Dec. 31, 1963 C. L. MITCHELL 3,115,858

HYDRAULIC PRESS

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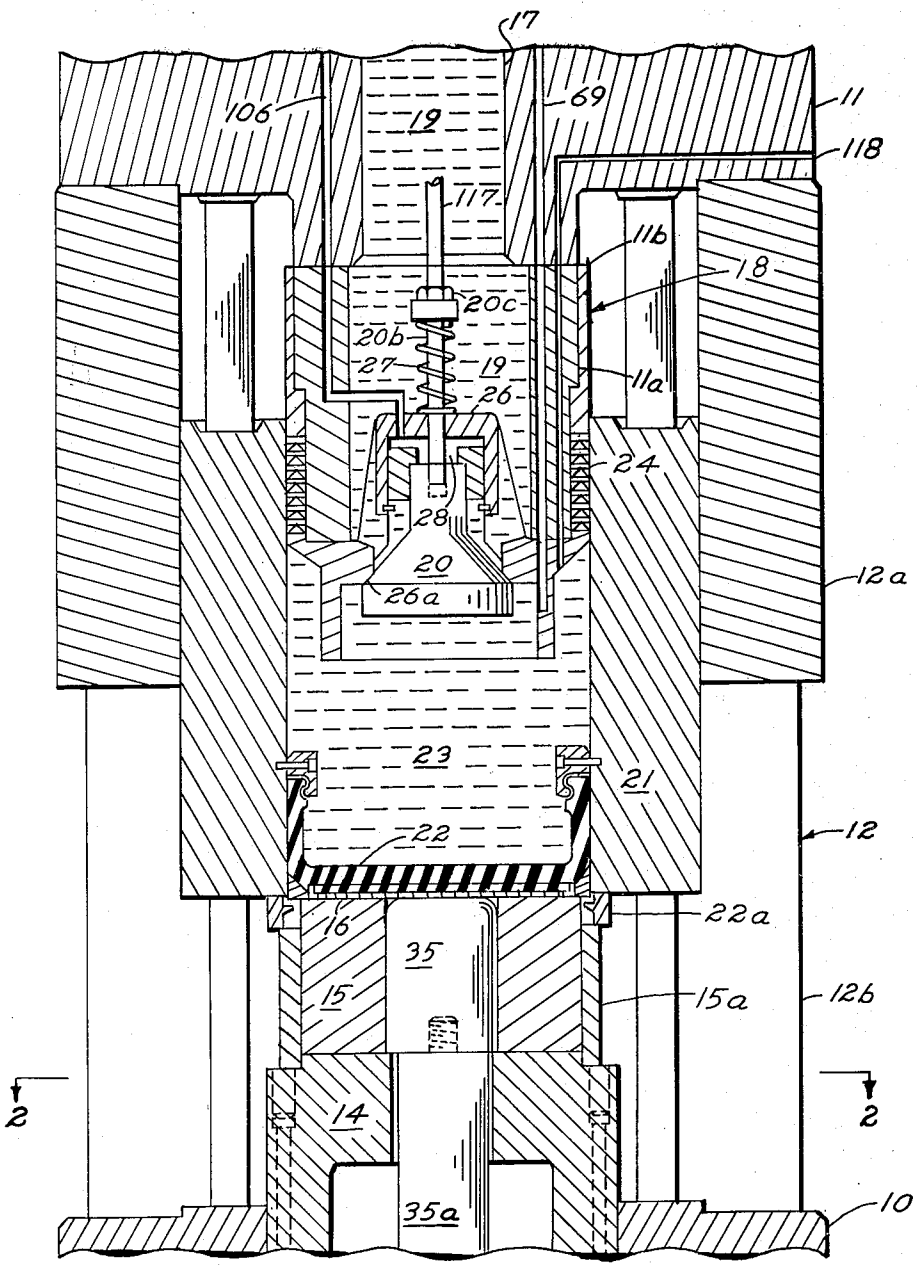

Fig. 1

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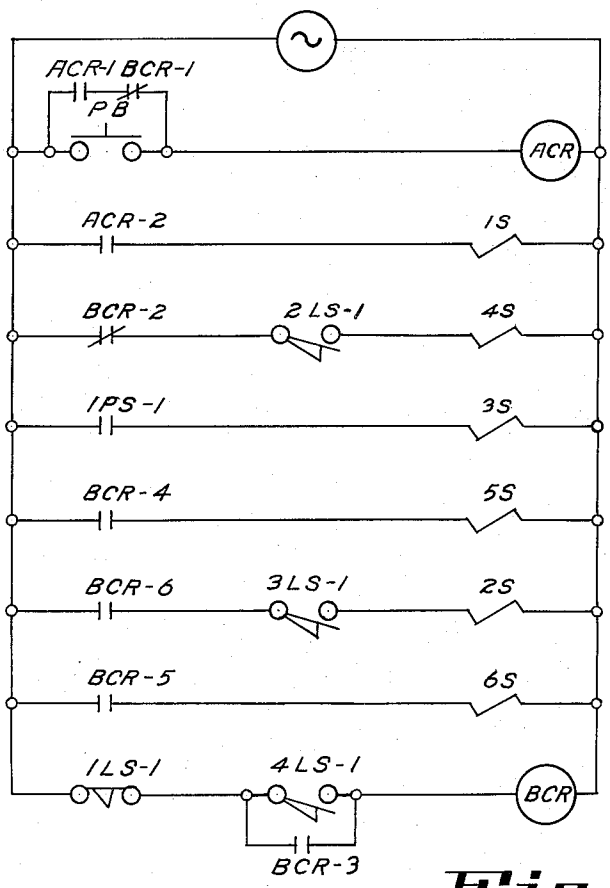

Fig. 5

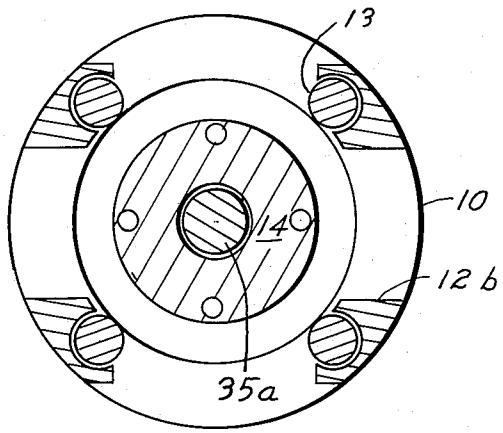

Fig. 2

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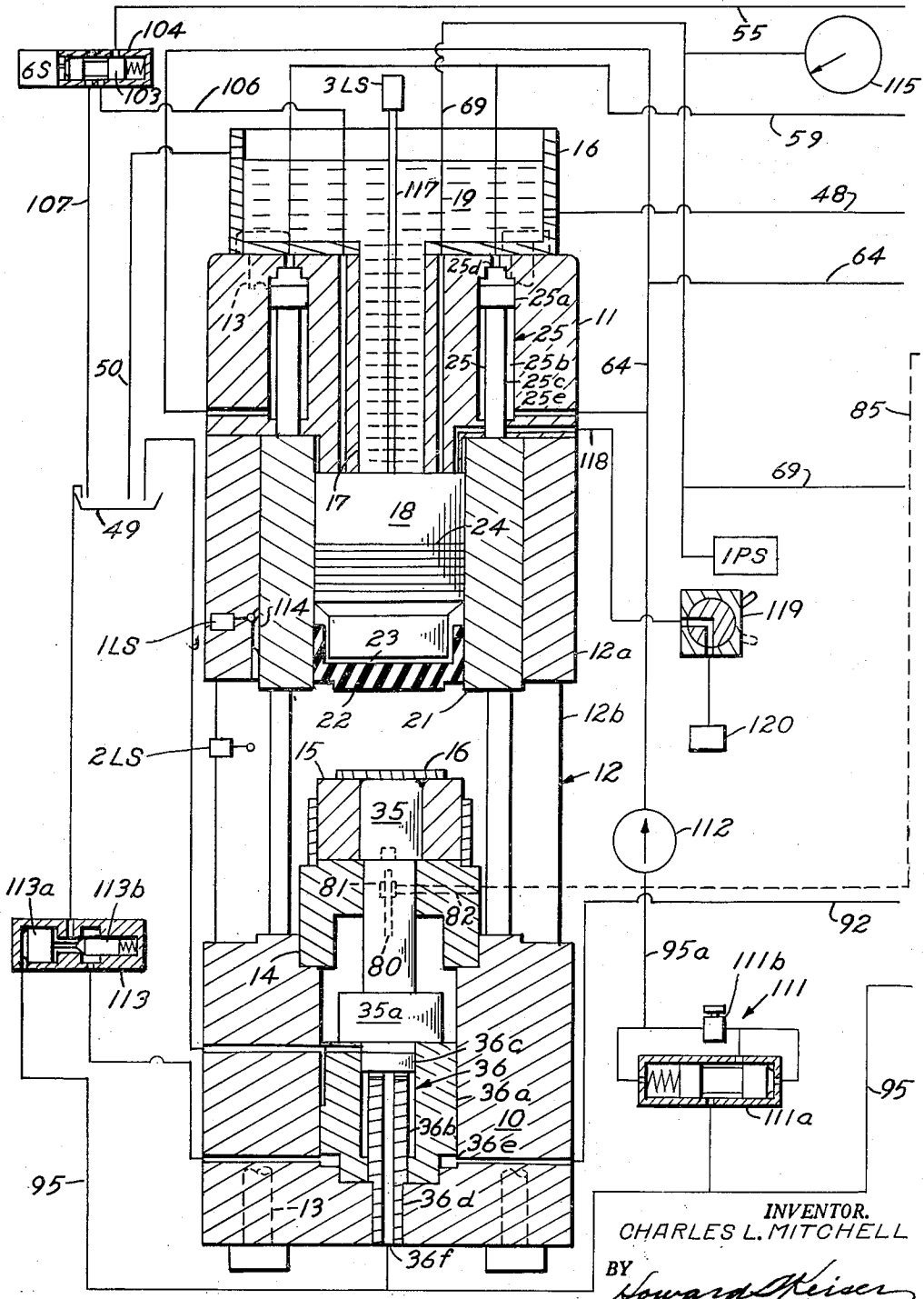

Fig. 3

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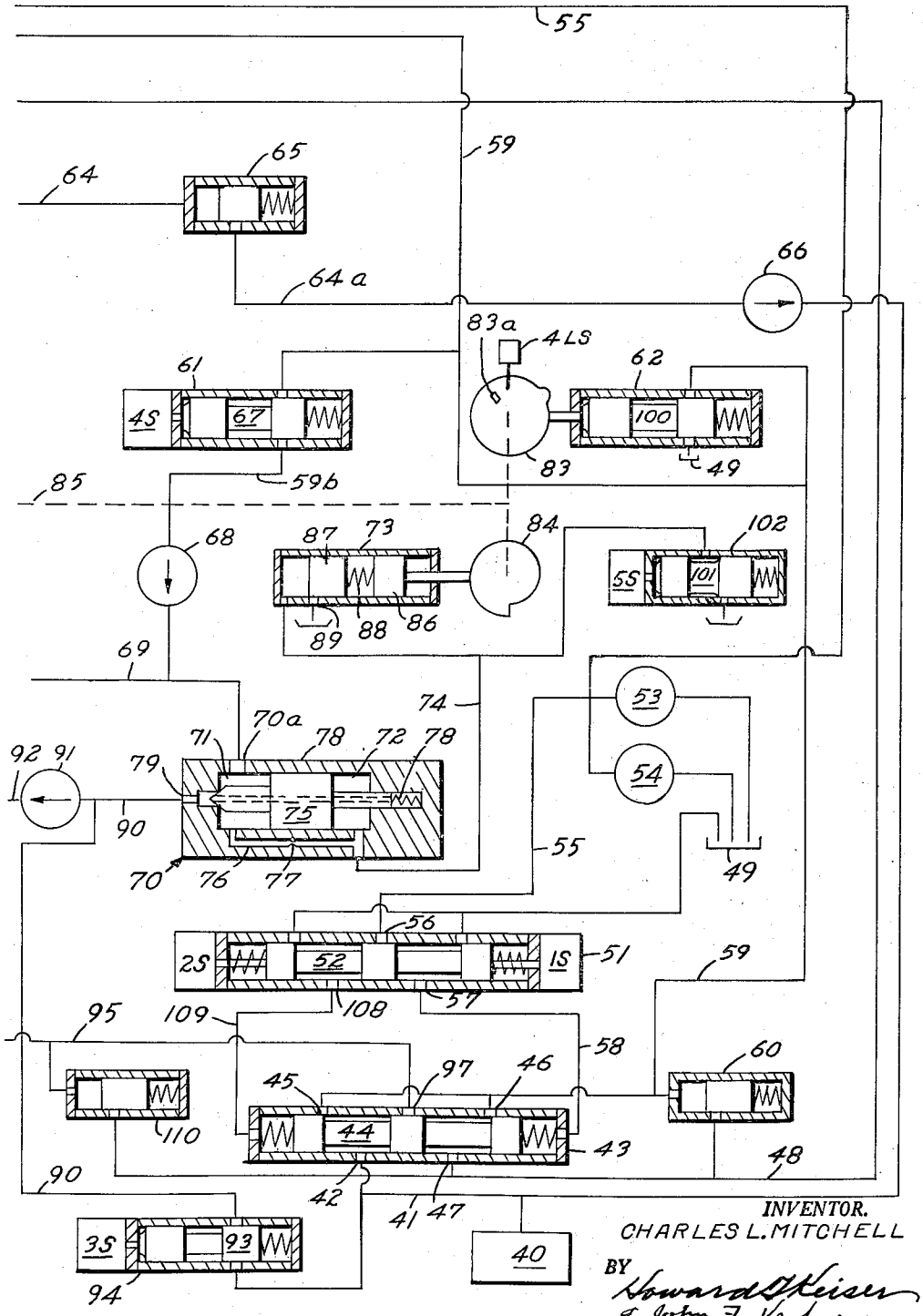

Fig. 4

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3,115,858

HYDRAULIC PRESS

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5 Claims. (Cl. 113—45)

The present invention relates to a hydraulic forming press of the type having a flexible die member enclosing a fluid pressure chamber.

In one type of hydraulic press, one member of the press, as, for example, the head member has a pressure chamber therein containing hydraulic fluid and enclosed by a flexible diaphragm which defines a flexible die member for the press. In operation the head member is lowered to a workpiece blank supported on a bed member and the head member is clamped to the bed member to prevent separation of these members when the pressure in the pressure chamber, acting on the bed member through the diaphragm, creates a reaction on the head member overcoming the lowering force applied thereto. After the head and bed members are clamped, fluid is added to the pressure chamber from a charging pump and, after a desired initial forming pressure is developed in the pressure chamber, fluid is supplied from a forming pump to raise a male die plunger, mounted in the bed under the workpiece blank, to urge the blank into the flexible die member. The pressure in the pressure chamber, acting through the flexible diaphragm, presses the workpiece blank about the male die plunger to form the workpiece in conformity therewith.

In forming workpieces by this type of operation, the size of the pressure chamber diminishes during forming as the male die member is advanced and it is desirable to control the pressure in the pressure chamber, in coordination with the elevation of the die plunger, during forming. In some instances a natural pressure cycle is desired, that is, a cycle in which the quantity of oil in the pressure chamber remains constant after a predetermined initial forming pressure is developed and the pressure thereafter rises solely as a result of diminution of the pressure chamber due to extension of the die plunger. In these instances the charging pump is rendered ineffective to supply fluid to the pressure chamber after the initial forming pressure has been reached. If pressures below those resulting from a natural pressure cycle are desired, fluid from the chamber is released in controlled amounts to the sump during the cycle; if pressures above those resulting from a natural cycle are desired, fluid is supplied to the pressure chamber during the pressure cycle from the charging pump, excess fluid output of the charging pump above that required to yield the desired pressures in the pressure chamber being returned to the sump. In either of these latter two cycles pressure fluid not required in the pressure chamber to yield desired pressures therein is returned to the sump.

In a press constructed in accordance with the preferred form of the present invention a variable relief valve is connected to the pressure chamber, the output of which leads, not to the sump, but to the hydraulic motor which drives the die plunger. The relief valve is continuously adjusted during the forming cycle by means coordinated with the elevation of the plunger, said means including a cam driven by the plunger, so that fluid above the amount required at any stage of the forming cycle to maintain the desired pressure in the chamber is diverted from the chamber to the motor which drives the plunger. With this construction even a single pump, connected to the pressure chamber, can both charge the pressure chamber and effect forming advance of the plunger. The output

of the pump will automatically begin raising the plunger the instant the initial forming pressure is reached in the pressure chamber and, if pressures above those resulting from a natural cycle are required, the pump will continue to supply fluid to the pressure chamber during forming and the pump output not required for the pressure chamber will be diverted to the plunger motor throughout the forming cycle. Since it is only the fluid in excess of the requirements of the pressure chamber which is supplied to the plunger motor, there is no possibility, regardless of the pressure desired in the chamber, that the pressure cycle therein will lag behind the movement of the plunger. In other words, the desired coordination between movement of the plunger and pressures in the pressure chamber is assured. If two or more pumps are used, a larger proportion of the pump capacity than would normally be desired can be assigned to the pressure chamber since the excess fluid output therefrom will not be dumped to the sump but will, instead, be available to assist whatever capacity is assigned to the plunger motor.

In the preferred form of the press a nest ring mounted on the base of the press has a plunger received therein and is adapted to support a workpiece blank over the plunger. The pressure chamber of the press is defined by an annular casing, or sleeve, having a flexible die member secured in its lower end, the sleeve slidably received over a stationary, depending, cylindrical tub portion of the head of the press which constitutes the lower portion of a hydraulic fluid reservoir. During each cycle the sleeve is lowered on the head portion, moving the flexible diaphragm from an open position adjacent the head portion to a closed position on the workpiece blank, thereby expanding the pressure chamber behind the flexible diaphragm to draw fluid from the reservoir through a valve in the depending portion of the head member. After the forming cycle, the sleeve is raised to return the diaphragm to the open position, collapsing the chamber and returning the fluid therein to the reservoir through the valve. The pressure chamber has an expanded size, when the press is closed for forming, determined by the spacing between the nest ring and the tub portion of the head. Thus the size of the expanded pressure chamber can be readily modified, by changing the nest ring and plunger, so that the size of the pressure chamber during forming will be as small as the depth of draw of the particular workpiece conveniently permits. This not only reduces the stroke of the sleeve to shorten the operating cycle, but because of a smaller pressure chamber when the press is closed for forming, less fluid is required in the pressure chamber to produce a desired pressure therein. Thus more fluid is more quickly diverted from the chamber to the hydraulic motor driving the die plunger so that each forming cycle is more quickly effected.

Other advantages accrue from the preferred construction of the present invention. When the press is closed, the head member need not be clamped to the nest ring since the reaction of any force exerted through the flexible die member to the nest ring and die plunger is transmitted to the stationary head portion inside the sleeve, and not to the movable sleeve. Moreover, the sleeve provides a strong pressure chamber casing, without small radius corners likely to fracture under the high pressures developed in the chamber. Since the pressure chamber is collapsed and the oil evacuated therefrom on each operating cycle, the flexible diaphragm, which must be replaced from time to time, can be quickly replaced when the press is open after completion of any operating cycle without dumping oil from the pressure chamber.

It is therefore one object of the present invention to provide a hydraulic press of the type having a flexible

female die member and an extendable male die member in which fluid in excess of that required to provide the desired pressure in the pressure chamber behind the flexible die member is diverted to driving the male die plunger whereby optimum utilization of the pump capacity of the machine is realized.

It is another object of the present invention to provide a hydraulic press having a flexible diaphragm in which the pressure chamber behind the diaphragm is in communication with a reservoir and is expanded and collapsed on each operating cycle whereby the diaphragm can be quickly replaced between cycles.

It is another object of the present invention to provide a press of the type having a flexible die member enclosing a pressure chamber in which pressure in the pressure chamber when the press is closed for forming does not tend to open the press so that clamping of the relatively movable press members in the closed position is not required.

It is yet another object of the present invention to provide a pressure chamber which has a size when closed for forming which can be modified to provide optimum pressure chamber size during forming for the particular workpiece being formed.

It is another object of the present invention to provide a simple, efficient, rapid cycling hydraulic press, easily adapted to forming different size workpieces, and particularly effective for quantity production of formed workpieces.

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

In the drawings:

FIG. 1 is a cross sectional view showing the press in a closed position;

FIG. 2 is a view through the lines 2—2 of FIG. 1;

FIG. 3 is a somewhat schematic view, partly in cross section, showing the press in the open position and showing a part of the hydraulic circuit;

FIG. 4 is a schematic diagram showing a part of the hydraulic circuit of the machine; and

FIG. 5 shows the electric circuit for the machine.

The hydraulic forming press of the present invention, as shown best in FIG. 3, has a frame including base member 10, a head 11, and an intermediate frame member 12. The three frame members are securely held together by four rods 13 extending therethrough. The base has an annular bed supporting member 14 mounted thereon to which is detachably connected by bolts (not shown) the stationary nest ring 15 constituting the bed member adapted to receive the workpiece blank 16. The intermediate frame member 12 comprises an upper annular portion 12*a* held against the head member 11, and four depending legs 12*b* (see FIG. 2) spaced around the bed supporting member 14 and seated on the base member 10. The area between the legs permits loading of workpiece blank 16 and removal of a formed workpiece, when the press is open.

The head member 11 has a tank 16 mounted thereon and has a sleeve 11*a* secured to the under side thereof by bolts (not shown) to form a cylindrical depending tub portion (designated generally as 18) of the head member. The stationary tub portion 18 is spaced from the stationary bed member 15 and in registration therewith. The tank 16 is connected through a large passage 17 in the head to the depending cylindrical tub portion 18 of the head to define a reservoir 19 for hydraulic fluid. A valve housing 26 having a large normally closed poppet valve 20 is received in sleeve 11*a* and connected to the lower edge thereof. Slidably received between the stationary sleeve portion 12*a* of the frame and the depending stationary head portion 18 is a sleeve, or cylindrical casing, 21. The depending portion 18 includes flexible sealing rings 24 received over sleeve 11*a* and held in position by valve housing 26 and a jacket 11*b* received over and secured to sleeve 11*a*. The rings 24 provide a fluid tight seal between the movable sleeve 21 and the stationary tub portion 18. The sleeve 21 has a flexible diaphragm 22 detachably secured in the end toward the bed by any suitable means as, for example, shown in U.S. Patent 2,878,767. The sleeve 21, the depending tub portion 18 of the reservoir, the valve 20 and the diaphragm 22 define a chamber 23. During the operating cycle the sleeve 21 is lowered and raised in telescopic relation to the stationary tub portion 18 by a pair of hydraulic motors 25 to close and open the press. When the press is closed the diaphragm 22 is positioned adjacent the bed 15 (as shown in FIG. 1) and when the press is open, the diaphragm 22 is positioned adjacent the cylindrical tub portion 18 of the reservoir (as shown in FIG. 3). The telescoping movement of the chamber casing 21 during the operating cycle thus expands the chamber 23 as the press is closed, and collapses that chamber as the press is opened. Each motor 25 comprises a piston 25*a* received in cylindrical chamber 25*b* of the head 11, the pistons connected by piston rods 25*c* to the casing 21. Each motor has a pair of ports 25*d* and 25*e*, the piston advancing to lower the sleeve 21 and close the press when pressure is received at port 25*d*, and retracting the piston to raise the sleeve and open the press when pressure is received at port 25*e*.

The valve housing 26 secured in the extending tub portion 18 of the reservoir has a valve seat 26*a* and slidably receives valve stem 20*b* which has a nut 20*c* spaced above the valve housing. A spring 27 interposed between the nut and the valve housing normally holds the valve 20 closed against seat 26*a* but the force exerted by the spring 27 is set (by adjustment of nut 20*c*) so that the valve is opened by the suction developed in the chamber 23 when the chamber is expanding. Thus as the press closes, fluid freely passes from reservoir 19 to chamber 23. The valve housing has a chamber 28 and as the press is opened the valve 20 can again be opened by introduction of pressure to chamber 28 to permit escape of the fluid from the collapsing chamber 23 into reservoir 19.

The nest ring 15 has a male die plunger 35 slidably received therein. When the chamber casing member 21 is down and the press is closed for forming, as shown in FIG. 1, the pressure in chamber 23, acting through flexible diaphragm 22, shapes the workpiece blank around the plunger 35 as the plunger is extended from the nest ring 15. Plunger 35, which is detachably connected to rod 35*a*, is advanced and retracted by a hydraulic motor 36 comprising a movable piston 36*a* connected to rod 35*a* and slidably received in the base member 10. Piston 36*a* has a chamber 36*b* slidably receiving therein a stationary piston 36*c* which is connected by piston rod 36*d* to the base member 10. The motor 36 has on one side a port 36*e* and when pressure fluid is supplied to this port piston 36*a* is advanced to raise the plunger 35. On the opposite side the motor has a port 36*f* communicating with chamber 36*b* and when pressure is received at this port the piston 36*a* is retracted to lower the plunger 35.

There is shown in FIGS. 3 and 4 the hydraulic circuit for the forming press. A source of hydraulic fluid under pressure 40, which may comprise a single pump, is connected to a pressure line 41 connected to the pressure port 42 of a directional valve 43. A spring centered plunger 44, when in its normal center position as shown in FIG. 4, connects port 42 to port 45 which, in turn, is connected to port 46 through line 59. When the valve is in the position shown port 46 is connected to return port 47 which is connected to return line 48. Return line 48 discharges into tank 16 so that reservoir 19 is kept full,

the excess fluid dumping to a sump 49 through sump line 50. Directional valve 43 is controlled by a solenoid operated pilot valve 51 having a spring centered plunger 52. Pump 53 supplies fluid at a pressure established by relief valve 54 to a pilot supply line 55 which is connected to pressure port 56 of pilot valve 51. When solenoid 1S is energized the shiftable valve member 52 is moved to the left and port 56 is connected to port 57 to supply pilot pressure to line 58 and thereby shift valve member 44 of directional valve 43 to the left. This closes off port 46 and pressure builds up in line 59. Relief valve 60 connected to line 59 is set to permit a relatively high pressure, say 10,000 p.s.i., in that line. When the blocking valves 61 and 62 are in the positions shown the full pressure from line 59 is directed to the ports 25*d* of hydraulic motors 25 to advance the casing member 21 and close the press. The fluid on the backside of pistons 25*a* is discharged through line 64, relief valve 65, branch line 64*a*, and check valve 66 to the supply line 41. Relief valve 65 is set at a pressure of, for example, two hundred and fifty p.s.i. sufficient to provide a back pressure in line 64 to hold up casing member 21 before pressure is applied to ports 25*d*.

When the press is almost closed solenoid 4S of valve 61 is energized to shift the valve member 67 to the right and connect line 59 to branch 59*b* which is connected through check valve 68 to the pressure chamber line 69. Line 69 is connected directly to the pressure chamber 23. A pressure chamber variable relief valve 70 has a shiftable valve member 75 separating two valve chambers, a chamber 71 connected through inlet port 70*a* to line 69 and a chamber 72 connected to a pilot relief valve 73 through pilot line 74. The areas of the valve member 75 exposed to the chambers 71 and 72 are substantially the same so that when no flow occurs through pilot line 74, and the pressure in chambers 71 and 72, which are connected by line 76 containing restriction 77, are equal, the valve member is held in the left hand position by spring 78. The variable relief valve 70 has an outlet port 79 which communicates with chamber 71 and is closed by valve member 75 when that member is in the left hand position.

The plunger 35 has a rack 80 thereon engaged with pinion 81 carried by a shaft 82 journaled in the bed supporting member 14, and the cams 83 and 84 are mechanically connected to shaft 82, as indicated at 85, for rotation in accordance with vertical movement of the plunger 35. When the plunger 35 is in its retracted position, as shown in FIGS. 1 and 3, the cam 84 holds plunger 86 of pilot relief valve 73 in a predetermined position. Plunger 87 of the pilot relief valve, which is separated by spring 88 from plunger 86, holds discharge port 89 of the pilot relief valve closed until a predetermined initial forming pressure is developed in pressure chamber 23 of the press. Until the pressure in chamber 23 reaches a predetermined initial forming pressure, there is no flow in pilot line 74 or line 76 and the pressures in chambers 71 and 72 are equal so that outlet port 79 of the variable relief valve 70 is held closed.

As fluid continues to be supplied by line 59*b* to chamber 23, the pressure in chambers 71, 72, and pilot line 74 increase, and at the initial forming pressure established by the cam, port 89 of the pilot relief valve is cracked, lowering the pressure in pilot line 74 and chamber 72 to shift valve member 75 to the right. This permits fluid from line 69 and chamber 71 to discharge through port 79. Fluid escaping from port 79, instead of being dumped to the sump, passes into line 90, through check valve 91, to line 92 connected to the port 36*e* of hydraulic motor 36.

If a natural cycle, or a cycle with pressures below those of a natural cycle, is desired, solenoid 3S is energized when the initial forming pressure is reached to shift valve member 93 to the right and connect line 90 directly to pressure line 41. Since piston 36*a* is larger than plunger 35, the motor 36, which extends the plunger 35 against the resistance of the closed pressure chamber 23, will offer less resistance to the fluid in line 41 than the chamber 23 so that even with valve plunger 44 held in the left hand position, no additional fluid is supplied to the pressure chamber 23. If the cam 84 is programmed for a natural cycle, port 89 of the pilot relief valve 70 is held closed throughout the cycle so that port 79 is held closed, preventing escape of fluid from the pressure chamber 23. If a pressure cycle lower than a natural pressure cycle is required, the cam 84 is programmed so that port 89, and hence port 79, are opened to permit fluid to escape from chamber 23 throughout the cycle, the escaping fluid being supplied to motor 36 to aid in the advance of the plunger 35. During the advance of plunger 35, fluid from chamber 36*b* of motor 36 is discharged through line 95, port 97 of directional valve 43, port 47 thereof to return line 48.

If a pressure cycle in which pressures above those achieved in a natural cycle is required, additional fluid must be supplied to the pressure chamber 23 during the cycle and therefore solenoid 3S is not energized when the initial forming pressure is reached. Thus, fluid continues to be supplied through line 59, line 59*b*, to line 69. When the pressure in chamber 23, and hence in line 69 connected thereto, reaches the particular value programmed into cam 84 for the particular position of the plunger 35, fluid in excess of that required to maintain the programmed pressure is discharged through outlet port 79 to the hydraulic motor 36. As the plunger 35 is elevated cam 84 rotates in a clockwise direction and relief valve 73 is continuously adjusted in accordance with the cam conformation. Since the pressure in chamber 72 is regulated by the relief valve, and port 79 is opened to maintain pressure in chamber 71 and line 69 in accordance with the pressure in chamber 72, the pressure in the pressure chamber 23 is maintained in accordance with the conformation of the cam. It should be noted that if a pressure is required in chamber 23 which is higher than the pressure in line 59 (as established by relief valve 60) it can not be attained by supplying fluid to the pressure chamber 23 and hydraulic motor 36 through lines 59 and 59*b* because flow through check valve 68 will be blocked when the pressure in line 69 reaches the pressure in line 59*b*. Therefore solenoid 3S must be energized when this condition exists so that motor 36 will continue to advance plunger 35. From that point in the cycle to the conclusion thereof pressure in the chamber 23 will be determined by the diminution of the chamber and the release, if any, of fluid through valve 70 in accordance with the pressures programmed into cam 84.

After the plunger 35 has been extended to completely form the workpiece, the valve 62 is operated by cam 83 to shift the valve member 100 thereof to the right and relieve the pressure in line 59. At this time solenoid 1S is deenergized and plungers 52 and 44 of valves 51 and 43, respectively, return to their center positions. At the same time, solenoid 5S is energized to shift valve member 101 of a blocking valve 102 to the right. Operation of valve 102, which is connected to pilot line 74, relieves the pressure in that line and thereby relieves the pressure in line 69 and pressure chamber 23. Solenoid 6S is energized to shift valve member 103 of valve 104 to the right to connect pilot pressure line 55 to pilot line 106, disconnecting line 106 from line 107 leading to the sump. Line 106 is connected to chamber 28 in valve housing 26 and after the pressure in pressure chamber 23 is reduced the poppet valve 20 opens.

Thereafter solenoid 2S is energized to shift valve member 52 to the right, thereby connecting pressure port 56 of the pilot valve to port 108 thereof. Pressure is thus introduced to line 109 connected to port 108 and the valve member 44 of the directional valve 43 is shifted to the right, connecting the pressure port 42 thereof with

port 97. This connects pressure supply line 41 to line 95 which has a relief valve 110 set as relief valve 60. Fluid from the line 95 is simultaneously directed to the port 36*f* of the plunger motor 36 and, through line 95*a*, check valve 112, and line 64, to ports 25*e* of the casing motors 25. The amount of fluid from line 95 diverted to line 64 is restricted by valve 111 so that plunger 35 will be fully retracted and stripped from the workpiece when the press fully opens to terminate its cycle. Valve 111 comprises a normally open pressure reducing portion 111*a* and an adjustable restriction 111*b*, lines on each side of the restriction being connected to the ends of the pressure reducing portion to maintain the pressure drop constant across the restriction 111*b*. Although fluid from line 64 can escape through valve 65 this valve is set to maintain a pressure in line 64 great enough to raise the chamber member 21 when motor ports 25*d* are connected to the return lines 48 through line 59 and ports 46 and 47 of directional valve 43. Pressure in line 95 shifts piston 113*a* and plunger 113*b* of valve 113 to the right so that fluid beneath piston 36*a* is discharged to the sump as the plunger 35 is retracted.

For quantity production of parts a nest ring and plunger 35 are selected, and limit switch 2LS adjusted, so that the size of the expanded chamber 23 will be no larger than required for the particular depth to which the workpieces are to be formed. When the press is in the open position, as shown in FIG. 3, the switch 1LS is operated by dog 114 mounted on casing 21, and limit switches 2LS, 3LS and 4LS are unoperated. The chamber 23 is collapsed and the valve 20 is held closed by spring 27. The plunger 35 is retracted and the cams 83 and 84 are in the positions corresponding to the retracted position of the plunger. Workpiece blank 16 is placed on the bed, or nest ring, 15 and push button switch PB is momentarily depressed to energize relay ACR, the relay being sealed in through the normally open contacts ACR–1 and normally closed contacts BCR–1 which are connected in series across switch PB. This closes contacts ACR–2 to energize solenoid 1S for operation of pilot valve 51. This lowers casing member 21 and with it diaphragm 22 to expand chamber 23. The suction developed thereby opens valve 20 and fluid from reservoir 19 is dumped into the expanding chamber. As casing member 21 approaches bed 15, limit switch 2LS is operated, energizing solenoid 4S through the normally open contacts 2LS–1 thereof and the normally closed contacts BCR–2. This connects the line 59 to line 59*b* and the pressure chamber 23 to apply pressure to the fluid therein. Downward movement of casing 21 is arrested when the diaphragm holding ring 22*a* connected to the end of casing 21 engages the sleeve 15*a* of nest ring 15. Thus the height of the nest ring and the sleeve thereof determines the expanded size of chamber 23.

Pressure switch 1PS is connected to line 69 and will be set to operate at the chamber pressure at which it is desired to operate valve 94, which is operated by energization of solenoid 3S through pressure switch contacts 1PS–1. Pressure in the pressure chamber 23 is indicated on gage 115 connected to line 69. With the press closed, as shown in FIG. 1, the plunger 35 is raised to a predetermined height, the switch 4LS being operated by dog 83*a* on cam 83 when the workpiece is formed. Since at this time the press is closed and switch 1LS released, relay BCR is picked up through normally closed contacts 1LS–1 and normally open contacts 4LS–1, and is sealed in by normally open contacts BCR–3 connected across contacts 4LS–1. This opens contacts BCR–1, dropping out relay ACR and deenergizing solenoid 1S as normally open contacts ACR–2 open. Contacts BCR–2 open to drop out solenoid 4S. At the same time, normally open contacts BCR–4 close to energize solenoid 5S and thereby relieve the pressure in pressure chamber 23. Simultaneously normally open contacts BCR–5 close, energizing solenoid 6S to introduce pilot pressure to chamber 23 in the valve housing 26. When the pressure in chamber 23 drops, valve 20 opens. At this time, also, normally open contacts BCR–6 are closed and, when valve 20 opens, limit switch 3LS, which has a rod 117 engaged with valve stem 20*b*, os operated to close normally open contacts 3LS–1. Solenoid 2S is energized through contacts BCR–6 and 3LS–1 to shift the pilot valve to the right and apply pressure to line 95. Thus fluid is supplied at the ports 36*f* and 25*e* of the plunger and chamber member motors, respectively, and the press is opened, the fluid in chamber 23 being transferred from the collapsing chamber 23 to the reservoir 19. When the casing member 21 is up, with chamber 23 fully collapsed, switch 1LS is operated, opening contacts 1LS–1 and deenergizing relay BCR.

When the press is opened the diaphragm 22 can be easily and quickly replaced with no significant loss of oil and without the need of refilling the pressure chamber 23 after replacement. To this end a line 118 leading to chamber 23 is connected through a shut off valve 119 to a source of air under pressure 120 so that air pressure as required can be supplied to the collapsed chamber 23 to facilitate removal of the diaphragm.

What is claimed is:

1. In a hydraulic press having a pressure chamber enclosed by a flexible die member and having a movable die plunger adapted to urge a workpiece blank into the flexible die member as the plunger is extended, the combination of a hydraulic motor connected to the die plunger having a port to receive fluid under pressure for extension of the plunger, a hydraulic pump, means to connect the output of said pump to the pressure chamber, a variable relief valve having an inlet port and an outlet port and operable to pass fluid above a pressure determined by the setting of the relief valve from the inlet port to the outlet port, said inlet port connected to the pressure chamber and said outlet port connected to said port of the hydraulic motor, a cam operatively connected to the die plunger for movement as the die plunger is extended, and means responsive to the position of the cam to set the relief valve for passage of fluid therethrough.

2. In a hydraulic press having a pressure chamber enclosed by a flexible die member and having a movable die plunger adapted to urge a workpiece blank into the flexible die member as the plunger is extended, the combination of a hydraulic motor connected to the die plunger having a port to receive fluid under pressure for extension of the plunger, a hydraulic pump, means to connect the output of said pump to the pressure chamber, a cam operatively connected to the die plunger for movement as the die plunger is extended, a pilot relief valve having a pilot line connected thereto and a movable valve plunger positionable in accordance with the pressure in the pilot line and the position of the cam to establish the pressure in the pilot line, a variable relief valve connected to said pilot line and having an inlet port and an outlet port, said inlet port connected to the pressure chamber and said outlet port connected to said port of the hydraulic motor, said variable relief valve having a movable plunger adaptable to block said outlet port in one position and shiftable from said position in response to the pressure in the pilot line and the pressure at said inlet port to pass fluid from the inlet port to the outlet port.

3. In a forming press a base member having a nest ring thereon adapted to receive a workpiece blank, a die plunger received in the nest ring and having a hydraulic motor for extension therefrom, a head member having a tank and a depending cylindrical portion, said tank, said head member, and the depending portion thereof defining a reservoir for hydraulic fluid, a valve in the depending portion of the head member operable to pass fluid to and from the reservoir, a sleeve telescopically received over said depending portion of the head

member in sealing relation therewith and having a flexible diaphragm enclosing the lower end thereof, said sleeve, said flexible die member, and said depending portion of the head member defining a pressure chamber, a reversible hydraulic motor connected to the sleeve to reciprocate said sleeve on the depending head portion and move the flexible die member between an open position adjacent the head portion and a closed position on the workpiece blank to expand and collapse said pressure chamber, a hydraulic pump, means to connect the pump to the pressure chamber to supply additional fluid under pressure thereto when the flexible die member is in the closed position, means to regulate the pressure in the pressure chamber in accordance with the position of the die plunger, said means including a variable relief valve operable to divert fluid from the chamber to the plunger hydraulic motor.

4. In a forming press a bed member having a die member therein, a frame member having an extending portion spaced from said bed and in registration therewith, said extending frame member portion defining a reservoir for hydraulic fluid, a casing telescopically received over said extending portion of the frame member and having a flexible die member enclosing the end toward the bed, said casing, said flexible die member, and said frame member portion defining a pressure chamber, means to reciprocate the casing on the frame member portion to move the flexible die member between the bed member and said portion of the frame member to expand and collapse said chamber, a valve in said extending frame member portion blocking flow of fluid between the reservoir and the chamber when the valve is closed, and means for controlling the opening of said valve to permit passage of hydraulic fluid between the reservoir and the chamber as the chamber expands and collapses.

5. In a forming press a bed member having a die member therein, a head member having a depending cylindrical portion spaced from said bed member and in registration therewith, said depending cylindrical portion defining a reservoir for hydraulic fluid over the bed member, a cylindrical casing telescopically received over said depending portion of the head member in sealing relation therewith and having a flexible die member enclosing the end toward the bed, said casing, said flexible die member, and said head member portion defining a pressure chamber, means to reciprocate the casing on the head member portion to move the flexible die member between a position adjacent the bed member and a position adjacent said portion of the head member to expand and collapse said chamber, a valve in the bottom of said depending cylindrical head member portion operable when closed to block flow of fluid between the reservoir and the pressure chamber, said valve opening by expansion of the chamber to permit passage of fluid from the reservoir to the expanding chamber, means to supply additional fluid under pressure to the expanded chamber, and means to open the valve as the chamber collapses to permit passage of fluid from the collapsing chamber to the reservoir.

References Cited in the file of this patent

UNITED STATES PATENTS

2,696,183	Chyba	Dec. 7, 1954
2,761,405	Moller	Sept. 4, 1956
2,766,711	Dever et al.	Oct. 16, 1956
2,937,606	Paulton	May 24, 1960
3,046,923	Yolin	July 31, 1962

FOREIGN PATENTS

1,217,001	France	Dec. 7, 1959