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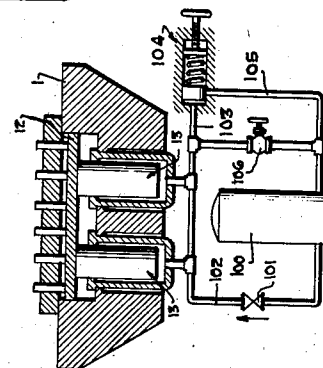
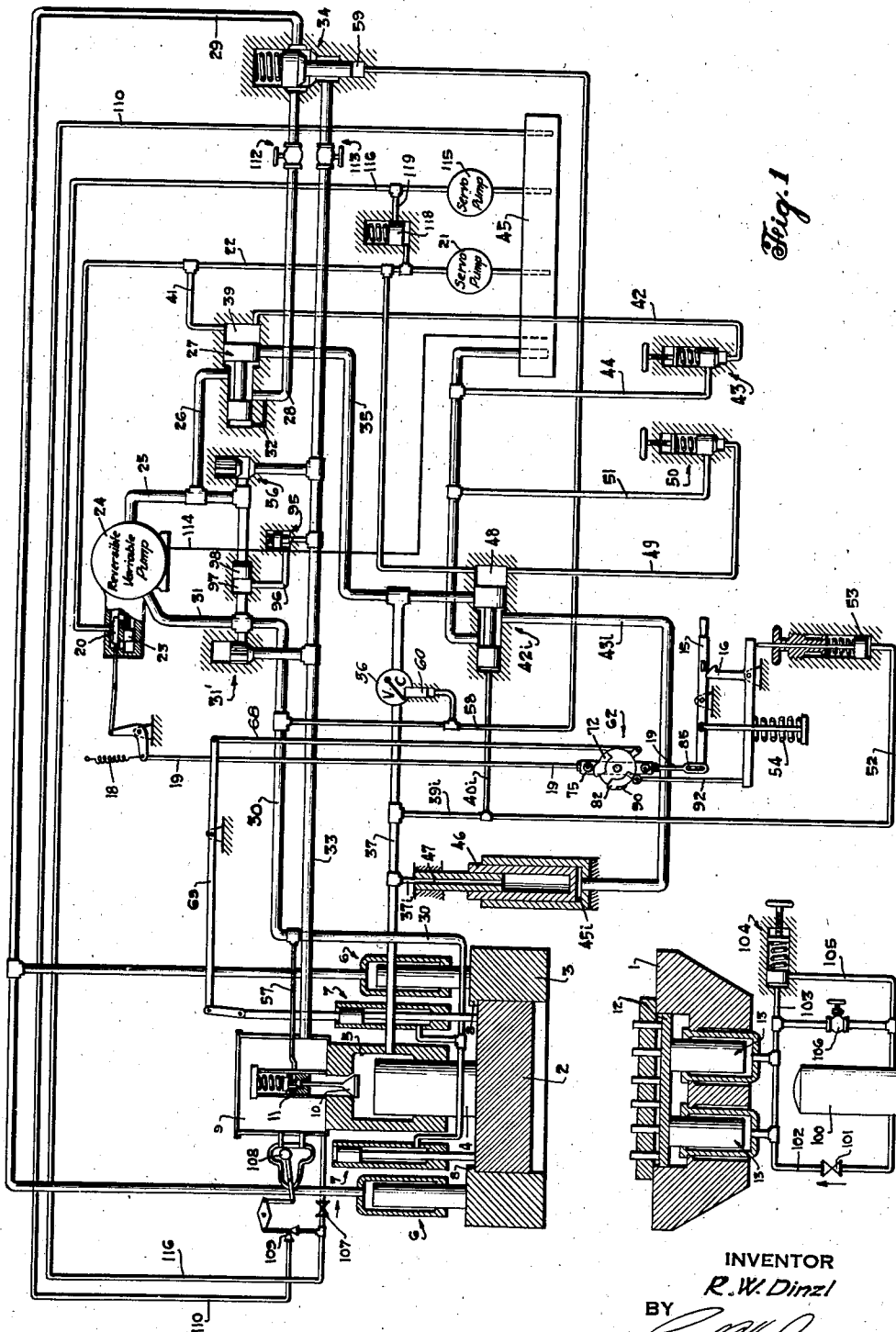
R. W. DINZL

2,242,209

HYDRAULIC PRESS

Original Filed Nov. 16, 1935

3 Sheets-Sheet 1



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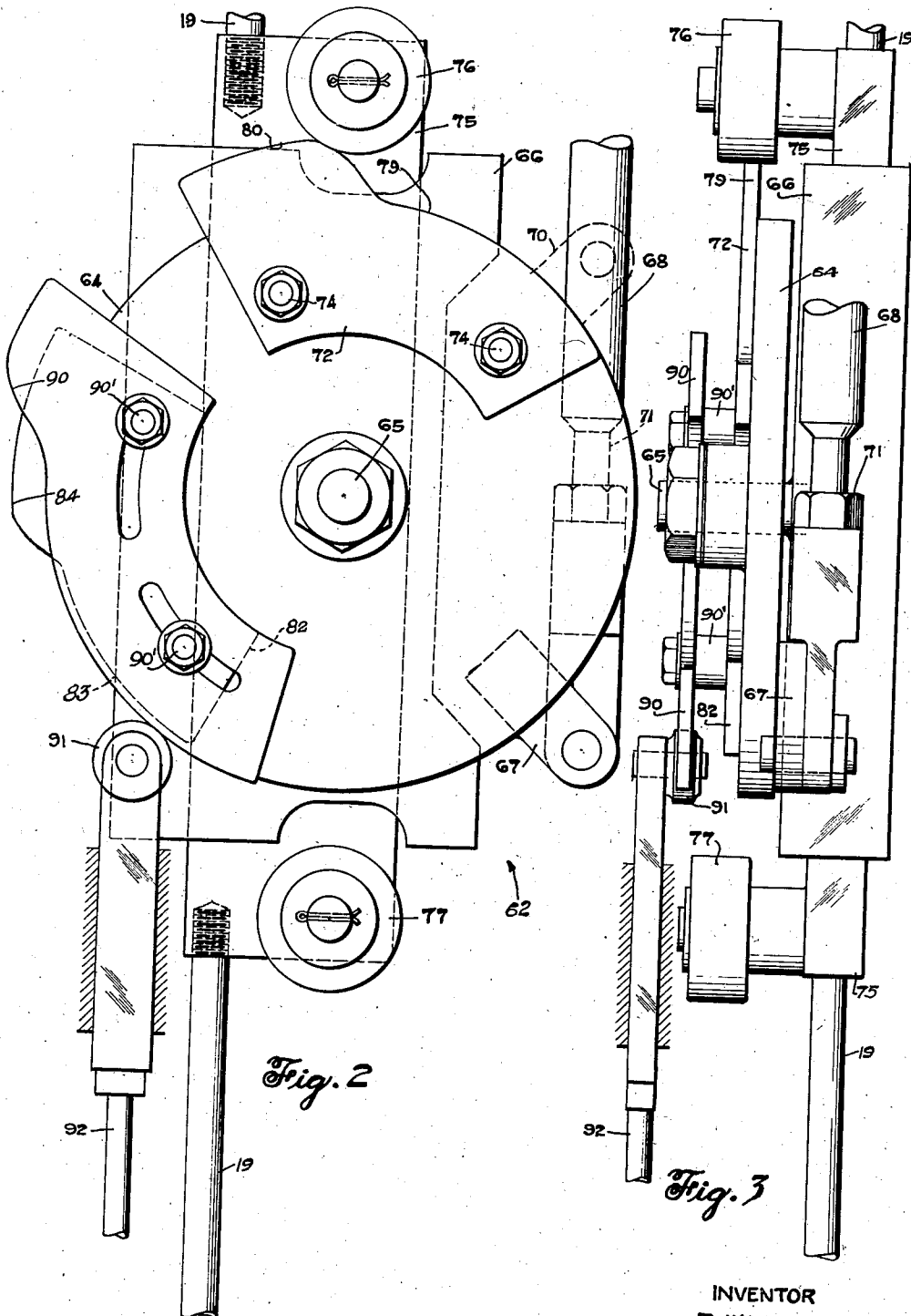
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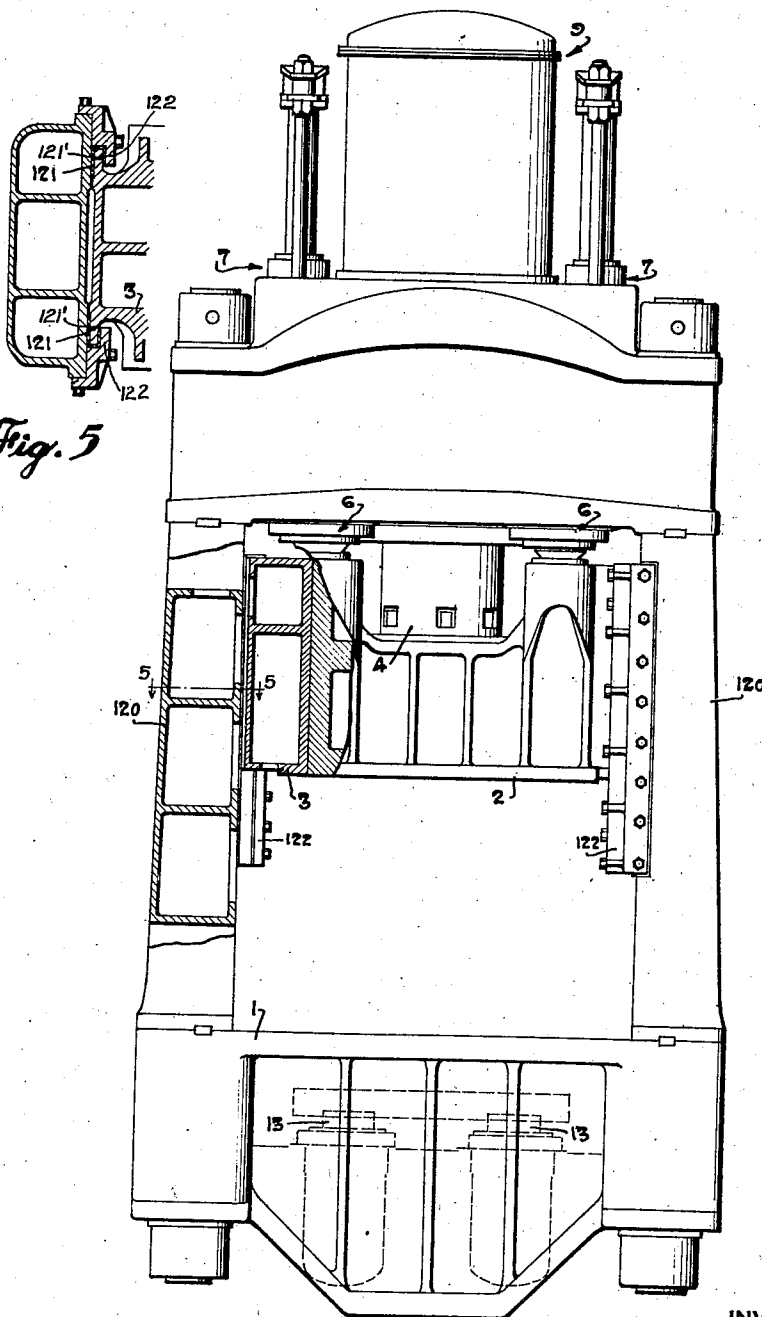
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3 Sheets-Sheet 3



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## UNITED STATES PATENT OFFICE

2,242,209

## HYDRAULIC PRESS

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mesne assignments, to The Baldwin Locomo-  
tive Works, a corporation of Pennsylvania

Application November 16, 1935, Serial No. 50,198  
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22 Claims. (Cl. 113—45)

This invention relates generally to a hydraulic press and control system therefor and more particularly to an improved combination of control elements for effecting relatively high speed press operation.

It is one object of my invention to provide an improved control system for hydraulic presses whereby the same may efficiently operate at relatively high speeds with a high degree of flexibility of operation and control while at the same time accomplishing these results in a simple, economical and compact manner insofar as the character of the invention permits. A more specific object of the invention is to provide an improved combination adapted to permit a single pump to be most effectively used for all press operations such as blank holding, pressing and returning the press to its upper position, and especially of having improved means for determining the operating pressures for said operations and for automatically effecting the various sequence of operations.

A further object is to provide an improved method and apparatus for effecting down movement of a hydraulic press so that it simulates the action of power presses wherein the die platen moves rapidly during its approach stroke and then has a slower movement during the drawing operation, thereby reducing the time of the complete cycle with consequent greater productive capacity of the press while at the same time maintaining the many desirable characteristics of a hydraulically operated press. Broadly, I accomplish the variable speed operation by controlling the rate of supply of operating fluid from any suitable source automatically in accordance with progressive movements of the press slide or platen. In one specific aspect of the invention I provide a reversible pump of the general type shown in Hele-Shaw Patent No. 1,152,729 adapted to be adjusted from full stroke to neutral during either forward or reverse operation and then provide suitable means for effecting adjustment of the pump stroke in accordance with predetermined successive positions of the press platen. In such a specific arrangement the pump is of the positive displacement type and hence the speed of press movement is directly proportional to the pump displacement which is controlled in accordance with the pump stroke. It will be apparent from the principles disclosed herein that various specific arrangements may be provided for supplying variable quantities of fluid automatically in accordance with predetermined positions of the press platen, including elec-

trically, pneumatically or mechanically operated elements for controlling the fluid supply at successive positions of the press. In the preferred embodiment of the invention I employ mechanical control means in the form of cam elements oscillated in synchronism with movement of the press platen and arranged to mechanically operate a pump pilot valve, thereby providing a simple, positive and efficient means for accomplishing my improved mode of operation.

A further object is to provide an improved position return as well as a pressure return preferably arranged in cooperative relation to the improved variable speed control apparatus and to incorporate therewith a top position control for stopping the press on its return stroke.

Other objects and advantages will be more apparent to those skilled in the art from the following description of the accompanying drawings in which:

Fig. 1 is a diagrammatic outline of my improved control system applied to a hydraulic press;

Fig. 2 is an enlarged elevational view of the cam mechanism;

Fig. 3 is a side elevation of Fig. 2;

Fig. 4 is a front elevation of a press embodying improved platen guiding means;

Fig. 5 is a transverse section taken on line 5—5 of Fig. 4.

In the particular embodiment of the invention which is shown herein merely for the purpose of disclosing one specific form among possible others that the invention might take in practice, I have diagrammatically shown a press having a lower stationary platen 1 and an upper main die platen or inner slide 2 surrounded by an outer slide or blank holder 3. The inner die 2 is moved downwardly by a ram 4 disposed within a cylinder 5 while the outer slide 3 is moved downwardly preferably by a pair of cylinders and rams generally indicated at 6. A pair of pull-back cylinders and rams generally indicated at 7 are connected to inner slide 2 and are adapted to raise the outer slide 3 by any suitable interlocking mechanism between the inner and outer slides 2 and 3. One such mechanism is diagrammatically shown as comprising lips 8 projecting inwardly from outer slide 3 and overlying the top of slide 2 whereby upon upward movement thereof the slide 3 is automatically returned therewith. Normally the outer slide 3 projects below die slide 2, thereby permitting the outer slide 3 to engage a blank prior to engagement of the die with the work piece. The work piece is usually

sheet metal or the like. A filling tank 9 contains liquid under any desired air pressure, e. g., 25 pounds, while a filling valve 10 normally urged closed by a light spring permits substantially free flow of liquid into the main cylinder 5 during initial downward movement of the press. A usual pilot cylinder and piston generally indicated at 11 is adapted to open the filling valve during upward movement of the press to permit free return of liquid from the main cylinder to the filling tank. The lower platen 1 is provided with a usual cushion pad 12 which is urged upwardly preferably by a pair of cushioning cylinders and rams generally indicated at 13.

The combination of elements and the structure thereof in my improved control system will be more readily understood by describing the general mode of operation of the system as a whole.

*To start the press down.*—To initiate press operation, a pivotally supported hand lever 15 is pressed down and held by a latch 16, thereby permitting a spring 18 to move a pump control rod 19 upwardly and accordingly shift a pump stroke-control valve 20 inwardly whereupon fluid is admitted from a servo-pump 21 and pipe 22 to the left end of a pump stroke-adjusting piston 23. The stroke of a main pump 24 is thereby adjusted for full forward operation, it being understood that this pump is preferably of the reversible Hele-Shaw type adapted to positively displace variable quantities of liquid with a variable stroke in either forward or reverse directions from a neutral position. This type of pump and its reversible and variable stroke adjusting means is well known, and hence it need not be described further. With the pump in its forward position, fluid is discharged successively through pipes 25 and 26, a blanking pressure control valve 27, pipe 28, around a valve 34, thence through a pipe 29 to the outer slide cylinders 6. At the same time fluid is drawn from pull-back cylinders 7 through pipes 30 and 31 now functioning as the suction side of the pump. The fluid drawn from the pull-back cylinders is of limited volume, and hence to permit the pump to discharge a large volume to the main cylinder 5, a check valve 31' opens to permit fluid from filling tank 9 to be supplied to the suction side of the pump through pipes 33 and 31. Exhaust of pull-back pressure permits the inner and outer slides to drop by their own weight but at a controlled rate determined by the rate at which the pump exhausts fluid from the pullback cylinders. Hence the exhausting fluid is under a pressure equal to the weight of the rams and cylinders so long as the slides are moving downwardly under their own weight. While the fluid is being exhausted from the pullback cylinders, the outer slide cylinders 6 are filled by fluid not only from pump 24 but also from filling tank 9 through a pipe 33 and check valve 34, which opens under the filling tank pressure during this operation and therefore may be termed a blank holder filling valve. Also during this time main cylinder 5 will fill from tank 9 through filling valve 10.

*Blank holding pressure followed by main cylinder pressure.*—When the outer blank holding slide 3 engages the work, the pump will build up pressure in outer slide cylinders 6 to a predetermined value, this pressure then being transmitted through a passage 32 to shift valve 27 to the right, thereby connecting pipe 26 to a pipe 35 for admitting fluid from pump 24 to the under side of a normally closed check valve, conventionally shown at 36, thereby to open the check

valve and allow pump fluid to continue through pipe 37 to main cylinder 5. The filling valve 10 closes when pump pressure builds up in the main cylinder sufficiently to overcome the filling pressure. The main ram and inner die slide 2 thereupon perform the draw stroke.

Blank holder control valve 27 insures that a predetermined constant pressure is maintained on the outer blank holding slide 3 regardless of pressure variations in the main cylinder 5 during the drawing operation. Hence by proper adjustment of the blank holding pressure, the sheet metal may slip with the proper degree of resistance so as to avoid tearing the metal. It is of considerable importance that the blanking pressure control valve 27 should be controlled with stability and accuracy over a wide range of different adjustments so as to maintain any given blank holding pressure constant. To accomplish this, valve 27 is provided preferably with spools of different diameters and fluid pressure is constantly supplied to a chamber 39 to act on the large spool and thus bias valve 27 in a left direction. This control pressure is supplied from servo-pump 21 through a pipe 41, while the pressure in chamber 39 is adjustably controlled by a bleed pipe 42 connected to an adjustable blanking pressure-determining valve 43 adapted to open to a throttling position by pressure in pipe 42 so as to maintain such pressure constant. Fluid exhausted through valve 43 is discharged through a pipe 44 to a sump or slippage tank 45.

*Initiation of intensifier operation.*—As the work resists downward movement of inner slide 2, the pressure of the pump will increase until a predetermined pressure is reached in the main cylinder, this pressure being transmitted from pipe 37 through pipe 39i and 40i to shift a three-way valve 42i to the right for initiating intensifier operation. Fluid is thereupon supplied from the pump through pipes 35 and 43i to a low pressure intensifier cylinder 45i. As the intensifier ram 46 is raised, high pressure fluid is discharged through a passage 47 and pipes 37i and 37 to main cylinder 5. Check valve 36 closes when the intensifier pressure in pipe 37 exceeds the pump pressure in pipe 35. Intensifier initiating valve 42i is adjustably controlled by constant pressure in a chamber 48 supplied from pump 21 while a bleed-off pipe 49 is connected to an adjustable valve 50 for controlling or determining the maximum intensifier pressure for a given operation. This valve is opened to a throttling position by pressure in pipe 49 and connected through a pipe 51 to sump 45, thereby to maintain said predetermined constant pressure in chamber 48.

*Pressure controlled press reversal.*—To reverse the press when a predetermined intensified pressure is built up in cylinder 5, this pressure is transmitted from pipe 37 through pipes 39i and 52 to raise an adjustable spring pressed plunger 53 whose stem engages and raises a bellcrank arm of latch 16 to release handle 15 whereupon a spring 54 rotates handle 15 in a counterclockwise direction and pulls control rod 19 down against the force of a smaller spring 18 to shift pump stroke-control valve 20 to the left and thus reverse the operation of pump 24. Thereupon the pump draws liquid from filling tank 9 through pipe 33, past check valve 56 and pipe 25 and discharges the fluid through pipes 31 and 30 to the pull-back cylinders 7. At the same time both filling valve 10 and check valve 34 are

opened to permit free discharge of fluid to the filling tank from the main cylinder 5 and blank holding cylinders 6, the simultaneous opening of these valves being effected by the supply of fluid from pipe 30 through a pipe 57 to pilot cylinder 11 and through a pipe 58 to a plunger cylinder 59. Likewise the pressure in pipe 58 operates a plunger 60 to open check valve 36 and thus permit fluid from the high pressure side of the intensifier to be connected to the suction side of the pump through pipe 35. The press is thereupon returned to its top position.

*Position control to stop press when returned to top.*—The press upon reaching its top position, operates a position control generally indicated at 62. This functions to raise rod 19 and throw pump 24 on short stroke to maintain just sufficient pressure for holding the press up. One specific form of suitable mechanism for this operation comprises, as shown in Figs. 2 and 3, a cam dial 64 journaled on a stud 65 which in turn is supported by a suitable stationary guide bracket 66. The dial 64 is provided with a short arm 67 to which one end of a rod 68 is pivotally connected while the other end of said rod is suitably operatively connected to the inner die slide 2, specifically through a pivoted lever 69, Fig. 1, connected to the pullback rams 5. Hence cam dial 64 will be oscillated in synchronism with movement of a die slide, the upper and lower limits of rotation being from the full line position of arm 67, Fig. 2, to its upper dotted line position indicated at 70. Rod 68 may be provided with any suitable adjustable connection 71 for varying its length and adjusting the cam dial. A cam 72 is removably secured to dial 64 by a series of bolts 74 in order that cams of different contour may be used if desired. A member 75 is suitably supported for reciprocating vertical movement in stationary guide 56 and carries upper and lower cam engaging rollers 76 and 77. Slide 75 is connected to pump control rod 19 as an integral part thereof, and hence actuation of slide 75 by cam 72 will cause similar actuation of rod 19. The manner in which the control 62 functions to short stroke pump 24 when the press reaches its top position will now be apparent from the foregoing structural description. For instance, when spring 54 pulled rod 19 downwardly so as to reverse the pump as previously described, the extent of this downward movement was limited by contact of roller 76 with surface 79 of cam 72, the cam dial 64 at this moment being in the dotted position 70, Fig. 2, due to the down position of the press. The foregoing relation of cam and roller permitted full reverse pump stroke. During upward movement of the die slide, lever 69 and link 68 cause clockwise rotation of cam dial 64 from the dotted line position 70 of arm 67 down to its full line position, thereby causing roller 76 and accordingly pump control rod 19 to be partially moved upwardly by the raised cam portion 80 as shown in Fig. 2. The pump is thereupon returned toward neutral position but sufficiently offset therefrom so that it has a short stroke to maintain the necessary pressure for holding up the press. By adjusting the angular position of cam 72 on dial 64 or by substituting another cam, it is possible to determine the top return position of the press in any portion of its travel. The description to this point covers a complete cycle of operation with pressure controlled reversal and top position control.

*Variable press speed.*—If it is desired to have fast initial down movement of the main ram, such

as during the approach stroke thereof, followed by a subsequent slow drawing movement, I have provided a cam 82 angularly adjustably secured to dial 64 and having a surface 83 for engaging roller 77 which thereby limits uppermost movement of pump control rod 19 and accordingly determines the maximum rate of forward displacement of liquid from the pump when hand lever 15 is initially pressed down to its latched position. The cam dial 64 moves in a counterclockwise direction during down movement of the press so that when a raised cam portion 84 engages roller 77 to move slide 75 and pump control rod 19 partially downwardly against the tension of spring 18, the pump will be short stroked so as to reduce its volumetric capacity and accordingly slow down the press to the desired drawing rate. A slot 85, Fig. 1, permits this downward movement of rod 19 without interference from lever 15 even though latched in its down position. Cam 82 may, of course, be given any desired configuration corresponding to any desired rate or variable rate of movement of the ram during its downward travel, such as having one portion of the cam cause a decreased rate of speed and a subsequent portion allow a higher rate of speed followed by another portion for effecting a slower rate of speed, thus providing different rates of draw in the event of forming a complicated piece of work. These or other conditions can be arranged so as to be effective through the entire press stroke.

Referring now to the continued cycle of events, and assuming that variable speed control has been effective on the down stroke, then when the platen reaches its down position the main cylinder pressure builds up to a predetermined value, so that, in the manner previously described, latch 16 is released by pressure transmitted to plunger 53, thus permitting spring 54 which is of greater strength than spring 18 to pull slide 75 and rod 19 entirely down to reverse the pump and return the press to its upper position. As the press moves upwardly, cam 72 will rotate in a clockwise direction and cause cam surface 80 to engage roller 76 and move pump control rod 19 upwardly to short stroke the pump and cause it to maintain just sufficient pressure to hold the press in its upper position, all in the manner as previously described.

*Position controlled reversal.*—If it is desired to employ position control for reversing the press, a cam 90 is attached to dial 64 through studs 90', Fig. 3, for suitable angular adjustment if desired. Hence when the press reaches a predetermined down position, cam 90 will have been rotated so as to engage a roller 91 and thus move a rod 92 downwardly against one arm of latch 16 to release the same, whereupon spring 54 moves slide 75 and rod 19 downwardly to reverse the pump in the manner previously described. By suitably adjusting the angular position of cam 90, it is possible to effect reversal of the pump and press at any desired point in the down stroke.

*Relief valve.*—Inasmuch as the pump herein disclosed is of the reversible type, it is desirable to minimize the number of control elements as far as possible consistent with obtaining all desired functions and results. In one aspect of the invention I have accomplished this by providing an improved and simplified pressure relief system whereby a single relief valve 95 is operative for either direction of pump operation, thus avoiding duplication of expensive relief valve apparatus. This valve may be of any usual construction hav-

ing an inlet pipe 96 communicating with a shuttle valve chamber 97 connected to the two pump lines 25 and 31. A shuttle valve 98 is moved to the left when the pump discharges through pipe 25 and is moved to the right, past passages 96, when the pump discharges through pipe 31. Hence it is seen that the high pressure side of the pump is always in communication with the inlet passage 96 leading to relief valve 95. The relief valve discharges into pipe 33 leading to the filling tank.

*Cushioning pressure.*—To provide suitable cushioning pressure for pad 12, cushioning cylinders 13 are supplied with fluid from a tank 100. The liquid therein is maintained under predetermined air pressure and is supplied to the cushioning cylinders through a check valve 101 and pipe 102. The cushion rams and pad will normally be in their raised position so that when the working stroke of the press takes place, the liquid in the cushion cylinders will be forced back through pipe 103 and through an adjustable cushion pressure control valve 104. A predetermined cushioning pressure in excess of the pressure in tank 100 may be maintained by valve 104 which opens only sufficiently to maintain the desired pressure. Any fluid that is discharged through said valve flows back through a pipe 105 to the lower end of tank 100. Under certain conditions, the full pressure in tank 100 can be used for cushioning, in which case a bypass valve 106 is opened so as to eliminate the operation of pressure control valve 104.

To provide a relatively small size filling tank and still have enough oil available for normal operations, leakage tank 45 is of sufficient capacity to receive slippage oil from pump 24 through a pipe 114 and also receive oil from the entire system in the event that it is desired to drain filling tank 9 or other portions of the system. Normally the filling tank and leakage tank are of the same capacity, but in my improved combination I can employ a small filling tank. This is accomplished by operating a leakage pump 115 so as to continuously circulate oil from the tank 45 through a pipe 116 and check valve 107 to the filling tank and when the oil level therein reaches a predetermined height, then a float 108 opens a valve 109 to bypass fluid from line 116 to line 110 and back to the slippage or auxiliary tank 45. Hence even though the capacity of the filling tank is materially less than normally required, yet the cooperative action of the slippage tank in combination with pump 115 permits a normal supply of filling fluid to be always available, this being accomplished preferably by having pump 115 operate continuously. To permit pump 21 to continuously operate in its closed system and maintain a substantially constant operating pressure of say 250 pounds per square inch, I provide a relief valve 118 for discharging excess fluid through a pipe 119 into the low pressure filling tank system by way of pipe 116.

In the event that single acting press operation is desired, that is, that only one slide shall be used, I either provide a single slide or I can secure the inner and outer slides together to form a unit. I then close stop valves 112 and 113, thus eliminating the blank holder operation but maintaining all other functions and results of the remaining portion of the press. As shown in Figs. 4 and 5, the outer slide 3, or a single slide if such is used, may be guided in an im-

proved manner so as to prevent spreading of the side frame members 120. This is accomplished by providing a guide surface 121 on the inner faces of the frame for slidably engaging the outer surface of slides 3. The slide is provided with laterally projecting flanges 121' along each of its vertical edges, and inner guiding members 122 are secured to the frame members and overlap said flanges to slidably guide the same on the inside thereof. Thus each side of the frame has self-contained means to independently support the slide against bi-lateral movement, e. g., either inwardly or outwardly. As a result, the slide will not tend to spread the frame members in case of any tilting action as has heretofore been the case when the side frames constituted the sole guiding surface.

From the foregoing disclosure of the various features of my improved combination, it is seen that I have provided an improved press and control system adapted to accomplish many desirable results in an effective and efficient manner and with minimum complications consistent with the character of the invention. I am able to positively, accurately and rapidly control the press operations regardless of varying pressures that may be simultaneously required such as is involved in the improved control arrangement including blank holding control valve 27 and pressure control valve 42 for stepping in the intensifier whenever desired. The improved adjustable pressure control of the blank holding and intensifier valves is particularly effective in assuring rapid, smooth and convenient adjustment and control. There is also the very desirable feature of variable speed control operative automatically in accordance with press operation whereby a die slide may be deliberately and positively operated at controlled variable rates of speed at any portion of its entire stroke or cycle, thus rendering the press highly conducive to maximum speed of operation while at the same time maintaining a precise desired rate of draw.

It will of course be understood that various changes in details of construction and arrangement of parts may be made by those skilled in the art without departing from the spirit of the invention as set forth in the appended claims.

I claim:

1. In combination, a hydraulic press having a vertically movable hydraulically operated slide and pull-back mechanism therefor, a source of fluid pressure for operating said slide and pull-back mechanism, cam mechanism including cam and cam follower elements each mounted separately from said slide, means operatively connecting the cam element to said slide so that the cam element has movement in accordance with but proportionately reduced from the movement of the slide, and means controlled by said cam mechanism for returning the slide when it reaches a predetermined lower position.

2. In combination, a hydraulic press having a slide, means for operating said slide including a main cylinder and ram and a pull-back cylinder and ram, a reversible positive displacement pump for supplying fluid to said cylinders, manually operable means for initiating forward operation of said pump to effect a pressing operation, means for latching said manual means in its pressing position, cam mechanism operated in synchronism with movement of said slide for variably controlling the displacement of said pump in accordance with slide movement thereby to ef-

fect a variable rate of slide movement, means responsive to pressure in said main cylinder for releasing said latch, and means for thereupon reversing operation of said pump to return the slide.

3. In combination, a hydraulic press having a slide, means for operating said slide including a main cylinder and ram and a pull-back cylinder and ram, a reversible positive displacement pump for supplying fluid to said cylinders, manually operable means for initiating forward operation of said pump to effect a pressing operation, means for latching said manual means in its pressing position, cam mechanism operated in synchronism with movement of said slide for variably controlling the displacement of said pump in accordance with slide movement thereby to effect a variable rate of slide movement, means responsive to pressure in said main cylinder for releasing said latch, means for also releasing said latch automatically when said slide reaches a predetermined lower position, and means for thereupon reversing operation of the pump to return the press.

4. In combination, a hydraulic press having a plurality of slides operated respectively by blank holding and main hydraulic cylinders and rams, a positive displacement pump for supplying fluid to said blank holding cylinder during initial movement of the ram therein, means adapted upon occurrence of a predetermined pressure in said blank holding cylinder to cause pump fluid to be supplied to said main cylinder, an intensifier, and means for supplying fluid from said pump to said intensifier and from said intensifier to said main cylinder automatically when the pump pressure therein reaches a predetermined value.

5. In combination, a hydraulic press having a slide operated by a hydraulic cylinder and ram, a positive displacement pump for supplying fluid to said cylinder during initial movement thereof, an intensifier, means for supplying fluid from said pump to said intensifier and from said intensifier to said cylinder automatically when the pump pressure therein reaches a predetermined value including a valve responsive to pump pressure for initiating said intensifier operation, means for supplying a substantially uniform fluid pressure to one end of said valve for constantly biasing the same in one direction, and a control valve for variably determining said biasing pressure.

6. In combination, a hydraulic press having a slide operated by a cylinder and ram, a blank holder slide also operated by a ram and cylinder, means for supplying operating fluid to said cylinders, means including a control valve adapted to establish a predetermined holding pressure in the blank holder cylinder and to maintain such pressure substantially constant while permitting pump pressure to build up in said main cylinder for effecting a pressing operation, means for supplying a substantially uniform fluid pressure to one end of said control valve for constantly biasing the same in one direction, and an adjustable valve for determining said biasing pressure.

7. In combination, a hydraulic press having a plurality of slides and cylinders and rams for operating the same, a variable displacement pump for supplying operating fluid to said cylinders, means for causing said pump to build up pressure in one of said cylinders to a predetermined value and thereafter build up pressure in the other cylinder while maintaining said predetermined pressure, a cam and cam follower each

supported separately from said slides, means connecting said cam to one of the slides so that the cam is moved in accordance with but proportionately reduced from the movement of said slide to which the cam is connected, and means controlled by said cam whereby said pump is short-stroked during the period when pressure is being built up in said other cylinder thereby to effect a variable rate of slide movement between the extremes of slide movement.

8. In combination, a hydraulic press having a die slide and a main cylinder and ram for operating the same, a blank holder slide and operating ram and cylinder therefor, a single pump for supplying operating fluid to both of said cylinders, a blanking pressure control valve adapted to permit pump pressure to build up to a predetermined pressure in the blank holder cylinder, and means responsive to said blanking pressure for shifting said valve to supply pump fluid under a predetermined pressure to the die slide cylinder while maintaining the blank holding pressure substantially constant.

9. The combination set forth in claim 8 further characterized by the provision of pressure fluid means for constantly biasing said valve in the direction for admitting pump fluid to said blank holder cylinder, and a valve for adjustably controlling said biasing pressure.

10. In combination, a hydraulic press having a main slide operated by a ram and cylinder, a blank holder slide also operated by a ram and cylinder, a filling tank, a plurality of filling valves one for each of said cylinders whereby said cylinders may be supplied with low pressure filling fluid from said tank during initial down movement of the slides, a pump, and means for supplying fluid from said pump to said blank holding cylinder for building up a predetermined pressure therein and thereafter maintaining said pressure while supplying fluid from the pump to the main cylinder.

11. The combination set forth in claim 10 further characterized in that the press has a pull-back cylinder and ram, means for automatically reversing discharge of fluid from said pump so as to supply fluid therefrom to said pull-back cylinder automatically in accordance with a predetermined press operation, and means responsive to said reversing operation for opening said filling valves and permitting fluid from the blank holder and main slide cylinders to freely return to the filling tank.

12. In combination, a hydraulic press having a die slide and a main cylinder and ram for operating the same, a pull-back cylinder and ram for said slide, a reversible pump for supplying fluid alternatively to said cylinders, a relief valve for pump pressure, and means for rendering said relief valve operative for either direction of pump operation.

13. In combination, a hydraulic press having a slide, a cylinder and ram for operating said slide, means providing a source of pressure fluid for actuating said ram, cam means including a cam and cam follower each supported separately from said slide, means operatively connecting said cam to said slide for effecting movement relative thereto and in synchronism therewith, means controlled by said cam follower for varying the speed of movement of the slide automatically in accordance with predetermined press operations, said cam means also including a second cam and cam follower one of which is operatively connected to said slide for determining the position

at which the ram is to be reversed, and means controlled by said second cam follower for reversing the movement of the ram in accordance with said predetermined position thereof.

14. In combination, a hydraulic press having a slide, a cylinder and ram for operating said slide, means providing a source of pressure fluid for actuating said ram, cam means including cam and cam follower elements each supported separately from said slide, means operatively connecting one of said cam elements to said slide for effecting movement relative thereto and in synchronism therewith, means controlled by said cam means for varying the volumetric supply of fluid to said cylinder automatically during successive positions of the slide thereby to effect variable rates of slide movement between the extremes of the slide stroke, and means responsive to cylinder pressure for operating said controlled means to effect reversal of slide movement.

15. In combination, a hydraulic press having a slide, means for reciprocating said slide including a main cylinder and ram and a pullback cylinder and ram, a reversible positive displacement pump for alternatively supplying fluid to said cylinders, means for short stroking said pump as the slide progresses toward the end of its stroke under power of the main cylinder and ram, mechanism for reversing said pump whereby fluid is supplied to said pullback cylinder to effect press reversal, means for determining the maximum reverse displacement of said pump during the initial pullback operation, means for short stroking said pump during said reverse operation when said slide approaches the other end of its stroke, and operative connections between said slide and all of said several mentioned means for controlling the same automatically in accordance with slide movement.

16. The combination set forth in claim 15 further characterized in that all of the several mentioned means includes cams mounted upon a single movable cam support which is separate from the slide, and said operative connections include a connection between said slide and said movable cam support for effecting movement thereof in proportion to movement of the slide.

17. The combination set forth in claim 15 further characterized in that all of the several mentioned means includes cams mounted upon a single movable cam support which is separate from

the slide and said operative connections include a connection between said slide and said movable cam support for effecting movement thereof in proportion to movement of the slide, and means whereby certain of said cams may be adjusted relative to others to effect different timing of the press operations.

18. The combination set forth in claim 15 further characterized in that all of the several mentioned means includes cams mounted upon an oscillatable cam dial which is supported separately from said slide, and said operative connections include a connection between said slide and dial so that the dial is oscillated by the slide but in reduced proportion to the movement thereof.

19. The combination set forth in claim 1 further characterized by the provision of oscillatable cam supporting means oscillated by said slide through said operative connecting means.

20. The combination set forth in claim 1 further characterized by the provision of oscillating cam supporting means oscillated by said slide through said operative connecting means, and a crosshead guide having a reciprocable crosshead upon which the cam follower element is mounted, said crosshead being connected to said cam controlled means which returns the slide when it reaches a predetermined lower position.

21. The combination set forth in claim 1 further characterized in that said cam mechanism has two cams and two followers and oscillating cam supporting means oscillated by said slide through said operative connecting means, a crosshead guide having a reciprocable crosshead upon which the cam follower elements are mounted, said crosshead being connected to said cam controlled means which returns the slide when it reaches a predetermined lower position and also controls the slide during its reverse movement, said cam follower elements being mounted upon said crosshead on the opposite sides of the axis of said oscillatable means thereby to enable shifting of the crosshead in opposite directions under control of the cams.

22. The combination set forth in claim 14 further characterized in that said cam means has oscillating cam supporting means, and said oscillating means is oscillated by said slide through said operative connecting means.

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