Jan. 13, 1942. W. P. MERRILL 2,269,778

METAL WORKING PRESS

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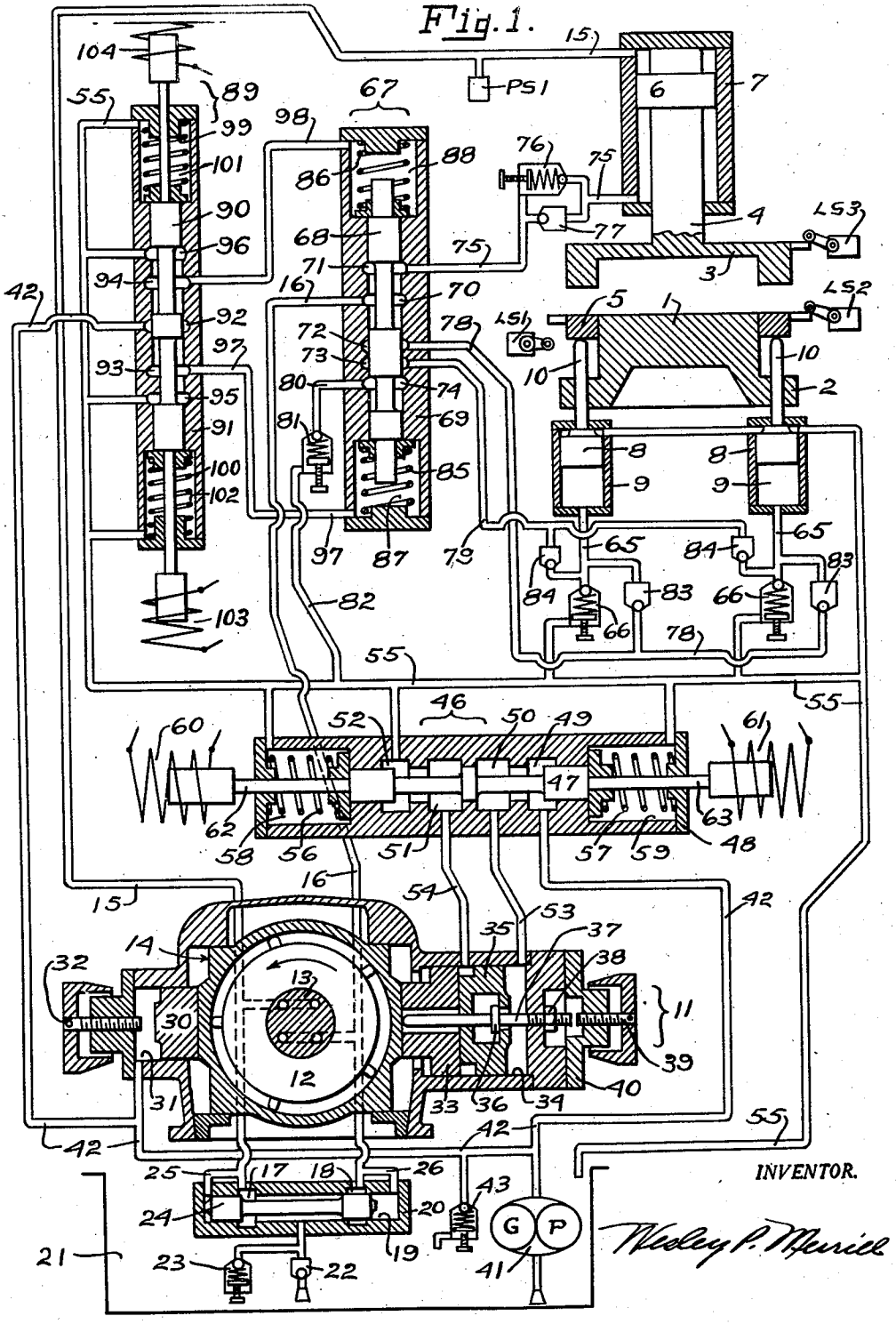
Fig. 1.



INVENTOR.

Wesley P. Merrill

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METAL WORKING PRESS

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Fig. 8.

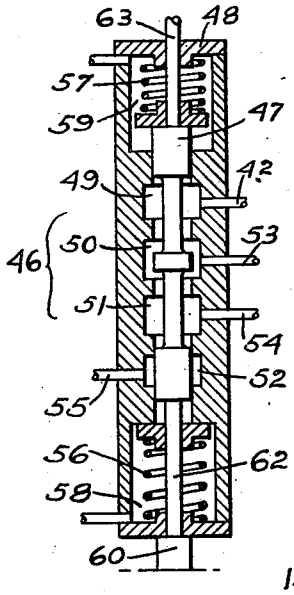


Fig. 9.

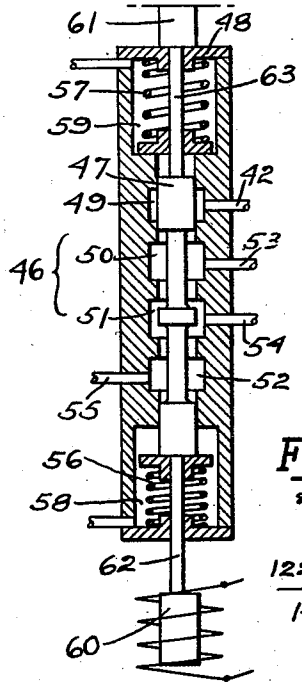


Fig. 2.

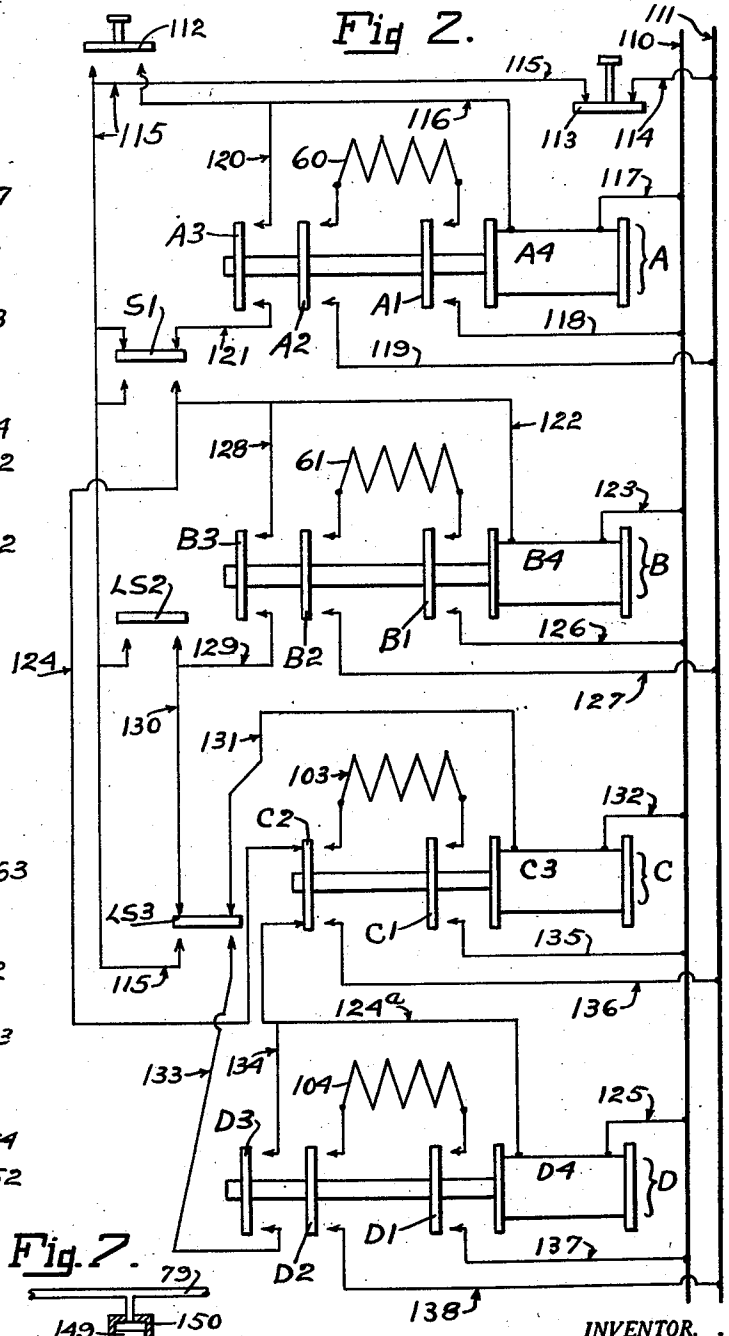
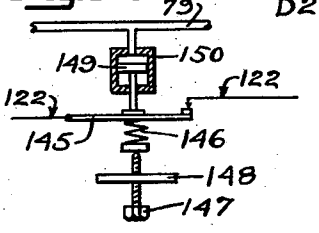


Fig. 7.



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METAL WORKING PRESS

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Fig. 3.

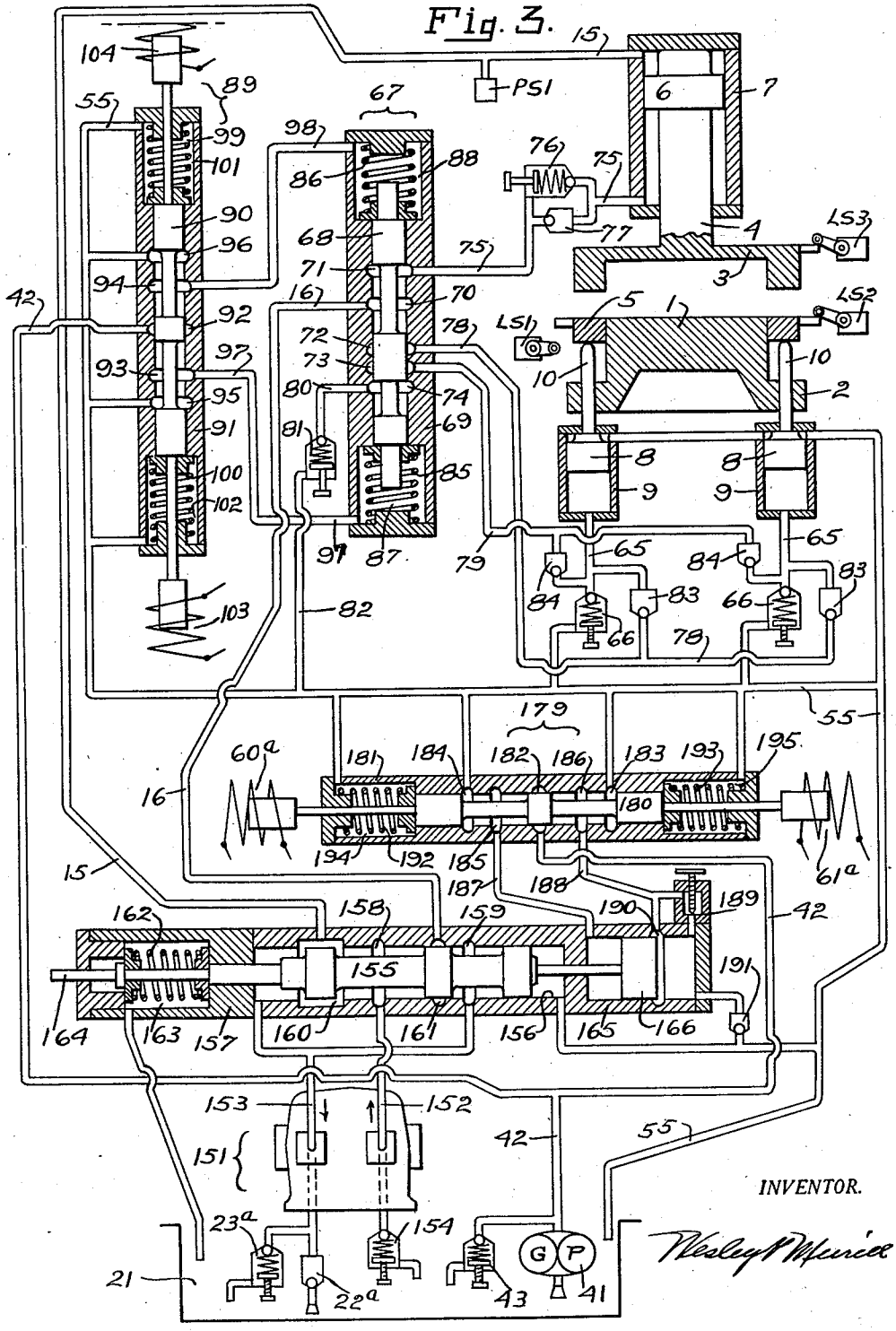

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Fig 4

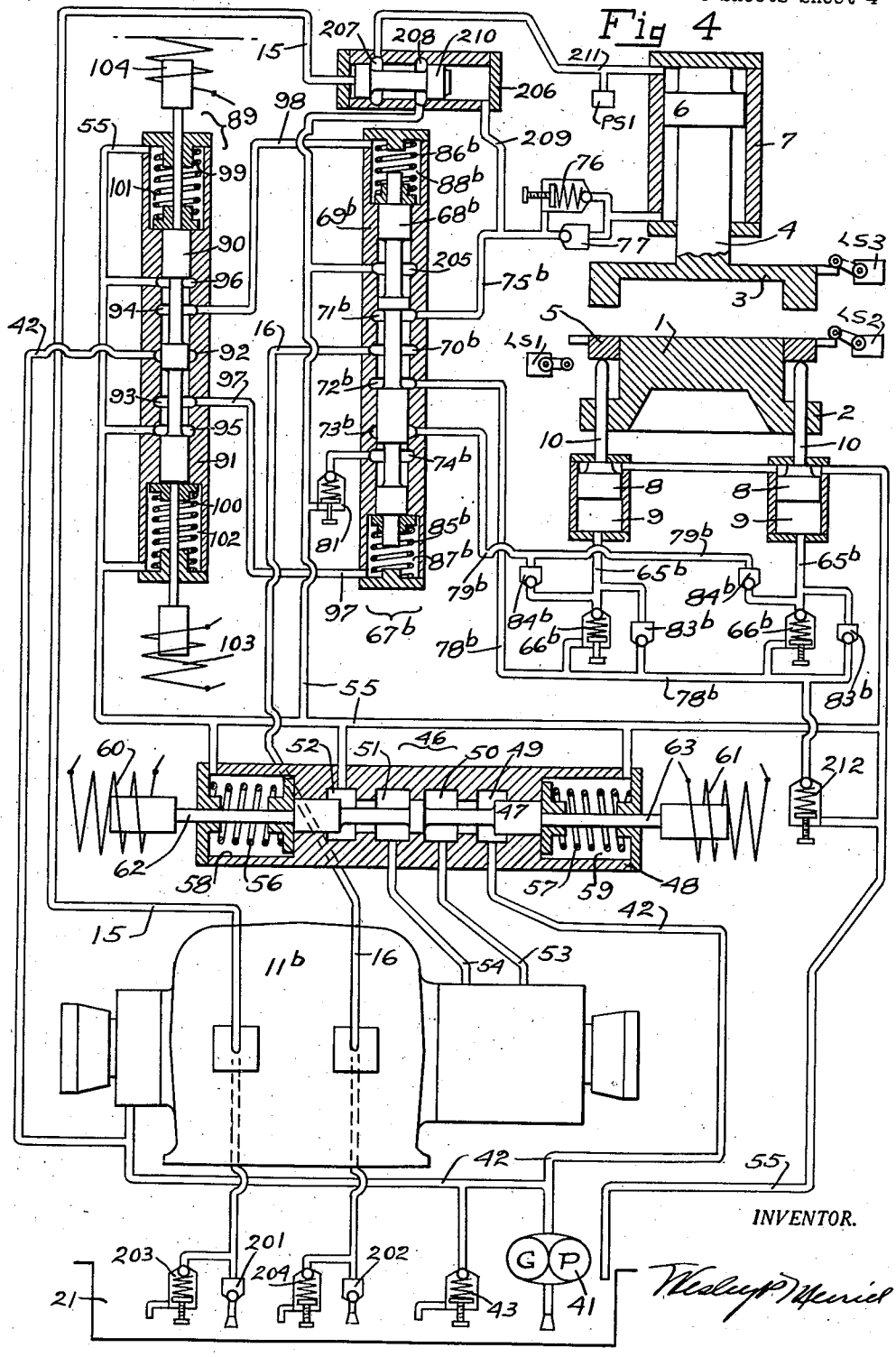

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Fig 14.

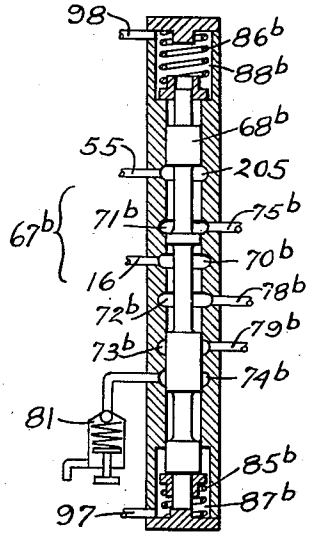


Fig. 15.

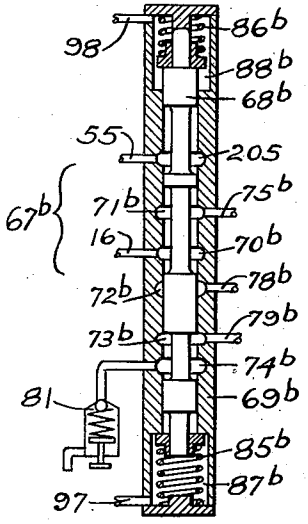


Fig. 5.

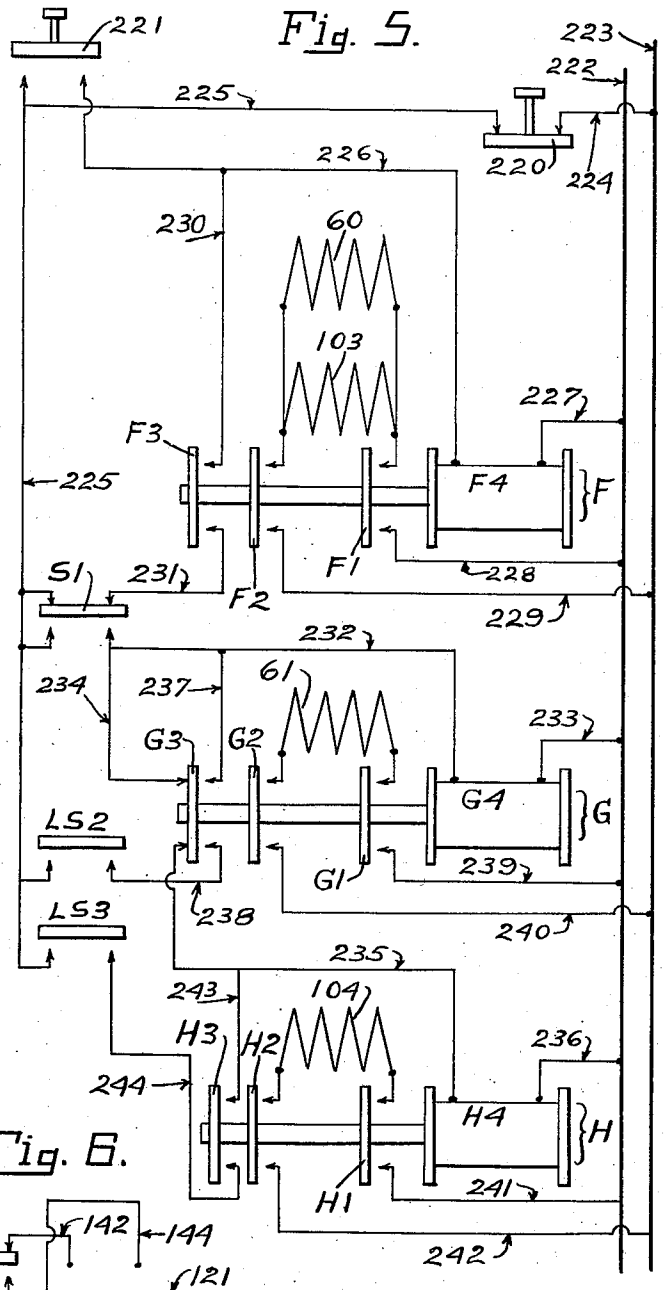


Fig. 6.

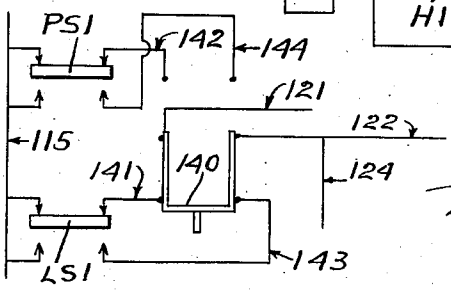
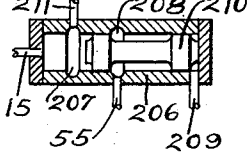


Fig. 16.



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METAL WORKING PRESS

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Fig. 10.

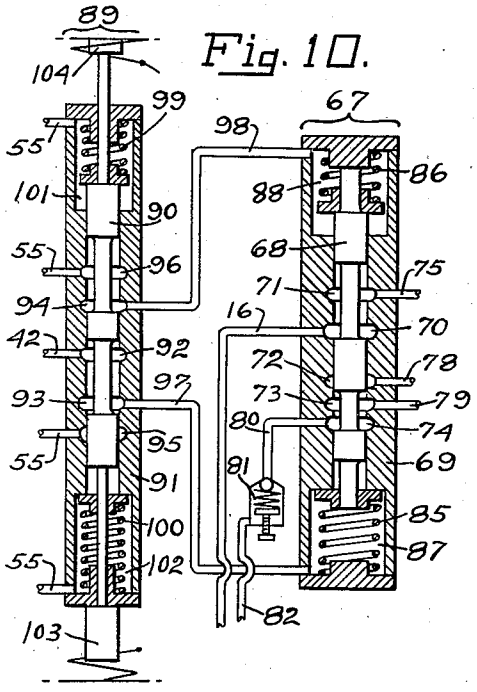


Fig. 11.

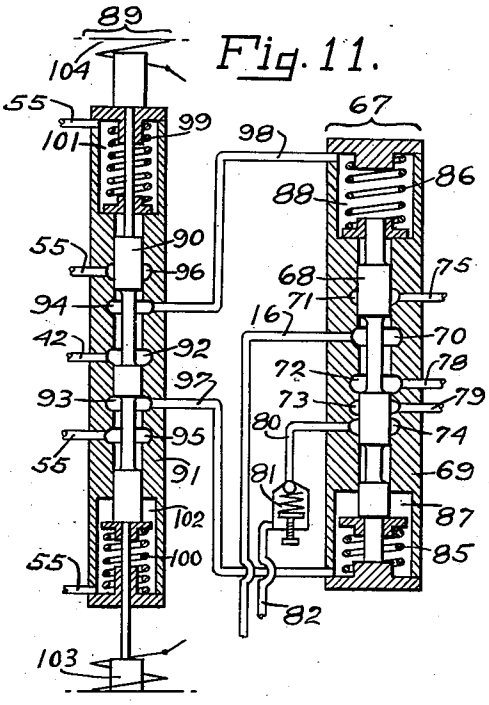


Fig. 12.

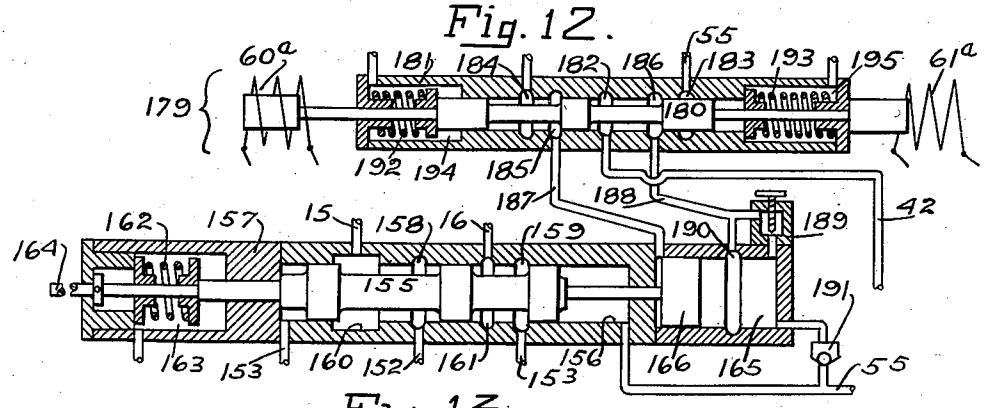
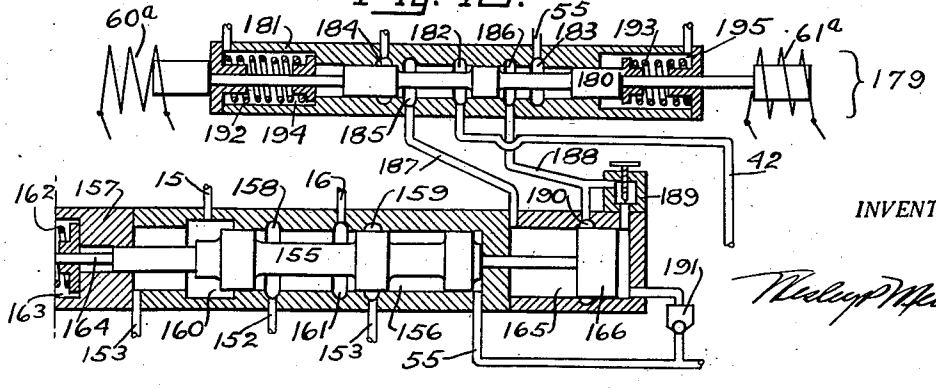


Fig. 13.



INVENTOR.

Rodney P. Merrill

Patented Jan. 13, 1942 2,269,778

UNITED STATES PATENT OFFICE

2,269,778

METAL WORKING PRESS

Wesley P. Merrill, Milwaukee, Wis., assignor to The Oilgear Company, Milwaukee, Wis., a corporation of Wisconsin

Application March 3, 1939, Serial No. 259,553

20 Claims. (Cl. 113—45)

This invention relates to metal working presses of the type having a ram which advances and retracts a movable die toward and from a stationary die to enable the dies to form metal into a desired shape, a pressure pad which supports the metal in position to be operated upon by the dies and which is moved relative to the stationary die by the ram or the movable die during advance movement thereof, and a cushioning device which resists the movement of the pressure pad under the thrust of the ram or movable die.

The cushioning device ordinarily includes one or more pistons each of which is fitted in a cylinder and provided with a rod which engages the pressure pad so that movement of the pressure pad under the thrust of the ram or movable die will cause a corresponding movement of each piston in its cylinder. Each cylinder contains a fluid under sufficient pressure to enable the piston or pistons to provide the desired resistance to movement of the pressure pad by the ram or movable die. The fluid employed is sometimes compressed air having a predetermined pressure and sometimes it is a liquid the pressure of which is determined by a resistance through which the liquid is expelled from the cylinder by the piston as it is moved by the pressure pad.

When the movable die is retracted after forming an article, the compressed fluid in the cylinder or cylinders of the cushioning device will expand and cause the pressure pad to follow the movable die unless means are provided to prevent it. While the compressibility of liquid is slight relative to that of air, the liquid in the cushioning cylinder or cylinders is capable of expanding sufficiently to cause the pressure pad to be moved an appreciable distance from the position into which it was moved by the ram or movable die.

When forming metal into articles of certain shapes, it is essential that the pressure pad be prevented from immediately following the movable die during retraction thereof in order to avoid distorting or otherwise damaging the article just formed by the dies.

Both mechanical and hydraulic devices have been produced by locking the pressure pad in the position to which it is moved by the ram or die but such devices do not function accurately due to lost motion or back lash in the mechanical devices and to expansion of liquid in the hydraulic devices. Devices have also been provided which will move the pressure pad slightly farther than it is moved by the ram or die but such devices require the use of both liquid and compressed air.

The present invention has as an object to provide a metal working press having means for accurately retaining the pressure pad thereof in the position to which it is moved by the ram or die.

Another object is to provide a metal working press having the ram actuating means and the pressure pad cushioning means energized by liquid from a single pump.

Another object is to provide a metal working press in which the greater part of the energy consumed by the cushioning means is regenerated.

Another object is to provide a hydraulically operated metal working press which is at least semi-automatic in operation.

Other objects and advantages will appear from the description hereinafter given of metal working presses in which the invention is embodied.

According to the invention in its general aspect, a metal working press has a pressure pad supported by a hydraulic cushioning device, the press ram during its working stroke moves the pressure pad and causes liquid to be ejected from the cushioning device through a high resistance which causes a high pressure to be created in the cushioning device, and at the end of the working stroke the pressure in the cushioning device is automatically reduced to a value which is low enough to prevent the cushioning device from causing the pressure pad to follow the ram when it starts its return stroke but which is high enough to enable the cushioning device to sustain the pressure pad in the position to which it was moved during the working stroke.

According to the invention in another aspect, the ram of a metal working press is reciprocated by a hydraulic motor which is energized by a pump, the ram during its down stroke depresses a pressure pad, downward movement of the pressure pad is resisted by a hydraulic cushioning device from which liquid is ejected as the pressure pad is depressed, the volume of liquid ejected from the pressure pad is in excess of the volume of liquid delivered by the pump to the motor to cause it to move the ram downward, the cushioning device is connected to the intake of the pump and to a high pressure relief valve during the down stroke of the ram so that the liquid expelled from the cushioning device in excess of the volume required by the pump is exhausted through the relief valve and the pump is supercharged at a pressure equal to the resistance of

the relief valve, and at the end of the down stroke the pressure in the cushioning device is automatically reduced to a value which is low enough to prevent the cushioning device from causing the pressure pad to follow the ram when it ascends but which is high enough to enable the cushioning device to sustain the pressure pad in the position to which it was depressed during the working stroke.

The invention is exemplified by the metal working presses shown schematically in the accompanying drawings in which the views are as follows:

Fig. 1 is a diagram of the hydraulic circuit of a metal working press which is operated by liquid supplied by a reversible pump, the several parts being shown in the positions occupied when the press is idle.

Fig. 2 is a diagram of an electric circuit for controlling the operation of the presses shown in Figs. 1 and 3.

Fig. 3 is a view similar to Fig. 1 but showing the press provided with a uni-directional pump and adapted to be reversed by means of a reversing valve.

Fig. 4 is a view similar to Fig. 1 but showing means for causing the pump to be supercharged by the liquid expelled from the cushioning device during the down stroke of the press ram.

Fig. 5 is a diagram of an electric circuit for controlling the operation of the press shown in Fig. 4.

Fig. 6 is a diagram showing how the circuits shown in Figs. 2 and 5 may be modified.

Fig. 7 is a diagram showing another modification of the circuits shown in Figs. 2 and 5.

Figs. 8 and 9 are views showing other characteristic positions of the pump pilot valve shown in Figs. 1 and 4.

Figs. 10 and 11 are views showing other characteristic positions of the control valve and pilot valve shown in Figs. 1 and 3.

Figs. 12 and 13 are views showing other characteristic positions of the reversing valve and its pilot valve shown in Fig. 2.

Figs. 14 and 15 are views showing other characteristic positions of the control valve shown in Fig. 4.

Fig. 16 is a view showing another position of the differential valve shown in Fig. 4.

Figs. 1 and 2

Since the frame, platen, die, die blocks, etc., of a metal working press are well known and may be of various forms, only so much of the press structure has been schematically shown as is necessary to an explanation of the invention, and the dies have been shown as being formed integral with the bolster and with the platen or ram but it is to be understood that the press is not so constructed in practice.

For the purpose of illustration, the press has been shown as having a lower die 1 arranged upon a bolster 2 which is fixed in a stationary position, an upper die 3 which is carried by a ram 4, and a pressure pad 5 which is arranged around lower die 1.

Ram 4 is fixed to a piston 6 which is fitted in a stationary cylinder 7 and forms therewith a hydraulic motor for reciprocating ram 4 to move die 3 toward and from die 1.

The metal to be operated upon is placed upon die 1 and pressure pad 5 and then die 3 is advanced. Die 3 will first press the edge of the metal against pressure pad 5 and will then cooperate with die 1 to form the metal into the shape determined by the contour of the dies, pressure pad 5 being depressed by die 3 during the shaping of the metal.

In order that the edge of the metal may be gripped with a predetermined force, downward movement of pressure pad 5 is resisted by a hydraulic cushioning device which includes one or more pistons 8 each of which is fitted in a stationary cylinder 9 and provided with a piston rod 10 which extends loosely through bolster 2 into contact with the underside of pressure pad 5. The number of pistons and cylinders required will depend upon the size and type of the dies employed. With the type of dies shown, at least four pistons and cylinders are ordinarily employed but only two have been shown in order to avoid unnecessary complication of the view.

Liquid for operating motor 6—7 and for causing pistons 8 to raise pressure pad 5 after it has been depressed, is supplied by a pump 11. While any suitable pump will suffice, pump 11 has been shown as being of the rolling piston type which is fully illustrated and described in Patent No. 2,074,068. It is deemed sufficient to state herein that pump 11 has its cylinders arranged radially in a cylinder barrel 12 which is journaled upon a stationary valve shaft or pintle 13 having ports and passages formed therein through which liquid flows to and from the cylinders, that the outer ends of the pistons react against the angular inner surface of a reaction member carried by a thrust member or slide block 14, that no liquid will be discharged by pump 11 when slide block 14 is in its central or neutral position at which time its axis coincides with the axis of cylinder barrel 12, and that pump 11 will deliver liquid in a direction and at a rate dependent upon the direction and distance slide block 14 is shifted from its neutral position. As shown, pump 11 is adapted to deliver liquid into one and have liquid returned to it through the other of two channels 15 and 16 which are connected to pintle 13 in communication with the passages formed therein.

Since motor 6—7 is of the differential type so that, when operating, liquid is discharged therefrom at rates which are always either in excess of or less than the rate required to supply pump 11 with liquid, channels 15 and 16 communicate at points intermediate their ends with pintle 13 and have their lower ends connected, respectively, to two annular grooves or ports 17 and 18 formed in the wall of a bore 19 which is formed in a valve casing 20 and connected at a point between ports 17 and 18 with a reservoir 21 through a check valve 22 and a low pressure resistance valve 23. Each of channels 15 and 16 are also connected to a high pressure relief valve which has been omitted from the drawings to avoid crowding the view.

Bore 19 contains a differential valve 24 having heads or pistons formed upon its ends and closely fitted in bore 19 to block one or the other of ports 17 and 18, and opposite ends of bore 19 are connected by channels 25 and 26 to channels 15 and 16 respectively.

The arrangement is such that, when pump 11 discharges liquid into channel 16 to raise piston 6, pressure will extend through channel 26 to the right end of bore 19 and shift valve 24 toward the left to the position shown to block the end of channel 16 and uncover the end of channel 15 so that the liquid expelled from cylinder 7 by piston 6 in excess of the volume required by pump 11 may be discharged through resistance

valve 23 into reservoir 21 and, when pump 11 discharges liquid into channel 15 to cause piston 6 to descend, pressure will extend through channel 25 to the left end of bore 19 and shift valve 24 toward the right to block the end of channel 15 and uncover the end of channel 16 so that pump 11 may draw liquid from reservoir 21 through check valve 22.

When slide block 14 is shifted toward the right from its neutral position, pump 11 will discharge liquid into channel 15 and have liquid returned to it through channel 16 and, when it is shifted toward the left from its neutral position, pump 11 will discharge liquid into channel 16 and have liquid returned to it through channel 15.

Slide block 14 is at all times urged toward the right by liquid acting upon a piston 30 which is connected to or in engagement with slide block 14 and is fitted in a stationary cylinder 31 carried by the casing of pump 11.

An adjusting screw 32 is threaded through the head of cylinder 31 to limit the movement of piston 30 and slide block 14 toward the left. Turning screw 32 will adjust the rate at which pump 11 will discharge liquid into channel 16.

Slide block 14 is adapted to be moved toward the left by liquid acting upon a piston 33, which engages slide block 14 and is fitted in a stationary cylinder 34 carried by the pump casing, and by liquid acting upon a piston 35 which is fitted in cylinder 34 and adapted to engage the outer face of piston 33.

The movement of piston 35 toward the left is limited by a collar 36 fixed on a stop rod 37 which extends loosely through pistons 33 and 35 and through the head of cylinder 34. The inner end of rod 37 is adapted to engage slide block 14 and the outer end of rod 37 is provided with a nut 38 which is adjusted to so position collar 36 that piston 35 when energized will move slide block 14 exactly to its neutral position.

The outer end of rod 37 is adapted to engage an adjusting screw 39 which is threaded through a cap 40 fixed to the head of cylinder 34. Turning screw 39 adjusts the distance rod 37 and slide block 14 may be moved toward the right to thereby determine the rate at which pump 11 will deliver liquid into channel 15.

Pistons 33 and 35 are larger than piston 30 so that slide block 14 will be moved toward the left when liquid is simultaneously supplied to both of cylinders 31 and 34 at the same pressure.

Liquid for operating pistons 33 and 35 is supplied by a gear pump 41 which is ordinarily driven in unison with pump 11 and arranged in the casing thereof according to the usual practice.

Gear pump 41 draws liquid from reservoir 21 and discharges it into a branched supply channel 42 at a rate in excess of requirements, the excess liquid being exhausted through a relief valve 43 which enables gear pump 41 to maintain in channel 42 a pressure equal to the resistance of relief valve 43.

Supply channel 42 has one of its branches connected to the outer end of cylinder 31 so that piston 30 is constantly urged toward the right by a constant force which is proportional to gear pump pressure.

Delivery of liquid from gear pump 41 to cylinder 34 is under the control of a pump control valve 46 having a valve member or plunger 47 fitted in a valve casing 48 to control communication between four annular grooves or ports 49, 50, 51 and 52 formed in valve casing 48.

Port 49 has another branch of supply channel 42 connected thereto. Port 50 is connected by a channel 53 to cylinder 34 at or near the outer end thereof. Port 51 is connected by a channel 54 to cylinder 34 at a point between pistons 33 and 35. Port 52 is connected to a drain channel 55 which discharges into reservoir 21.

When valve member 47 is in its central position as shown in Fig. 1, pressure extends from channel 42 through valve casing 48 and channel 53 to the right end of cylinder 34 and holds piston 35 against collar 36 on stop rod 37, and the space between pistons 33 and 35 communicates through channel 54 and valve casing 48 with drain channel 55 so that the pressure in cylinder 31 will cause piston 30 to hold slide block 14 against piston 33 and piston 33 against piston 35 in which position of slide block 14 pump 11 is at zero stroke and no liquid will be delivered thereby.

When valve member 47 is shifted toward the left to the position shown in Fig. 9, port 49 is blocked and channels 53 and 54 are open to drain channel 55 so that liquid supplied by gear pump 41 to cylinder 31 can cause piston 30 to move slide block 14 toward the right until rod 37 abuts adjusting screw 39 at which time pump 11 will discharge liquid into channel 15 at a rate determined by the adjustment of screw 39.

When valve member 47 is shifted toward the right to the position shown in Fig. 8, port 52 is blocked and channels 53 and 54 are open to port 49 so that liquid from gear pump 41 can flow through channel 42, valve casing 48 and channels 53 and 54 to cylinder 34 and cause pistons 33 and 35 to move slide block 14 toward the left until piston 30 abuts adjusting screw 32 at which time pump 11 will discharge liquid into channel 16 at a rate determined by the adjustment of screw 32.

Valve member 47 is normally held in its central or neutral position by two springs 56 and 57 arranged, respectively, in two chambers 58 and 59 which are formed in opposite ends of valve casing 48 and connected to drain channel 55.

Valve member 47 is adapted to be shifted in one direction or the other by one or the other of two solenoids 60 and 61 the cores of which are connected, respectively, to valve stems 62 and 63 which are fixed to opposite ends of valve member 47 and extend outward through chambers 58 and 59. Solenoids 60 and 61 are controlled in a manner to be presently described.

Channel 15 has its other end connected directly to the upper end of cylinder 7 so that, when slide block 14 is moved toward the right, the liquid discharged by pump 11 into channel 15 will cause piston 6 to move ram 4 and die 3 downward and thereby cause pressure pad 5 to be depressed and move pistons 8 downward in cylinders 9.

The lower end of each cylinder 9 is connected by a channel 65 to the inlet of a resistance valve 66 the outlet of which is connected to drain channel 55 so that, when pressure pad 5 moves downward, pistons 8 will expell liquid from cylinders 9 through resistance valves 66 which resist the discharge of liquid therethrough and thereby enable pistons 8 to resist the downward movement of pressure pad 5 and cause it to exert a predetermined holding force upon the metal being formed by the dies. The several resistance valves 66 are individually adjustable so that the holding force may be varied at as many points on pressure pad 5 as there are pistons 8.

When slide block 14 is moved toward the left, the liquid discharged by pump 11 into channel 16 is directed either to the lower end of cylinder 7 or to the lower ends of cylinders 9 by means of a control valve 67 having a valve member or plunger 68 fitted in a valve casing 69.

Valve member 68 controls communication between five annular grooves or ports 70, 71, 72, 73 and 74 which are formed in the inner wall of casing 69.

Port 70 is connected by channel 16 to one port of pump 11. Port 71 is connected to the lower end of ram cylinder 7 by a channel 75 having a resistance valve 76 and a check valve 77 connected therein in parallel with each other and adapted to open in opposite directions. Check valve 77 permits liquid to flow freely to the lower end of cylinder 7 but prevents liquid from flowing therefrom except through resistance valve 76 which offers enough resistance to the discharge of liquid from the lower end of cylinder 7 to prevent piston 6 from descending until forced downward by liquid supplied to the upper end of cylinder 7.

Ports 72 and 73 have two channels 78 and 79 connected thereto respectively, and port 74 is connected by a channel 80 to the inlet of a low pressure relief valve 81 the outlet of which is connected by a channel 82 to drain channel 55.

Channel 78 is connected to each of channels 65 through a check valve 83 which permits liquid to flow freely from channel 78 into channel 65 but prevents liquid from flowing from channel 65 into channel 78, and channel 79 is connected to each of channels 65 through a check valve 84 which permits liquid to flow freely from channel 65 into channel 79 but prevents liquid from flowing from channel 79 into channel 65 so that, when valve member 68 is in the position shown in Fig. 11, liquid from pump 11 may flow through channel 16, valve 67, channel 78, check valves 83 and channels 65 to the lower ends of cylinders 9 and cause pistons 8 to raise pressure pad 5 and, when valve member 68 is in the position shown in Fig. 10, liquid may escape from cylinders 9 through low pressure relief valve 81 and thereby drop the pressure in cylinders 9 to a value capable of supporting pressure pad 5 but incapable of causing pressure pad 5 to follow die 3 when it ascends but, when pressure pad 5 is being moved downward and causing pistons 8 to eject liquid from cylinders 9 through resistance valves 66, check valves 83 and 84 will prevent liquid from flowing from a cylinder 9 containing liquid under a high pressure to a cylinder 9 containing liquid under a lower pressure and thereby enable resistance valves 66 to maintain different pressures in the several cylinders 9.

Valve member 68 is normally held in its central or neutral position by two springs 85 and 86 arranged, respectively, in two chambers 87 and 88 formed in opposite ends of valve casing 69, and it is adapted to be shifted in one direction or the other by liquid supplied to one or the other of chambers 87 and 88 and acting upon one end or the other of valve member 68.

The delivery of liquid to chambers 87 and 88 is under the control of a pilot valve 89 having a valve member or plunger 90 arranged in a valve casing 91 and controlling communication between five ports 92, 93, 94, 95 and 96.

Port 92 has a branch of gear pump supply channel 42 connected thereto, port 93 is connected to chamber 87 by a channel 97, port 94 is connected to chamber 88 by a channel 98, and ports 95 and 96 have drain channel 55 connected thereto.

Valve member 90 is normally held in its central or neutral position by two springs 99 and 100 arranged, respectively, in two spring chambers 101 and 102 which are formed in opposite ends of valve casing 91 and have drain channel 55 connected thereto to prevent liquid or air from being trapped therein.

Valve member 90 is adapted to be shifted in one direction or the other by one or the other of two solenoids 103 and 104 arranged at opposite ends of valve casing 91 and having the cores thereof connected to suitable valve stems which extend through the spring chambers and are fixed to opposite ends of valve member 90.

When solenoid 104 is energized, it will shift valve member 90 to the position shown in Fig. 10 and then liquid from gear pump 41 will flow through channel 42, pilot valve 89 and channel 97 to chamber 87 and shift control valve member 68 to the position shown in Fig. 10 to open port 73 to port 74 so that liquid may escape from cylinder 9 through low pressure relief valve 81.

When solenoid 103 is energized, it will shift valve member 90 to the position shown in Fig. 11 and then liquid from gear pump 41 will flow through channel 42, pilot valve 89 and channel 98 to chamber 88 and shift control valve member 68 to the position shown in Fig. 11 to open port 72 to port 70 so that liquid from pump 11 may flow through channel 16, valve 67, channel 78, check valves 83 and channels 65 to the lower ends of cylinders 9 and cause pistons 8 to raise pressure pad 5.

The electric circuit

Referring now more particularly to Fig. 2, current for energizing solenoids 60 and 61 is supplied thereto under the control, respectively, of two contactor switches A and B from a power line shown as consisting of two conductors 110 and 111, and current for energizing solenoids 103 and 104 is supplied thereto under the control, respectively, of two contactor switches C and D from power line 110—111.

Contactor switch A includes three switches A1, A2 and A3 and an electro-magnet A4 for operating its switches, contactor switch B includes three switches B1, B2 and B3 and an electro-magnet B4 for operating its switches, contactor switch C includes two switches C1 and C2 and an electro-magnet C3 for operating its switches, and contactor switch D includes three switches D1, D2 and D3 and an electro-magnet D4 for operating its switches.

In order to simplify the drawing, contactor switches A, B, C and D have been shown arranged horizontally but in practice they are arranged vertically so that, when the magnets are deenergized, the switches will open by gravity to the positions shown.

Contactor switch A is controlled in part by a normally open manually operable starting switch 112 and in part by a switch S1 which may either be a limit switch LS1 (Fig. 1), which is operated by pressure pad 5 at the end of its downward movement, or it may be a pressure responsive switch PS1 which operates in response to a predetermined maximum pressure in the upper end of the ram cylinder as by being connected to channel 15 as shown in Fig. 1.

Contactor switch B is controlled in part by switch S1 and in part by a limit switch LS2 which is operated by pressure pad 5 when it reaches the

limit of its upward movement as shown in Fig. 1. Switch B may also be controlled in part by a pressure responsive switch as will presently be explained in connection with an explanation of the operation of the press.

Contactor switch C is controlled in part by limit switch LS2 and in part by a limit switch LS3 which is operated by die 3 when it reaches the limit of its upward movement as shown in Fig. 1.

Contactor switch D is controlled in part by switch S1 and in part by limit switch LS3.

In order that the press may be stopped at any time, the circuit is provided with a normally closed manually operable stop switch 113 which has one of its terminals connected to conductor 111 by a conductor 114 and its other terminal connected by a conductor 115 to one terminal of starting switch 112, to two opposed terminals of switch S1, to one terminal of switch LS2 and to one terminal of switch LS3. The other terminal of switch 112 is connected by a conductor 116 to one end of the winding of magnet A4 the other end of which is connected to conductor 110 by a conductor 117 so that, when switch 112 is closed, magnet A4 will be energized and close switches A1, A2 and A3.

Switch A1 has one of its terminals connected to conductor 110 by a conductor 118 and its other terminal connected to one end of the winding of solenoid 60 the other end of which is connected to one terminal of switch A2. The other terminal of switch A2 is connected to conductor 111 by a conductor 119.

Switch A3 has one of its terminals connected by a conductor 120 to conductor 116 intermediate the ends thereof and its other terminal connected to a third terminal of switch S1 by a conductor 121.

The fourth terminal of switch S1 is connected by a conductor 122 to one end of the winding of magnet B4 the other end of which is connected to conductor 110 by a conductor 123.

The fourth terminal of switch S1 is also connected by a conductor 124 to one terminal of switch C2 and normally connected through switch C2 to one end of a conductor 124a. The other end of conductor 124a is connected to one end of the winding of magnet D4 the other end of which is connected to conductor 110 by a conductor 125.

Switch B1 has one of its terminals connnected to conductor 110 by a conductor 126 and its other terminal connected to one end of the winding of solenoid 61 the other end of which is connected to one terminal of switch B2. The other terminal of switch B2 is connected to conductor 111 by a conductor 127.

Switch B3 has one of its terminals connected by a conductor 128 to conductor 122 intermediate the ends thereof and its other terminal connected to a second terminal of switch LS2 by a conductor 129. The second terminal of switch LS2 is also connected by a conductor 130 to the terminal of switch LS3 opposite the terminal to which conductor 115 is connected.

A third terminal of switch LS3 is connected by a conductor 131 to one end of the winding of magnet C3 the other end of which is connected to conductor 110 by a conductor 132. The fourth terminal of switch LS3 is connected by conductor 133 to one terminal of switch D3 the other terminal of which is connected to conductor 124a by a conductor 134.

Switch C1 has one of its terminals connected to conductor 110 by a conductor 135 and its other terminal connected to one end of the winding of solenoid 103 the other end of which is connected to a third terminal of switch C2. The fourth terminal of switch C2 is connected to conductor 111 by a conductor 136.

Switch D1 has one of its terminals connected to conductor 110 by a conductor 137 and its other terminal connected to one end of the winding of solenoid 104 the other end of which is connected to one terminal of switch D2. The other terminal of switch D2 is connected to conductor 111 by a conductor 138.

If it is desired to provide the press with both a limit switch and a pressure responsive switch as shown in Fig. 1, the two switches may be alternatively connected into the circuit by means of a suitable selector switch.

For the purpose of illustration, switches LS1 and PS1 have been shown in Fig. 6 as being adapted to be connected into the circuit by means of a double throw two pole selector switch 140. As shown, conductor 121 is connected to the center terminal on one side of switch 140 and the two end terminals on the same side of switch 140 are connected to corresponding terminals of switches of LS1 and PS1, respectively, by two conductors 141 and 142, and conductor 122 is connected to the other center terminal of switch 140 and the other two end terminals of switch 140 are connected to corresponding terminals of switches LS1 and PS1, respectively, by two conductors 143 and 144.

It will be obvious that either one of the two switches LS1 and PS1 may be rendered operative and the other inoperative by moving switch 140 from one to the other of its two positions, switch LS1 being moved out of the path of its actuator when switch PS1 is operative.

Operation

Assuming that the several parts are in the positions shown in Figs. 1 and 2, that pumps 11 and 41 are running and that a metal blank is arranged upon die 1 and pressure pad 5, the press will operate as follows:

When starting switch 112 is closed, a circuit will be established from conductor 111 through conductor 114, stop switch 113, conductor 115, switch 112, conductor 116, magnet A4 and conductor 117 to conductor 110, thereby energizing magnet A4 which will close switches A1, A2 and A3.

The above circuit will be broken when switch 112 is released but, as soon as switch A3 closes, it will establish a circuit from conductor 110 through conductor 117, magnet A4, conductors 116 and 120, switch A3, conductor 121 and switch S1 to conductor 115 which is always connected to conductor 111 as long as switch 113 remains closed, thereby preventing magnet A4 from being deenergized when starting switch 112 opens.

Closing switches A1 and A2 establishes a circuit from conductor 110 through conductor 118, switch A1, solenoid 60, switch A3 and conductor 119 to conductor 111, thereby energizing solenoid 60 which will shift plunger 47 of pump control valve 46 to the position shown in Fig. 9 to connect channels 53 and 54 to drain channel 55 so that the liquid supplied to cylinder 31 by gear pump 41 may shift slide block 14 toward the

right and cause pump 11 to discharge liquid into channel 15, and pressure will extend from channel 15 through channel 25 to the left end of bore 19 and shift differential valve 24 toward the right.

The liquid discharged by pump 11 will flow through channel 15 to the upper end of cylinder 7 and cause piston 6 to move die 3 downward, and it will expel liquid from the lower end of cylinder 7 through resistance valve 76, channel 75, valve 67 and channel 16 to the intake of pump 11, the additional liquid required by pump 11, being drawn from reservoir 21 through check valve 22 and differential valve casing 20.

Just after die 3 starts downward, limit switch LS3 operates to disconnect conductor 131 from conductor 130 and to connect conductor 133 to conductor 115 but this has no effect at this time.

When die 3 engages the blank, it will press the edge portion thereof against pressure pad 5 and then move pressure pad 5 downward and force the blank over die 1 to form it into a desired shaped. Just after pressure pad 5 starts downward, limit switch LS2 operates to connect conductors 129 and 130 to conductor 115 but this has no effect at this time.

As pressure pad 5 moves downward, it causes pistons 8 to expel liquid from cylinders 9 through channels 65 and resistance valves 66 into drain channel 55. Resistance valves 66 will resist the discharge of liquid therethrough and thereby cause the edge portion of the blank to be firmly gripped between pressure pad 5 and die 3.

When the blank has been formed into the desired shape, switch S1 is operated to disconnect conductor 121 from conductor 115 and to connect conductors 122 and 124 to conductor 115. If switch S1 is a limit switch, it is operated when die 3 or pressure pad 5 reaches a predetermined point in its downward movement. If switch S1 is a pressure responsive switch, it operates when die 3 is pressing the metal against die 1 with a predetermined force.

Disconnecting conductor 121 from conductor 115 breaks the circuit through magnet A4 so that magnet A4 is deenergized and switches A1, A2 and A3 open, thereby deenergizing solenoid 60.

Connecting conductor 122 to conductor 115 establishes a circuit from conductor 115 through switch S1, conductor 122, magnet B4 and conductor 123 to conductor 110 and causes magnet B4 to be energized, and it establishes a circuit from conductor 115 through switch S1, conductor 124, switch C2, conductor 124^a, magnet D4 and conductor 125 to conductor 110 and causes magnet D4 to be energized.

Magnet B4 will close switches B1, B2 and B3 to establish a circuit from conductor 110 through conductor 126, switch B1, solenoid 61, switch B2 and conductor 127 to conductor 111 so that solenoid 61 is energized, and to establish a circuit from conductor 115 through switch LS2, conductor 129, switch B3, conductors 128 and 122, magnet B4 and conductor 123 to conductor 110 so that magnet B4 will not be deenergized when switch S1 is returned to its initial position.

Magnet D4 will close switches D1, D2 and D3 to establish a circuit from conductor 110 through conductor 137, switch D1, solenoid 104, switch D2 and conductor 138 to conductor 111, so that solenoid 104 is energized, and to establish a circuit from conductor 115 through switch LS3, conductor 133, switch D3, conductors 134 and 124^a, magnet D4 and conductor 125 to conductor 110 so that magnet D4 will not be deenergized should switch S1 disconnect conductor 124 from conductor 115 when die 3 starts upward.

Energizing solenoid 104 will cause it to shift plunger 90 of pilot valve 89 to the position shown in Fig. 10 and then liquid from gear pump 41 will flow through channel 42, valve 89 and channel 97 to chamber 87 and shift plunger 68 of control valve 67 to the position shown in Fig. 10, thereby opening channel 79 to channel 80 so that enough liquid can escape from cylinders 8 through low pressure relief valve 81 to cause the pressure in cylinders 8 to drop to a value which is low enough to prevent pistons 8 from moving pressure pad 5 upward when die 3 ascends but which is high enough to support pressure pad 5 in the position to which it was moved by die 3.

Deenergizing solenoid 60 and energizing solenoid 61 causes solenoid 61 to shift plunger 47 of valve 46 to the position shown in Fig. 8 and then liquid from gear pump 41 flows through channel 42, valve 46 and channel 54 to cylinder 34 and causes piston 33 to shift slide block 14 toward the left and thereby reverse pump 11.

Liquid from pump 11 will then flow through channel 16, valve 67, channel 75 and check valve 77 to the lower end of cylinder 7 and cause piston 6 to raise die 3 and pressure will extend from channel 16 through channel 26 to the right end of bore 19 and shift differential valve 24 to the position shown so that, as piston 6 moves upward and expels liquid from the upper end of cylinder 7, the liquid expelled from cylinder 7 in excess of the volume required by pump 11 may be exhausted through bore 19 and resistance valve 23 into reservoir 21.

Solenoids 61 and 104 are energized simultaneously so that valve plungers 47 and 90 are shifted and cause gear pump pressure to be applied to piston 33 and to the end of valve plunger 68 substantially simultaneously. However, valve plunger 68 will be shifted almost instantly but there will be a slight delay in shifting slide block 14 due to its inertia. While this delay is very slight it is sufficient to permit the pressure in cylinders 8 to drop to the desired low value.

However, if pump 11 should tend to reverse too quickly, reversal thereof may be delayed either by delaying the operation of valve 46 or by delaying the energization of solenoid 61.

The operation of valve 46 may be delayed by connecting a choke into channel 54 in the well known manner and as shown in Fig. 3 in which the operation of a reversing valve is delayed by a choke.

Energization of solenoid 61 may be delayed by a pressure responsive switch which remains open until the pressure in cylinders 8 has dropped to substantially the desired low value. As shown in Fig. 7, conductor 122 is divided into two parts and the adjacent ends of the two parts are connected to the terminals of a switch 145 which is urged toward closed position by a spring 146 the tension of which is adjusted by a screw 147 threaded through a stationary abutment 148. Switch 145 is adapted to be opened by a piston 149 fitted in a cylinder 150 which is connected to channel 79.

The arrangement is such that, when pressure pad 5 is moved downward and causes a high pressure to be created in cylinders 8, pressure will extend through channels 65, check valves 84 and channel 79 to cylinder 150 and cause piston 149 to open switch 145, thereby preventing magnet B4 from being energized when switch S1 oper-

ates. As soon as the pressure in cylinders 8 is reduced to the desired low value, spring 146 will close switch 145 and cause magnet B4 to be energized and cause switches B1 and B2 to close and energize solenoid 61.

When die 3 reaches its upper position, it operates limit switch LS3 to disconnect conductor 133 from conductor 115 and to connect conductor 131 to conductor 130.

If switch S1 disconnects conductor 124 from conductor 115 when die 3 starts upward, which it would probably do if it were a pressure responsive switch, disconnecting conductor 133 from conductor 115 would break the circuit through magnet D4 and thereby deenergizing it but, if switch S1 were a limit switch and did not disconnect conductor 124 from conductor 115 when die 3 moved upward, disconnecting conductor 133 from conductor 115 would not deenergize magnet D4 as a circuit therethrough is maintained by switch C2.

Connecting conductor 131 to conductor 130 establishes a circuit from conductor 115 through switch LS2, conductor 130, switch LS3, conductor 131, magnet C3, and conductor 132 to conductor 110, thereby causing magnet C3 to be energized.

Magnet C3 will operate switches C1 and C2 to connect opposite ends of solenoid 103 to conductors 135 and 136, so that solenoid 103 is energized, and to disconnect conductor 124^a from conductor 124 so that magnet D4 is deenergized and permits switches D1 and D2 to open and deenergize solenoid 104.

Deenergizing solenoid 104 and energizing solenoid 103 causes solenoid 103 to shift plunger 90 of pilot valve 89 to the position shown in Fig. 11 so that liquid from gear pump 41 may flow through channel 42, valve 89 and channel 98 to chamber 88 and shift plunger 68 of control valve 67 to the position shown in Fig. 11 and then liquid from pump 11 will flow through channel 16, valve 67, channel 78, check valves 83 and channels 65 to cylinders 9 and cause pistons 8 to raise pressure pad 5.

As pressure pad 5 starts upward, switch S1, if a limit switch, will operate to disconnect conductors 122 and 124 from conductor 115 and to connect conductor 121 to conductor 115 but this has no effect until the press starts another cycle of operation.

When pressure pad 5 reaches its upper limit, it operates limit switch LS2 to disconnect conductors 129 and 130 from conductor 115, thereby deenergizing magnets B4 and C3 so that switches C1, C2, B1 and B2 may operate to deenergize solenoids 61 and 103.

Deenergizing solenoid 103 permits spring 100 to move plunger 90 of pilot valve 89 to its neutral position so that chambers 87 and 88 are open to drain channel 55 and spring 85 is permitted to shift plunger 68 of control valve 67 to its neutral position as shown in Fig. 1.

Deenergizing solenoid 61 permits spring 57 to shift plunger 47 of valve 46 to its neutral position as shown in Fig. 1, thereby connecting channel 54 to drain channel 55 so that gear pump liquid acting upon piston 30 may move slide block 14 to its neutral position and cause the press to come to rest upon the parts thereof in the proper positions to start a second cycle of operation when switch 112 is closed.

Fig. 3

The press shown in this figure differs from the press shown in Fig. 1 only in that it is powered by a unidirectional pump and reversed through a reversing valve. Consequently, like parts have been indicated by like reference numerals, so that further description thereof is unnecessary, and corresponding parts have been indicated by corresponding reference numerals with the exponent "a" added thereto.

As shown, the press is powered by a unidirectional pump 151 which is driven at a substantially constant speed from a power source (not shown) and delivers liquid into a channel 152 and has liquid returned to it through a channel 153. In order to protect the pump from developing excessive pressures, a high pressure relief valve 154 is connected to the outlet of the pump and discharges into reservoir 21.

Since the volume returned to the pump from the circuit is always greater or less than the volume discharged by the pump when the press is in operation, a check valve 22^a and a low pressure resistance valve 23^a are connected to the intake of the pump and extend into reservoir 21 so that, when piston 6 moves downward, pump 151 may draw additional liquid from reservoir 21 through check valve 22^a and, when piston 6 moves upward, the liquid expelled thereby from cylinder 7 in excess of pump requirements may be exhausted through resistance valve 23^a into reservoir 21.

The liquid discharged by pump 151 is directed either into channel 15 or into channel 16 by a reversing valve 155 fitted in a bore 156 which is formed in a valve casing 157 and has four annular grooves or ports 158, 159, 160 and 161 formed in the wall thereof. Channel 152 is connected to port 158. Channel 153 is divided into two branches one of which is connected to port 159 and the other of which is connected to the left end of bore 156, the other end of bore 156 being connected to a branch of drain channel 55. Channel 15, which has one of its ends connected to the upper end of ram cylinder 7, has its other end connected to port 160. Channel 16, which has one of its ends connected to port 70 in control valve 67, has its other end connected to port 161.

Reversing valve 155 is urged toward and normally held in its central or neutral position by a caged spring 162 arranged in a spring chamber 163 which is fixed to the left end of valve casing 157. Spring 162 acts upon a valve stem 164 which is fixed to the left end of valve 155 and extends through chamber 163.

Reversing valve 155 is adapted to be shifted in one direction or the other by a hydraulic servomotor consisting of a cylinder 165, which is fixed to the right end of valve casing 157, and a piston 166 which is fitted in cylinder 165 and connected by a suitable valve stem to valve 155.

Servo-motor 165—166 is energized by liquid supplied thereto by gear pump 41 under the control of a pilot valve 179 having a valve member or plunger 180 arranged in a casing 181 and controlling communication between five annular grooves or ports 182, 183, 184, 185 and 186 which are formed in the inner wall of casing 181.

Port 182 has gear pump supply channel 42 connected thereto, ports 183 and 184 have drain channel 55 connected thereto, port 185 is connected by a channel 187 to the inner end of cylinder 165, and port 186 has connected thereto a channel 188 having two branches one of which is connected to the extreme right end of cylinder 165 through a choke 189 and the other of which is connected to a port 190 formed in the

wall of cylinder 165 and so located that it is covered by piston 166 as soon as piston 166 moves toward the right from its central or neutral position. Cylinder 165 also has its right end connected to drain channel 55 through a check valve 191 which permits liquid to be drawn from channel 55 into cylinder 165 but prevents liquid from being expelled from cylinder 165 directly into channel 55.

The arrangement is such that, when valve member 180 of pilot valve 179 is in the position shown in Fig. 3, port 182 is blocked and both ends of cylinder 165 are open to drain channel 55 through channels 187 and 188 and pilot valve 179 so that reversing valve 155 is held in its central or neutral position by spring 162 in which position of valve 155 channel 152 is open to return channel 153 through bore 156 so that pump 151 is bypassed.

Pilot valve member 180 is urged toward and normally retained in its central or neutral position by two springs 192 and 193 arranged, respectively, in two spring chambers 194 and 195 which are formed in opposite ends of valve casing 181 and have drain channel 55 connected thereto to prevent liquid or air from being trapped therein.

Valve member 180 is adapted to be shifted in one direction or the other by one or the other of two solenoids 60^a and 61^a arranged at opposite ends of valve casing 181 and having the cores thereof connected to suitable valve stems which extend through the spring chambers and are fixed to opposite ends of valve member 180. Solenoids 60^a and 61^a correspond, respectively, to solenoids 60 and 61 (Figs. 1 and 2) and are connected into the electric circuit and controlled in the same manner as solenoids 60 and 61.

The press is controlled by the electric circuit shown in Fig. 2 and it operates in exactly the same manner as the press shown in Fig. 1 except that the flow of liquid is reversed by means of a reversing valve instead of reversing the pump, and choke 189 functions to delay the movement of the reversing valve in one direction.

When starting switch 112 is closed, solenoid 60^a will be energized in the previously described manner and will shift pilot valve member 180 toward the left to the position shown in Fig. 12 so that liquid from gear pump 41 may flow through channel 42, valve casing 181 and channel 188 to the right end of cylinder 165 and cause piston 166 to shift reversing valve 155 toward the left to the position shown in Fig. 12.

Liquid from pump 151 will then flow through channel 152, bore 156 and channel 15 to the upper end of ram cylinder 7 and cause piston 6 to move die 3 downward. Limit switches LS3 and LS2 will operate during downward movement of die 3 and switch S1 will be operated when die 3 reaches the end of its down stroke as previously explained.

Operating switch S1 will cause solenoid 60^a to be deenergized and solenoid 61^a and 104 to be energized in the previously described manner.

Solenoid 104 will shift valve member 90 of pilot valve 89 to the position shown in Fig. 10, thereby causing valve member 68 of control valve 67 to be shifted to the position shown in Fig. 10 so that liquid can escape from cylinders 8 through low pressure relief valve 81 as previously explained.

Solenoid 61^a will shift pilot valve member 180 toward the right to the position shown in Fig. 13 so that liquid from gear pump 41 may flow through channel 42, valve casing 181 and channel 187 to the left end of cylinder 165 and cause piston 166 to move reversing valve 155 toward the right to the position shown in Fig. 13, thereby causing the liquid discharged by pump 151 to flow through channel 16, control valve 67, channel 75 and check valve 77 to the lower end of ram cylinder 7 and move piston 6 and die 3 upward.

Piston 166 will move at high speed and eject liquid from the right end of cylinder 165 through channel 188 and pilot valve casing 181 into drain channel 55 until reversing valve 155 reaches its neutral position and bypasses pump 151 and then piston 166 will cover port 190 so that liquid must then be ejected through choke 189 which causes piston 166 to move at a much slower speed and thereby delay the upward movement of die 3 until after enough liquid has escaped from cylinders 9 to drop the pressure therein to the desired low value.

When die 3 reaches its upper position, it operates limit switch LS3 to deenergize solenoid 104 and energize solenoid 103 so that valve plungers 90 and 68 are shifted and then the liquid discharged by pump 151 will enter cylinders 9 and cause pistons 8 to raise pressure pad 5 as previously explained.

When pressure pad 5 reaches its upper limit, it operates limit switch LS2 to deenergize solenoids 103 and 61^a in a previously described manner. Deenergizing solenoid 103 permits spring 100 to move pilot valve plunger 90 to its neutral position and then spring 85 will move control valve plunger 68 to its neutral position as previously explained.

Deenergizing solenoid 61^a permits spring 162 to shift reversing valve 155 to its neutral position to bypass pump 151 and stop the press, piston 166 drawing liquid from drain channel 55 through check valve 191 into cylinder 165 as valve 155 moves toward its neutral position.

Figs. 4 and 5

The press shown in Fig. 4 is the same as the press shown in Fig. 1 except that means are provided for regenerating the greater part of the power required to resist the downward movement of the pressure pad. Consequently, like parts have been indicated by like reference numerals, so that further description thereof is unnecessary, and corresponding parts have been indicated by corresponding reference numerals with the exponent "b" added thereto.

In order that the greater part of the power required to resist downward movement of pressure pad 5 may be regenerated, cylinders 7 and 9 are so proportioned that the volume of liquid expelled from cylinders 9 by pistons 8 during downward movement of pressure pad 5 is greater than the volume delivered by pump 11^b to the upper end of ram cylinder 7 to cause piston 6 to move die 3 and pressure pad 5 downward, the liquid expelled from cylinders 9 is directed to the intake of pump 11^b, and the liquid expelled from cylinders 9 in excess of the liquid required to supercharge pump 11^b is forced through a high pressure relief valve.

Pump 11^b and its control valve 46 are the same as the pump and the pump control valve shown in Fig. 1 and they are operated and controlled in exactly the same manner. However, since pump 11^b is supplied during a part of a cycle of operation with liquid from cylinders 9, the liquid expelled from ram cylinder 7 by piston 6 is directed through drain channel 55 into reservoir 21.

Therefore, instead of connecting pump 11b to reservoir 21 through a differential valve 20—24 as shown in Fig. 1, its two ports are connected, respectively, to the outlets of two check valves 201 and 202, which permit pump 11b to draw liquid from reservoir 21 in either direction of pump delivery, and to the inlet of two high pressure relief valves 203 and 204 which protect the pump from developing excessive pressures in either direction of pump delivery.

Liquid is delivered from pump 11b either to the lower end of ram cylinder 7 or to pressure pad cylinders 9 under the control of a valve 67b having a valve member or plunger 68b fitted in a valve casing 69b and controlling communication between six annular grooves or ports 70b, 71b, 72b, 73b, 74b and 205 which are formed in the inner wall of casing 69b.

Port 70b is connected by channel 16 to one port of pump 11b, port 71b is connected to the lower end of ram cylinder 7 by a channel 75b having a resistance valve 76 and a check valve 77 connected therein in parallel with each other and adapted to open in opposite directions, port 72b has one end of a channel 78b connected thereto, port 73b has one end of a channel 79b connected thereto, port 74b is connected to the inlet of low pressure resistance valve 81 which discharges into drain channel 55 and has only enough resistance to enable piston 8 to support pressure pad 5 as previously explained, and port 205 has drain channel 55 connected thereto.

Valve member 68b is normally held in its central or neutral position by two springs 85b and 86b arranged, respectively, in two chambers 87b and 88b formed in opposite ends of valve casing 69b, and it is adapted to be shifted in one direction or the other by liquid supplied to one or the other of chambers 87b and 88b and acting upon one end or the other of valve member 68b. The delivery of liquid to chambers 87b and 88b is controlled by pilot valve 89 which is connected into the circuit and functions in exactly the same manner as in the circuit shown in Fig. 1.

Instead of channel 15 connecting one port of the pump directly to the upper end of the ram cylinder as in the press shown in Fig. 1, it connects one port of pump 11b to one end of a valve casing 206 which has two ports 207 and 208 formed therein intermediate the ends thereof, its other end connected to channel 75b by a channel 209, and a valve 210 fitted therein to control the flow of liquid thereto, port 207 being connected by a channel 211 to the upper end of ram cylinder 7 and port 208 having drain channel 55 connected thereto.

The arrangement is such that, when pump 11b discharges liquid through channel 15 at which time valve plunger 68b is in the position shown in Fig. 14, liquid will flow through channel 15 to valve casing 206, shift valve 210 to the position shown in Fig. 16 and then flow through casing 206 and channel 211 to the upper end of cylinder 7 and cause piston 6 to move downward and expel liquid from the lower end of cylinder 6 through resistance valve 76, channel 75b and valve 67b into drain channel 55.

When pump 11b discharges liquid into channel 16 at which time valve plunger 68b is in the position shown in Fig. 15, liquid will flow through channel 16, control valve 67b, channel 75b and check valve 77 to the lower end of cylinder 7 and pressure will extend through channel 209 to the right end of valve casing 206 and shift valve 210 to the position shown in Fig. 4. The liquid delivered to the lower end of cylinder 7 will move piston 6 upward and cause it to expel liquid from the upper end of cylinder 7 through channel 211 and valve casing 206 into drain channel 55.

In order to maintain pressure in the several cylinders 9 during downward movement of pressure pad 5, and in order that the pressure in one cylinder may be varied relative to the pressure in another cylinder, channel 78b is connected intermediate its ends to the inlet of a high pressure relief valve 212, the outlet of which is connected to drain channel 55, and each cylinder 9 is connected by a channel 65b to the inlet of a low pressure resistance valve 66b the outlet of which is connected to channel 78b.

In order that liquid may escape from cylinders 9 through low pressure resistance valve 81 when valve plunger 68b is in the position shown in Fig. 15, each channel 65b is connected to channel 79b through a check valve 84b and, in order that liquid may be delivered to cylinders 9 when valve plunger 68b is in the position shown in Fig. 4, each channel 65b is connected to channel 78b through a check valve 83b.

The electric circuit

Referring now more particularly to Fig. 5, solenoids 60 and 103 are controlled by a contactor switch F having three switches F1, F2 and F3 and a magnet F4 for operating the switches, solenoid 61 is controlled by a contactor switch G having three switches G1, G2 and G3 and a magnet G4 for operating the switches, and solenoid 104 is controlled by a contactor switch H having three switches H1, H2 and H3 and a magnet H4 for operating the switches.

In order to simplify the drawing, contactor switches F, G and H have been shown arranged horizontally but in practice they are arranged vertically so that, when the magnets are deenergized, the switches will open by gravity to the positions shown.

The operation of the press is controlled by a normally closed manually operable switch 220 which may be opened to stop the press at any time, a normally open starting switch 221, a switch S1 which is operated at the end of the downward movement of die 3 and which may be either a limit switch or a pressure responsive switch as previously explained, a limit switch LS2 which is operated by pressure pad 5 at the limit of its upward movement, and a limit switch LS3 which is operated by die 3 at the end of its upward movement.

Current for energizing the solenoids and the magnets is supplied from a suitable source such as a power line which has been representated by two conductors 222 and 223. Stop switch 220 has one of its terminals connected by conductor 224 to conductor 223 and its other terminal connected by a conductor 225 to one terminal of starting switch 221, to two opposed terminals of switch S1, to one terminal of switch LS2 and to one terminal of switch LSR.

The second terminal of switch 221 is connected by conductor 226 to one end of the winding of magnet F4 the other end of which is connected to conductor 222 by a conductor 227 so that closing switch 221 will cause magnet F4 to be energized and close switches F1, F2 and F3.

Switch F1 has one of its terminals connected to conductor 222 by a conductor 228 and its other terminal connected to one end of each of the windings of the solenoids 60 and 103 the other ends of which are connected to one terminal of

switch F2. The other terminal of switch F2 is connected to conductor 223 by a conductor 229 so that solenoids 60 and 103 are energized when switches F1 and F2 are closed.

Switch F3 has one of its terminals connected by a conductor 230 to conductor 226 intermediate the ends thereof and its other terminal connected to a third terminal of switch S1 by a conductor 231.

The fourth terminal of switch S1 is connected by a conductor 232 to one end of the winding of magnet G4 the other end of which is connected to conductor 222 by a conductor 233.

The fourth terminal of switch S1 is also connected by a conductor 234 to one terminal of switch G3 a second terminal of which is connected to one end of a conductor 235. The other end of conductor 235 is connected to one end of the winding of magnet H4 the other end of which is connected to conductor 222 by a conductor 236.

A third terminal of switch G3 is connected by a conductor 237 to conductor 232 intermediate the ends thereof and the fourth terminal of switch G3 is connected by a conductor 238 to the other terminal of limit switch LS2 in order to maintain a holding circuit through magnet G4 when switch S1 operates.

Switch G1 has one of its terminals connected to conductor 222 by a conductor 239 and its other terminal connected to one end of the winding of solenoid 61 the other end of which is connected to one terminal of switch G2. The other terminal of switch G2 is connected to conductor 223 by a conductor 240.

Switch H1 has one of its terminals connected to conductor 222 by a conductor 241 and its other terminal connected to one end of the winding of solenoid 104 the other end of which is connected to one terminal of switch H2. The other terminal of switch H2 is connected to conductor 223 by a conductor 242. Switch H3 has one of its terminals connected by conductor 243 to conductor 235 intermediate the ends thereof and its other terminal connected by a conductor 244 to the second terminal of limit switch LS3 in order to maintain a holding circuit through magnet H4 when switch S1 operates.

Operation

Assuming that the several parts are in the positions shown in Figs. 4 and 5, that pumps 11b and 41 are running and that a metal blank is arranged upon die 1 and pressure pad 5, the press will operate as follows:

When starting switch 221 is closed, a circuit will be established from conductor 223 through conductor 224, stop switch 220, conductor 225, switch 221, conductor 226, magnet F4 and conductor 227 to conductor 222, thereby energizing magnet F4 which will close switches F1, F2 and F3.

The above circuit will be broken when switch 221 is released but, as soon as switch F3 closes, it will establish a circuit from conductor 222 through conductor 227, magnet F4, conductors 226 and 230, switch F3, conductor 231 and switch S1 to conductor 225 which is aways connected to conductor 223 as long as switch 220 remains closed, thereby preventing magnet F4 from being deenergized when starting switch 221 opens.

Closing switches F1 and F2 establishes a circuit from conductor 222 through conductor 228, switch F1, solenoids 60 and 103, switch F2 and conductor 229 to conductor 223, thereby energizing solenoids 60 and 103.

Solenoids 103 when energized will shift pilot valve plunger 90 to the position shown in Fig. 11 and then liquid from gear pump 41 will flow through channel 42, pilot valve 89 and channel 98 to chamber 88b and shift control valve plunger 68b to the position shown in Fig. 14.

Solenoid 60 when energized will shift plunger 47 of pump control valve 46 to the position shown in Fig. 9 and thereby cause pump 11b to draw liquid from reservoir 21 through check valve 202 and discharge it into channel 15. This liquid will flow through channel 15 to valve casing 206 and shift valve 210 to the position shown in Fig. 16 and then the liquid will flow through valve casing 206 and channel 211 to the upper end of ram cylinder 7 and cause piston 6 to move die 3 downward. Piston 6 in moving downward will expel liquid from the lower end of cylinder 7 through resistance valve 76, channel 75b and control valve 67b into drain channel 55.

When die 3 engages the blank, it will press the edge portion thereof against pressure pad 5 and then move pressure pad 5 downward and force the blank over die 1 to form it into a desired shape. Just after die 3 starts downward, limit switch LS3 operates to connect conductor 244 to conductor 225 and, just after pressure pad 5 starts downward, limit switch LS2 operates to connect conductor 238 to conductor 225 so that switches G and H will be operated when switch S1 is operated.

As pressure pad 5 is moved downward by die 3, it causes pistons 8 to expel liquid from cylinders 9 through channels 65b and low pressure resistance valves 66b into channel 78b. Enough of this liquid to supply pump 11b flows through channel 78b, control valve 67b and channel 16 to the intake of pump 11b and the remainder is expelled through high pressure relief valve 212 into drain channel 55.

The arrangement is such that the pressure in each cylinder 9 is equal to the resistance of the resistance valve 66b connected thereto plus the resistance of relief valve 212 so that the liquid in cylinders 9 resist the downward movement of pressure pad 5 and thereby causes the edge portion of the blank to be firmly gripped between pressure pad 5 and die 3, and pump 11b is supercharged at a pressure equal to the resistance of high pressure relief valve 212, thereby regenerating the greater part of the energy expended in resisting downward movement of pressure pad 5.

When the blank has been formed into the desired shape, switch S1 is operated to disconnect conductor 231 from conductor 225 and to connect conductors 232 and 234 to conductor 225. If switch S1 is a limit switch, it is operated when die 3 and pressure pad 5 reach predetermined points in their downward movements. If switch S1 is a pressure responsive switch, it operates when die 3 is pressing the metal against die 1 with a predetermined force.

Disconnecting conductor 231 from conductor 225 breaks the circuit through magnet F4 so that magnet F4 is deenergized and switches F1, F2 and F3 open, thereby deenergizing solenoids 60 and 103.

Connecting conductor 234 to conductor 225 establishes a circuit from conductor 225 through switch S1, conductor 234, switch G3, conductor 235, magnet H4 and conductor 236 to conductor

222 and causes magnet H4 to be energized and close switches H1, H2 and H3.

Closing switch H3 will establish a holding circuit from conductor 225 through limit switch LS3, conductor 244, switch H3, conductors 243 and 235, magnet H4 and conductor 236 to conductor 222 and keep magnet H4 energized when switch S1 operates. Closing switches H1 and H2 will establish a circuit from conductor 222 through conductor 241, switch H1, solenoid 104, switch H2 and conductor 242 to conductor 223, thereby energizing solenoid 104.

Connecting conductor 232 to conductor 225 establishes a circuit from conductor 225 through switch S1, conductor 232, magnet G4 and conductor 233 to conductor 222 and causes magnet G4 to be energized and operate switches G1, G2 and G3 to establish a circuit from conductor 222 through conductor 239, switch G1, solenoid 61, switch G2 and conductor 240 to conductor 223, so that solenoid 61 is energized, and to establish a circuit from conductor 225 through switch LS2, conductor 238, switch G3, conductor 237 and 232, magnet G4 and conductor 233 to conductor 222 so that magnet G4 will not be deenergized when switch S1 is returned to its neutral position.

Deenergizing solenoid 103 and energizing solenoid 104 will cause solenoid 104 to shift valve plunger 90 of pilot valve 89 to the position shown in Fig. 10 and then liquid from gear pump 41 will flow through channel 42, valve 89 and channel 97 to chamber 87b and shift plunger 68b of control valve 67b to the position shown in Fig. 15, thereby opening port 73b to port 74b so that enough liquid can escape from cylinders 8 through low pressure relief valve 81 to cause the pressure in cylinders 8 to drop to a value which is low enough to prevent pistons 8 from moving pressure pad 5 upward when die 3 ascends but which is high enough to support pressure pad 5 in the position to which it was moved by die 3.

Deenergizing solenoid 60 and energizing solenoid 61 causes solenoid 61 to shift plunger 47 of valve 46 to the position shown in Fig. 8 so that pump 11b is reversed as previously explained. Liquid from pump 11b will then flow through channel 16, valve 67b channel 75b and check valve 77 to the lower end of cylinder 7 and cause piston 6 to raise die 3 and pressure will extend from channel 75b through channel 209 to right end of valve casing 206 and shift valve 210 to the position shown in Fig. 4 so that piston 6 may expel liquid from the upper end of ram cylinder 7 through channel 211 and valve casing 206 into drain channel 55.

Solenoids 61 and 104 are energized simultaneously but control valve 67b will shift and permit the pressure in cylinders 9 to drop to a low value before pump 11b reverses and causes piston 6 to raise die 3 as previously explained.

When die 3 reaches its upper position, it operates limit switch LS3 to disconnect conductor 244 from conductor 225, thereby deenergizing magnet H4 which permits switches H1 and H2 to open and deenergize solenoid 104.

Deenergizing solenoid 104 permits spring 99 to shift plunger 90 of pilot valve 89 to the neutral position shown in Fig. 4 so that chambers 87b and 88b are open to drain channel 55. Then spring 86b will shift plunger 68b of control valve 67b to the position shown in Fig. 4 to permit the liquid discharged by pump 11b to flow through channel 16, valve 67b, channel 78b, check valves 83b and channels 65b to cylinders 9 and cause pistons 8 to raise pressure pad 5.

As pressure pad 5 starts upward, switch S1 if a limit switch will operate to disconnect conductors 232 and 234 from conductor 225 and to connect conductor 231 to conductor 225 but this has no effect until the press starts another cycle of operation.

When pressure pad 5 reaches its upper limit, it operates limit switch LS2 to disconnect conductor 238 from conductor 225 thereby deenergizing magnet G4. Deenergizing magnet G4 permits switches G1 and G2 to open and deenergize solenoid 61 which permits spring 57 to shift plunger 47 of pump control valve 46 to its neutral position, thereby causing pump displacement to be reduced to zero in the previously described manner and the press to come to rest with the several parts thereof in the proper positions to start a second cycle of operation when starting switch 221 is closed.

While the invention has been shown embodied in vertical presses of the downward acting type, it is to be understood that the invention may be as readily embodied in other types of presses, that the terms used in the claims to denote direction are illustrative only and not limiting, and that the invention is susceptible of various modifications and adaptations without departing from the scope thereof.

The invention is hereby claimed as follows:

1. In a metal working press, the combination of a die, a pressure member arranged below said die and adapted to be moved downward thereby, hydraulic means including liquid containing means having displacement means arranged therein for supporting said member, said hydraulic means being adapted to have liquid expelled therefrom during downward movement of said member, means for providing sufficient resistance to the expulsion of liquid from said hydraulic means to cause a high pressure to be created therein and thereby enable said hydraulic means to resist downward movement of said member, means adapted when effective to reduce the pressure in said hydraulic means to a value which is low enough to prevent said hydraulic means from raising said member when said die starts upward but which is high enough to support said member in the position to which it was moved by said die, and means responsive to said die reaching the end of its downward movement for rendering said last named means effective before said die starts upward.

2. In a metal working press, the combination of a die, a pressure member arranged below said die and adapted to be moved downward thereby, hydraulic means including liquid containing means having displacement means arranged therein for supporting said member, said hydraulic means being adapted to have liquid expelled therefrom during downward movement of said member, a high pressure relief valve for resisting the expulsion of liquid from said hydraulic means to cause a high pressure to be created therein and thereby enable said hydraulic means to resist downward movement of said member, a low pressure relief valve, and means operable at the end of the downward movement of said die for connecting said hydraulic means to said low pressure valve before said die starts upward to thereby reduce the pressure in said hydraulic means to a low value.

3. In a metal working press, the combination of a die, a pressure member arranged below said die and adapted to be moved downward thereby, hydraulic means including liquid containing

means having displacement means arranged therein for supporting said member, said hydraulic means being adapted to have liquid expelled therefrom during downward movement of said member, means for providing sufficient resistance to the expulsion of liquid from said hydraulic means to cause a high pressure to be created therein and thereby enable said hydraulic means to resist downward movement of said member, means adapted where effective to reduce the pressure in said hydraulic means to a value which is low enough to prevent said hydraulic means from raising said member when said die starts upward but which is high enough to support said member in the position to which it was moved by said die, means responsive to said die reaching the end of its downward movement for rendering said last named means effective before said die starts upward, and means responsive to said die reaching a given point in its upward movement for directing liquid to said hydraulic means to cause it to raise said pressure member.

4. In a metal working press, the combination of a die, a pressure member arranged below said die and adapted to be moved downward thereby, hydraulic means including liquid containing means having displacement means arranged therein for supporting said member, said hydraulic means being adapted to have liquid expelled therefrom during downward movement of said member, a high pressure relief valve for resisting the expulsion of liquid from said hydraulic means to cause a high pressure to be created therein and thereby enable said hydraulic means to resist downward movement of said member, a low pressure relief valve, means operable at the end of the downward movement of said die for connecting said hydraulic means to said low pressure valve before said die starts upward to thereby reduce the pressure in said hydraulic means to a low value, and means responsive to said die reaching a given point in its upward movement for directing liquid to said hydraulic means to cause it to raise said pressure member.

5. In a metal working press, the combination of a die, a pressure member arranged below said die and adapted to be moved downward thereby, hydraulic means including liquid containing means having displacement means arranged therein for supporting said member, said hydraulic means being adapted to have liquid expelled therefrom during downward movement of said member, a high pressure relief valve for resisting the expulsion of liquid from said hydraulic means to cause a high pressure to be created therein and thereby enable said hydraulic means to resist downward movement of said member, a low pressure relief valve, means including an element responsive to said die reaching a given point in its downward movement and an element responsive to pump pressure reaching a predetermined maximum for connecting said hydraulic means to said low pressure valve to thereby reduce the pressure in said hydraulic means to a low value, and means for rendering either one or the other of said elements effective.

6. In a metal working press, the combination of a die, a hydraulic motor for moving said die upward and downward, a pressure member arranged below said die and adapted to be moved downward thereby, hydraulic means including liquid containing means having displacement means arranged therein for supporting said member, said hydraulic means being adapted to have liquid expelled therefrom during downward movement of said member, a high pressure relief valve for resisting the expulsion of liquid from said hydraulic means to cause a high pressure to be created therein and thereby enable said hydraulic means to resist downward movement of said member, a pump, fluid channels connecting said pump to said motor and said hydraulic means and forming therewith a hydraulic circuit, means for causing said pump to deliver liquid in a direction to cause said motor to move said die downward and thereby cause said member to be moved downward, a low pressure relief valve, means operable at the end of the downward movement of said die for first connecting said hydraulic means to said low pressure valve before said die starts upward to thereby reduce the pressure in said hydraulic means to a low value and for then causing reversal of the flow in said circuit to thereby cause said motor to move said die upward, and means responsive to said die reaching a given point in its upward movement for directing liquid from said pump said hydraulic means to cause it to raise said pressure member.

7. In a metal working press, the combination of a die, a hydraulic motor for moving said die upward and downward, a pressure member arranged below said die and adapted to be moved downward thereby, hydraulic means including liquid containing means having displacement means arranged therein for supporting said member, said hydraulic means being adapted to have liquid expelled therefrom during downward movement of said member, means for providing sufficient resistance to the expulsion of liquid from said hydraulic means to cause a high pressure to be created therein and thereby enable said hydraulic means to resist downward movement of said member, a pump, fluid channels connecting said pump to said motor and said hydraulic means and forming therewith a hydraulic circuit, means for causing said pump to deliver liquid in a direction to cause said motor to move said die downward and thereby cause said member to be moved downward, means operable at the end of the downward movement of said die and before said die starts upward for first reducing the pressure in said hydraulic means to a value which is low enough to prevent said hydraulic means from raising said member when said die starts upward but which is high enough to support said member in the position to which it was moved by said die, and means responsive to the pressure in said hydraulic means being reduced to a low value for causing reversal of the flow in said circuit to thereby cause said motor to move said die upward.

8. In a metal working press, the combination of a die, a hydraulic motor for moving said die upward and downward, a pressure member arranged below said die and adapted to be moved downward thereby, hydraulic means including liquid containing means having displacement means arranged therein for supporting said member, said hydraulic means being adapted to have liquid expelled therefrom during downward movement of said member, means for providing sufficient resistance to the expulsion of liquid from said hydraulic means to cause a high pressure to be created therein and thereby enable said hydraulic means to resist downward

movement of said member, a pump, fluid channels connecting said pump to said motor and said hydraulic means and forming therewith a hydraulic circuit, means for causing said pump to deliver liquid in a direction to cause said motor to move said die downward and thereby cause said member to be moved downward, and means operable at the end of the downward movement of said die and before said die starts upward for first reducing the pressure in said hyldraulic means to a value which is low enough to prevent said hydraulic means from raising said member when said die starts upward but which is high enough to support said member in the position to which it was moved by said die and for then causing reversal of the flow in said circuit to thereby cause said motor to move said die upward.

9. In a metal working press, the combination of a die, a hydraulic motor for moving said die upward and downward, a pressure member arranged below said die and adapted to be moved downward thereby, hydraulic means including liquid containing means having displacement means arranged therein for supporting said member, said hydraulic means being adapted to have liquid expelled therefrom during downward movement of said member, a high pressure relief valve for resisting the expulsion of liquid from said hydraulic means to cause a high pressure to be created therein and thereby enable said hydraulic means to resist downward movement of said member, a pump, fluid channels connecting said pump to said motor and said hydraulic means and forming therewith a hydraulic circuit, means for causing said pump to deliver liquid in a direction to cause said motor to move said die downward and thereby cause said member to be moved downward, a low pressure relief valve, and means operable at the end of the downward movement of said die for first connecting said hydraulic means to said low pressure valve before said die starts upward to thereby reduce the pressure in said hydraulic means to a low value and for then causing reversal of the flow in said circuit to thereby cause said motor to move said die upward.

10. In a metal working press, the combination of a die, a hydraulic motor for moving said die upward and downward, a pressure member arranged below said die and adapted to be moved downward thereby, hydraulic means including liquid containing means having displacement means arranged therein for supporting said member, said hydraulic means being adapted to have liquid expelled therefrom during downward movement of said member, means for providing sufficient resistance to the expulsion of liquid from said hydraulic means to cause a high pressure to be created therein and thereby enable said hydraulic means to resist downward movement of said member, a pump, fluid channels connecting said pump to said motor and said hydraulic means and forming therewith a hydraulic circuit, means for causing said pump to deliver liquid in a direction to cause said motor to move said die downward and thereby cause said member to be moved downward, means operable at the end of the downward movement of said die and before said die starts upward for first reducing the pressure in said hydraulic means to a value which is low enough to prevent said hydraulic means from raising said member when said die starts upward but which is high enough to support said member in the position to which it was moved by said die and for then causing reversal of the flow in said circuit to thereby cause said motor to move said die upward, and means responsive to said die reaching a given point in its upward movement for directing liquid from said pump to said hydraulic means to cause it to raise said pressure member.

11. In a metal working press, the combination of a die, a hydraulic motor for moving said die upward and downward, a pressure member arranged below said die and adapted to be moved downward thereby, hydraulic means including liquid containing means having displacement means arranged therein for supporting said member, said hydraulic means being adapted to have liquid expelled therefrom during downward movement of said member, a high pressure relief valve for resisting the expulsion of liquid from said hydraulic means to cause a high pressure to be created therein and thereby enable said hydraulic means to resist ownward movement of said member, a pump, fluid channels connecting said pump to said motor and said hydraulic means and forming therewith a hydraulic circuit, means for causing said pump to deliver liquid in a direction to cause said motor to move said die downward and thereby cause said member to be moved downward, a low pressure relief valve, means operable at the end of the downward movement of said die for first connecting said hydraulic means to said low pressure valve before said die starts upward to thereby reduce the pressure in said hydraulic means to a low value and for then causing reversal of the flow in said circuit to thereby cause said motor to move said die upward, means responsive to said die reaching a given point in its upward movement for directing liquid from said pump to said hydraulic means to cause it to raise said pressure member, and means responsive to said member reaching a predetermined point in its upward movement for arresting the flow in said circuit to thereby stop said press.

12. In a metal working press, the combination of a die, a hydraulic motor for moving said die upward and downward, a pressure member arranged below said die and adapted to be moved downward thereby, a pump, means for directing liquid from said pump to said motor to cause it to move said die and said member downward, hydraulic means including liquid containing means having displacement means arranged therein for supporting said member, said hydraulic means being adapted to have liquid expelled therefrom during downward movement of said member and being of such capacity that liquid is expelled therefrom at a rate in excess of the rate at which said pump delivers liquid to said motor, a high pressure relief valve, means for connecting said hydraulic means to said relief valve and to the intake of said pump simultaneously whereby the liquid expelled from said hydraulic means in excess of pump requirements is exhausted through said relief valve and said pump is supercharged at a pressure substantially equal to the resistance of said relief valve, and means operable at the end of the downward movement of said die for first reducing the pressure in said hydraulic means to a value which is low enough to prevent said hydraulic means from raising said member when said die starts upward but which is high enough to sup-

port said member in the position to which it was moved by said die and for then reversing the delivery of liquid to said motor to cause it to move said die upward.

13. In a metal working press, the combination of a die, a hydraulic motor for moving said die upward and downward, a pressure member arranged below said die and adapted to be moved downward thereby, a pump, means for directing liquid from said pump to said motor to cause it to move said die and said member downward, hydraulic means including liquid containing means having displacement means arranged therein for supporting said member, said hydraulic means being adapted to have liquid expelled therefrom during downward movement of said member and being of such capacity that liquid is expelled therefrom at a rate in excess of the rate at which said pump delivers liquid to said motor, a high pressure relief valve, means for connecting said hydraulic means to said relief valve and to the intake of said pump simultaneously whereby the liquid expelled from said hydraulic means in excess of pump requirements is exhausted through said relief valve and said pump is supercharged at a pressure substantially equal to the resistance of said relief valve, a low pressure relief valve, and means operable at the end of the downward movement of said die for first connecting said hydraulic means to said low pressure valve to thereby reduce the pressure in said hydraulic means to a low value and for then reversing the delivery of liquid to said motor to cause it to move said die upward.

14. In a metal working press, the combination of a die, a hydraulic motor for moving said die upward and downward, a pressure member arranged below said die and adapted to be moved downward thereby, a pump, means for directing liquid from said pump to said motor to cause it to move said die and said member downward, hydraulic means including liquid containing means having displacement means arranged therein for supporting said member, said hydraulic means being adapted to have liquid expelled therefrom during downward movement of said member and being of such capacity that liquid is expelled therefrom at a rate in excess of the rate at which said pump delivers liquid to said motor, a high pressure relief valve, means for connecting said hydraulic means to said relief valve and to the intake of said pump simultaneously whereby the liquid expelled from said hydraulic means in excess of pump requirements is exhausted through said relief valve and said pump is supercharged at a pressure substantially equal to the resistance of said relief valve, a low pressure relief valve, means including an element responsive to said die reaching a given point in its downward movement and an element responsive to pump pressure reaching a predetermined maximum for connecting said hydraulic means to said low pressure valve to thereby reduce the pressure in said hydraulic means to a low value, and means for rendering either one or the other of said elements effective.

15. In a metal working press, the combination of a die, a hydraulic motor for moving said die upward and downward, a pressure member arranged below said die and adapted to be moved downward thereby, a pump, means for directing liquid from said pump to said motor to cause it to move said die and said member downward, hydraulic means including liquid containing means having displacement means arranged therein for supporting said member, said hydraulic means being adapted to have liquid expelled therefrom during downward movement of said member and being of such capacity that liquid is expelled therefrom at a rate in excess of the rate at which said pump delivers liquid to said motor, a high pressure relief valve, means for connecting said hydraulic means to said relief valve and to the intake of said pump simultaneously whereby the liquid expelled from said hydraulic means in excess of pump requirements is exhausted through said relief valve and said pump is supercharged at a pressure substantially equal to the resistance of said relief valve, means operable at the end of the downward movement of said die for first reducing the pressure in said hydraulic means to a value which is low enough to prevent said hydraulic means from raising said member when said die starts upward but which is high enough to support said member in the position to which it was moved by said die and for then reversing the delivery of liquid to said motor to cause it to move said die upward, means responsive to said die reaching a given point in its upward movement for directing the flow of liquid from said pump to said hydraulic means to cause it to raise said member, and means responsive to said member being raised to a given point for arresting said flow of liquid.

16. In a metal working press, the combination of a die, a hydraulic motor for moving said die upward and downward, a pressure member arranged below said die and adapted to be moved downward thereby, a pump, means for directing liquid from said pump to said motor to cause it to move said die and said member downward, hydraulic means including liquid containing means having displacement means arranged therein for supporting said member, said hydraulic means being adapted to have liquid expelled therefrom during downward movement of said member and being of such capacity that liquid is expelled therefrom at a rate in excess of the rate at which said pump delivers liquid to said motor, a high pressure relief valve, means for connecting said hydraulic means to said relief valve and to the intake of said pump simultaneously whereby the liquid expelled from said hydraulic means in excess of pump requirements is exhausted through said relief valve and said pump is supercharged at a pressure substantially equal to the resistance of said relief valve, a low pressure relief valve, means operable at the end of the downward movement of said die for first connecting said hydraulic means to said low pressure valve to thereby reduce the pressure in said hydraulic means to a low value and for then reversing the delivery of liquid to said motor to cause it to move said die upward, means responsive to said die reaching a given point in its upward movement for directing the flow of liquid from said pump to said hydraulic means to cause it to raise said member, and means responsive to said member being raised to a given point for arresting said flow of liquid.

17. In a metal working press, the combination of a die, a hydraulic motor for moving said die upward and downward, a pressure member arranged below said die and adapted to be moved downward thereby, a pump, means for directing liquid from said pump to said motor to cause it to move said die and said member downward, hydraulic means including liquid containing means

having displacement means arranged therein for supporting said member, said hydraulic means being adapted to have liquid expelled therefrom during downward movement of said member and being of such capacity that liquid is expelled therefrom at a rate in excess of the rate at which said pump delivers liquid to said motor, a high pressure relief valve, means for connecting said hydraulic means to said relief valve and to the intake of said pump simultaneously whereby the liquid expelled from said hydraulic means in excess of pump requirements is exhausted through said relief valve and said pump is supercharged at a pressure substantially equal to the resistance of said relief valve, means operable at the end of the downward movement of said die for reducing the pressure in said hydraulic means to a value which is low enough to prevent said hydraulic means from raising said member when said die starts upward but which is high enough to support said member in the position to which it was moved by said die, and means operable only after the pressure in said hydraulic means has been reduced to a low value for reversing the delivery of liquid to said motor to cause it to move said die upward.

18. In a metal working press, the combination of a die, a hydraulic motor for moving said die upward and downward, a pressure member arranged below said die and adapted to be moved downward thereby, a pump, means for directing liquid from said pump to said motor to cause it to move said die and said member downward, hydraulic means including liquid containing means having displacement means arranged therein for supporting said member, said hydraulic means being adapted to have liquid expelled therefrom during downward movement of said member and being of such capacity that liquid is expelled therefrom at a rate in excess of the rate at which said pump delivers liquid to said motor, a high pressure relief valve, means for connecting said hydraulic means to said relief valve and to the intake of said pump simultaneously whereby the liquid expelled from said hydraulic means in excess of pump requirements is exhausted through said relief valve and said pump is supercharged at a pressure substantially equal to the resistance of said relief valve, a low pressure relief valve, means operable at the end of the downward movement of said die for connecting said hydraulic means to said low pressure valve to thereby reduce the pressure in said hydraulic means to a low value, and means operable only after the pressure in said hydraulic means has been reduced to a low value for reversing the delivery of liquid to said motor to cause it to move said die upward.

19. In a metal working press, the combination of a die, a hydraulic motor for moving said die upward and downward, a pressure member arranged below said die and adapted to be moved downward thereby, a pump, means for directing liquid from said pump to said motor to cause it to move said die and said member downward, hydraulic means including liquid containing means having displacement means arranged therein for supporting said member, said hydraulic means being adapted to have liquid expelled therefrom during downward movement of said member and being of such capacity that liquid is expelled therefrom at a rate in excess of the rate at which said pump delivers liquid to said motor, a high pressure relief valve, means for connecting said hydraulic means to said relief valve and to the intake of said pump simultaneously whereby the liquid expelled from said hydraulic means in excess of pump requirements is exhausted through said relief valve and said pump is supercharged at a pressure substantially equal to the resistance of said relief valve, means operable at the end of the downward movement of said die for reducing the pressure in said hydraulic means to a value which is low enough to prevent said hydraulic means from raising said member when said die starts upward but which is high enough to support said member in the position to which it was moved by said die, means operable only after the pressure in said hydraulic means has been reduced to a low value for reversing the delivery of liquid to said motor to cause it to move said die upward, means responsive to said die reaching a given point in its upward movement for directing the flow of liquid from said pump to said hydraulic means to cause it to raise said member, and means responsive to said member being raised to a given point for arresting said flow of liquid.

20. In a metal working press, the combination of a die, a hydraulic motor for moving said die upward and downward, a pressure member arranged below said die and adapted to be moved downward thereby, a pump, means for directing liquid from said pump to said motor to cause it to move said die and said member downward, hydraulic means including liquid containing means having displacement means arranged therein for supporting said member, said hydraulic means being adapted to have liquid expelled therefrom during downward movement of said member and being of such capacity that liquid is expelled therefrom at a rate in excess of the rate at which said pump delivers liquid to said motor, a high pressure relief valve, means for connecting said hydraulic means to said relief valve and to the intake of said pump simultaneously whereby the liquid expelled from said hydraulic means in excess of pump requirements is exhausted through said relief valve and said pump is supercharged at a pressure substantially equal to the resistance of said relief valve, means operable at the end of the downward movement of said die for reducing the pressure in said hydraulic means to a value which is low enough to prevent said hydraulic means from raising said member when said die starts upward but which is high enough to support said member in the position to which it was moved by said die, means operable only after the pressure in said hydraulic means has been reduced to a low value for reversing the delivery of liquid to said motor to cause it to move said die upward, means responsive to said die reaching a given point in its upward movement for directing the flow of liquid from said pump to said hydraulic means to cause it to raise said member, and means responsive to said member being raised to a given point for arresting said flow of liquid.

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