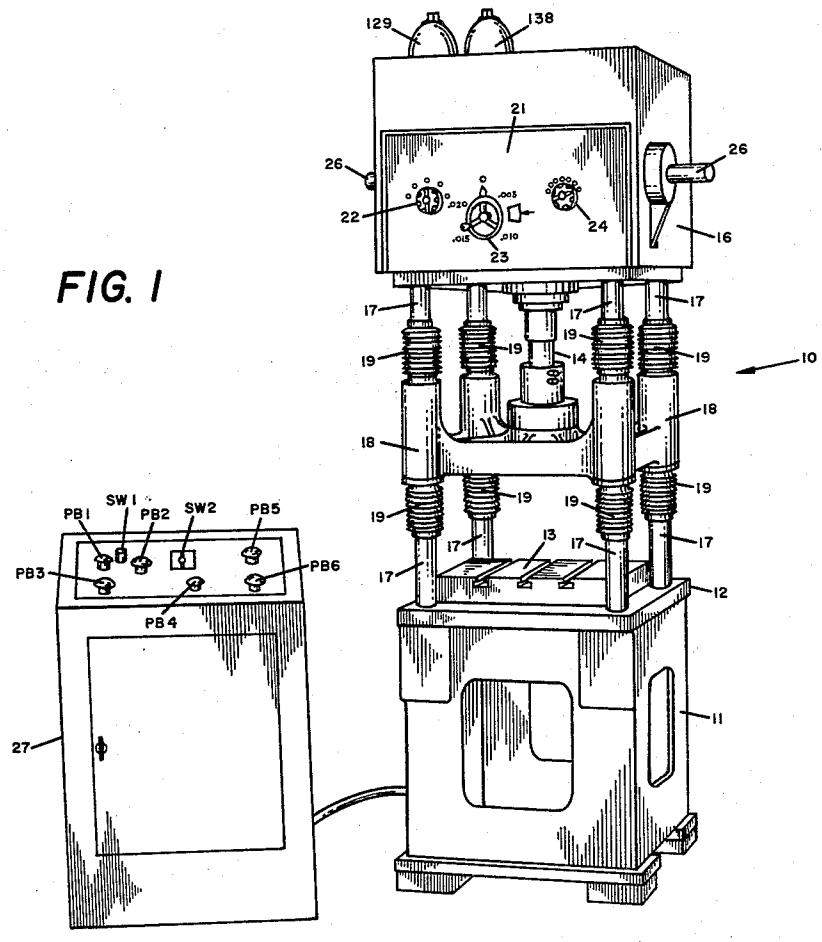
April 6, 1965 E. C. PINSENSCHAUM 3,176,466

HYDRAULIC PRESS

Filed Dec. 1, 1961 4 Sheets-Sheet 1

FIG. 1



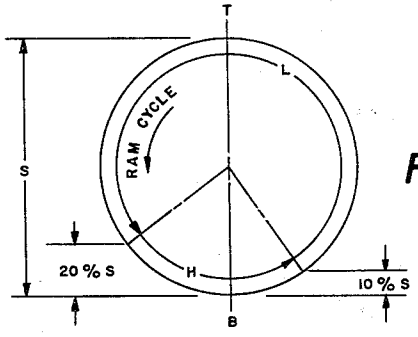


FIG. 3

INVENTOR.
EDWIN C. PINSENSCHAUM

BY
WOOD, HERRON & EVANS

April 6, 1965 E. C. PINSENSCHAUM 3,176,466

HYDRAULIC PRESS

Filed Dec. 1, 1961 4 Sheets-Sheet 2

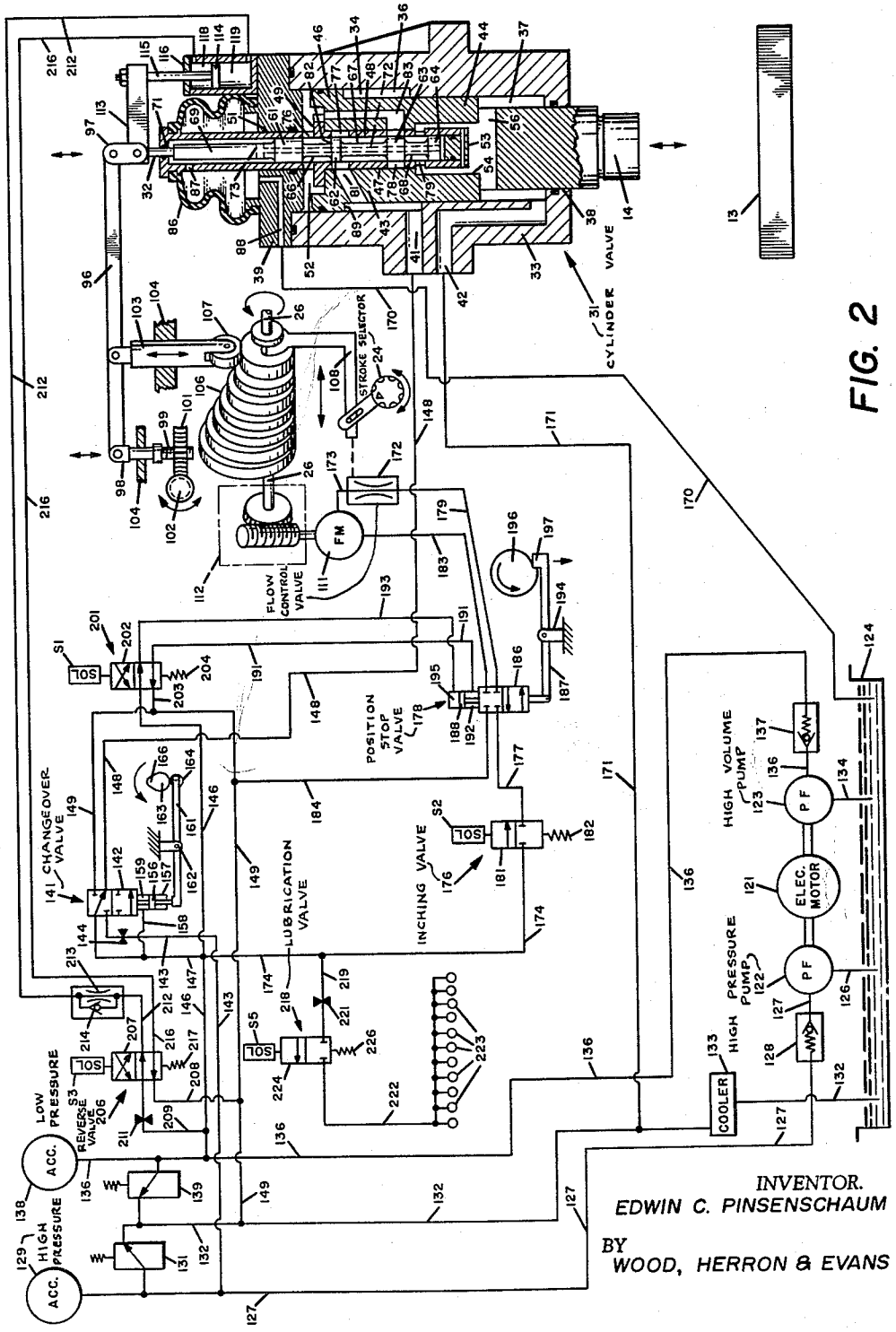


FIG. 2

INVENTOR.
EDWIN C. PINSENSCHAUM

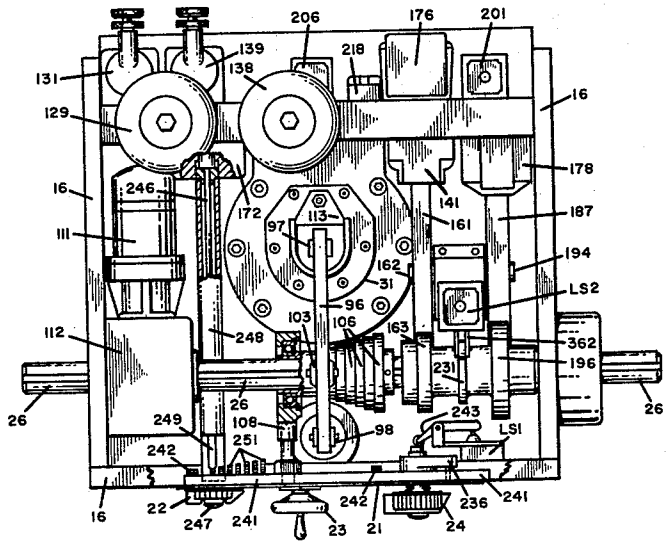
BY
WOOD, HERRON & EVANS

April 6, 1965 E. C. PINSENSCHAUM 3,176,466

HYDRAULIC PRESS

Filed Dec. 1, 1961 4 Sheets-Sheet 3

FIG. 4



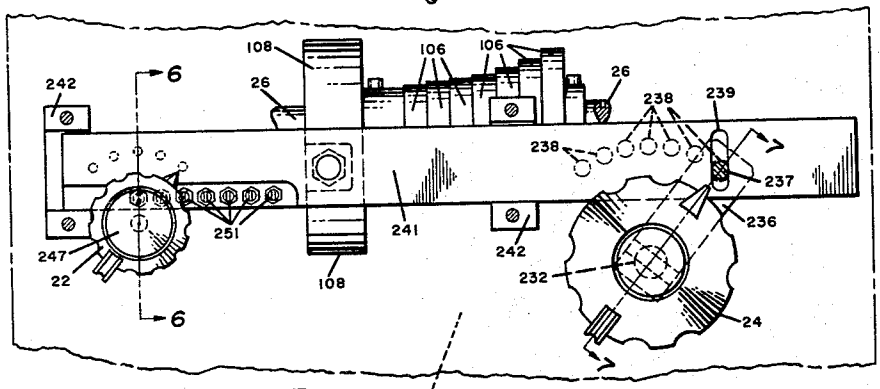


FIG. 5

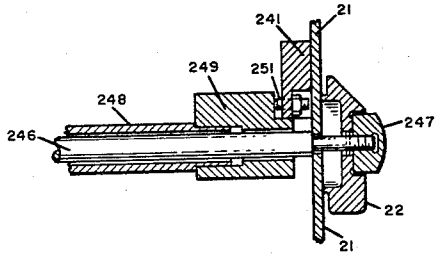


FIG. 6

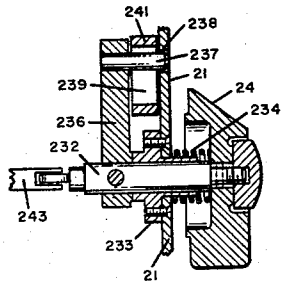


FIG. 7

INVENTOR.
EDWIN C. PINSENSCHAUM

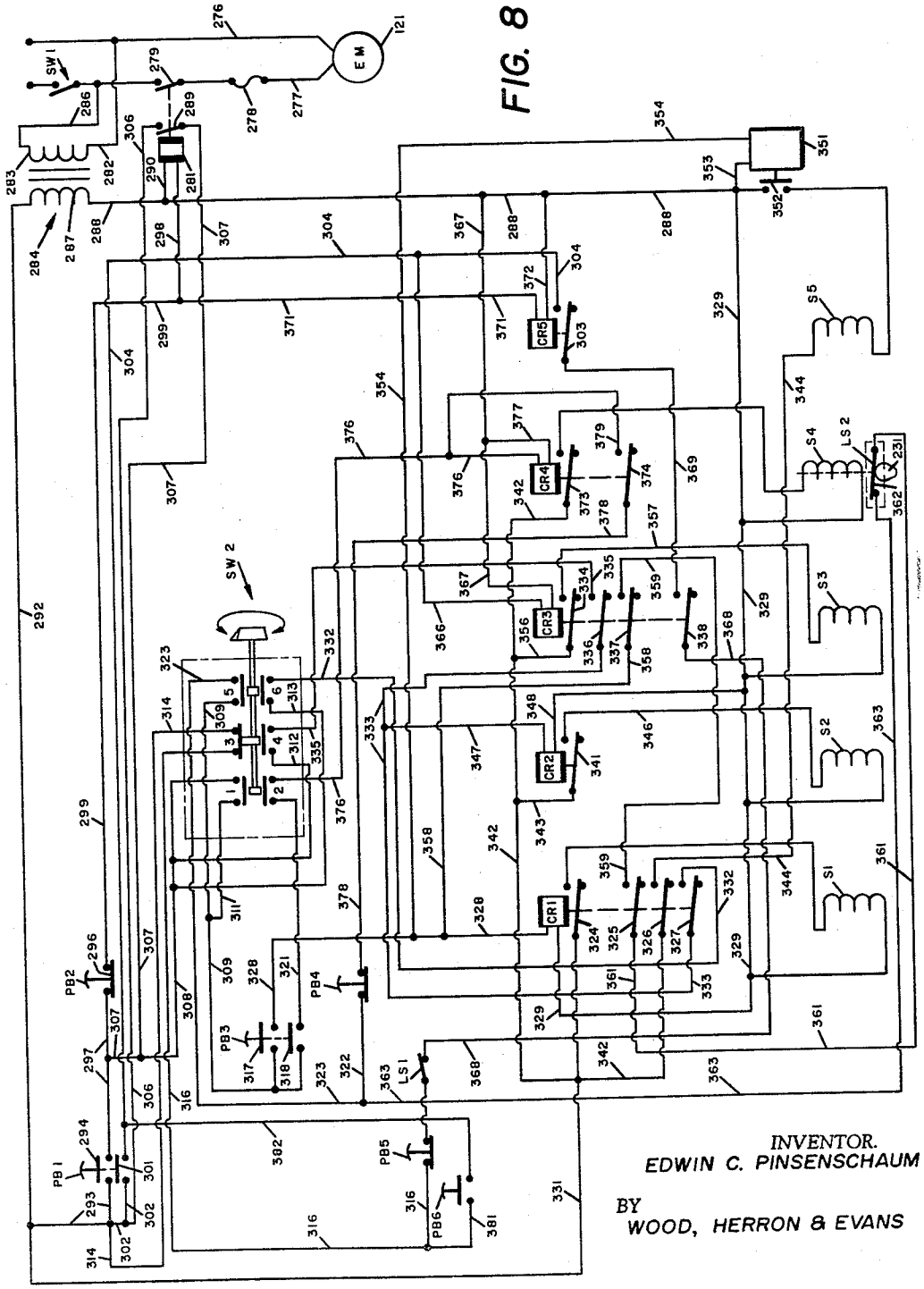
BY
WOOD, HERRON & EVANS

April 6, 1965 E. C. PINSENSCHAUM 3,176,466

HYDRAULIC PRESS

Filed Dec. 1, 1961 4 Sheets-Sheet 4

FIG. 8



INVENTOR.
EDWIN C. PINSENSCHAUM

BY
WOOD, HERRON & EVANS

United States Patent Office 3,176,466 Patented Apr. 6, 1965

3,176,466

HYDRAULIC PRESS

Edwin C. Pinsenschaum, Columbus, Ohio, assignor to American Brake Shoe Company, New York, N.Y., a corporation of Delaware

Filed Dec. 1, 1961, Ser. No. 156,326
8 Claims. (Cl. 60—51)

This invention relates to hydraulic presses. More particularly, the invention relates to an automatic hydraulic press which can be adjusted to provide a wide range of operating conditions.

Broadly speaking, presses of the type to which this invention is directed are adapted to cause a ram to cycle automatically and continuously toward and away from a work piece or plurality of work pieces, which are sequentially positioned with respect to the ram, to perform some work function thereon. Such presses are used in fully or semiautomatic manufacturing operations, for example in stamping operations to "blank out" stock on a high speed mass production basis.

The press of this invention is broadly characterized in that both the length and the rate of ram movement are readily and independently adjustable over a wide range of operating conditions. For example, the press may be set to provide a ram stroke length of ¼, ½, ¾, 1, 1½, 2, or 3 inches. Moreover, at any preselected stroke length, the ram may also be set to provide any desired number of ram cycles per unit time, up to a predetermined maximum rate, for example, from 0 to 600 cycles per minute at ¼" stroke. Once set in operation the press will automatically cause the ram to cycle continuously at the selected rate and stroke length.

In addition to the foregoing features, this press is further characterized in that for each stroke length there is a corresponding maximum ram cycle speed to which the press is automatically limited, which maximum rate decreases with increasing stroke length in accordance with a fixed relationship. It has been found that for any given stroke length there is an approximate maximum cycle speed above which the ram should not be operated, by reason of the vibration and stresses set up at the very high speeds of operation of which the present press is capable. To this end, the press is provided with means whereby the maximum cycle speed is automatically limited in accordance with stroke length. Cycle speed is adjustable independently of stroke length up to this maximum, but the press will not operate above the maximum for any given stroke length. For example, the press will operate at any desired rate up to 600 strokes per minute at a stroke length of ¼", but is limited to a maximum speed of 50 strokes per minute at a stroke length of 3".

Another important feature of the invention is the ease with which cycle speed and stroke length can be adjusted. In many past constructions, press shut-down was required to effect such adjustment. In the press of this invention, these parameters are adjustable respectively by means of speed and stroke selector control knobs mounted on a control panel, and cycle speed can in fact be adjusted while the press is cycling. Ram cycling is automatically suspended while stroke length is being changed and is resumed without press shutdown once the stroke selector knob has been set to the desired position. Operation controls including motor start and stop, ram cycle start and stop, and the emergency reverse control are electrically operated from a control console which can be positioned at any convenient location.

The press includes a safety feature whereby at any time when the ram is cycling, the ram may immediately be moved to topmost position by pushing an emergency reverse button.

Another important feature of the invention is the provision of automatic lubricating means whereby the moving elements of the press are automatically lubricated at regular timed intervals when the press is in operation.

The press includes a power take-off for operating stock feed equipment, whereby a work piece can be fed automatically into position with respect to the ram, which power take-off is automatically sequenced to reflect any changes in ram stroke or speed. Inching and set up controls for the ram and stock feed equipment are provided and can be operated either simultaneously or separately.

The ram of the press is operated by a main valve of the servo type, wherein the ram movement "follows" the movement imparted by actuating mechanism to a servo-spool; as the spool is cycled up and down, the ram follows its movement, relatively little control force being necessary to move the spool and cause great pressure to be applied to the ram. The ram is actuated to move rapidly for the major part of its movement toward the work piece, when it is not actually in contact with the work piece, and to move at a slower rate and with maximum hydraulic force as it engages the work piece. As the ram moves in the opposite direction, away from the work piece, it moves slowly as it disengages the work piece, and then at a high rate to top position. In this manner the speed of operation of the press is greatly increased. The servo-spool actuating mechanism is operated by a system of cams, hydraulic components and electric circuitry, whereby the desired motion is imparted to the servo-spool to cause the ram to move for the desired distance and at the desired speed, and whereby control over press operation is effected.

These and other aspects of the invention can best be further described by referring to the accompanying drawings.

FIGURE 1 is a perspective view of a blanking press and an accompanying control console, and illustrates the general appearance of one type of press which embodies the invention.

FIGURE 2 is diagrammatic view showing a preferred hydraulic system for operating the press shown in FIGURE 1.

FIGURE 3 is a diagram which illustrates how the hydraulic pressure applied to the ram varies during the cycle of ram movement.

FIGURE 4 is a top plan view, partly broken away, of the press of FIGURE 1, and shows a preferred arrangement of the various hydraulic and mechanical components of the press.

FIGURE 5 is a front elevation of the control mechanism for varying the length and speed of the ram stroke.

FIGURE 6 is a longitudinal cross section of the ram speed adjusting mechanism, and is taken on line 6—6 of FIGURE 5.

FIGURE 7 is a longitudinal cross section of the stroke length adjusting mechanism, and is taken on line 7—7 of FIGURE 5.

FIGURE 8 is a circuit diagram illustrating a preferred electrical circuit for operating the press shown in FIGURE 1.

In FIGURE 1, a high speed 4-strain rod blanking press is designated generally by the numeral **10** and illustrates a preferred embodiment of this invention. The press **10** comprises a base **11** having a bed plate **12** onto which a bolster plate **13** is mounted. The bolster plate **13** is adapted to hold the work piece (not shown) upon which the press is to operate. The ram **14** of the press is automatically cycled toward and away from the work piece by hydraulic mechanism to be described which is enclosed in a housing **16** and which is connected to the base of the press by four strain rods **17**. At its lower

end ram 14 is connected to a platen 18 the corners of which are carried on the strain rods 17 for sliding movement therealong as the ram is operated. Flexible boots 19 are fastened to the corners of the platen 18 and over the strain rods 17 to prevent dirt or grit from entering between the slide bearings in the platen 18 and the strain rods 17.

Controls for adjusting the operation of the press are mounted on a control panel 21 on the front of housing 16. The number of cycles per minute at which the ram operates, i.e., the speed of the ram, is adjusted by a speed control knob 22, which permits the speed to be set at any desired value between zero and a predetermined maximum speed which depends upon the length of the ram stroke. The position of the ram 14 with respect to the bolster plate 13 at the bottom of its stroke is adjusted by a ram position fine adjustment wheel 23, and the length of the ram stroke, that is, the distance traversed by the ram between its uppermost and lowermost positions during its operating cycle, is adjusted by a stroke selector knob 24. In the particular press which is illustrated for purposes of description, the stroke may be set ¼", ½", ¾", 1", 1½", 2" or 3". A drive shaft 26 projects from the left and right sides of housing 16, and provides a power take-off for stock feeding or other accessory equipment not shown.

All of the electric controls for operating the press are panel mounted on a separate control console 27 which may be remotely positioned at any convenient location. These electrical controls include a main power switch SW1, a motor start push button PB1 for starting the electric motor which operates the hydraulic pumps of the press and a motor stop push button PB2 for stopping the motor. A function selector switch SW2 controls the manner in which the ram 14 moves. The switch SW2 has four positions, as follows: off, run, inch, and inch feed. When switch SW2 is in the run position, the ram cycles automatically and continuously at the rate which is determined by the setting of the speed control knob 22 and at a stroke length which is determined by the setting of the stroke selector knob 24. When switch SW2 is in inch position, the ram can be inched discontinuously toward or away from the work piece, and simultaneously drive shaft 26 is jogged to provide inching of a work piece by stock feed equipment driven by the shaft 26. When switch SW2 is set in inch feed position, the shaft 26 can be jogged to inch stock feed equipment driven by the shaft while the ram remains stationary in top position. Cycling of the ram is initiated by a cycle start push button PB3, and cycling is terminated by a cycle stop push button PB4. At any time during operation of the press the ram may be immediately moved to its uppermost position by an emergency reverse push button PB5. A push button PB6 resets the electrical circuit after the emergency reverse push button PB5 has been depressed.

A preferred hydraulic circuit for operating the press 10 is illustrated in FIGURE 2, in which the ram 14 and bolster plate 13 are illustrated diagrammatically at the right. Movement of the ram 14 toward and away from the plate 13 is effected by a servo-type main cylinder-valve 31, the operation of which is in turn controlled by a servo-spool 32.

The cylinder-valve 31 has a body 33 in which a stepped bore 34 is formed, the diameter of the upper portion 36 of the bore 34 being slightly larger than the diameter of the lower portion 37 of the bore. The ram 14 extends slidably through an opening 38 in the lower end of the body 33 which is coaxial with bore 34, appropriate means being provided around this opening to prevent the loss of hydraulic fluid through it. The upper end of the bore is closed by a cap plate 39 which is secured to the body by means not shown. An inlet 41 communicates through body 33 with the upper portion 36 of bore 34, and an outlet 42 communicates with the lower portion 37 of the bore.

A stepped cylindrical piston 43 which is preferably integral with ram 14 is slidably fitted in bore 34 of the cylinder valve. The lower portion 44 of the piston 43 fits in the smaller diameter lower portion 37 of bore 34, and the upper end 46 of the piston is enlarged and is slidably received in the larger diameter portion 36 of the bore. Suitable fluid seals are provided around piston 43 to prevent the leakage of hydraulic fluid around it.

Piston 43 is provided with a stepped central bore 47 in which a generally cylindrical hollow sleeve 48 is fastened. Sleeve 48 has an annular flange 49 which is seated against a shoulder in bore 47 in piston 43 and which is secured to the piston by means not shown, so that sleeve 48 moves with the piston 43 and ram 14. The upper end of sleeve 48 extends slidably through an opening 51 in cap plate 39, and is sealed thereto by suitable means. A chamber 52 is defined in bore 34 between cap plate 39 and piston 43. The lower end of sleeve 48 is closed by a plug 53 which is pinned to it, and extends into an enlarged portion 54 of bore 47 in piston 43. Portion 54 of bore 47 communicates with the lower portion 37 of bore 34 through a transverse passageway 56 in piston 43.

The servo-spool 32 which controls the operation of cylinder-valve 31 is snugly but slidably fitted inside sleeve 48. Spool 32 is generally cylindrical and is provided with four lands 61, 62, 63, and 64 which form fluid seals with sleeve 48, grooves 66, 67 and 68 being defined between the respective pairs of lands. The elongated upper end 69 of spool 32 extends through an opening 71 in the closed upper end of sleeve 48 and is slidably sealed thereto. A fluid passageway 72 is formed longitudinally through spool 32 between the lower end thereof and a transverse bore 73 above land 61.

Several sets of ports 76, 77, 78, and 79 are formed through sleeve 48 through which fluid flows to effect operation of the ram. Ports 76 extend through sleeve 48 to provide fluid communication between chamber 52 in bore 34 above piston 43 and groove 66 of spool 32 which is between lands 61 and 62. Another set of ports 77 provide fluid communication between groove 67 of spool 32, between lands 62 and 63, and a passageway 81 which is formed in piston 43 and which communicates with portion 36 of bore 34 and inlet 41 of the cylinder-valve 31. A third set of ports 78 having axial dimensions equal to the axial dimension of land 63 are formed through sleeve 48 at such position that when the upper edge 82 of land 62 is in line contact with the upper edge of ports 77, the ports 78 are aligned with and are closed by land 63 (see FIGURE 2). A fluid passageway 83 is formed in piston 43 between the upper end thereof and ports 78 in sleeve 48. Ports 79 extend through sleeve 48 and provide fluid communication between groove 68 of spool 32 and the enlarged portion 54 of bore 47 in piston 43 which in turn communicates with outlet 42 through portion 37 of bore 34.

To prevent loss of hydraulic fluid through opening 51 in cap plate 39 through which sleeve 48 extends, a flexible bellows 86 is sealingly connected between the plate cap 39 and the upper end of the sleeve 48. As sleeve 48 moves with respect to cap plate 39, bellows 86 accordions with it and prevents loss of hydraulic fluid. A drain port 87 is formed through sleeve 48 adjacent the upper end thereof, and a port 88 extends through cap plate 39 from inside the region enclosed by bellows 86 to the outside thereof.

Movement of the ram 14 is controlled by and actually follows the movement of spool 32 in sleeve 48. When fluid under pressure is applied to inlet 41 of cylinder valve 31, that fluid exerts an upward force on the annular surface 89 of piston 43 where the enlarged head portion 46 of piston 43 meets the smaller diameter portion 44 of the piston, and thus tends to lift the piston and ram with re-

spect to the valve. However, if spool 32 is in the neutral position shown in FIGURE 2, this lifting force is resisted by the force of fluid which is sealed in chamber 52 above piston 43. In this neutral position, the upper edge 82 of land 62 of the spool closes ports 77 in sleeve 48 and prevents the fluid under pressure in passageway 81 from flowing through ports 77 and groove 66 into chamber 52, and land 63 closes ports 78 and thereby prevents the fluid in chamber 52 from being released through passageway 83 in piston 43. With the spoool 32 in the neutral position shown, therefore, the hydraulic forces tending to lift the pitson 43 and ram 14 are equally and oppositely opposed by the force of fluid trapped above the piston 43 in chamber 52, and the piston 43 does not move. It will also be seen that under these conditions the spool 32 is in substantial hydraulic balance and that the pressure of fluid in grooves 66 and 67 will act equally on the opposite faces of the lands which define each groove. The spool may therefore be moved from neutral position by the application of relatively little external force.

If force is applied to the upper end of the spool 32 so that the spool is caused to move downwardly relative to the sleeve 48, hydraulic forces act on the piston 43 which cause it to "follow" the spool downwardly and which tend to restore the piston to neutral position with respect to the spool at a lower position in bore 34. The piston 43 will follow the spool 32 more or less closely depending on the speed with which the spool 32 is moved downwardly, but will catch up with the spool when the downward movement of the spool stops.

When the spool 32 moves downwardly relative to sleeve 48, the upper edge 82 of land 62 moves downwardly with respect to the upper edges of ports 77, and fluid under pressure flows into the chamber 52 above the piston 43 through passageway 81 in piston 43 and ports 77 into groove 66 of spool 32, and through ports 76 into chamber 52. Ports 78 are opened by downward movement of land 63, and fluid flows into groove 67 from ports 77, through ports 78 and pasageway 83 into chamber 52. Land 63 closes groove 68 from ports 78 so that the flow of fluid from chamber 52 to the outlet 42 is prevented. The upwardly acting force of fluid on annulus 89 is then exceeded by the downwardly acting force of fluid under pressure on the entire exposed area of piston 43 in chamber 52, and the piston 43 is moved downwardly, fluid in the smaller diameter portion 37 of bore 34 being displaced therefrom to the outlet 42. Movement of the pitson 43 and ram 14 in the downward direction will continue until the downward motion of the spool 32 has stopped and the piston 43 has caught up with the spool 32, in such position that the upper edge 82 of land 62 closes ports 77 from chamber 52.

If the spool 32 is raised with respect to the valve from neutral position, the lower edge of land 63 opens ports 78 to groove 68, and the fluid in chamber 52 flows through passageway 83, ports 78, groove 68, ports 79 into portion 54 of bore 34 and then to the outlet 42. Fluid under pressure at ports 77 is prevented from entering chamber 52 by land 62. Under these circumstances the upwardly acting pressure of fluid on annulus 89 exceeds the force of fluid in chamber 52, and the piston and ram move upwardly displacing fluid from that chamber, following the spool and restoring the piston to neutral position with respect to the spool at a higher position in bore 34 when the spool stops moving. (In FIGURE 2, the piston is shown nearly in topmost position in bore 34.)

From the foregoing explanation it will be seen that a slight force applied to the spool 32 will cause a large force to be applied to the ram 14 such that the motion of the ram follows motion of the spool.

Movement of spool 32 is normally controlled by a lever arm 96 to one end of which spool 32 is connected by a link 97. The other end of lever arm 96 is swingably connected to a pivot member 98. The elevation of the pivot member 98 is adjustable relative to valve 31, whereby the lower limit of spool travel, and therefore of ram movement, may be adjusted. Pivot member 98 is provided with threads 99 at its lower end, which are engaged in driven relation with internal threads of a gear 101. Gear 101 is rotated by means of a worm gear 102 which is connected to the ram position adjustment wheel 23. As the wheel 23 (FIGURE 1) is rotated, gear 101 (FIGURE 2) is rotated and raises or lowers pivot member 98 to which lever arm 96 is connected. As will be explained, this has the effect of adjusting the upper and lower points of ram travel without changing the length of the stroke of ram 14.

Between pivot member 98 and link 97 by which it is connected to spool 32, lever arm 96 is connected to a vertically movable cam follower 103, which is journalled in a guide bearing 104. When the cam follower 103 moves up and down, the right end of lever arm 96 is caused to swing up and down, thereby moving spool 32 relative to cylinder-valve 31, the movement of spool 32 in relation to movement of cam follower 103 being dependent upon the position of cam follower 103 between pivot member 98 and link 97.

Movement of cam follower 103 is effected by a set of cams 106 which are mounted on drive shaft 26. Cam follower 103 is provided with a wheel 107 which rides on cams 106 as drive shaft 26 rotates them. In the press shown, seven cams are mounted on shaft 26, the eccentricities of which are such that rotation of the cams establishes spool movements of ¼", ½", ¾", 1", 1½", 2", and 3". In FIGURE 2 cam follower wheel 107 is shown engaging the smallest cam which provides a spool and ram stroke of ¼". As the cams 106 are rotated, the cam follower 103 moves up and down in its guide bearing 104, swinging lever arm 96 up and down and cycling spool 32. The shape of the cams 106 is preferably such that they effect harmonic motion of the ram 14. That is, the ram moves slowly at the beginning of its movement in a given direction, picks up speed to a maximum in the middle of its stroke, and then slows down again as it approaches the end of its stroke. It is noted, however, that other ram motions can be provided with specially shaped cams. For example, dwell periods can be established at any point. Thus, the ram can be held stationary at the top of its stroke while material is being fed into the press. Also, cams with small eccentricities can be used to establish very short strokes.

The cam cluster 106 is made so that bottom ram position is the same for all strokes.

It can be seen that when cam follower 103 is in its lowermost position, the position of the spool 32 will depend on the relative elevation of pivot member 98, and that wheel 23 which adjusts the elevation of member 98 thus in effect controls the lower limit of ram travel.

The set of cams 106 are slidably keyed to drive shaft 26 and may be slid therealong relative to cam follower 103 so that the cam follower can be engaged with each cam of the set. Axial movement of the cams along shaft 26 is effected by a cam shifting arm 108. Arm 108 is operated to shift the cams for different stroke lengths by the stroke selector knob 24 (see FIGURE 1) as will be explained in more detail subsequently.

The cams 106 are driven by a hydraulically operated fluid motor 111 to which shaft 26 is connected through a speed reduction gear mechanism 112.

An arm 113 is connected at one end to spool 32, and at its other end is connected by a rod 115 to a piston 114 which is slidable in a hydraulic cylinder 116. This arm and piston mechanism 113–116 is hydraulically operated to provide hold-down pressure on lever arm 96 so that cam follower 103 will remain engaged with the cams 106 as it moves up and down. As will be explained, when fluid under pressure is admitted to chamber 118 in cylinder 116 above piston 114 and the pressure of fluid in the chamber 119 below piston 114 is released, the piston 114 is urged downwardly, urging lever arm 96 downwardly

about pivot member 98, so that downward pressure is exerted on cam follower 103 to hold it in engagement with the cams 106. This downward force constantly holds the cam follower 103 on the cams 106 as they rotate, thereby eliminating backlash. The pressure of the fluid admitted to chamber 118 for this purpose is relatively low, and the downward force on the cam follower 103 can be overcome by the lifting force which the cam 106 exerts on the cam follower as shaft 26 rotates.

Mechanism 113–116 has the important additional function of lifting the spool 32 and cam follower 103 whenever the emergency reverse push button PB5 (FIGURES 1 and 8) is pushed, and at certain other times, as will be explained, to hold the ram 14 in top position. This is effected by admitting fluid under pressure to chamber 119 below the piston 114 in cylinder 116 and by releasing pressure on the upper side of the piston in chamber 118, whereby piston 114 moves upwardly and lifts spool 32 (and therefore ram 14), and raises cam follower 103 off the cams 106.

Fluid pressure for the operation of the hydraulic system is provided by an electric motor 121 which drives two fluid pumps 122 and 123. Pump 122 is a high pressure low volume pump, for example which supplies 6 gallons of fluid per minute at a pressure of 3700 p.s.i., and the other pump 123 is a low pressure high volume pump which for example suplies 24 gallons of fluid per minute at a pressure of 1000 p.s.i. As illustrated in FIGURE 3 and more fully described hereinafter, the low pressure high volume pump 123 supplies fluid to cylinder-valve 31 at a high rate during the initial portion of the ram cycle when the ram 14 is approaching the work piece, so that the ram will move rapidly, and again after the ram has performed its work on the work piece to lift it rapidly to top position. In other words, the function of the high volume, low pressure pump 123 is to supply a large volume of fluid to effect rapid traverse of the ram 14 during the major portion of its cycle, when it is not actually in contact with the work piece. The function of the high pressure, low volume pump 122 is to supply fluid at high pressure to the cylinder-valve 31 during that portion of the ram cycle when the ram 14 engages the work piece and performs work on it. Thus the ram 14 rapidly traverses up to and away from the work piece, whereby a higher speed of operation is achieved.

The high pressure pump 122 receives fluid from a main reservoir or tank 124 through an intake line 126, and discharges fluid under pressure to a line 127. A check valve 128 is connected in line 127 to permit flow away from but not toward the high pressure pump 122. Line 127 is connected to a high pressure accumulator 129 which stores fluid at the pressure established by pump 122. As will be explained more fully later, when fluid at high pressure is to be supplied to the cylinder-valve 31 the demand for the fluid may be greater than the rate at which fluid can be supplied by the low volume pump 122. Under these circumstances fluid at high pressure is supplied to the cylinder-valve 31 from the high pressure accumulator 129. When the ram is being operated by fluid from the low pressure pump 123, the high pressure pump 122 charges the high pressure accumulator 129 for the next time high pressure fluid will be needed. A relief valve 131 is connected between the line 127 and a drain line 132 to prevent excessive pressure in pump 122 or in accumulator 129. Drain line 132 returns the fluid to the reservoir 124 through a cooler 133 which prevents the hydraulic fluid from overheating during the operation of the press.

The low pressure pump 123 has an intake line 134, and supplies fluid under pressure to a line 136. A check valve 137 which permits flow from but not toward the pump 123 is connected in line 136, and line 136 is connected to a low pressure accumulator 138. The low pressure accumulator 138 stores fluid at low pressure when such fluid is not being supplied to the cylinder-valve 31. Line 136 is connected to drain line 132 through a low pressure relief valve 139. It will thus be seen that the high and low pressure accumulators 129 and 138 keep pump volume and horsepower requirements to a minimum, in that they store pumped oil when the system demand is less than the available supply, and supply oil when the demand is greater than the pump capacities.

The admission to the cylinder-valve 31 of fluid at high pressure from line 127 and fluid from line 136 at the lower pressure established by pump 123 is controlled by a cam operated changeover valve 141. This valve 141, which is illustrated diagrammatically in FIGURE 2, has a pair of inlet ports on its left side and a pair of outlet ports on its right side, communication between which is controlled by the position of a shiftable spool 142. One of the inlet ports is connected by a line 143 to high pressure line 127 through an orifice 144 which restricts the flow of oil at high pressure in line 143. The other inlet port is connected to line 136 by lines 146 and 147. One of the outlets of the changeover valve 141 is connected to inlet 41 of cylinder valve 31 by a line 148, and the other outlet is connected to tank 124 by a line 149 which is connected to line 132.

A hydraulically operated piston 156 which is slidably received in a cylinder 157 is connected to one end of the changeover valve spool 142, and fluid under pressure from line 147 is admitted through a line 158 to the chamber 159 above piston 156 in cylinder 157, whereby the spool 142 is normally held downwardly in the valve 141 in the position shown in FIGURE 2. A lever arm 161 which is connected to piston 156 is swingable about a pivot 162, and engages a cam 163 at its opposite end through a wheel 164. As can be seen in FIGURE 4, cam 163 is mounted on shaft 26 and is driven by the fluid motor 111. Cam 163 has a high spot 166 which, once each rotation of shaft 26, urges wheel 166 downwardly, swinging the left end of lever arm 161 upwardly. Spool 142 is thereby shifted upwardly in the changeover valve 141 to change the flow of fluid between the inlet and outlet ports. In the normal position shown in FIGURE 2, in which wheel 164 is not depressed by the high spot 166 of cam 163, fluid at the pressure established by the low pressure pump 123 in line 147 is directed by valve 141 to line 148 and flows to the inlet 41 of the cylinder-valve 31. When, however, the high spot 166 on cam 163 causes the spool 142 to be shifted upwardly, high pressure line 143 is connected to line 148. It will thus be seen that depending upon the angular position of cam 163, either fluid at high pressure from pump 122 or fluid at lower pressure from pump 123 will be directed to the inlet 41 of the cylinder-valve 31. Fluid under pressure in chamber 159 above piston 156 exerts holddown force on arm 161 to maintain wheel 164 in engagement with cam 163. The shape of cam 163 and the angular position thereof on shaft 26 with respect to cams 106 determines when and for what proportion of the ram cycle high pressure fluid is directed to the inlet port of cylinder-valve 31. It is preferred that the high pressure fluid be applied to the cylinder-valve 31 during the lower 20% of ram movement in the downward direction, during which time the ram will engage the work piece, and during the first 10% of ram movement in the upward direction. This relationship is illustrated graphically in FIGURE 3, in which the ram cycle is illustrated as a circle, the diameter of which corresponds to stroke length. The letter L indicates the portion of the cycle during which low pressure is applied to the ram, and the letter H indicates the portion of the cycle during which high pressure is applied to the ram. The letters T and B indicate the top and bottom limits respectively of ram travel. The relationships between high and low pressure periods shown in the graph are unvarying re-

gardless of the ram speed and are also independent of the length of ram stroke.

The outlet 42 of valve 31 is connected to drain line 132 by a line 171. Drain port 88 in cap plate 39 is connected to tank 124 by a conduit 170.

The rate of rotation of the cams 106 and, therefore, the speed at which the ram 14 moves, is governed by the rate of rotation of the fluid motor 111 which drives shaft 26 on which the cams are mounted. This is in turn dependent upon the rate of flow of hydraulic fluid under pressure through the fluid motor 111. The rate of flow of the fluid which is supplied to the fluid motor is controlled by an adjustable flow control valve 172 which is adjustable to provide greater or lesser flow through the motor 111 to control the ram cycle speed, high rate of flow through the valve 172 to the motor corresponding to a high ram speed.

The flow control valve 172 is preferably similar to the flow control valve which is disclosed in W. E. Renick Patent No. 2,936,152, issued May 10, 1960, and entitled "Structure Forming an Adjustable Orifice," and reference is made to that patent for a complete disclosure of this valve. Briefly, in the valve disclosed in the Renick patent, a flow control orifice is formed between two relatively movable elements, and is adjustable in area to provide different flow volumes through it. The flow control valve includes mechanism for establishing a constant pressure differential across the orifice, so that for any given orifice size the flow through the orifice will be constant regardless of external pressure conditions. The flow control valve 172 is connected to the inlet side of the fluid motor 111 by a line 173.

Fluid is supplied to flow control valve 172 from low pressure pump 123 through lines 136, 146, a line 174 which is connected to line 146, through an inching valve 176 to a line 177 which is connected to a position stop valve 178, and a line 179 which is connected to the inlet side of the flow control valve 172. Both the inching valve 176 and the position stop valve 178 must be properly actuated before fluid can be supplied through them to the flow control valve 172 and fluid motor 111.

The inching valve 176 is a spring return solenoid operated valve having a spool 181 which is movable by a solenoid S2 to connect line 174 to line 177 which is connected to the position stop valve 178. When the solenoid S2 is not energized, the spool 181 of inching valve 176 is held by a spring 182 in the position indicated in FIGURE 2, and fluid is not permitted to flow through inching valve 176; the solenoid S2 of the inching valve must be energized for the fluid motor 111 to operate.

The position stop valve 178 directly controls the flow of fluid through the fluid motor 111. It has four ports, two of which are inlet ports and two of which are outlet ports. One inlet port is connected to line 177 from the inching valve 176 and the other inlet port is connected to the outlet side of the fluid motor by a line 183. One of the outlet ports is connected to fluid motor inlet line 179, and the other is connected to a line 184 which is connected to drain line 149. Communication between these ports is controlled by a shiftable spool 186, and the position of the spool 186 is in turn controlled by a cam actuated lever arm 187 which is connected to one end of the spool 186 and by a hydraulically operated piston 188 which is connected to the other end of the spool. When the spool 186 is in the position shown in FIGURE 2, lines 179 and 183 to and from the fluid motor 111 are closed and the motor is stopped. When the spool 186 is raised, line 177 is connected to line 179 through the valve 178, to supply fluid to the motor 111, and motor outlet line 183 is connected to line 184. Movement of the spool 186 is normally controlled by the hydraulically operated piston 188. When the motor 111 is to be operated, fluid under pressure is admitted through a line 191 to the chamber 192 beneath piston 188, whereby the spool 186 is raised and fluid is directed through the motor 111. A line 193 is connected to the chamber 194 on the upper side of piston 188, and when fluid under pressure is supplied through this line and the fluid beneath the piston 188 in chamber 192 is released, the spool 186 tends to be moved downwardly to shut off flow to the motor 111. Downward movement of the spool 186 is, however, limited by the lever arm 187 which is connected to the other end of the spool 186. This lever arm 187 is swingably mounted on a pivot 194, and follows a cam 196. Cam 196 is mounted to shaft 26 (see FIGURE 4) and is rotated by the fluid motor 111. This cam 196 is so shaped that it permits the spool 186 to drop to the position shown in FIGURE 2 only at the precise moment such that the ram 14 will stop moving at its top position; in other words, the function of this cam 196 is to cause the ram to stop moving when it is at the very top of its stroke. Cam 196 is so shaped that the cam follower 197 of lever arm 187 is normally urged downwardly, so that the spool 186 is held upwardly in valve 178 against the pressure, if any, of fluid in chamber 194 above piston 188 which tends to hold the spool 186 downwardly. The cam 196 has a notch which is so positioned thereon that when the spool 186 is urged downwardly by fluid pressure above piston 188, the cam follower 197 will engage the notch in the cam 196 and permit the spool 186 to drop down, closing the position stop valve 178, at the precise moment which will cause the ram 14 to stop in top position, taking into account the inertia of the various moving parts. When the ram is cycling in normal operation of the press, fluid under pressure in chamber 192 beneath piston 188 holds the spool 186 upwardly so that the cam follower 197 is disengaged from cam 196.

The admission of fluid under pressure to chamber 192, beneath piston 188 of the position stop valve 178, holds the spool 186 up and permits the fluid motor 111 to run, while the admission of fluid under pressure to the chamber 195 above piston 188 tends to hold the spool 186 down and therefore tends to cause the fluid motor to stop. The selective admission of fluid to the chambers described is controlled by a solenoid operated valve 201. This valve 201 has four ports, communication between which is controlled by a spring returned spool 202. One port is connected to drain line 149 through line 203. Another port is connected to line 146, which is connected to the low pressure pump 123. Lines 191 and 193 are connected to the other two ports of valve 201. When the solenoid S1 of the valve 201 is not energized, spring 204 holds the spool 202 in its upward position, as shown in FIGURE 2, in which position fluid from line 146 is admitted to line 193 through the valve 201 and is supplied to the chamber 195 above piston 188 of the position stop valve 178. Line 191 is connected to drain line 149 through valve 201, so that the spool 186 of the position stop valve 178 is urged downwardly. When the solenoid S1 is energized, however, the spool 202 is moved downwardly against spring 204 and the lines are oppositely connected; that is, fluid from line 146 is directed through the valve 201 to line 191 and chamber 192 beneath piston 188 of the position stop valve 178, and line 193 is connected to line 203, so that the spool 186 of the position stop valve is lifted, permitting the fluid motor 111 to run. The function of valve 201 is thus to control the position of the spool 186 of the position stop valve 178, and thereby indirectly control the operation of the fluid motor 111.

The piston and cylinder mechanism 113–116 of the cylinder-valve 31 which provides hold-down pressure on cam follower 103 and which also lifts the spool 32 of the cylinder-valve 31, is controlled by an emergency reverse valve 206. This valve 206 has a solenoid operated, spring returned spool 207 which directs fluid under pressure to either the chamber 118 above piston 114 in cylinder 116, or to the chamber 119 below piston 114. The emergency reverse valve 206 has four ports, one of which

is connected to drain line 149 by a line 208. Fluid under pressure from line 146 is supplied to another port by a line 209 which includes a restrictor in the form of an orifice 211. Another port is connected by a line 212 through a restrictor or orifice 213, which is by-passed by a check valve 214, to the chamber 119 below piston 114 in cylinder 116. The chamber 118 above piston 114 is connected to the fourth port of emergency reverse valve 206 by a line 216.

When solenoid S3 of emergency reverse valve 206 is not energized, spring 217 holds the spool 207 in the upward position shown in FIGURE 2, in which line 209 communicates through the valve with line 212, and line 216 is connected with drain line 149. Under these conditions, fluid under pressure from lines 136, 146 and 209 is supplied through the restrictor or orifice 211 to the chamber 119 below piston 114, thereby raising the piston 114 and holding spool 32 and ram 14 in top position. The flow control orifice 213 limits the flow to the cylinder 116. The ram 14 is thus put in "emergency reverse." Fluid in chamber 118 above piston 114 is released through line 216, valve 206 and line 208 to drain line 149. When solenoid S3 is energized, the spool 207 is held downwardly against spring 217. Line 209 then communicates through valve 206 with line 216, and fluid under pressure is supplied to the chamber 118 above piston 114, providing hold-down pressure which holds the cam follower 103 in contact with the cams 106. Line 216 is then connected to drain line 208, and the fluid in chamber 119 below piston 114 is displaced therefrom as the piston moves downwardly following the movement of the cam follower 103, flowing through check valve 214 to drain line 208.

One of the important features of the press of this invention is that it includes an automatic lubrication system whereby the various relatively moving parts of the press are automatically oiled at regular predetermined intervals as the press operates. This lubricating system includes a solenoid operated lubrication valve 218. Valve 218 has 2 ports, one of which is connected to line 174 through a line 219 which includes a restrictor or orifice 221. The other port is connected by a line 222 to a plurality of oilers 223 which are installed at the various points of the press to which lubricant is to be supplied. When solenoid S5 of the lubrication valve 218 is not energized, the spool 224 of the valve is held by spring 226 in raised position, in which the valve is closed. As will be explained, solenoid S5 is periodically energized to move spool 224 downwardly to connect line 219 to line 222, whereby a measured quantity of fluid under pressure is supplied to each of the lubrication outlets 223 at the various lubrication points of the press. Lubrication of the press is thus substantially automatic and does not require individual attention even at the very high speeds at which the press is capable of operating.

Operation of the hydraulic system

The operation of the above described hydraulic system may now be explained. Assuming that the electric motor 121 is in operation and that pumps 122 and 123 are supplying fluid under pressure to lines 127 and 136 respectively, the ram 14 is started cycling from top position by energizing the solenoids S1, S2 and S3 which respectively control valve 201, inching valve 176, and emergency reverse valve 206. Energization of the solenoid S3 of the emergency reverse valve 206 causes the spool 207 of that valve to be moved downwardly from the position shown in FIGURE 2 so that fluid under pressure is supplied to chamber 118 above piston 114 to exert hold-down pressure on cam follower 103. Energization of the solenoid S2 of inching valve 176 shifts the spool 181 of that valve downwardly from the position shown in FIGURE 2 and supplies fluid under pressure from line 174 to line 177 which is connected to the position stop valve 178. Energization of the solenoid S1 of valve 201 shifts the spool 202 of that valve downwardly so that fluid from line 146 is supplied through line 191 to the chamber 192 below piston 188 of the position stop valve 178, causing the spool 186 of that valve to lift and swing cam follower 197 away from cam 196. The chamber 195 above piston 188 is connected through valve 201 to drain line 149. The spool 188 of the position stop valve 178 having been raised, fluid under pressure from line 177 is supplied to the fluid motor 111 through the flow control valve 172, setting the motor 111 in operation. Fluid from the outlet side of the motor 111 is returned to tank 124 through line 183, valve 178 and lines 184, 149, and 132. The fluid motor begins to rotate, driving shaft 26 and rotating cams 105. Fluid from the low pressure pump 123 in lines 146 and 147 is directed through the changeover valve 141 to the inlet 41 of the cylinder-valve 31, and as cams 106 rotate from their initial position shown in FIGURE 2, cam follower 103 moves downwardly, moving spool 32 with it and causing the ram 14 to move downwardly as previously explained. When the fluid motor 111 has rotated shaft 26 to that position at which the high spot 166 on cam 163 shifts the position of the spool 142 of the changeover valve 141, fluid from either the high pressure pump 122 or accumulator 129 is directed from line 143 to the inlet of cylinder valve 31. When the cams 105 have turned 180° from initial position, the cam follower 103 is lifted, and ram 14 moves upwardly again. When cam 163 has rotated to a position such that spool 142 is lowered in the changeover valve 141, fluid from the low pressure high volume pump 123 is again directed to the cylinder-valve 31, causing ram 14 to move rapidly to top position.

When cycling of the ram 14 is to be terminated, the solenoid S1 of valve 201 is de-energized, whereupon the spool 202 thereof is raised by spring 204, and fluid under pressure is directed to the chamber 195 above piston 188 of the position stop valve 178, so that the spool 186 of that valve is moved downwardly when cam follower 197 engages the low spot in cam 196. Movement of this spool 186 downwardly shuts off flow to and from the motor 111 and the ram 14 stops in top position.

If at any time it is desired to return the ram to its top position immediately, the solenoid S3 of the emergency reverse valve 206 is de-energized, whereupon the spool 207 of that valve is lifted by spring 217 and fluid under pressure is directed to chamber 119 beneath piston 114, lifting spool 32 and the ram 14. The ram 14 will remain in top position as long as the solenoid S3 of the emergency reverse valve 206 is de-energized.

The inching valve 176 permits the ram to be inched upwardly and downwardly. When the solenoids S3 and S1 of the emergency reverse valve 206 and valve 201 respectively are energized, the cam follower 103 is held engaged with the cams 106, and the spool 186 of the position stop valve 178 is held in raised position, permitting flow through that valve. If, under these conditions, the solenoid S2 of the inching valve 176 is de-energized, no fluid can flow through the inching valve to the fluid motor 111, and the cams 106 will not be rotated, with the result that spool 32 of cylinder-valve 31 will remain in neutral position. If the solenoid S2 of the inching valve 176 is intermittently energized and de-energized, that valve will jog open and closed to supply fluid discontinuously to the fluid motor 111 through lines 174 and 177, causing the motor 111 to rotate intermittently, thereby causing the cams 106 to be rotated intermittenly and the spool 32 and ram 14 to be inched up and down. Inching of the ram 14 is useful in setting up the press for a manufacturing operation.

The length of the ram stroke may be changed at any time by de-energizing the solenoid S3 of the emergency reverse valve 206, which causes the cam follower 103 to be lifted off cams 106. The axial position of the cams 106 on shaft 26 may then be changed, as will be explained, by turning the stroke selector knob 24 to align

the desired cam with cam follower 103. When the solenoid S3 of the emergency reverse valve 206 is again energized, cam follower 103 is held down on the newly aligned cam to provide greater or lesser movement of the servo-spool 32.

FIGURE 4 of the drawings shows the arrangement of the various hydraulic elements of the circuit in the housing 16 of the press. The various hydraulic components have the same numbers as in FIGURE 2. The fluid motor 111 is mounted on the left side of the housing 16, and drives shaft 26 through speed reducing mechanism 112. The high and low pressure accumulators 129 and 138 respectively and their respective relief valves 131 and 139 are mounted at the rear of the housing. The main cylinder-valve 31 is centrally positioned and lever arm 96 extends toward the front of the housing above shaft 26. The ram position adjustment wheel 23 has a worm gear attached to its shaft, not visible in FIGURE 4 but which extends through the front panel 21 of the housing 16, which gear engages the gear 101 attached to pivot member 98 whereby lowermost ram position is adjusted. Cams 106 are keyed to shaft 26 for rotation therewith, as previously described, as are cams 163 and 196.

A position stop limit switch cam 231, the function of which will be described, is also mounted on shaft 26 for rotation therewith. The changeover valve 141 and the position stop valves 178 are positioned toward the back of the housing at the right, their respective lever arms 161 and 187 being pivotally mounted in position to engage their cams 163 and 196. The emergency reverse valve 206, lubrication valve 218, inching valve 176, and valve 201 are also mounted at the rear of the housing. The ends of shaft 26 extend through openings in both sides of the housing 16, and it is contemplated that this shaft may be used to supply power for operating work feed apparatus, not shown, by which a work piece may be automatically fed beneath the ram as the ram is operated. Such apparatus may be conventional and need not be described herein.

The electric motor 121, pumps 122 and 123, tank 124, and check valves 128 and 137 are preferably housed separately as a unit and are not shown in FIGURE 4.

One of the important features of this invention is the provision of means whereby the maximum speed of the ram 14 is limited in accordance with the length of the ram stroke. It can be appreciated that the vibration set up by a long ram stroke will be greater than that set up by a short stroke at the same cycle speed. Actual tests have demonstrated the unfeasibility in commercial practice of operating the ram at very high cycle speeds at long strokes. At the high speeds at which the present press is capable of operating the vibration can become severe at long stroke lengths. To prevent the press from being operated at speeds which are excessive in relation to the stroke length to which the stroke selector knob 24 is set, the press is equipped with means interrelating stroke length to the maximum cycle speed which the press will provide. A preferred relationship between maximum ram speed and stroke length is as follows:

Stroke length:	Max. No. of strokes
¼	600
½	300
¾	200
1	150
1½	100
2	75
3	50

From this chart it can be seen that stroke length multiplied by maximum ram speed is equal to a fixed value.

This control function is achieved by reducing the maximum flow permitted through valve 172, upon which maximum cycle rate depends, as the stroke length is increased. As mentioned above, the flow control valve 172 is preferably the adjustable flow control valve shown in Renick Patent No. 2,936,152. The Renick valve provides independent control over maximum flow and actual flow. Maximum flow through the orifice of the flow control valve is determined by the axial position of a movable orifice-forming valve element with respect to a fixed orifice-forming valve element, which relation in effect determines the height of the orifice. For given axial position of the movable orifice-forming element of the flow control valve, the maximum flow through the valve is predetermined and fixed. Actual flow up to that maximum is determined by the angular position of the movable element with respect to the fixed element, which in effect determines the width of the orifice. The Renick valve is incorporated in the present invention in such fashion that the axial position of the movable valve element is changed as the stroke length is changed, to limit the maximum flow through the valve in accordance with the above-given schedule. Actual flow up to the maximum for any given stroke length is controlled by the speed control knob 22 which regulates the angular position of the movable element of the flow control valve 172.

The interconnection between the stroke selector knob 24, the speed control knob 22 and the flow control valve 172, whereby such control is achieved, is illustrated in FIGURES 4, 5, 6 and 7. The stroke selector knob 24 is secured to a shaft 232 (see FIGURE 7) which is journalled in a sleeve or bushing 233 that is mounted to the front panel 21 of the housing 16. A coil spring 234 around shaft 232 urges the knob 24 and shaft 232 outwardly. Inwardly of sleeve 233, an arm 236 is pinned to shaft 232 for rotation therewith. At its outer end, this arm 236 has a forwardly extending pin 237 which is engageable in a series of openings 238 formed in panel 21. These openings 238 correspond to the various stroke lengths. Pin 237 extends through a transverse slot 239 formed in a bar 241 which is mounted by guides 242 for horizontal sliding movement parallel to shaft 26. Cam shifting arm 108 is mounted to bar 241 and engages the cams 106, which are slidably keyed to shaft 26, axially positioning the cams on the shaft 26 with respect to cam follower 103. (The cams 163, 231 and 196 are fixed with respect to shaft 26, and are not shiftable.)

The length of the ram stroke is changed by pushing in on the stroke selector knob 24 to disengage pin 237 from the opening 238 in panel 21 in which it had been engaged, and turning knob 24 to align the pin 237 with the particular opening 238 which corresponds to the desired stroke length. As the knob 24 is turned, arm 236 swings with it, and pin 237 which is engaged in slot 239 in bar 241 shifts bar 241 horizontally with it, and thereby shifts the position of the cam shifting arm 108 and the cams 106 accordingly. When pin 237 is aligned with the appropriate opening 238, the knob 24 is released and spring 234 holds the pin in the opening so that bar 241 cannot thereafter accidentally shift.

A normally closed limit switch LS1 (FIGURES 4 and 8) has an actuating arm 243 (FIGURES 4 and 7) which bears on the end of shaft 232 of the stroke selector knob 24. When knob 24 is depressed to change the stroke, arm 243 is depressed and opens switch LS1. As will be shown in connection with FIGURE 8, opening switch LS1 de-energizes the solenoid S3 of the emergency reverse valve 206, so that the ram 14 will automatically be held in top position while the stroke is being changed. This is done as a safety precaution. When the pin 237 is re-engaged in one of the openings 238, spring 234 moves the knob 24 and shaft 232 outwardly, and the switch LS1 is closed. However, the ram 14 remains in emergency reverse position until the emergency reverse reset push button PB6 (FIGURES 1 and 8) is depressed to re-energize the solenoid S3 (FIGURES 2 and 8) of the emergency reverse valve 206.

The speed control knob 22 (FIGURES 4 and 6) is connected by a shaft 246 to the movable orifice-forming element of the flow control valve 172 (this movable

element is designated by the numeral 55 in the previously referred to U.S. Patent No. 2,936,152). The angular position of knob 22 thus fixes the angular position of the movable orifice-forming element of the flow control valve relative to the fixed orifice-forming valve element (which element is designated by the numeral 49 in Patent No. 2,936,152). Knob 22 is held against rotation by a friction lock nut 247 which can be tightened to hold the knob 22 tightly against panel 21. The axial position of the movable orifice-forming element of the flow control valve is fixed by a threaded bushing which abuts the movable element (this bushing is designated 63 in Patent No. 2,936,152). This bushing, which is shown only in FIGURE 4, is connected to a tubular sleeve 248 around shaft 246. An abutment collar 249 is fixed to the forward end of sleeve 248 inwardly adjacent bar 241.

Bar 241 is provided with a set of threaded adjustable stops 251 which extend inwardly at longitudinally spaced positions and which sequentially abut the collar 249 as bar 241 is shifted to change the stroke. The length of these stops controls the forward position of collar 249 and shaft 248 which is connected to the collar, and thereby determines the axial position of the movable orifice-forming element of the flow control valve 172. In other words, the lengths of these stops fix the maximum flow through the flow control valve and the maximum speed of the press for each stroke. The lengths of the stops are so adjusted that the maximum speed of the press for each stroke will correspond to the previously given schedule. Up to this predetermined maximum, the angular position of speed knob 22 determines the actual speed of the motor 111. It will be apparent from this description that changing the stroke automatically and simultaneously changes the maximum speed without separate attention.

The electrical circuit

FIGURE 8 shows a preferred electrical circuit for operating the hydraulic system of FIGURE 2. The component parts shown in FIGURE 2 which appear in FIGURE 8 have the same numbers in each figure.

The electric motor 121 is connected to conventional source of power by a lead 276 and a lead 277 in which the main off-on switch SW1, a fuse 278 and the contact 279 of a relay 281 are connected in series. Off-on switch SW1 must be closed and relay 281 must be energized for motor 121 to operate.

One lead 282 of the primary winding 283 of a transformer 284 is connected to lead 276, and the other lead 286 of the transformer primary 283 is connected to lead 277 and switch SW1. The transformer 284 is of the step-down type, and its secondary winding 287 supplies power for energizing the various valve solenoids previously described. One of the leads 288 of the secondary winding 287 of the transformer 284 is connected to lead 290 of relay coil 281. Relay coil 281 actuates two sets of normally open contacts which are designated by 279 and 289, contact 279 being connected in series with the electric motor 121 as previously described. The other lead 292 of secondary winding 287 is connected to a lead 293, which in turn is connected to one set of contacts 294 of the normally open motor start push button PB1. The other side of contact 294 of PB1 is connected to the contact 296 of normally closed motor stop push button PB2 through a lead 297. The other side of contact 296 is connected to the coil lead 298 of relay coil 281 by a lead 299.

Motor start push button PB1 actuates a second set of contacts 301, one side of which is connected to lead 293 by a lead 302 and the other side of which is connected to the normally open contact 303 of a relay CR5 by lead 304. A lead 306 connects lead 302 to one side of contact 289 of relay 281, the other side of contact 289 being connected to lead 297 by a lead 307.

The function selector switch SW2 (see FIGURE 1), has six sets of contacts which are designated by the numerals 1–6 and is so arranged that certain of these contacts will be opened or closed depending upon the setting of the switch. In the off position, only contacts 3 of SW2 are closed. In the run position contacts, 1, 2, 3, 4 and 5 are closed; in the inch position, contacts 1, 3 and 6 are closed, and in the inch feed position contacts 1 and 6 are closed.

One side of contact 1 of SW2 is connected to a lead 308 which in turn is connected to lead 307, and the other side of contact 1 is connected to a lead 309 through a lead 311. One side of contact 4 of SW2 is connected to lead 308 through a lead 312, and one side of contact 6 of SW2 is connected to lead 308 through a lead 313. One side of contact 3 is connected to lead 293 through a lead 314, and the other side of contact 3 is connected by a lead 316 to one side of the emergency reverse push button PB5, which is normally closed.

The cycle start push button PB3, which is normally open, has two sets of contacts 317 and 318 associated with it. One side of contact 317 is connected to one side of contact 5 of SW2 through lead 309, and one side of contact 318 of PB3 is also connected to lead 309. The other side of contact 318 is connected to one side of contact 2 of SW2 through a lead 321. One side of the contact of cycle stop push button PB4, which is normally closed, is connected to one side of contact 5 of switch SW2 through leads 322 and 323.

A control relay CR1 actuates four sets of normally open contacts which are designated by 324, 325, 326 and 327. Coil lead 328 of relay CR1 is connected to contact 317 of cycle start push button PB3. Coil lead 329 of relay CR1 is connected to lead 288 of secondary winding 287 of transformer 284. One side of contact 324 of CR1 is connected to secondary winding lead 292 through a lead 331. The other side of contact 324 is connected through solenoid S1 of valve 201 to lead 329. One side of contact 327 of relay CR1 is connected to one side of contact 6 of switch SW2 by a lead 332, and the other side of contact 327 of CR1 is connected by a lead 333 to a contact 336 of a control relay CR3. The other side of contact 336 of relay CR3 is connected to contact 4 of SW2 by a lead 335. Control relay CR3 actuates four sets of normally open contacts, designated by 334, 336, 337 and 338. One side of contact 326 of relay CR1 is connected to normally open contact 341 of relay CR2 through leads 342 and 343, and the other side of contact 326 of relay CR1 is connected by lead 344 to the solenoid S5 of the lubrication valve 218. The other side of contact 341 of relay CR2 is connected by a lead 346 through the solenoid S2 of the inching valve 176 to lead 329. Coil lead 247 of relay CR2 is connected to lead 333, and coil lead 348 is connected to lead 329.

Lubrication timer 351 is electrically operated and, when running, periodically closes a contact 352 for a short time. The timing mechanism of the lubrication timer 351 is energized through a lead 353, which is connected to lead 288, and through a lead 354 which is connected to lead 328. One side of contact 352 of the lubrication timer 351 is connected to the solenoid S5 of lubrication valve 218, and the other side of contact 352 is connected to lead 288.

One side of contact 334 of relay CR3 is connected by a lead 356 to lead 342. The other side of contact 334 of CR3 is connected by lead 357 through the solenoid S3 of the emergency reverse valve 206 to lead 329. One side of contact 337 of relay CR3 is connected to lead 328 by a lead 358. The other side of contact 337 is connected by lead 359 to one side of contact 325 of relay CR1. The other side of contact 325 of CR1 is connected by lead 361 to one side of the limit stop switch LS2.

The entire limit stop switch LS2 is moved by a solenoid S4 toward and away from cam 231 (see FIGURE 4). When solenoid S4 is not energized, the actuating arm 362 of switch LS2 rides on cam 231. Cam 231 is

mounted on shaft 26, as previously described, and has a high spot which, if solenoid S4 has been de-energized so that arm 362 is following the cam, opens switch LS2 at the precise moment which will cause the ram 14 to stop in top position. The other side of switch LS2 is connected to lead 323 through lead 363.

Coil lead 366 of control relay CR3 is connected to lead 304, and coil lead 367 of CR3 is connected to lead 288. One side of contact 338 of relay CR3 is connected by a lead 368 through normally closed limit switch LS1 to one side of the emergency reverse push button PB5. The other side of contact 338 of CR3 is connected by a lead 369 to normally open contact 303 of relay CR5, the other side of which is connected by lead 304 to contact 301 of the motor start push button PB1 as previously described. Coil lead 371 of relay CR5 is connected to lead 299, and coil lead 372 is connected to lead 288.

Relay CR4 operates two normally open contacts, 373 and 374. Coil lead 376 of relay CR4 is connected to contact 2 of switch SW2, and coil lead 377 of relay CR4 is connected to lead 367. Contact 373 of relay CR4 is connected at one side to lead 342 and at the other side through solenoid S4, which positions switch LS2 relative to cam 231, to lead 329. One side of contact 374 of relay CR4 is connected by a lead 378 to the cycle stop push button PB4, and the other side of contact 374 is connected through lead 379 to lead 376.

One side of the normally open contact of the emergency reverse reset push button PB6 is connected to lead 316 through a lead 381, and the oher side of PB6 is connected to lead 304 by a lead 382.

Operation of the electrical circuit

When the main off-on switch SW1 is closed, a voltage is induced in the secondary winding of 287 of transformer 284. The motor 121 is energized by depressing the motor start push button PB1. Closing PB1 completes a circuit from secondary winding 287 through leads 292 and 293, contact 294 of motor start push button PB1, lead 297, the normally closed contact 296 of the motor stop push button PB2, leads 299 and 298, relay coil 281 and leads 290 and 288 to the other side of the secondary. Relay coil 281 is thus energized by the potential across the secondary of the transformer and closes its associated contacts 279 and 289. Closure of contacts 279 completes the circuit to the electric motor 121, and the motor is set in operation. The motor start push button PB1 is depressed only momentarily, and is released after relay 281 has closed contacts 279 and 289. However, after push button PB1 has been released, relay 281 remains energized by a holding circuit through leads 288 and 290, relay 281, leads 289 and 299, contact 296 of PB2, leads 297 and 307, contact 289 of relay 281, and leads 306, 302, 293 and 292 to the secondary, and thus the electric motor continues to operate after the motor start push button PB1 has been released. The motor can be stopped at any time by momentarily depressing the motor stop push button PB2, which breaks the above described holding circuit for relay 281, whereby contact 279 of the relay is opened and the motor circuit is broken.

Assuming that the function selector switch SW2 is set in the off position, the motor will run, upon depressing PB1, but the ram will not cycle. SW2 must be set in the run position to condition the circuit for ram cycling.

When SW2 is in the off position, depressing motor start button PB1 energizes relays CR5 and CR3. When push button PB1 is closed, relay CR5 is energized by the secondary 287 of the transformer through the circuit which comprises leads 288, 372, CR5, leads 371 and 299, contacts 296 of PB2, lead 297, contact 294 of PB1, which is momentarily closed, and leads 293 and 292. Energization of CR5 causes its contact 303 to close, and this contact is thereafter held closed by energization of CR5 through a holding circuit comprising leads 288 and 372, CR5, leads 371 and 299, contact 296 of PB2, leads 297 and 307, contact 289 of relay 281, and leads 306, 302, 293 and 292. Relay CR3 is energized upon closure of PB1 through the circuit made up of leads 288 and 367, CR3, leads 366, 304, momentarily closed contact 301 of PB1, leads 302, 293 and 292, and thus closes its associated contacts. CR3 remains energized after PB1 is released by a holding circuit including leads 288 and 367, CR3, leads 366 and 304, contact 303 of CR5, which now is closed, lead 369, contact 338 of CR3, which is closed, lead 368, normally closed switch LS1, emergency reverse push button PB5, lead 316, closed contact 3 of SW2, and leads 314, 293 and 292. Relay CR3 energizes the solenoid S3 of the emergency reverse valve 206 through leads 288 and 329, S3, lead 357, closed contact 334 of CR3, leads 356, 342, 331 and 292, whereby the spool 207 of the emergency reverse valve 206 is held down and hold-down pressure is supplied to the chamber 118 above piston 114, thus holding cam follower 103 on cams 106 (see FIGURE 2). When the function selector switch SW2 is set at the off position, therefore, the electric motor 121 may be set in operation to drive the pumps 122 and 123 and to cause pressure to be accumulated in the accumulators 129 and 138, but the ram 14 will not cycle and the other elements of the circuit are inoperative.

To condition the circuit for operation of the ram, the function selector switch SW2 is set to the run position, in which contacts 1, 2, 3, 4, and 5 thereof are closed. Since contacts 3 of SW2 are closed, relays CR3 and CR5 will be energized as previously explained, once the motor start button PB1 has been pushed, and the solenoid S3 of the emergency reverse valve 206 will be energized. In addition, relay CR2 is energized through the circuit comprising leads 288, 329 and 348, CR2, leads 347 and 333, contact 336 of CR3, which is closed, lead 335, contact 4 of SW2, leads 312, 308 and 307, contact 289 of relay 281, and leads 306, 302, 293 and 292. Energization of CR2 and closure of its associated contact 341 causes solenoid S2 of the inching valve 176 to be energized, thereby shifting the spool 181 therein to direct fluid under pressure through line 177 to the position stop valve 178. Solenoid S2 is energized through the circuit comprising leads 288 and 329, S2, lead 346, contact 341 of CR2, and leads 343, 342, 331 and 292. It should be noted that the solenoid S1 of valve 201 is not yet energized, and fluid pressure is applied above the piston 188 of position stop valve 178 to hold spool 186 downwardly therein and prevent flow to and from the fluid motor 111. Also, although pressure is supplied to the inlet port 41 of the main valve 31 the ram 14 is not yet in motion because the cams 106 which actuate the servo-spool 32 to move downwardly are not yet being rotated.

To initiate cycling of the press ram 14, it is necessary to depress the cycle start push button PB3. When this button is pushed, relays CR1 and CR4 are energized and the contacts associated with those relays are closed. When push button PB3 is depressed, CR1 is energized through leads 288 and 329, CR1, lead 328, contact 317 of PB3, leads 309 and 311, contact 1 of SW2, leads 308, 307, contact 289 of relay 281, and leads 306, 302, 293 and 292. When button PB3 is released, coil CR1 remains energized through the holding circuit comprising leads 288 and 329, CR1, leads 328 and 358, contact 337 of CR3, which is closed, lead 359, contact 325 of CR1, which is closed, lead 361, the limit stop switch LS2, which is closed, leads 363 and 323, contact 5 of SW2, leads 309 and 311, contact 1 of SW2, leads 308 and 307, contact 289 of relay 281, and leads 306, 302, 293 and 292. Energization of relay CR1 causes the solenoid S1 of valve 201 to be energized, which shifts the spool 202 thereof downwardly and causes fluid pressure to be applied through line 191 below the piston 188 of the position stop valve 178, raising the spool 186 of that valve and permitting fluid to flow to the fluid motor 111 so that the fluid motor will operate and start the ram cycling. Solenoid S1 is energized through

leads 288 and 329, S1, contact 324 of CR1, which is closed, and leads 331 and 292.

When the cycle start button PB3 is depressed, the relay CR4 is energized through leads 288 and 367, CR4, lead 376, contact 2 of SW2, lead 321, contact 318 of PB3, which is closed, leads 309 and 311, contact 1 of SW2, leads 308 and 307, contact 289, and leads 306, 302, 293 and 292, thereby causing contacts 373 and 374 to close. Coil CR4 thereafter remains energized through the holding circuit which comprises leads 288, 367 and 377, CR4, leads 376 and 379, contact 374 of CR4, which is closed, lead 378, normally closed cycle stop push button PB4, leads 322 and 323, contact 5 of SW2, leads 309 and 311, contact 1 of SW2, leads 308 and 307, contact 289, and leads 306, 302, 293 and 292. Energization of CR4 causes solenoid S4 to be energized through leads 288 and 329, S4, contact 373 of CR4, and leads 342, 331 and 292. Solenoid S4 then lifts the limit switch LS2 off cam 231, the switch remaining closed, so that as the cam rotates it will not open the switch.

The fluid motor 111 begins to rotate the cams 106, causing the ram 14 to follow spool 32 downwardly. Low pressure oil is supplied to the main cylinder-valve 31 until the ram reaches approximately the bottom 20% of its stroke, when the high spot 166 on cam 163 lifts the spool 142 of the changeover valve 141, causing high pressure oil to be directed to the main cylinder-valve 31. High pressure oil is supplied to the main cylinder-valve 31 until the ram has completed 10% of its upward travel, when cam 163 permits the spool 142 of the changeover valve 141 to shift downwardly and redirects low pressure oil to the main valve. The press will continue to operate in this manner until the cycle stop push button PB4 is depressed. When this is done, the holding circuit for relay CR4 is broken, and CR4 is consequently de-energized. When contact 373 of relay CR4 opens, solenoid S4 is de-energized, and limit switch LS2 drops back on cam 231. Cam 231 opens the contacts 362 of switch LS2 when the cam has rotated to a position such that the ram 14 will stop moving at the top of its stroke. Opening of LS2 breaks the holding circuit for CR1, which in turn de-energizes solenoid S1. When solenoid S1 is de-energized, the spool 202 of valve 201 shifts upwardly and fluid under pressure is applied to the chamber 194 above the piston 188 of the position stop valve 178, and the spool 186 of that valve is urged downwardly, so that cam follower 197 is held against cam 196. When cam follower 197 hits the low spot on cam 196, it permits the spool 186 of the position stop valve 178 to move downwardly in response to the downward fluid force being applied to it, shutting off flow to the motor 111. Since the holding circuits have been broken, release of cycle stop button PB4 does not cause the fluid motor again to rotate.

At any time when the press is cycling, the ram may be moved to emergency reverse (i.e., uppermost) position by momentarily pressing the emergency reverse push button PB5. Depression of this button opens the previously described holding circuit for relay CR3, thereby de-energizing solenoid S3 and shifting the spool 207 of the emergency reverse valve 206, causing piston 114 to lift servo-spool 32. Operation of the emergency reverse push button PB5 also de-energizes the solenoid S2 of inching valve 176, because opening of the holding circuit for CR3 opens the holding circuit of CR2, which in turn controls energization of S2. When S2 is de-energized, flow of fluid through the inching valve 176 to the fluid motor 111 is immediately stopped, which stops shaft 26. The effect is to interrupt the operation of any stock feed mechanism driven off shaft 26. This safety feature is useful in the event of jammed tooling or feeding devices.

Release of the emergency reverse push button PB5 does not permit the ram to begin cycling again since the holding circuit for CR3 is broken. Once the emergency reverse button has been depressed, it is necessary to press the emergency reverse reset button PB6 to again condition the circuit for cycling operation. This feature provides an additional safety precaution. Momentary closure of PB6, which is normally open, energizes CR3 through leads 288 and 367, CR3, leads 366, 304 and 382, PB6, leads 381 and 316, contact 3 of SW2, and leads 314, 293 and 292, which in turn re-energizes the solenoid S3 of the emergency reverse valve 206. This re-establishes the former holding circuit for CR3 through contacts 338, and when the reset button PB6 is thereafter released, CR3 remains energized, as does solenoid S3.

Limit switch LS1 (see FIGURES 4 and 8) is connected in series with the emergency reverse push button PB5, and moves the ram to emergency reverse position when the stroke selector knob 24 is depressed to change the length of the stroke. Thus, when the stroke is to be changed when the ram is cycling, depression of knob 24 raises the servo-spool and ram, lifting cam follower 103 off cams 106 so that the cams can be shifted along shaft 26 relative to the cam follower.

When it is desired to inch or jog the ram discontinuously toward or away from the work piece, as for example in setting up the press for an operation to be performed, the function selector switch SW2 is set at the inch position, in which contacts 1, 3 and 6 of SW2 are closed. When the motor start push button PB1 is depressed, relays CR3 and CR5 will be energized in the manner already described. The emergency reverse valve solenoid S3 is energized and hold-down pressure is applied to cam follower 103. When the cycle start button PB3 is depressed, relay CR1 is energized through leads 288 and 329, CR1, lead 328, contact 317 of PB3 which is closed as long as the button remains depressed, leads 309 and 311, contact 1 of SW2, leads 308 and 307, contact 289, and leads 306, 302, 293, and 292. Closure of the contacts of CR1 in turn causes relay CR2 to be energized through leads 288, 329 and 348, CR2, leads 347 and 333, contact 327 of CR1, which is closed, lead 332, contact 6 of SW2, leads 313, 308 and 307, contact 289, and leads 306, 302, 293 and 292. When these two relays are energized, solenoids S1 and S2 are energized, as has previously been described, S1 being energized through leads 288 and 329, S1, contact 324 of CR1, and leads 331 and 292, and S2 being energized through leads 288 and 329, S2, lead 346, contact 341 of CR2, and leads 343, 342, 331 and 292. Energization of S2 shifts the spool 181 of inching valve 176, and fluid is directed through the valve to the position stop valve 178. The spool of valve 201 is shifted by S1 to lift the spool of position stop valve 178 to open position and fluid is supplied to the fluid motor 111. However, relays CR1 and CR2 will be de-energized as soon as the cycle start push button is released, de-energizing solenoids S1 and S2 so that flow to the fluid motor will stop. (When the function selector switch SW2 is in the inch position, relay CR4 is not energized, and the previously referred to holding circuits for CR1 and CR2 are open, so that CR1 and CR2 do not remain energized.) Thus, by repeatedly depressing and releasing the cycle start push button PB3, the fluid motor is rotated for only brief intervals, and the ram inches toward and away from the work piece.

When the fluid motor 111 rotates, it turns shaft 26 to which cams 106 are mounted. If work piece feed mechanism is connected for operation by the rotation of shaft 26, this mechanism will also be operated by inching of the ram when the function selector switch SW2 is in inch position, and will cause the work piece to be inched toward or away from the ram.

When the function selector switch SW2 is set in the inch feed position, the fluid motor 111 is caused to operate as in the inch position, but fluid under pressure is supplied to the chamber 119 beneath piston 114 so that the servo-spool 32 is held in emergency reverse position and does not move as the fluid motor 111 rotates the cams 106, the cam follower 103 being disengaged from the cams.

Under these conditions, the fluid motor 111 causes the stock feeding mechanism to inch as shaft 26 is rotated, but the servo-spool 32 and piston 44 remain in their uppermost positions. Such inch feeding of the work piece is useful in setting up the press for production operation.

When the function selector switch SW2 is in inch feed position, only contacts 1 and 6 of SW2 are closed. When the motor start push button PB1 is depressed, relay 281 is energized as previously described, closing contacts 289 and 279, and is thereafter held in by the holding circuit previously referred to. When contacts 279 are closed, the electric motor 121 is energized. Relay CR3 is not energized, and since its contacts remain open, the solenoid S3 of the emergency reverse valve 206 is not energized and the spool 207 of that valve directs fluid under pressure to chamber 119 below piston 114, holding servo-spool 32 in emergency reverse position. When the cycle start push button PB3 is depressed, CR1 is energized through leads 288 and 329, CR1, lead 328, contact 317 of PB3, leads 309 and 311, contact 1 or SW2, leads 308 and 307, contact 289, and leads 306, 302, 293, and 292. Energization of CR1 causes S1 to be energized through leads 288 and 329, S1, contact 324 of CR1, and leads 331 and 292. The coil of CR2 is energized through leads 288, 329 and 348, CR2, leads 347 and 333, contact 327 of CR1, which is closed, lead 332, contact 6 of SF2, leads, 313, 308, and 307, contact 289, and leads 306, 302, 293, and 292. Closure of the contacts of CR2 causes S2 to be energized through leads 288, 329, S2, lead 346, contact 341 of CR2, which is closed, and leads 343, 342, 331 and 292. The inching valve 176 and the position stop valve 178 are thereby actuated to supply fluid to the fluid motor 111, causing it to rotate shaft 26, but since the emergency stop valve solenoid S3 is not energized the ram 14 does not move. No holding circuits for CR1 and CR2 are completed, and the fluid motor will rotate only as long as the cycle start button PB3 is depressed.

The lubrication timer 351 is energized whenever the fluid motor runs, since it is connected in parallel with CR1 (which controls the motor) through leads 329, 354 and 328. When CR1 is energized, therefore, the lubrication timer 351 is also energized, and at predetermined intervals, the timer briefly closes its associated contacts 352. Closure of these contacts completes a circuit through the solenoid of the lubrication valve solenoid S5 through lead 288, contact 352, S5, lead 344, contact 326 of CR1, and leads 342, 331 and 292. When the solenoid S5 of the lubrication valve 218 is energized, the spool 224 of that valve is shifted downwardly by the solenoid, and fluid under pressure from line 219 is directed to the various lubrication outlets 223 of the press so that lubrication takes place automatically. The lubrication timer 351 does not operate unless the fluid motor is also running.

The foregoing is a description of a preferred embodiment of an automatic hydraulic press in accordance with the present invention. It is to be understood that the principles of the invention are not limited to that embodiment alone, and that the invention also includes modifications and variations which come within the scope of the claims which follow.

I claim:

1. A hydraulic press comprising a ram, means for operating said ram in continuous reciprocating movement, a high pressure, low volume pump and a high volume, low pressure pump, a changeover valve having a pair of inlets and an outlet, said valve being selectively actuatable to alternately connect said inlets to said outlet, fluid passageways connecting one of said inlets to said high pressure pump, the other of said inlets to said high volume pump and said outlet to said ram operating means, a cam, means moving said cam in fixed relation to the reciprocating movement of said ram, and cam follower means actuating said valve to connect said high volume pump to said ram operating means for a predetermined portion of the movement of said ram in a given direction and to connect said high pressure pump to said ram operating means for the remaining portion of the movement of said ram in said given direction.

2. A hydraulic press in accordance with claim 1, wherein said cam is shaped to connect said high pressure pump to said ram operating means for a terminal portion of the ram movement in one direction and for an initial portion of ram movement in the opposite direction and to connect said high volume pump to said ram operating means for the remaining portion of ram movement.

3. An automatic hydraulic press comprising, a ram, a servo-controlled main valve for moving said ram, said main valve being of the type which includes a lineally movable servo-spool movement of which is followed by said ram, a high pressure pump and a high volume pump, a motor, cam means rotated by said motor, cam follower means engaged with said cam means for establishing cammed movement, means mechanically connecting said cam follower means with said servo-spool whereby said servo-spool is moved lineally with respect to said main valve in response to cammed movement of said cam follower means, hydraulic conduits connected between said pumps and said main valve, valve means connected in said conduits and actuable to connect said high pressure pump and said high volume pump alternately to said main valve to supply operating pressure thereto, and means actuating said valve means to connect said high volume pump to said main valve during a predetermined portion of the rotation of said cam means and to connect said high pressure pump to said main valve during the remaining portion of the rotation of said cam means.

4. An automatic press in accordance with claim 3 wherein said actuating means comprise a cam rotated by said motor and cam follower means mechanically linked thereto for actuating said valve means in the manner specified.

5. An automatic hydraulic press comprising, a ram, a servo-controlled main valve for reciprocating said ram, said main valve being of the type which includes a lineally movable servo-spool movement of which is followed by said ram, a high pressure pump and a high volume pump, a fluid motor, cam means rotated by said motor, cam follower means engaged with said cam means for establishing cammed movement, means mechanically linking said cam follower means with said servo-spool whereby said servo-spool is moved lineally with respect to said main valve in response to cammed movement of said cam follower means, a changeover valve having a pair of inlets and an outlet, said changeover valve being actuable to selectively and alternately connect said inlets to said outlet, fluid passageways connecting one of said inlets to said high pressure pump, the other of said inlets to said high volume pump and said outlet to said main valve, a cam, means rotating said cam in fixed relation to the movement of said ram, and cam follower means engaged with said cam whereby said changeover valve is actuated to connect said high volume pump to said main valve for a predetermined portion of the movement of said ram in a given direction and is actuated to connect said high pressure pump to said main valve for the remaining portion of the movement of said ram in said given direction.

6. An automatic hydraulic press comprising, a ram, a servo-controlled main valve for operating said ram, said main valve being of the type which includes an inlet port and a lineally movable servo-spool movement of which is followed by said ram when fluid pressure is applied to said inlet port, a changeover valve having a pair of inlets and an outlet, said outlet being connected to the inlet port of said main valve, said changeover valve including a lineally shiftable spool shifting of which connects said outlet from one to the other of said inlets, a first source of fluid pressure including a pump and an accumulator connected to one of said inlets, a second source of fluid pressure including a pump and an accumu-

lator connected to the other of said inlets, said second source being effective to supply fluid at greater pressure and at lower volume than said first source, means imparting reciprocating lineal movement to said servo-spool, and means effective to shift the spool of said changeover valve when said servo-spool is in predetermined position with respect to said main valve.

7. An automatic hydraulic press comprising, a ram, a servo-controlled main valve for operating said ram, said main valve being of the type which includes an inlet port and a lineally movable servo-spool movement of which is followed by said ram when fluid pressure is applied to said inlet port, a changeover valve having a pair of inlets and an outlet, said outlet being connected to the inlet port of said main valve, said changeover valve including a lineally shiftable spool shifting of which connects said outlet from one to the other of said inlets, a first source of fluid pressure including a pump and an accumulator connected to one of said inlets, a second source of fluid pressure including a pump and an accumulator connected to the other of said inlets, said second source being effective to supply fluid at greater pressure and at lower volume than said first source, means for imparting reciprocating lineal movement to said servo-spool, and means effective to shift the spool of said changeover valve when said servo-spool is in predetermined position with respect to said main valve, said means comprising, a cam, means rotating said cam in fixed relation to the lineal movement imparted to said servo-spool, cam follower means riding on said cam, and a lever connecting said cam follower means to the spool of said changeover valve, said cam having a cam surface adapted to cause said cam follower means and lever to shift the spool of said changeover valve when said cam is in predetermined angular position.

8. An automatic hydraulic press comprising, a ram, a servo-controlled main valve for moving said ram, said

main valve being of the type which includes a lineally movable servo-spool movement of which is followed by said ram, a high pressure pump and a high volume pump, a fluid motor, first cam means rotated by said motor, cam follower means engaged with said first cam means for establishing cammed movement, means mechanically linking said cam follower means with said servo-spool whereby said servo-spool is moved lineally with respect to said main valve in response to cammed movement of said cam follower means, valve means for alternately connecting said high pressure pump and said high volume pump to said main valve to supply operating pressure thereto, hydraulic circuitry connecting said pumps to said main valve through said valve means, said valve means including an operating arm for operating said valve means to selectively connect said pumps to said main valve, second cam means rotated by said fluid motor, and cam-follower means operatively interconnecting said second cam means to said operating arm, said second cam means being shaped to actuate said operating arm to connect said high volume pump to said main valve for a predetermined portion of the rotation of said second cam means and to actuate said operating arm to connect said high pressure pump to said main valve for the remaining portion of the rotation of said second cam means.

References Cited by the Examiner

UNITED STATES PATENTS

2,051,052	8/36	Morgan	60—52 X
2,581,434	1/52	Nowak	60—52 X
2,790,305	4/57	Towler et al.	60—52
2,875,733	3/59	Nelson	121—38
2,963,865	12/60	Thomas	60—51
2,980,064	4/61	Norton et al.	121—38

EDGAR W. GEOGHEGAN, *Primary Examiner.*