphragm received in said ram member to close said cavity, said diaphragm contacting the workpiece and draw ring when said ram member is in its advanced position,
   (e) fluid supply means for maintaining said cavity full of fluid behind said diaphragm and including means for raising the pressure of said fluid to a high level when said ram member is in its advanced position and said diaphragm is in contact with the workpiece,
   (f) a die extensible from and retractable into said draw ring at the location whereat said draw ring is adapted to receive the workpiece,
   (g) means for extending said die forcefully out of said draw ring and into said cavity when said ram member is in its advanced position to draw the workpiece into the shape of the contour of said die,
   (h) means for suddenly and momentarily increasing the fluid pressure on said diaphragm to a level greatly in excess of the high level to which the pressure of said fluid is raised by said fluid supply means when said die is extended fully into said cavity,
   (i) a shock wave generated by applying energy to the fluid in said cavity and causing said shock wave to propagate through the fluid and said cavity to strike said diaphragm and produce a high forming force thereon for drawing said workpiece accurately in accordance with the detail of the contour of said die,
   (j) means for producing a shock wave that is propagated through the fluid in said cavity to strike said diaphragm and produce a high forming force thereon for drawing said workpiece accurately in accordance with the detail of the contour of said die,
   (k) means for producing a shock wave that is propagated through the fluid in said cavity to strike said diaphragm and produce a high forming force thereon for drawing said workpiece accurately in accordance with the detail of the contour of said die.

2. The press of claim 1 wherein said last recited means is means for producing a shock wave that is propagated through the fluid in said cavity to strike said diaphragm and produce a high forming force thereon for drawing said workpiece accurately in accordance with the detail of the contour of said die.

3. The press of claim 2 wherein said means for producing a shock wave includes:
   (a) means for storing energy in one form, and
   (b) means for suddenly releasing the energy and applying it to the fluid in said cavity for conversion thereof in a mechanical process to produce said shock wave.

4. The press of claim 3 wherein:
   (a) said means for storing energy is a bank of electrical capacitors,
   (b) means are provided for charging said capacitors, and
   (c) said means for suddenly releasing the energy includes a pair of spaced electrodes received in said ram member and insulating therefrom, said electrodes extending into the fluid in said cavity, and said means for connecting said electrodes in an electrical circuit with said capacitors for discharge thereof.
from electrode to electrode through the fluid in said cavity, said discharge occurring as an arc of short duration through the fluid.

5. The press of claim 4 wherein:
(a) said electrodes extend into said cavity in close proximity to said diaphragm and die when said die is in its advanced position.
(b) raising the pressure of said fluid to a high level,
(c) advancing said die into the workpiece from the side opposite to said diaphragm, and
(d) applying energy suddenly to said volume of fluid tending to displace a portion thereof to thereby create a shock wave therein momentarily raising the pressure of said volume of fluid against said diaphragm to a level greatly in excess of said high level.

6. A process for drawing a workpiece to conform accurately to the shape of a die comprising the steps of:
(a) engaging the workpiece on one side with a flexible diaphragm having a volume of fluid confined therebehind,
(b) raising the pressure of said volume of fluid to a high level,
(c) advancing the die into said workpiece from the side opposite said diaphragm to push said workpiece into said diaphragm, and
(d) discharging electrical energy in the form of an arc in said volume of fluid to produce a sudden displacement of a portion thereof creating a shock wave therein momentarily raising the pressure of said volume of fluid on said diaphragm to a level greatly in excess of said high level.

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